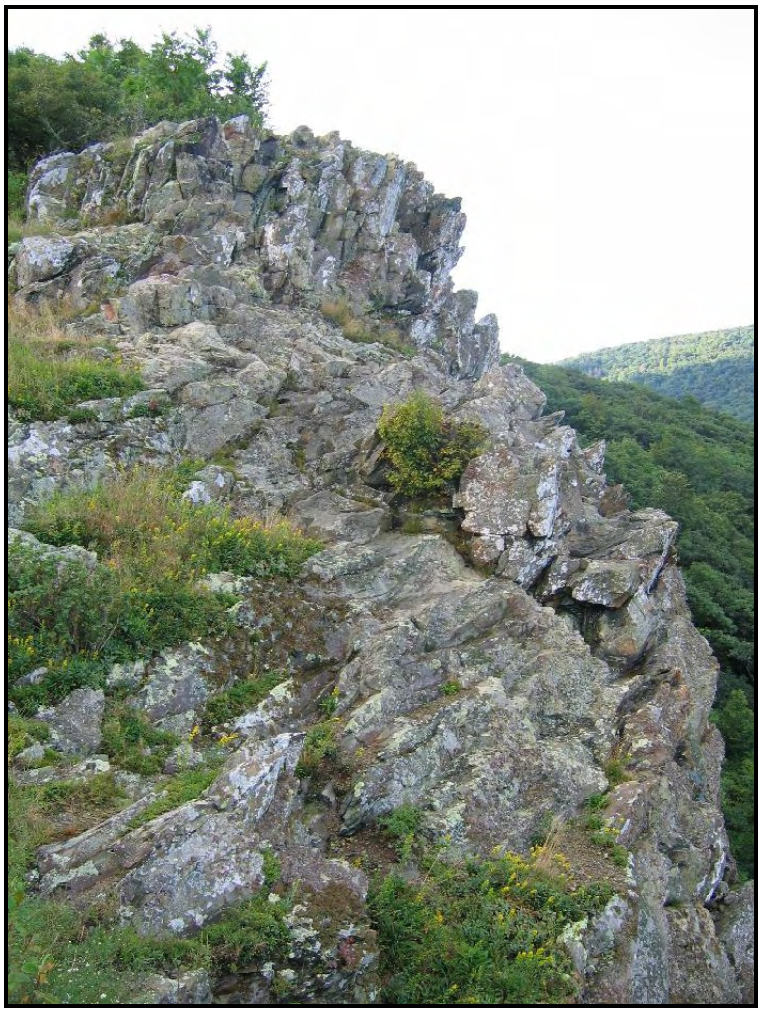
Character and Condition of Geological Resources of Interest to the Rock Outcrop Management Project
Final Report 2006



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Table of Contents

Page

Table of Contents 1

Tables 3

Figures 5

Appendixes 7

Key Project Data 9

Abstract 9

Executive Summary 9

Acknowledgements 10

Significant Findings 10

Management Recommendations 11

Introduction 11

Study Area 12

Methods 13

Discussion and Management Recommendations 18

Conclusions 19

Literature Cited 20

Tables

Page

Table 1. ROMP study sites and associated bedrock, sorted by site number 27

Table 2. ROMP study sites and associated bedrock, sorted by park district 28

Table 3. ROMP study sites and park district, sorted by bedrock type 29

Table 4. Site impact assessments from cooperating researchers. 30

Figures

Page

Figure 1. ROMP site locations and bedrock composition. 21

Figure 2. Photographic key to rock exposure classifications used for the ROMP at SHEN 22

Figure 3. Photographic key to physical impact ratings used for the ROMP at SHEN. 23

Figure 4. Examples of common geological structures found within SHEN. 24

Figure 5. Examples of common features of geologic interest found in SHEN..... 25

Figure 6. Average exposure morphologies by bedrock lithology. 26

Figure 7. Morphologic compositions of individual ROMP sites. 26

Appendixes

Page

Appendix A. Example data sheets and maps 31

Appendix B. Definitions of terms used in data collection and analysis 39

Appendix C. Geologic history and formations of SHEN. 43

Appendix D. Bedrock-influenced geomorphic patterns in SHEN. 51

Appendix E. Glossary of geologic terms and mineral compositions 55

Appendix F. ROMP geologic site reports 63

Key Project Data

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Abstract

This project obtained information on geologic resources within Shenandoah National Park (SHEN) that are of interest to the Rock Outcrop Management Project (ROMP). Many geologic factors influence the occurrence and nature of the 50 rock exposure sites selected by the project, including bedrock composition, exposure morphology, regional geologic history, physical stability, and geographic location. The three main bedrock types within SHEN, and their associated geologic structures, create distinctly different rock exposure patterns and habitats that directly affect vegetation growth patterns. There appears to be a direct correlation between ease of visitor access and level of physical impact observed, assessed through the prevalence of social trails, rock graffiti, trash, soil & vegetation damage, and other factors. General-purpose visitation, rather than rock climbing, appears to be the dominant producer of such impacts. Although many of the sites contain features of geologic interest, such as well-formed minerals or structures, none of the features identified appear to be under any direct threat from human activity or physical processes.

Executive Summary

The bedrock geology of Shenandoah National Park directly influences the location, physical character, and soil chemistry of open rock exposures within the park, and thus the vegetation communities that rely upon these exposures. Three fundamentally different rock types (igneous/metamorphic, greenstone, and metasedimentary) occur within discrete areas and elevations of the park, producing unique outcrop patterns and generating physically and chemically distinct landforms and habitats. For example, greenstone lava flows cap many of the highest peaks in the park, tend to produce high-elevation southwest to west facing cliff sites and gentle eastern slopes with deep canyons, create more open ledges than other rock types, and are particularly supportive of diverse vegetation communities due to their mineral/chemical composition. Documenting these patterns allows a deeper understanding of the rare plant and animal communities that rely upon open rock exposures within the park.

Bedrock geology also affects, and is affected by, patterns of human use. For example, rock climbing activity is centered on areas where geologic processes have created suitable exposures, and visitors are drawn to overlooks, vistas, and peaks dominated by open rock. The location, orientation, and physical character of such places are directly related to the geologic processes

that created them. In turn, human activities can have a noticeable impact on open rock areas. Development of social trails, stripping of soils, scratching of graffiti into rock surfaces, collection of minerals or samples, and various climbing impacts all contribute to altering the natural state of geologic resources within the park.

The purpose of this project is to document and interpret the geologic resources and processes that affect sites within the Rock Outcrop Management Project (ROMP). Between April 2005 and September 2006, 50 sites (see Fig. 1 and Tables 1-3) were studied and mapped in detail. Final reports (Appendix F) were produced for each site that document the bedrock composition, exposure morphology, regional geologic history, physical stability, and geographic location.

Collected data and observations support the conclusion that different rock types produce unique outcrop patterns and thus unique ecological habitats. For example, greenstone areas are most likely to contain cliffs and ledges, igneous/metamorphic basement rock areas are most likely to contain rounded faces, and metasedimentary areas are most likely to contain large amounts of talus (see Fig. 2 and Appendix B for definitions). Assessment of the physical condition of ROMP sites (see Fig. 3 and Table 4) shows a direct correlation between ease of visitor access and level of impact observed. Exceptions to this trend occur at certain popular, though difficult to access, sites such as Old Rag Mountain. The majority of impacts appear to be related to general-purpose visitation rather than climbing specifically. Although many of the sites contain features of geologic interest (see Fig. 4 & 5) such as well-formed minerals or structures, none of these features appear to be under any direct threat from human activity or physical processes.

Acknowledgements

Special thanks are due to G. Olson, W. Cass, and S. Bair of the National Park Service (NPS) for their widespread support of this project. J. Young of the United States Geologic Survey (USGS) gave valuable assistance with mapping and field work, as did G. Fleming, A. Belden, K. Heffernan and other cooperating researchers from the Virginia Department of Conservation and Recreation (VADCR). A. Williams (NPS) was instrumental in developing efficient data management tools and methods. S. Southworth (USGS) and L. McClelland (NPS) provided important feedback in developing the study plan.

Significant Findings

* Bedrock composition, internal structures, and other geologic factors directly affect the location and physical nature of open rock exposures, and thus the natural habitats and recreational opportunities these exposures provide.

* There is a correlation between ease of visitor access and level of physical impact observed at rock exposure sites, with a few exceptions. Every site with a form of trail access showed some level of impact, while remote sites showed little to no impact.

* No specific features of geologic interest appear to be under any direct threat from human activity or physical processes, although the general condition of the rock exposures may show significant degradation.

Management Recommendations

* No specific management tasks are needed to preserve features of significant geologic interest within ROMP sites, beyond the park policies already in place.

* Existing impacts to geologic or physical features are difficult to mitigate; e.g. graffiti scratched into rock cannot be removed. Any efforts directed this way should focus on prevention rather than mitigation.

* Efforts to reduce ongoing impact to geologic resources within ROMP sites could include closure of social trails, limitation of access to rock exposure areas through signage or low rope lines, and changes to interpretive literature and/or trail guides.

Introduction

Geologic processes operate over a wide range of time, distance, and rates. While many are no longer active, or operate at time scales not readily intuitive to people, their results continue to influence a wide variety of physical and chemical features within landscapes. For this reason, understanding geologic history is key to a robust investigation of ecological environments dependent on rock exposures.

Geologic studies of the Blue Ridge Mountains, and the Shenandoah area in particular, have been occurring since the turn of the past century. In 1976, Thomas Gathright of the Virginia Department of Mineral Resources published a volume entitled “Geology of the Shenandoah National Park, Virginia”, which provided a comprehensive description of the geologic history and resources of the park as understood at the time. With the development and acceptance of plate tectonic theory (culminating in the 1970s and 1980s), and introduction of new analytical methods, ongoing research provided an increasingly accurate reconstruction of the geologic processes that influenced the bedrock and landscape of SHEN and the surrounding regions (e.g. Badger et al. 2004, Burton and Southworth 2004, Tollo et al. 2004, and Morgan et al. 2004).

SHEN contains three major bedrock units of different age and composition: igneous/metamorphic, greenstone, and metasedimentary (Gathright, 1976). The oldest bedrock is composed of a complex set of igneous and metamorphic rocks formed over 1 billion years ago (the old “Pedlar Formation”, referred to in this report as “basement rocks”. See Appendix C or E for clarification). This classification includes the Old Rag Granite, a distinct rock type within the basement rocks. These rocks are capped by a thick sequence of basaltic lava flows, erupted onto the surface around 570 million years ago (the Catoctin Formation). There is a thin, intermittent layer of sediments between the Catoctin and the basement rocks, known as the Swift Run Formation. The Catoctin is overlain by several thousand feet of mixed sedimentary rocks, mostly

sandstones, siltstones, and shales (the Chilhowee Group). This entire sequence was physically and chemically altered by metamorphic processes generated during the formation of the Appalachian Mountains; thus the basaltic lavas became a related rock called greenstone, and the sedimentary rocks were folded and fused into related metasedimentary rocks such as quartzite and phyllite. Each of the three main bedrock formations (Basement, Catoctin, Chilhowee) have distinct chemical and physical properties that directly influence the surrounding landscape and vegetation communities. For more detail on the geologic formations and history of Shenandoah, see Appendices C and D.

Areas of exposed rock are common on all bedrock types within SHEN. Such exposures are found especially at high elevations, along ridgelines and waterfalls, and in other attractive and dramatic settings. These areas are naturally popular with visitors, as rock exposures tend to provide clear views and obvious recreational opportunities. Visitor use of these areas may range from passive activities such as resting and picnicking to active uses such as scrambling and climbing. The shape and location of any given rock exposure naturally affects if and how it is used by visitors, as does the means of access to the area.

The geologic field work conducted for this project focused on three major factors:

* Physical characterization of the landscape - What is the actual appearance and nature of the landscape at the site, independent of scientific interpretation?
* Geological characterization of the bedrock – What is the bedrock composition and structure of the site, and what geologic processes originally formed this rock?
* Geomorphic interpretation of the landscape – What processes and features combined to create the physical landscape present at the site today?

In addition, several other factors were studied or considered during this project:

* Mapping for future study – Developing a detailed map of exposure locations and access routes for use by current and future researchers in studying and/or managing the site.
* Assessment of human impacts – How has human use affected the physical nature of the site?
* Assessment of access potential – How easy is it for humans to reach and use the site?

Study Area

The ROMP includes 50 study sites, distributed throughout the park (see Figure 1 and Tables 1-3). These sites were selected from a large pool of candidates, initially identified by J. Young (United States Geologic Survey) using a computer algorithm to locate and delineate all possible sites of open rock within the park as visible on satellite and/or aerial imagery. This database was compared with a Digital Elevation Model (DEM)-based slope model of the park in order to further identify possible cliff/outcrop areas that may not have been obvious from overhead imagery. These data were used to confirm and constrain the location of known rock exposure areas, and to select several previously unknown or unvisited sites for possible inclusion in ROMP surveys.

Site selection was based on numerous factors, including perceived or documented threat to vegetation communities, bedrock geology, visitor use history, elevation/aspect, and in some cases the site's remoteness or pristine condition. Final site boundaries were drawn by cooperators from the Virginia Department of Conservation and Recreation using initial GIS data provided by J. Young of the USGS. Of the 50 sites, 32 are located on greenstone bedrock (which tends to support the most ecologic diversity), 10 on granitic/metamorphic (basement) bedrock, 7 on metasedimentary bedrock, and 1 contains exposures of both greenstone and basement rock (C69, Whiteoak Canyon).

Site access ranges from areas adjacent to Skyline Drive to remote sites involving long backcountry hikes and negotiation of significant topography. Most sites include steep, rugged areas of rock exposure, including sheer cliffs and semi-stable boulder fields. Thick vegetation is also common and is often a significant barrier to navigation. The average site covers an area approximately 170m x 460m, though the site boundaries are drawn generously and include a wide buffer of matrix forest adjacent to the rock exposures. In a few cases, site boundaries were altered to reflect the presence or absence of exposure areas near or outside the initial line.

Methods

This study consisted primarily of field mapping and personal observation of open rock exposures within the site boundaries established for the ROMP (for the purposes of this report, "open rock exposures" are those which are largely exposed to the sun, i.e. not covered or shaded by forest). All field work was conducted by geology consultant Eric Butler between April 2005 and September 2006, in cooperation with researchers from the United States Geologic Survey (USGS) and Virginia Department of Conservation and Recreation (VADCR). Field work consisted primarily of visiting each site and exploring the area within and near the established site boundary thoroughly on foot, on and off-trail, in order to fully document the location and nature of rock exposures, and their access routes. Throughout the site visit, observations and data were collected and noted on field data sheets. Later, these data were compiled into a database along with photos, maps, GPS data, and narrative summarized into individual site reports.

Study Design

The ROMP Detailed Implementation Plan summarizes the purpose of the geology survey as follows: "Classify geologic composition and condition of cliff resources". Following this broad guidance, a more detailed study plan was developed to assess the questions discussed above. While other studies of human impact on rock exposure-related vegetation have occurred (e.g. Camp and Knight, 1998), a lack of comparable geologically-focused studies led to a new design process, intended to produce a study uniquely formulated to the needs of the ROMP at SHEN. Several drafts of data sheets were developed and adapted, based on field tests and input from other cooperators including the National Park Service (NPS), United States Geologic Survey (USGS), and Virginia Department of Conservation (VADCR).

Certain types of data were considered but rejected as being less relevant to or realistic for the study, including falling hazard, percent lichen coverage, and soil classifications. Other types of

data were added, including space for geomorphic interpretations (at the request of VADCR researchers) and a five-part classification of rock exposure morphology (see Fig. 2 and Appendix B). This latter effort was designed specifically for Shenandoah rock exposures, in order to identify and distinguish morphologies present within the park that create distinctly different vegetation habitats. Certain data were intended primarily to characterize the conditions at each individual site (such as vegetation thickness and stability), while others were additionally intended to provide useful comparisons between sites (such as geomorphic classification and impacts).

The final data sheet (Appendix A) offers space to note field observations relevant to all questions on a single form, while the attached photo/GPS log sheet offers sufficient space for most sites on another single form. These final formats have not been changed through subsequent field work. See "Field Data Collection" below for more details.

Field Mapping

Each site was initially mapped in the field in conjunction with significant off-trail exploration in order to document the location of open rock exposures, access routes, significant features, and any other necessary geographic information. Initial field maps were drawn on a base map prepared in a GIS, containing the site boundary, topographic information, and existing trails/roads. GPS points were taken in the field to mark the location of important exposures or other features, and other information marked relative to the location of these points. GPS points were given a unique sequential number with the site code as a suffix; thus G059-C02 is the fifty-ninth point taken during the project and relates to C02 (Betty's Rock). Later, these points were entered into a GIS and used to produce a more complete map, on which the relevant geographic and navigational information was redrawn by hand to ensure accuracy and efficiency. These final maps were then scanned to produce JPG and PDF files. Examples of each stage of map development are given in Appendix A.

Two final maps were prepared for each site. A detailed field map documents the location of all open rock exposures, hazards, routes, and other info within the site boundary, while a broader regional map shows surrounding topography and full access routes from the best point of entry (usually Skyline Drive, occasionally outside roads). These maps were not intended to be truly to-scale, as this was deemed outside the scope and resources of the project. The field maps are reasonable representations of the physical location and nature of open rock exposures within the site. Where practical and meaningful, rough stratigraphic and/or topographic cross-sections were included on the maps to illustrate certain details about the site.

Field Data Collection

A comprehensive data sheet (see Appendix A) was designed to facilitate collection of necessary information. This sheet was divided into five fundamental categories:
* Geographic Characteristics – Location, elevation, dimensions, access, and other descriptions.
* Physical Characteristics – General description & nature of the site's landscape and vegetation.
* Geologic Characteristics - Bedrock composition, structures, and important resources.

* Geomorphic Characteristics – Analysis of processes and features that have or continue to influence the landscape at the site.
* Human Effects – Potential for visitor access, and assessment of human impact on the site.

Whenever possible, data related to these categories were collected using a rating system, allowing for efficient comparison of data among different sites. For example, human impacts were assigned a rating based on a four-point scale from *Pristine-Mild-Moderate-Heavy*, with corresponding definitions (see Fig. 3 and Appendix B). In addition, specific notes were taken to document unique feature at each site. This combination allows for consistent individual assessment of each site as well as overall data analysis.

Five classifications of rock exposure morphology within SHEN were defined for this project (see Fig. 2 and Appendix B). During a site visit, relative amounts of these different morphologies were observed and noted. At the conclusion of mapping, the relative abundance of each morphology was estimated as a percentage of the total open rock exposures (not of the entire site). Thus, a site dominated by tall cliffs capped by narrow ledges and a small band of open talus at the base might be listed as 70% cliff, 20% ledge, and 10% talus. It is important to note that these data are estimates only, as it was not deemed practical or necessary to attempt to measure rock exposure dimensions to a degree that would rigorously distinguish the results from careful estimation. It is also important to note that these data refer only to open rock exposures (e.g. non-forested), as these are the only areas of interest, botanically and ecologically, to the ROMP. Cliffs, outcrops, or other visible bedrock enclosed in forest were not usually included in mapping or morphology estimates, though they were taken into account when studying and describing the overall geology of the site.

Data Management

A Microsoft Access database was developed by the Natural Resources Data Manager (A. Williams) at Shenandoah National Park (SHEN) to manage all project data. Written, numeric, and image data were entered by site number, but are fully searchable by any category. In addition, image information and GPS data within the database are linked to the project GIS file.

Site Reports

The ROMP geologic database generates written site reports by compiling relevant data into a standardized format. These site reports are generally between six and eight pages long, depending on the complexity of the site. The reports contain all written observations and analyses for the site, with associated numerical data and ratings, along with photos, GPS data, and maps. Each report is finalized in PDF format. See Appendix F for copies of all 50 site reports.

Significant Findings or Results

Geologic Influences on Rock Exposures

Many geologic factors interact to affect the location and nature of rock exposures. The bedrock lithology of a site reflects not only the original geologic processes that formed the rock, but any later processes that affected it (such as faulting, metamorphism, or folding). Both the mineral composition of the rock and the physical structures imposed upon it by outside forces (such as faults, jointing, or cleavage) combine to shape specific rock exposures. For example, areas whose bedrock contains more fractures, layering, or other planar features tend to have higher percentages of ledges and talus than areas with more massive (structureless) bedrock, which tend to form more cliffs and rounded faces.

There are significant differences in the nature of rock exposures formed from the different lithologies present within SHEN (see Fig. 6 & 7). Greenstone areas most commonly form significant lines of cliffs and ledges, and open talus areas are not uncommon. In basement rock areas, smooth rock faces are far more common than in the other rock types, isolated outcrops are about as likely as significant cliffs, and ledges are rare. Metasedimentary areas tend to produce a mixture of cliff, outcrop, and ledge, but are often dominated by large, open talus fields. As ROMP sites were not selected as a representative sample of the park, some of the results shown in Figure 6 are admittedly skewed by the selection criteria or nature of certain sites, particularly considering the relatively low number of basement and metasedimentary sites. For example, several metasedimentary sites were chosen specifically because they consisted of large talus fields; in contrast, the expansive cliffs and open faces of Old Rag Mountain pull the basement rock results in that direction. Despite these limitations, the distinctions suggested by these data match up well with observed differences between lithologies both within ROMP sites and throughout SHEN as a whole. For a more thorough discussion of the geologic factors affecting rock exposures, and the typical patterns associated with each geologic formation present in Shenandoah, see Appendix B.

Impacts Assessed

Observed human impacts varied widely between and within ROMP sites. Evidence of impact included social trails, trampled or absent vegetation, compacted or stripped soil, polished or tarnished rock surfaces, unusual lichen patterns (or lack of lichens), rock graffiti, trash, fire rings, and footprints. Impact ratings assigned in this study considered both the worst impact observed and the overall physical condition of the site; even the most impacted sites included areas of lesser or no impact. This study focused on general physical impacts and those related to the geologic resources present, and did not assess specific plants or communities.

Comparison of Results

Comparing results from this and related ROMP studies (Table 4) offers additional insight into the nature of site impact patterns. Impact assessment data were collected between 2005 and 2006 by three sources: a social science team from Virginia Tech (VT), the geology consultant, and a stewardship biologist from the Virginia Department of Conservation and Recreaction (VADCR).

The VT researchers conducted detailed surveys of specific impact evidence, defined as "areas of reduced vegetation cover caused by human trampling". These included impact zones above and below cliff areas, campsites, and social trails (paths developed through visitor use, not maintained by NPS). The geology consultant gave the sites a more general rating based on the overall physical condition of the rock exposures, considering such elements as rock graffiti, garbage, soil stripping, and social trails. Sites were rated on a 4-point scale from Pristine-Mild-Moderate-Heavy (see Figure 3 and Appendix B for definitions). The potential for visitor access was also rated on a 4-point scale from Remote-Difficult-Moderate-Easy. The VADCR stewardship biologist also rated sites based on a general rating of overall condition, focusing on condition of plant communities and presence of invasive species, but used a 3-point scale from Pristine-Minor-Major.

As of October 2006, complete assessment data from VADCR were not available. Preliminary comparisons are discussed here, and the report will be updated with complete results and discussion when the data become available. To this point, the geologist and VADCR assessments are in close agreement; for the 36 sites rated by both, "Major" generally corresponded to "Heavy" while "Minor" generally straddled the difference between "Moderate" and "Mild". "Pristine" sites were almost always in agreement between the two studies. In addition, the observed impact level of a site appears to be directly related to its accessibility to visitors. Sites with no trail access were largely pristine, while all sites with easy access were impacted to some degree. Where exceptions occur, other factors such as popularity and terrain are often involved.

Sources of Impact

Most impact identified by this study appeared to be related to general-purpose visitor activities other than rock climbing (hiking, backpacking, vista enjoyment). These impacts were focused on areas directly reached by trail, and consisted largely of scratched graffiti, stripped soil, social trail development, and trash. Signs of climbing impact were found mostly at sites known to be recommended for climbing (e.g. Horst 2001) such as Old Rag Mountain, Little Stony Man, and North Marshall. Examples of climbing-specific impact include trampling and social trail development along cliff bases, equipment left in or near the rock (e.g. bolts, crash pads, and ropes), and cutting or disturbance of vegetation and lichens on and around cliff areas. However, in most areas where these impacts were present, day-use impacts were still the dominant human process observed. One significant exception to this correlation was the north face of Hawksbill Mountain, where apparent ice-climbing impacts (multiple occurrences of deep, parallel scratches in bedrock presumably from crampons) were found in an otherwise remote and pristine area. A subsequent visitor encounter confirmed recent ice-climbing activity in this location.

Impacts/Threats to Geologic Resources

Many sites contained features of geologic interest, such as columnar joints, unusual mineral deposits or formations, cross-bedding or other sedimentary structures, exposures of stratigraphically important units, fossils, and generally attractive rock formations. Most of these features, however, are of primary interest to geologists, and would often not be evident to the average visitor without identification and/or interpretation. In addition, most features are solid enough, large enough, and/or common enough not to warrant specific efforts at preservation in

any one place. The greatest human threat to geologic resources in Shenandoah is probably collection of loose rock samples by visitors, and such activity could not be observed or documented by this study. The general condition of the rock exposures is certainly degraded in places by human actions (graffiti, trampling, etc.) but no evidence of specific threats to individual features of interest was found. It should be noted that features which could require special attention do exist in the park, but not within the sites studied for ROMP.

Discussion and Management Recommendations

The primary factor affecting rock exposure impact appears to be ease of access for visitors. This factor takes two forms; ease of access from a trailhead, and ease of access from along a trail. The former reflects hiking distance and topography; a site several trail miles from the nearest road, with significant topography to negotiate, might reasonably be expected have much lower visitation than one very close to a road. The latter reflects visitors' ability to reach a specific exposure from a trail; a ledge just a few meters from a trail, but blocked by thick vegetation and no obvious access route, may have far less impact than a ledge farther from the trail but with an obvious social trail leading to it. This pattern is particularly common in long, linear sites with repeated exposures, such as North Marshall and South Marshall, where the impact of any individual exposure seems directly related to the presence (or not) of a social trail linking to the Appalachian Trail (which runs through the forest adjacent to the cliffs).

Another important factor appears to be the relative popularity/advertisement of a site. Certain areas within the park are commonly mentioned in hiking or interpretive guides (e.g. Old Rag Mountain), have park signs and/or parking lots devoted to them (e.g. Blackrock South District), or are simply well-known and prominent landmarks (e.g. Mary's Rock). Any of these factors can result in a site receiving a higher visitation rate (as estimated by impact level) than its accessibility might otherwise imply.

These results suggest that most management initiatives related to ROMP should focus primarily on biological resources. No sites studied require any special management attention to geologic resources, beyond general park policies already in place (prohibition of sample collection, alteration of resources, etc.). In most cases, mitigation of existing impacts would be difficult if not futile (rock graffiti cannot be removed, privately collected samples will not be returned, eroded outcrops cannot be rebuilt), and so the focus should be on preventative measures. Any management activity intended to preserve biological resources will likely also serve to protect geologic resources from further impact. Therefore, mitigation efforts might best be focused on affecting how visitors learn about and access rock exposure areas. It is unlikely that the existing popularity and general knowledge of sites could be altered, but lesser-known threatened sites could be excluded from further publications, signage, or otherwise protected from further discovery.

Decisions on prevention/mitigation efforts for individual sites are outside the scope of this study at this time, but the author has observed the successful use of low-cost, low-impact methods (single ropes delineating sensitive areas, small signs with simple symbols or wording) in the Green Mountains (Vermont) and Tettegouchee State Park (Minnesota). Often these methods are

partially self-regulating, as visitors observing others in non-compliance may say something in person, or to park staff, thus assisting the effort.

Conclusions

Geologic factors such as bedrock lithology, structures, and geologic history/processes contribute significantly to the physical location and character of open rock exposures within Shenandoah National Park. Within ROMP sites studied to this date, protection of geologic resources will require no special actions by park resource managers that are not already part of park regulations, or that will not be adopted to protect biological resources. Human impacts on open rock exposures are directly related to the ease of access routes to the site, and are predominately linked to general-purpose visitation, while climbing-specific impacts are found only in a few well-known areas. Therefore, management activities should focus on public education and/or altering visitor use patterns rather than significant closures or restrictions.

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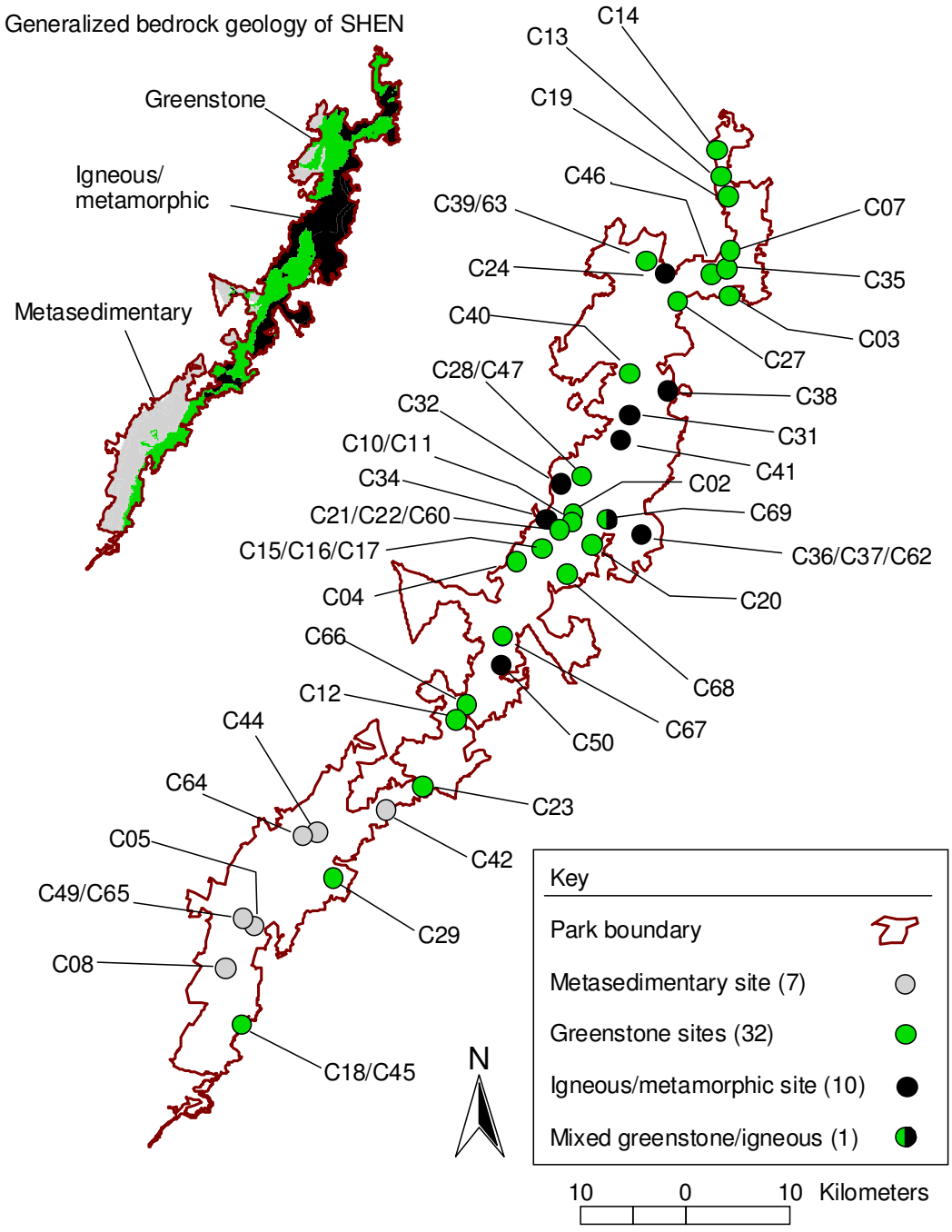


Figure 1. ROMP site locations and bedrock composition.



Cliff

Cliff – Near-vertical exposure that dominates or creates surrounding topography. Usually continuous across slope, though may be interrupted by talus slopes or other erosional features. Generally sheer, with minor ledges along the vertical drop.

Face – Continuous, rounded, gently sloping exposure (<45) of smoothly weathered rock. Not steep enough to be a cliff, too continuous and smooth to be an outcrop, and too sloping and rounded to be a ledge.

Outcrop – Intermittent exposures that stand out from surrounding topography but do not influence it. Most commonly sloping, rugged exposures with many associated ledges. May also consist of intermittent protruding rock ribs that are not continuous or wide enough to be a cliff.

Ledge – Near-horizontal exposure along top or sides of cliffs and outcrops, where a local break in slope occurs, but trees and thick soil have not yet accumulated. Often hosts vegetation.

Talus – Continuous to scattered rock debris with little to no soil development, covering general topography. May or may not be associated with in-place bedrock exposures.



Face



Outcrop



Ledge



Talus

Figure 2. Photographic key to rock exposure classifications used for the ROMP at SHEN.



Heavy impact (C31, Mary's Rock)
Definition: ubiquitous impacts; trails and compaction are prevalent, rocks are carved, polished, or otherwise obviously impacted, trash or other debris may be common, vegetation severely diminished.



Moderate impact (C02, Betty's Rock)
Definition: significant impacts; trails and compaction are common, areas of use are clearly visible, vegetation clearly affected and diminished.

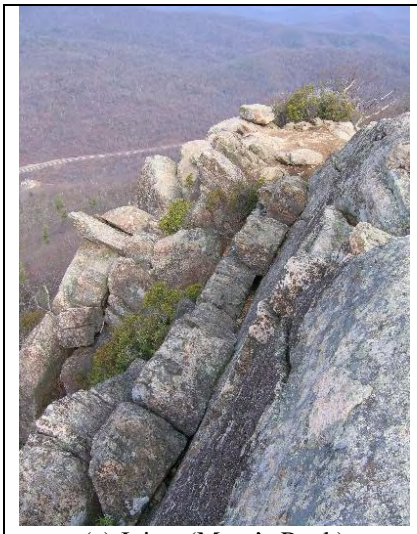


Mild impact (C11, Crescent Rock South)
Definition: minor impacts; minor trails, slight compaction, vegetation sporadically affected, most of site is untouched.



Pristine (C40, Pass Mountain)
Definition: no impacts; trails/compaction nonexistent, absolutely no signs of human use or visitation.

Figure 3. Photographic key to physical impact ratings used for the ROMP at SHEN.



(a) Joints (Mary's Rock)

(a) Joints –Large, planar, parallel fractures with a consistent orientation, generally more widely spaced than fractures or cleavage.

(b) Foliation – This is a banded texture within an igneous/ metamorphic rock that is formed by planar zones of minerals segregated by individual type.

(c) Fractures – These are random cracks within the rock, not uniformly planar and parallel like joints, and not related to mineral orientations like foliation or cleavage.

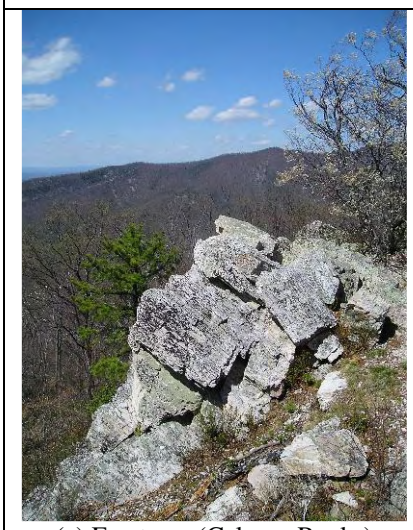
(d) Dike – This is an intrusion of dark igneous rock that generally follows a joint and forms a thin, planar body within the host rock.

(e) Cleavage – This creates a thin, platy set of fractures oriented in a roughly similar direction, and related to orientation of minerals such as chlorite. Much more densely occurring than joints, and more aligned than fractures.

(f) Layering – A planar structure internal to the rock, formed by deposition of sediment, and not segregated by mineral type & orientation as in foliation. May cut across older layers at different angles, forming cross-bedding (as seen here).



(b) Foliation (Pinnacles)



(c) Fractures (Calvary Rocks)



(d) Dike (Old Rag Mountain)



(e) Cleavage (Betty's Rock)



(f) Layering (Brown Mountain)

Figure 4. Examples of common geological structures found within SHEN.



(a) Volcanic breccia (Gooney Run)

(a) Volcanic breccia – Found between lava flows within the Catoctin Formation. It is formed as flowing lava "rips up" fragments of rock and sediment from the ground surface and mixes them into a new layer of rock containing angular fragments of various lithologies.

(b) Columnar jointing – A near-hexagonal fracture pattern formed in cooling lava flows, creating apparent columns within the rock.

(c) Mineral deposits – Thin layers containing copper, iron, and other metals are common within certain parts of the Catoctin greenstones and Chilhowee quartzites. These metallic minerals can often display brilliant colors, unusual crystal forms, or other attractive features.

(d,f) Skolithos – The only common fossil in Shenandoah, this "trace fossil" consists of preserved worm burrows in sedimentary rock. These burrows usually occur as clusters of thin, linear, straw-like features.

(e) Rounded boulders – Granitic areas often contain free-standing, rounded boulders that perch atop cliffs and peaks. Their formation is controlled by joint sets, which create angular blocks that are gradually smoothed into rounded forms by weathering processes.



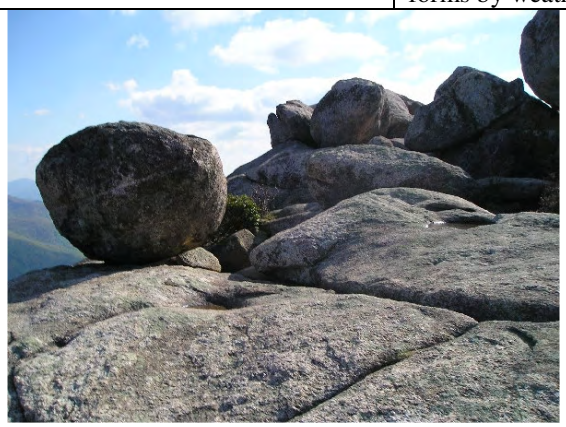
(b) Columnar jointing (Hawksbill)



(c) Copper minerals (Franklin Cliffs)



(d) Skolithos (Calvary Rocks)



(e) Rounded boulders (Old Rag Mountain)



(f) Skolithos (Brown Mountain)

Figure 5. Examples of common features of geologic interest found in SHEN.

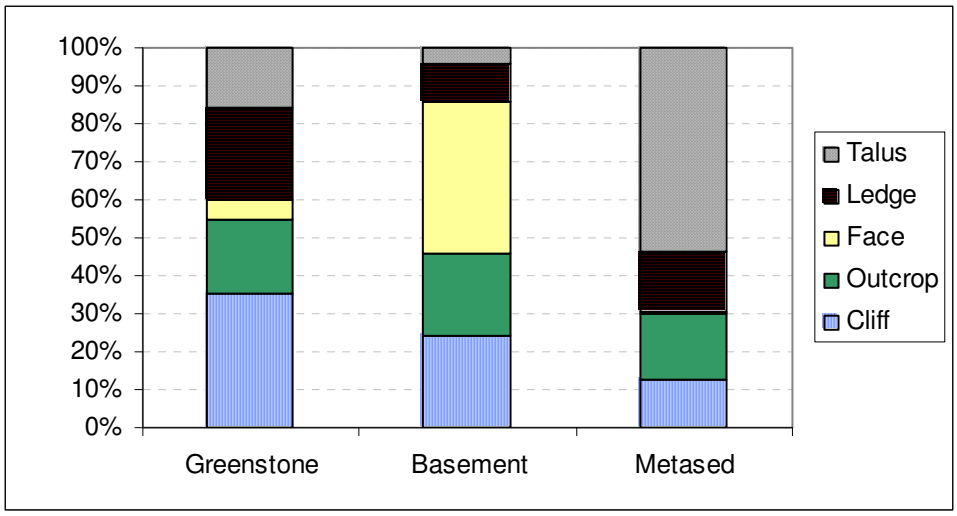


Figure 6. Average exposure morphologies by bedrock lithology.

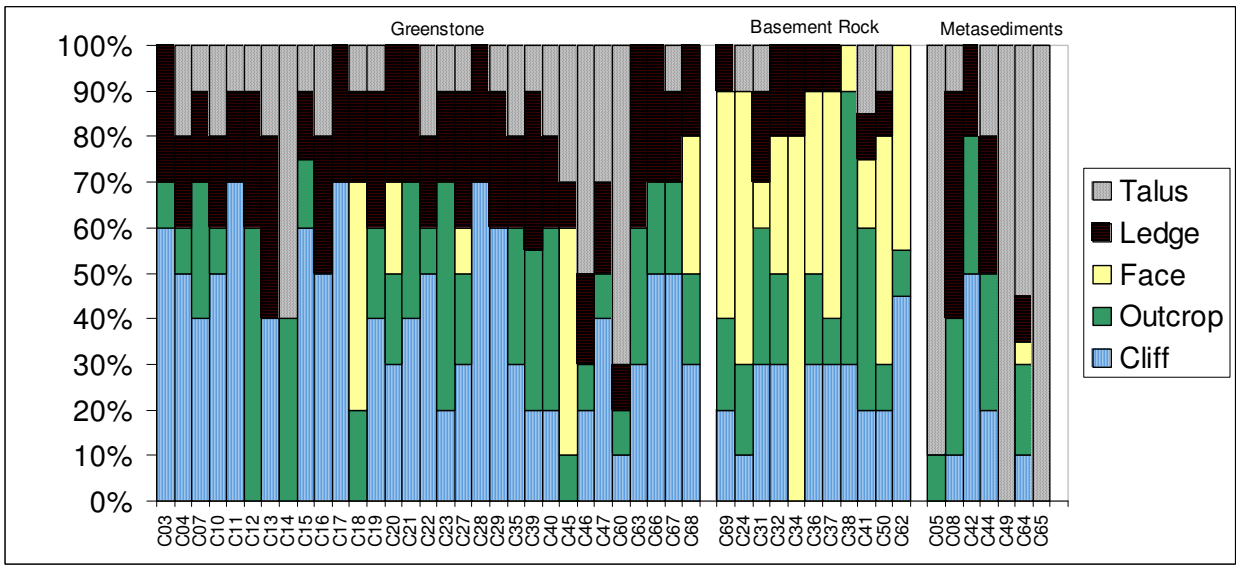


Figure 7. Morphologic compositions of individual ROMP sites.

Figures 6 and 7 are based on the five distinct bedrock exposure morphologies defined for this project (see Fig. 2 for definitions and photos). At each site, the percentage of total open rock exposure composed of each morphology was estimated and recorded (Fig. 7). When these figures are averaged (Fig. 6) the impact of bedrock composition on the physical nature of rock exposures is clear. For the purposes of these comparisons, the only site with two lithologies present (Whiteoak Canyon, C69) was included within Basement Rock as the granitic exposures within the site were far more extensive and open than the Greenstone exposures.

Table 1. ROMP study sites and associated bedrock, sorted by site number

Site ID #	SHEN District	Site Name	Site Bedrock
C02	Central	Bettys Rock	Greenstone (Catoctin)
C03	North	Big Devils Stairs	Greenstone (Catoctin)
C04	Central	Blackrock Central District	Greenstone (Catoctin)
C05	South	Blackrock South District	Quartzite (Chilhowee)
C07	North	Browntown Valley Overlook	Greenstone (Catoctin)
C08	South	Calvary Rocks / Chimney Rock	Quartzite (Chilhowee)
C10	Central	Crescent Rock Overlook	Greenstone (Catoctin)
C11	Central	Crescent Rock South	Greenstone (Catoctin)
C12	Central	Dean Mountain Ridge	Greenstone (Catoctin)
C13	North	Dickey Hill	Greenstone (Catoctin)
C14	North	Dickey Ridge	Greenstone (Catoctin)
C15	Central	Franklin Cliffs North	Greenstone (Catoctin)
C16	Central	Franklin Cliffs Overlook	Greenstone (Catoctin)
C17	Central	Franklin Cliffs South	Greenstone (Catoctin)
C18	South	Goat Ridge	Greenstone (Catoctin)
C19	North	Gooney Manor Overlook	Greenstone (Catoctin)
C20	Central	Halfmile Cliff	Greenstone (Catoctin)
C21	Central	Hawksbill N slope outcrops	Greenstone (Catoctin)
C22	Central	Hawksbill summit	Greenstone (Catoctin)
C23	South	Hightop	Greenstone (Catoctin)
C24	North	Hogback Mtn spur	Basement rock
C27	North	Little Devils Stairs	Greenstone (Catoctin)
C28	Central	Little Stony Man	Greenstone (Catoctin)
C29	South	Loft Mountain summit	Greenstone (Catoctin)
C31	Central	Marys Rock	Basement rock
C32	Central	Millers Head	Basement rock
C34	Central	Nakedtop Upper East Slope	Basement rock
C35	North	North Marshall summit	Greenstone (Catoctin)
C36	Central	Old Rag southside	Old Rag granite
C37	Central	Old Rag summit east	Old Rag granite
C38	North	Oventop	Old Rag granite
C39	North	Overall Run Falls south	Greenstone (Catoctin)
C40	North	Pass Mountain	Greenstone (Catoctin)
C41	Central	Pinnacles	Basement rock
C42	South	Powell Gap cliff	Metasediments (Swift Run)
C44	South	Rocky Mountain	Quartzite (Chilhowee)
C45	South	Sawlog Ridge	Greenstone (Catoctin)
C46	North	South Marshall cliff	Greenstone (Catoctin)
C47	Central	Stony Man summit	Greenstone (Catoctin)
C49	South	Trayfoot Saddle boulderfields E	Quartzite (Chilhowee)
C50	Central	Upper Devils Ditch	Basement rock
C60	Central	Hawksbill N slope talus	Greenstone (Catoctin)
C62	Central	Old Rag summit west	Old Rag granite
C63	North	Overall Run Falls north	Greenstone (Catoctin)
C64	South	Brown Mountain	Quartzite (Chilhowee)
C65	South	Trayfoot Saddle boulderfields W	Quartzite (Chilhowee)
C66	Central	Field Hollow Cliff	Greenstone (Catoctin)
C67	Central	Bearfence	Greenstone (Catoctin)
C68	Central	Rose River	Greenstone (Catoctin)
C69	Central	Whiteoak Canyon	Greenstone/Basement

Table 2. ROMP study sites and associated bedrock, sorted by park district

Site ID #	SHEN District	Site Name	Site Bedrock
C03	North	Big Devils Stairs	Greenstone (Catoctin)
C07	North	Browntown Valley Overlook	Greenstone (Catoctin)
C13	North	Dickey Hill	Greenstone (Catoctin)
C14	North	Dickey Ridge	Greenstone (Catoctin)
C19	North	Gooney Manor Overlook	Greenstone (Catoctin)
C24	North	Hogback Mtn spur	Basement rock
C27	North	Little Devils Stairs	Greenstone (Catoctin)
C35	North	North Marshall summit	Greenstone (Catoctin)
C38	North	Oventop	Old Rag granite
C39	North	Overall Run Falls south	Greenstone (Catoctin)
C40	North	Pass Mountain	Greenstone (Catoctin)
C46	North	South Marshall cliff	Greenstone (Catoctin)
C63	North	Overall Run Falls north	Greenstone (Catoctin)
C02	Central	Bettys Rock	Greenstone (Catoctin)
C04	Central	Blackrock Central District	Greenstone (Catoctin)
C10	Central	Crescent Rock Overlook	Greenstone (Catoctin)
C11	Central	Crescent Rock South	Greenstone (Catoctin)
C12	Central	Dean Mountain Ridge	Greenstone (Catoctin)
C15	Central	Franklin Cliffs North	Greenstone (Catoctin)
C16	Central	Franklin Cliffs Overlook	Greenstone (Catoctin)
C17	Central	Franklin Cliffs South	Greenstone (Catoctin)
C20	Central	Halfmile Cliff	Greenstone (Catoctin)
C21	Central	Hawksbill N slope outcrops	Greenstone (Catoctin)
C22	Central	Hawksbill summit	Greenstone (Catoctin)
C28	Central	Little Stony Man	Greenstone (Catoctin)
C31	Central	Marys Rock	Basement rock
C32	Central	Millers Head	Basement rock
C34	Central	Nakedtop Upper East Slope	Basement rock
C36	Central	Old Rag southside	Old Rag granite
C37	Central	Old Rag summit east	Old Rag granite
C41	Central	Pinnacles	Basement rock
C47	Central	Stony Man summit	Greenstone (Catoctin)
C50	Central	Upper Devils Ditch	Basement rock
C60	Central	Hawksbill N slope talus	Greenstone (Catoctin)
C62	Central	Old Rag summit west	Old Rag granite
C66	Central	Field Hollow Cliff	Greenstone (Catoctin)
C67	Central	Bearfence	Greenstone (Catoctin)
C68	Central	Rose River	Greenstone (Catoctin)
C69	Central	Whiteoak Canyon	Greenstone/Basement
C05	South	Blackrock South District	Quartzite (Chilhowee)
C08	South	Calvary Rocks / Chimney Rock	Quartzite (Chilhowee)
C18	South	Goat Ridge	Greenstone (Catoctin)
C23	South	Hightop	Greenstone (Catoctin)
C29	South	Loft Mountain summit	Greenstone (Catoctin)
C42	South	Powell Gap cliff	Metasediments (Swift Run)
C44	South	Rocky Mountain	Quartzite (Chilhowee)
C45	South	Sawlog Ridge	Greenstone (Catoctin)
C49	South	Trayfoot Saddle boulderfields E	Quartzite (Chilhowee)
C64	South	Brown Mountain	Quartzite (Chilhowee)
C65	South	Trayfoot Saddle boulderfields W	Quartzite (Chilhowee)

Table 3. ROMP study sites and park district, sorted by bedrock type

Site ID #	SHEN District	Site Name	Site Bedrock
C03	North	Big Devils Stairs	Greenstone (Catoctin)
C07	North	Browntown Valley Overlook	Greenstone (Catoctin)
C13	North	Dickey Hill	Greenstone (Catoctin)
C14	North	Dickey Ridge	Greenstone (Catoctin)
C19	North	Gooney Manor Overlook	Greenstone (Catoctin)
C27	North	Little Devils Stairs	Greenstone (Catoctin)
C35	North	North Marshall summit	Greenstone (Catoctin)
C39	North	Overall Run Falls south	Greenstone (Catoctin)
C40	North	Pass Mountain	Greenstone (Catoctin)
C46	North	South Marshall cliff	Greenstone (Catoctin)
C63	North	Overall Run Falls north	Greenstone (Catoctin)
C02	Central	Bettys Rock	Greenstone (Catoctin)
C04	Central	Blackrock Central District	Greenstone (Catoctin)
C10	Central	Crescent Rock Overlook	Greenstone (Catoctin)
C11	Central	Crescent Rock South	Greenstone (Catoctin)
C12	Central	Dean Mountain Ridge	Greenstone (Catoctin)
C15	Central	Franklin Cliffs North	Greenstone (Catoctin)
C16	Central	Franklin Cliffs Overlook	Greenstone (Catoctin)
C17	Central	Franklin Cliffs South	Greenstone (Catoctin)
C20	Central	Halfmile Cliff	Greenstone (Catoctin)
C21	Central	Hawksbill N slope outcrops	Greenstone (Catoctin)
C22	Central	Hawksbill summit	Greenstone (Catoctin)
C28	Central	Little Stony Man	Greenstone (Catoctin)
C47	Central	Stony Man summit	Greenstone (Catoctin)
C60	Central	Hawksbill N slope talus	Greenstone (Catoctin)
C66	Central	Field Hollow Cliff	Greenstone (Catoctin)
C67	Central	Bearfence	Greenstone (Catoctin)
C68	Central	Rose River	Greenstone (Catoctin)
C18	South	Goat Ridge	Greenstone (Catoctin)
C23	South	Hightop	Greenstone (Catoctin)
C29	South	Loft Mountain summit	Greenstone (Catoctin)
C45	South	Sawlog Ridge	Greenstone (Catoctin)
C24	North	Hogback Mtn spur	Basement rock
C31	Central	Marys Rock	Basement rock
C32	Central	Millers Head	Basement rock
C34	Central	Nakedtop Upper East Slope	Basement rock
C41	Central	Pinnacles	Basement rock
C50	Central	Upper Devils Ditch	Basement rock
C69	Central	Whiteoak Canyon	Greenstone/Basement
C38	North	Oventop	Old Rag granite
C36	Central	Old Rag southside	Old Rag granite
C37	Central	Old Rag summit east	Old Rag granite
C62	Central	Old Rag summit west	Old Rag granite
C42	South	Powell Gap cliff	Metasediments (Swift Run)
C05	South	Blackrock South District	Quartzite (Chilhowee)
C08	South	Calvary Rocks / Chimney Rock	Quartzite (Chilhowee)
C44	South	Rocky Mountain	Quartzite (Chilhowee)
C49	South	Trayfoot Saddle boulderfields E	Quartzite (Chilhowee)
C64	South	Brown Mountain	Quartzite (Chilhowee)
C65	South	Trayfoot Saddle boulderfields W	Quartzite (Chilhowee)

Table 4. Site impact assessments from cooperating researchers[1].

Site ID #	Site Name	Cliff top (VT) impact sites	Cliff base impact sites (VT)	Campsites (VT)	Social trails (VT)	Geologist's access rating	Geologist's impact rating	Biologist's impact rating
C02	Betty's Rock	1	0	0	3	Easy	Heavy	Major
C03	Big Devil's Stairs	No data	No data	No data	No data	Difficult	Mild	Minor
C04	Blackrock Central D	2	0	0	3	Easy	Heavy	Major
C05	Blackrock South D	No data	No data	No data	No data	Easy	Moderate	Minor
C07	Browntown Valley	No data	No data	No data	No data	Remote	Pristine	Pristine
C08	Calvary Rocks	2	0	1	0	Difficult	Mild	--
C10	Cres. Rock Overlook	2	0	0	1	Easy	Heavy	Major
C11	Crescent Rock South	No data	No data	No data	No data	Easy	Moderate	Minor
C12	Dean Mountain	No data	No data	No data	No data	Remote	Pristine	Pristine
C13	Dickey Hill	No data	No data	No data	No data	Remote	Pristine	--
C14	Dickey Ridge	No data	No data	No data	No data	Remote	Pristine	Pristine
C15	Franklin Cliffs North	No data	No data	No data	No data	Moderate	Mild	Minor
C16	Fr. Cliffs Overlook	2	0	0	1	Easy	Heavy	Major
C17	Franklin Cliffs South	No data	No data	No data	No data	Moderate	Mild	Major
C18	Goat Ridge	No data	No data	No data	No data	Remote	Pristine	--
C19	Gooney M. Overlook	0	0	0	1	Easy	Moderate	Minor
C20	Halfmile Cliff	No data	No data	No data	No data	Remote	Pristine	Pristine
C21	Hawksbill N. Face	No data	No data	No data	No data	Remote	Mild	Pristine
C22	Hawksbill Summit	5	0	0	4	Moderate	Heavy	Major
C23	Hightop	No data	No data	No data	No data	Moderate	Moderate	Minor
C24	Hogback Mt Spur	No data	No data	No data	No data	Remote	Pristine	--
C27	Little Devils Stairs	No data	No data	No data	No data	Difficult	Mild	--
C28	Little Stony Man	5	3	3	6	Moderate	Heavy	Major
C29	Loft Mountain	2	0	2	1	Easy	Moderate	Major
C31	Mary's Rock	2	0	1	5	Moderate	Heavy	Major
C32	Millers Head	No data	No data	No data	No data	Moderate	Mild	--
C34	Nakedtop	No data	No data	No data	No data	Remote	Pristine	--
C35	North Marshall	8	0	2	10	Easy	Moderate	Minor
C36	Old Rag Southside	0	3	0	2	Remote	Mild	--
C37	Old Rag Summit E.	No data	No data	No data	No data	Difficult	Heavy	Minor
C38	Oventop	No data	No data	No data	No data	Difficult	Mild	Pristine
C39	Overall Run S.	No data	No data	No data	No data	Remote	Pristine	--
C40	Pass Mountain	No data	No data	No data	No data	Moderate	Moderate	Minor
C41	Pinnacles	No data	No data	No data	No data	Moderate	Mild	--
C42	Powell Gap Cliffs	No data	No data	No data	No data	Moderate	Mild	Minor
C44	Rocky Mountain	No data	No data	No data	No data	Difficult	Moderate	Minor
C45	Sawlog Ridge	No data	No data	No data	No data	Remote	Pristine	Pristine
C46	South Marshall	3	0	0	2	Moderate	Moderate	Minor
C47	Stony Man Summit	3	0	0	4	Moderate	Heavy	Major
C49	Trayfoot W.	No data	No data	No data	No data	Difficult	Pristine	Pristine
C50	Upper Devil's Ditch	No data	No data	No data	No data	Remote	Pristine	Pristine
C60	Hawksbill N. Talus	No data	No data	No data	No data	Moderate	Mild	Minor
C62	Old Rag Summit W.	5	0	1	17	Difficult	Heavy	Major
C63	Overall Run Falls N	4	0	0	0	Difficult	Heavy	--
C64	Brown Mountain	No data	No data	No data	No data	Difficult	Mild	Minor
C65	Trayfoot E.	No data	No data	No data	No data	Difficult	Pristine	Pristine
C66	Field Hollow	No data	No data	No data	No data	Remote	Pristine	Pristine
C67	Bearfence	No data	No data	No data	No data	Difficult	Heavy	--
C68	Rose River	No data	No data	No data	No data	Remote	Pristine	--
C69	Whiteoak Canyon	No data	No data	No data	No data	Moderate	Mild	--

[1]Studies conducted by a social science team (Virginia Tech), geology consultant (NPS), and stewardship biologist (Virginia Department of Conservation and Recreation). VT selected 17 sites for detailed study, while the other cooperators visited all 50 sites. VADCR rankings are temporarily presented here as incomplete pending final release of data.

Appendix A. Example data sheets and maps

Table of Contents

Blank field data sheet…….32

Blank field photo/GPS log…….33

Example completed field map……...34

Example blank final map…….…..35

Example redrawn final map…….…..36

Example final regional map…….…..37

See Appendix B for definitions of terminology found on these sheets.

Appendix A. (continued).

Blank field data sheet

SHENANDOAH NATIONAL PARK

ROCK OUTCROP MANAGEMENT PROJECT – GEOLOGIC DATA SHEET

SITE CODE: _____ SITE NAME: _____ PAGE ____ OF ____

GENERAL LOCATION: DATA COLLECTOR: _____

DATE STUDIED: _____

GEOGRAPHIC CHARACTERISTICS

UTM COORDINATES: (E)_____

DATUM: _____ (N)_____

ELEVATION: _____

DIMENSIONS:

PHYSICAL CHARACTERISTICS

VEGETATION: *dense moderate open*

PHYSICAL DESCRIPTION:

GEOLOGIC CHARACTERISTICS

LITHOLOGY:

STRUCTURE:

GEOMORPHIC CHARACTERISTICS

EXPOSURE TYPE(S):

	Cliff	*Outcrop*	*Face*	*Ledge*	*Talus*
%Exposure					
Max Relief					

Aspect: Texture: Max slope:

STABILITY: *stable moderate loose*

GEOMORPHIC SETTING:

OTHER:

HUMAN EFFECTS

ACCESS: *remote difficult moderate easy*

IMPACTS: *pristine mild moderate heavy*

Appendix A. (continued).

Blank field GPS/photo log

SHENANDOAH NATIONAL PARK

ROCK OUTCROP MANAGEMENT PROJECT – GEOLOGIC PHOTO & GPS INDEX

SITE CODE:_____ **SITE NAME:**_____ **PAGE** ___ **OF** ___

PHOTOS

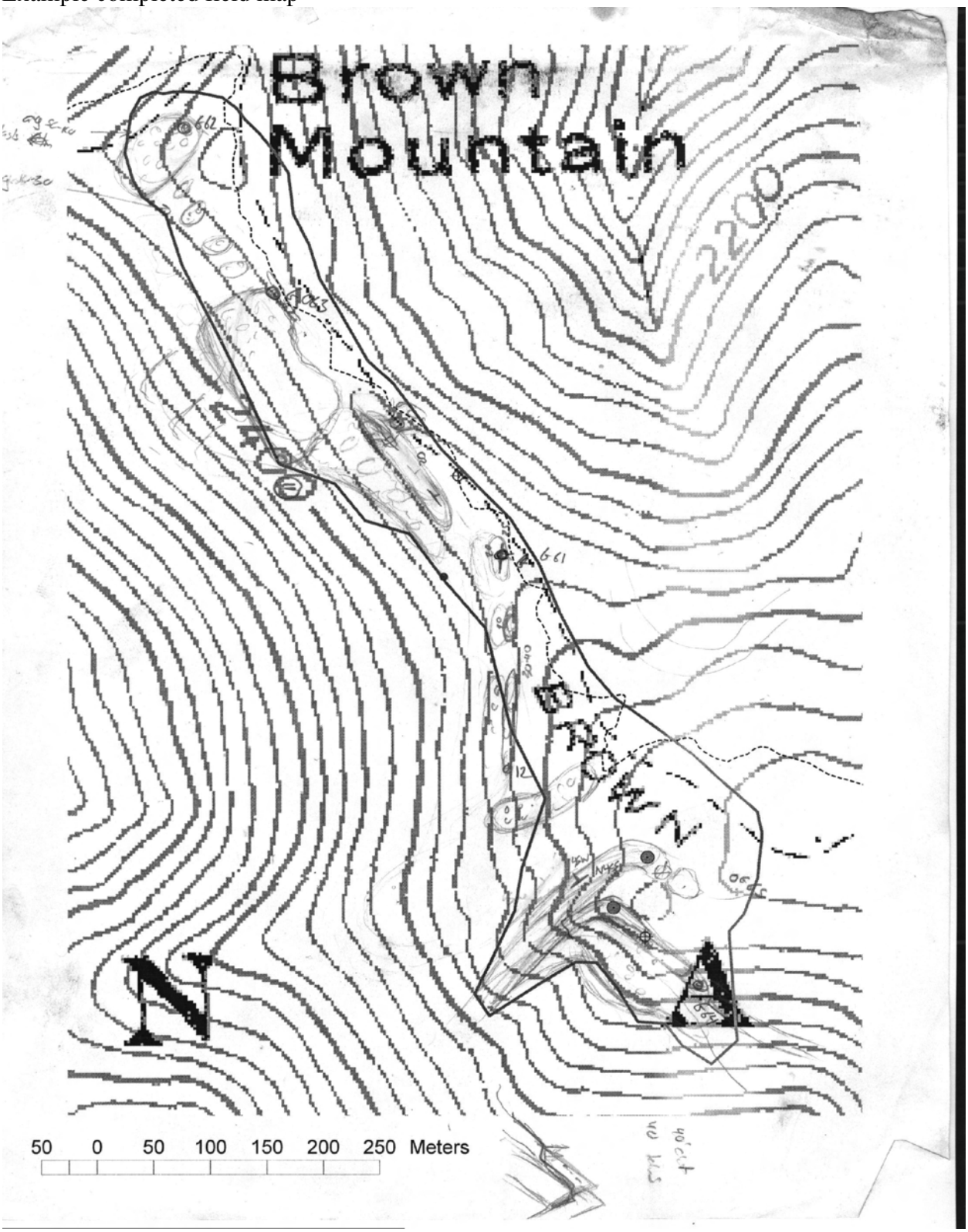
Date	GPS Point	#	Orientation	Comments

GPS POINTS (NAD 83)

Date	#	Easting	Northing	Elevation	Comments

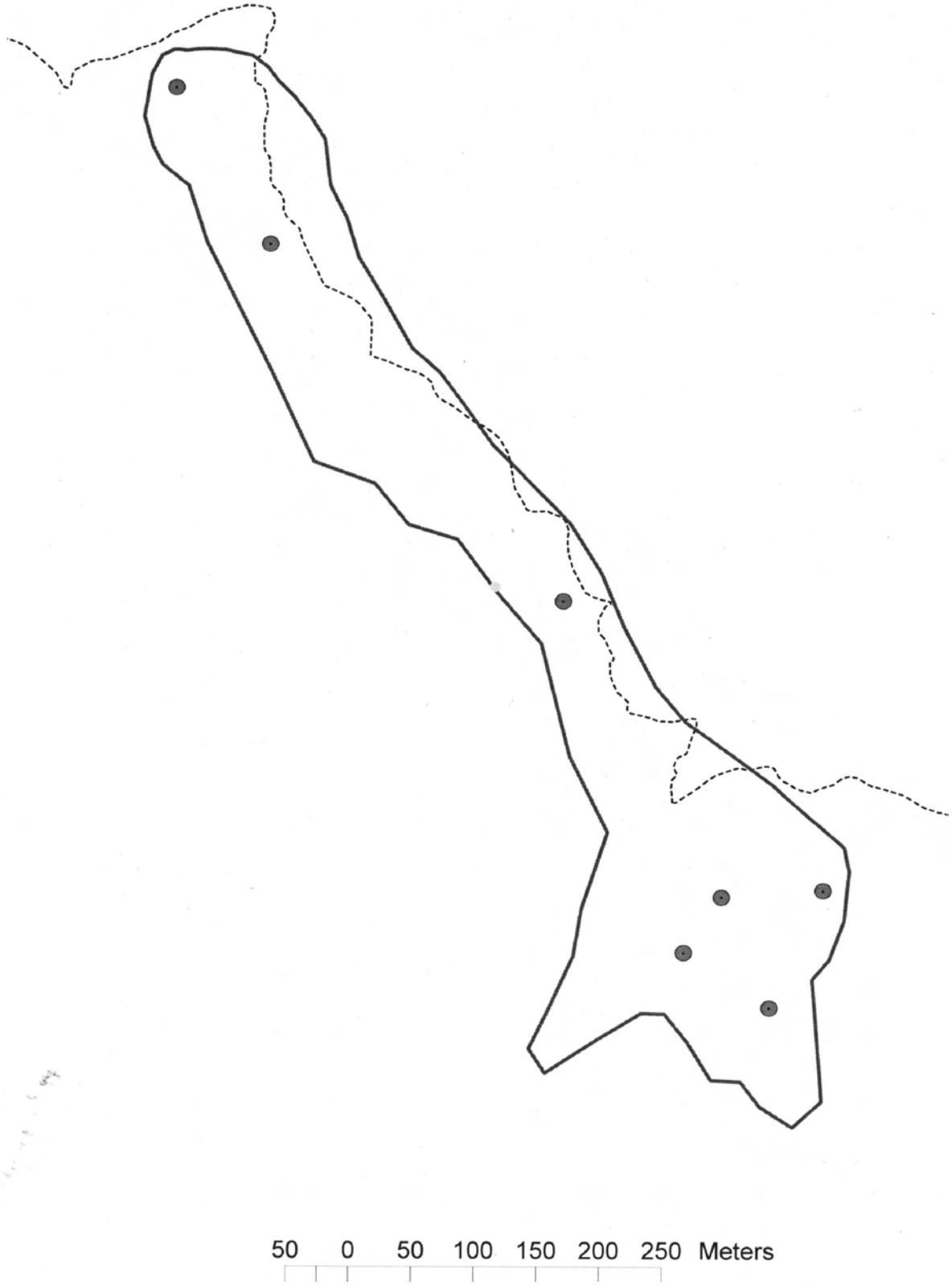
Appendix A. (continued).

Example completed field map



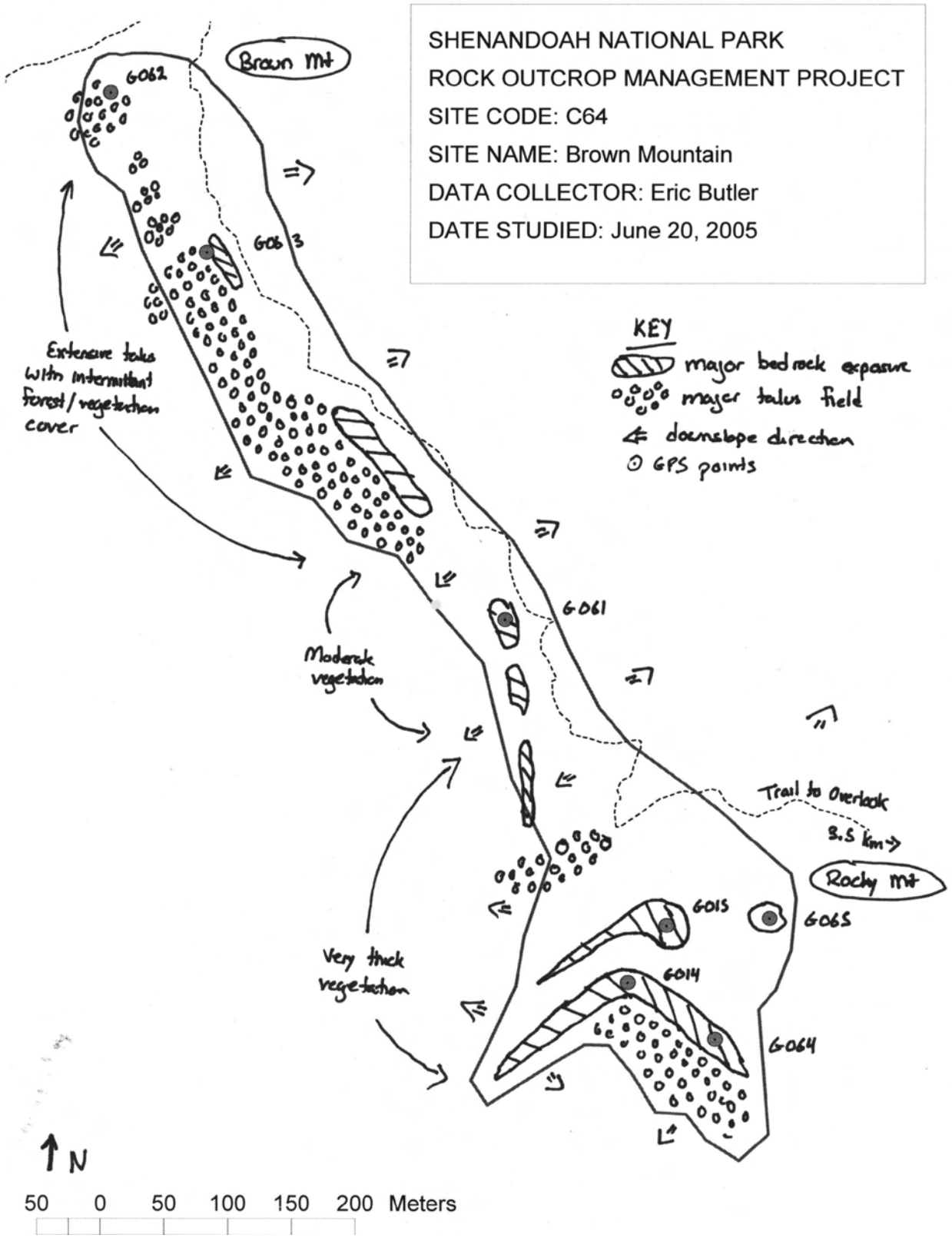
Appendix A. (continued).

Example blank final map



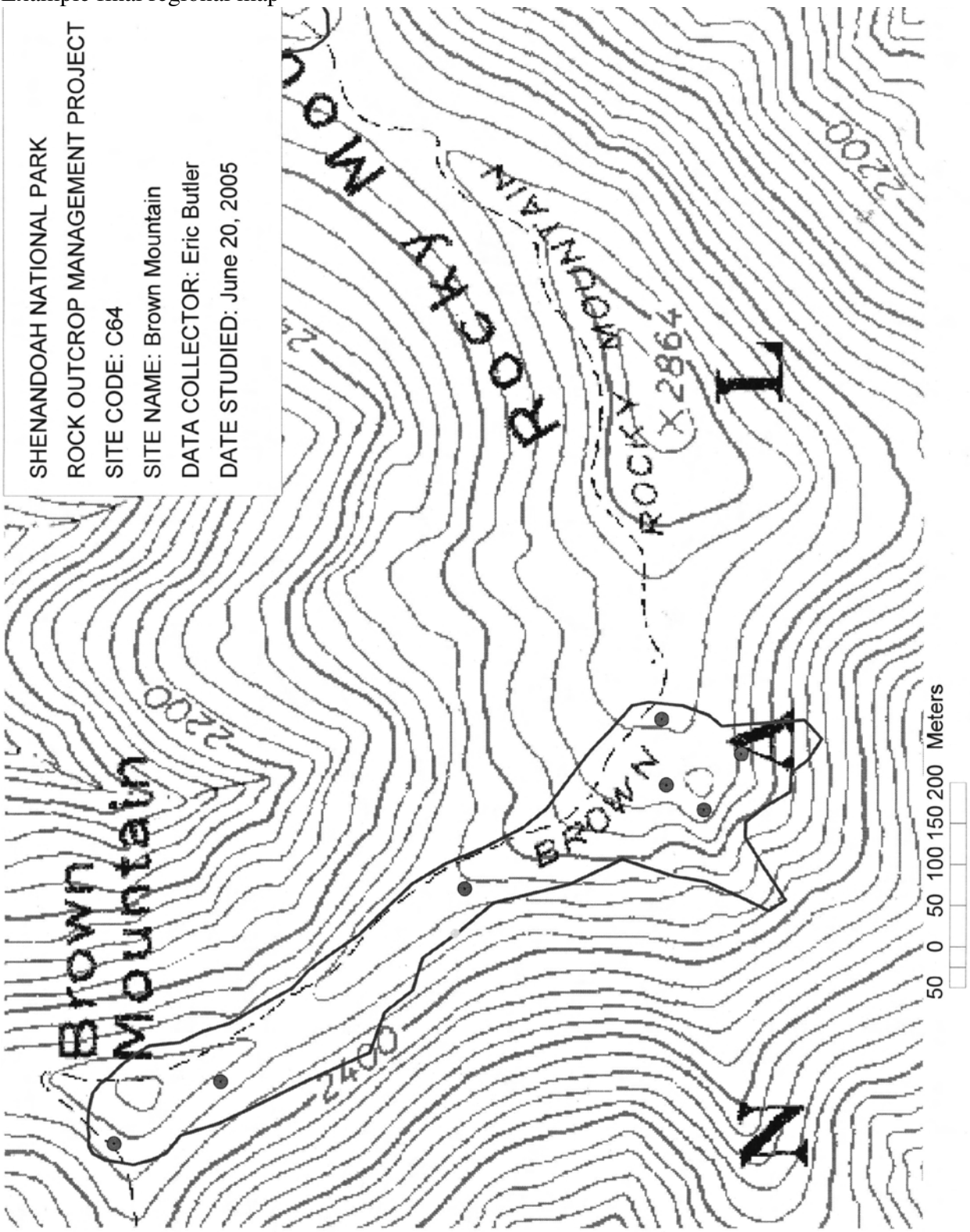
Appendix A. (continued).

Example redrawn final map



Appendix A. (continued).

Example final regional map



Appendix B. Definitions of terms used in data collection and analysis

Table of Contents

Geographic Characteristics……..……..……..40

Physical Characteristics……..40

Geologic Characteristics…….40

Geomorphic Characteristics…….…...40

Human Effects……....41

Appendix B. (continued).

Geographic Characteristics

UTM Coordinates – Coordinates of site centerpoint as calculated by GIS.
Elevation – range of elevation between bottom and top of site (i.e. 2600'-2750').
Dimensions – X and Y dimensions of site, measured on GIS.

Physical Characteristics

Vegetation – Overall thickness and condition of vegetation in site, re. ease of mobility.
dense: dominant thickets of vegetation significantly impede navigation.
moderate: mix of thickets and open forest, ease of navigation varies.
open: vegetation is not a significant barrier to navigation.
Physical description – Summary of general nature and appearance of site (not scientific).

Geologic Characteristics

Lithology – description & identification of major rock units found at site, including mineralogy, provenance, and history as necessary.
Structure – description of any important structures in rock, such as faults, folds, or joints, including measurements & interpretation if possible.
Other – any other necessary observations, potentially soils, springs, views, fossils, etc.

Geomorphic Characteristics (see Fig. 2 for examples)

Cliff – Near-vertical exposure that dominates or creates surrounding topography. Usually continuous across slope, though may be interrupted by talus slopes or other erosional features. Generally sheer, with minor ledges along the vertical drop.
Face – Continuous, rounded, gently sloping exposure (<45) of smoothly weathered rock. Not steep enough to be a cliff, too continuous and smooth to be an outcrop, and too large and rounded to be a ledge.
Outcrop – Intermittent exposures that stand out from surrounding topography but do not influence it. Most commonly sloping, rugged exposures with many associated ledges. May also consist of intermittent protruding rock ribs that are not continuous or wide enough to be a cliff.
Ledge – Near-horizontal exposure along top or sides of cliffs and outcrops, where a local break in slope occurs, but trees and thick soil have not yet accumulated. Often hosts vegetation.
Talus – Continuous to scattered rock debris, clast-dominated with little to no soil development, covering general topography. May or may not be associated with in-place bedrock exposures.
% Exposure – Percentage of total exposed rock (not of whole site) consisting of a certain geomorphic type. Estimated from field observations, should not be considered a quantitative measurement.
Max Relief – Greatest vertical distance between top and bottom of a single unit of a certain geomorphic type. Estimated from field observations, should not be considered a quantitative measurement.

Appendix B. (continued).

Geomorphic Characteristics (continued)

Max Slope – Steepest slope encountered in the site's surrounding topography, not including the rock exposures.

Aspect – Orientation(s) of rock exposures, recorded by alphabetic bearing (i.e., NW, SSE).

Texture – Overall surface morphology of the bedrock.

fractured: Widespread cracks, joints, or other breaks which dominate the surface. Generally no common surface identifiable.

rough: uneven and moderately fractured, but an identifiable, common surface is present.

smooth: continuous surface with no major disruptions; may have minor topography.

Stability – Physical condition and safety of exposures.

loose: bedrock is heavily fractured and appears to be actively eroding; not safe to approach edges of cliffs, for example. ALSO talus fields that are especially unstable.

moderate: site is a mix of loose and stable bedrock areas. ALSO talus fields that have low slopes and/or do not shift underfoot.

stable: bedrock is solid and provides no apparent danger of movement, little to no loose material on surrounding slopes.

Geomorphic Setting – Description & discussion of how exposures fit into surrounding area. Is there a geologic control on the physical shape and location of the site? How does it relate to the surrounding landscape? What geologic/geomorphic factors are affecting the site?

Human Effects

Impacts – Evidence of human activity on the outcrop.

pristine: no impacts; trails/compaction nonexistent, absolutely no signs of human use or visitation.

mild: minor impacts; minor trails, slight compaction, , vegetation sporadically affected, most of site is untouched.

moderate: significant impacts; trails and compaction are common, areas of use are clearly visible, vegetation clearly affected and diminished..

heavy: ubiquitous impacts; trails and compaction are prevalent, rocks are carved, polished, or otherwise obviously impacted, trash or other debris may be common, vegetation severely diminished..

Access – ability of visitors to reach the outcrop from starting point on an access road).

remote: not accessed by any trail or road. Generally not visible from trails or roads; if visible, requires negotiation of significant backcountry and/or topography to reach.

difficult: generally greater than 2 trail km from road OR nearer road but requires negotiation of strenuous topography or trail conditions to reach.

moderate: generally located within 2 trail km from road, visible from trails; may have some obstacles to access (slope, vegetation, etc…).

easy: generally located within 500m of road along clearly marked trails with signs leading to site OR located within 20m of road and clearly visible with obvious trails, no topography or other difficulties preventing access.

Appendix C. Geologic history and formations of SHEN.

Summary

The geologic history of Shenandoah National Park (SHEN) spans the rise and fall of two distinct mountain ranges. While the current Appalachian Mountains may be considered the oldest in North America, much of the region's bedrock is related to an earlier, larger mountain range that eroded away long before the current topography began to develop.

During a period of time 1.2-1.0 billion years ago, a major collision between tectonic plates created a long chain of mountains along what is now the eastern margin of North America (Burton and Southworth, 2004). This period of mountain-building, known as the Grenville Orogeny, produced a thick suite of metamorphic rocks deep beneath the earth's surface, as intense heat and pressure deformed pre-existing sedimentary and igneous rock into new compositions and structures. Some areas melted entirely, creating pockets of new igneous rocks that intruded into the surrounding metamorphic rock (Tollo et al., 2004).

These deep-rooted igneous and metamorphic rocks formed the core of the Grenville Mountains, which extended from present-day Texas to Newfoundland, although the North American continent had not yet formed as such (Badger, 1999). The peaks were likely as tall as any on Earth today, but as tectonic pressures faded, they slowly eroded away. By around 600 million years ago, the landscape was apparently reduced to low, rolling hills with a few higher points (perhaps several thousand feet tall), a scene not unlike today's Virginia Piedmont. With no terrestrial plants or animals having evolved yet, however, it would have been a landscape of barren, rock-strewn slopes, gravelly river valleys, and occasional lakes (Gathright, 1976).

Around 570 million years ago, the tectonic pressures reversed themselves and the plates began pulling apart, forming a rift zone thousands of miles long. This rifting allowed molten rock from deep within the earth to rise to the surface, resulting in widespread volcanism that erupted lava flows from Newfoundland to North Carolina, covering at least 11,000 km^2 (Badger and Sinha, 2004). Within SHEN, at least 16 lava flows form a sequence up to 2,000' thick, blanketing the old topography of the eroded Grenville landscape (Gathright, 1976).

While the duration of individual flows (and the time lapse between them) is unknown, the entire sequence likely erupted within a span of several million years (Badger, 1999). Following the cessation of active volcanism, the rift continued to spread, creating a growing ocean basin in a process similar to the formation of today's Atlantic Ocean. This ocean, however, predated the Atlantic by several hundred million years; it was named Iapetus, after the father of Atlantis in Greek mythology (Connors, 1988).

The Iapetus Ocean continued to grow as the rift widened, and rising marine waters began to deposit a thick sequence of sediments over the now-cooled lavas. The earliest deposits consist of gravelly sandstones, representing the river systems draining into the growing ocean. Following these came a mixture of siltstones (reflecting a shallow-marine beach/lagoon environment), shales (deeper water), and pure quartz sandstones (beach/dune environments); this complicated sequence reflects the minor fluctuations in sea level occurring during the overall advance of the

ocean. Many more layers of rock were deposited in the long history of the Iapetus Ocean, including thick units of limestone, but these exist mainly outside of SHEN.

By around 450 million years ago, plate movements had reversed themselves once again, and the Iapetus Ocean began to close as tectonic processes came full circle. A series of three major continental collisions took place between 450 and 300 million years ago, raising new mountains where the old Grenville range once stood (Badger, 1999). The Appalachian Mountains, like their predecessors, stretched thousands of miles and rose just as high in their prime. Deformation and faulting once again altered the bedrock, recent and ancient, in the formation of these mountains. Several major thrust faults stacked thick sequences of bedrock on top of one another, significantly increasing the thickness of the crust and the height of the mountains in these areas. Intense folding was especially prevalent in the sedimentary rocks above the lava flows and basement rocks; some of these folds can still be seen today. Both the folding and the faulting are a major control on the shape and nature of the topography in SHEN even today (Burton and Southworth, 2004).

Eventually the tectonic processes reversed themselves yet again, and the mountain building came to an end. Around 200 million years ago, the modern continents of Africa and North America began to split apart, in the same way as the old Grenville plates had. This final rifting event created the Atlantic Ocean, which continues to spread today. As tectonic pressures faded, the Appalachians stopped rising, but erosion continuted to wear down the landscape. Today, the former high, rugged peaks are worn down almost to their roots, once again exposing bedrock that was miles below Earth's surface during the peak of Appalachian mountain-building.

The bedrock found within SHEN preserves only the early portion of this long and complex history; the youngest rock found here is over 400 million years old. Tectonic processes and erosion have combined to remove everything younger. The remaining stratigraphy consists of "basement" gneisses and granites from Grenville times, overlain by basaltic/greenstone lava flows erupted during the Iapetus Ocean rifting, in turn overlain by a sequence of quartzites, siltstones, and limestone deposited by the early Iapetus (Gathright, 1976). The following sections will discuss these individual formations in more detail.

Basement rocks

The oldest rocks found within SHEN are a diverse set of igneous and metamorphic rocks which form the base of the Blue Ridge. Traditionally, these rocks were collectively treated as a single unit known as the Pedlar Formation, and were not further subdivided or studied in great detail (with a few exceptions). Recent research (e.g. Tollo et al., 2004) has investigated these rocks further, developing a more thorough understanding of their complex composition, structure, and history. Although the term "Pedlar Formation" is widely known and understood, it implies a homogeneity that is not representative of this diverse suite of rocks, and some recent researchers have ceased using that name. In this report, the term "basement rock" is used instead in reference to any and all Precambrian igneous or metamorphic rocks that form the base of the stratigraphic sequence within the Blue Ridge.

At a broad scale, the basement rock within SHEN consists of various high-grade gneisses (Tollo et al., 2004), rock which has been deformed at temperatures at or exceeding 700º-800ºC, and up to 12 kilobars of pressure (Blatt and Tracy, 1999). This grade of metamorphism is nearly as high as a rock can achieve without simply melting to form an igneous rock. These gneisses display varying degrees of foliation, a planar, banded appearance created by the alignment and segregation of similar mineral types during intense deformation. The composition of these rocks is generally granitoid, meaning they are dominated by the light-colored minerals quartz and feldspar, with variable but smaller amounts of darker accessory minerals such as pyroxene, amphibole, garnet, or biotite mica (Tollo et al., 2004). Rocks of this type often contain biotite, but in this region pyroxene is also common. Pyroxene-rich granitoids are referred to as "charnockite", and make up a significant portion of the basement rock in SHEN (Tollo et al., 2004).

Various bodies of igneous rocks, or plutons, are also present within the basement rock. The most distinct unit is the Old Rag Granite, an unusual rock composed almost exclusively of coarse crystals of blue-grey quartz and white-pink feldspar, giving it a very light-colored and distinctive appearance. It occurs mainly in a single body centered on Old Rag Mountain, with a long, narrow finger extending many kilometers to the north (Gathright, 1976). This rock is remarkably uniform in texture, composition, and appearance, generally having very little evidence of deformation (with the exception of a fault zone running west of Old Rag Mountain, through Weakley and Berry Hollows). Most other common igneous rocks within SHEN are similar in composition to the granitic gneisses described above, containing variable amounts of quartz and feldspar along with several darker accessory minerals, and most show some level of deformation.

In reality, the boundaries between these two major basement rock types within SHEN can be quite subtle and gradational. As discussed above, most of the gneisses are interpreted to be igneous in origin, while some of the igneous rocks are deformed enough to approach metamorphic status. All of these rocks developed into more or less their present form during the intense temperatures and pressures created by the mountain-building events associated with the Grenville Orogeny, 1.2-1.0 billion years ago (with later effects from Appalachian mountain-building). These extreme conditions deformed pre-existing igneous rocks to create the various gneisses, which were intruded by various bodies of magma while this deformation was ongoing, thus creating igneous bodies that themselves show signs of deformation. Tollo et al. (2004) defined three distinct periods of magmatic activity within the Grenville Orogeny; from 1160-1140 million years ago (Ma), 1112 Ma, and from 1080-1050 Ma.

The result of all this is a complex suite of rocks that grade between igneous and metamorphic textures and variable mineralogic compositions, blending and interfingering at scales ranging from tens of centimeters to tens of kilometers. While broad trends in these different rock units can be mapped at a large scale (see Tollo et al., 1999, fig. 3), it is difficult at the outcrop scale to distinguish between and map these units in a meaningful and consistent way, especially with plant and lichen cover. Therefore, this report considers the basement rocks as a single unit distinct from the volcanic and sedimentary rocks found in SHEN, though individual site reports

describe mineralogic and structural details of the local bedrock. The only exception to this practice is the Old Rag Granite, which is mineralogically and visually distinct enough to be identified separately, does not interfinger with other basement rocks at a significant scale, and occurs only within a specific, mappable area.

One other rock type is found within the basement rocks; greenstone dikes are common throughout these areas. These are narrow, planar units of igneous rock that intruded into the basement rocks along joint or fracture planes. These dikes were originally composed of diabase (the same mineral composition as basalt, only cooled underground), and like the Catoctin Formation metabasalts, were metamorphosed into greenstone later in their history. The age and relationship of these dikes to the very similar Catoctin Formation rocks is somewhat uncertain. The dikes are commonly assumed to be part of the “feeder system” that allowed the molten rock to intrude through the basement rocks before erupting onto the surface as lava flows, but it is unclear whether these specific dikes actually reached the surface, or are simply small outliers of a larger network of fractures located elsewhere.

The greenstone dikes are rarely found in-place, but more often as linear deposits of loose greenstone rocks on the forest floor, looking notably out-of-place when surrounded by granitic detritus. Where the dikes are found in-place, it is almost always on high, rugged peaks, where a lack of soil cover has exposed them. Old Rag Mountain is the primary example of this, where many dikes up to 3m wide can be found along the summit and exposed ridgelines.

Swift Run Formation metasediments

Overlying the basement rocks is a generally thin, discontinuous unit of metasediments. The Swift Run Formation preserves a diverse set of material that was deposited on the pre-Catoctin paleotopography by streams, rivers, lakes, and hillslope processes. The formation also includes some volcanic debris and ash, most likely from the earliest eruptions related to the Catoctin-era rifting events. The Swift Run is extremely variable in composition, grading quickly from shale/slate/phyllite units that likely reflect old ponds and lakes, to sandy/quartzitic/cobbly units that likely reflect rivers or bank environments, to coarse-clastic breccias that likely reflect debris flows or other hillslope erosion processes. The formation is often not present at all, which most likely indicates areas of higher relief (where sediments would not be deposited) or areas scraped clean of sediments by advancing Catoctin lava flows. In addition, layers of sediment similar to the Swift Run are often found between lava flows within the Catoctin, suggesting the repeated redevelopment of rivers and erosional processes between eruptive periods.

The Swift Run can be difficult to distinguish from other metasedimentary rocks of the much younger Chilhowee Group, and attention to a geologic map and surrounding rock units can be as useful in specimen identification as any other method.

Catoctin Formation greenstone

Overlying the basement rocks and the Swift Run Formation is a sequence of lava flows up to 2,000' thick (Gathright, 1976). These flows constitute the Catoctin Formation, a near-continuous unit of volcanic rock that can be traced from southern Virginia into southern Pennsylvania, covering over 11,000 square kilometers (Badger and Sinha, 2004). The lavas were originally formed from basalt, a dark-colored volcanic rock composed primarily of plagioclase feldspar and pyroxene (Blatt and Tracy, 1999). Basalt is very low in silica, and thus has a relatively low viscosity. Basaltic magmas tend to behave very fluidly, erupting onto the surface in liquid flows that follow topography and fill in low areas. In contrast, high-silica magmas are very viscous and tend to erupt as violent explosions (e.g. Mt. St. Helens) compared to flowing, low-silica magmas (e.g. Hawaii).

As the paleocontinent first began to rift apart around 570 million years ago, a process which would eventually form the Iapetus Ocean, large volumes of basalt from deep within the Earth followed the rifts in the crust upward and erupted onto the surface. This is a common process that still occurs at active rift zones today, such as those in Iceland and portions of eastern Africa. Similar eruptions occurred all along the rift zone, so that even today related deposits can be identified from Newfoundland to North Carolina (Badger and Sinha, 2004).

In the SHEN area, the basaltic lava flows spread across the rolling, rocky terrain underlain by Grenville basement rocks exposed by hundreds of millions of years of erosion, gradually filling in river valleys and lapping against the hillsides. This did not occur all at once, but rather in a series of separate events, allowing each flow to cool and solidify before the next flow erupted above it. The result was a thick (up to 2,000') sequence of distinct lava flows that can still be identified today (Gathright, 1976). While the time interval between each flow is unknown, it appears that the entire sequence was erupted over a span of only several millions years (Badger and Sinha, 2004).

Individual flows range in thickness from several meters to over 30m. Often, the upper few meters of a flow contains numerous preserved gas bubbles (vesicles) which are now filled by quartz and/or epidote (amygdules). This texture represents the "frothy" nature of a flow surface, in which pressurized gas is escaping in the same manner as a shaken bottle of soda. Flows may be separated by thin deposits of sediments, representing the re-establishment of drainage systems across the older flow surface prior to the next eruption. The thickness of these deposits may be a proxy for elapsed time between eruptions, but this has not been proven. Commonly, flows are separated by zones of breccia up to several meters thick, containing fragments of vesicular or amygdaloidal basalt, ripped-up clasts of sediments, and/or quartz pebbles, generally surrounded by a greenish, highly epidotized matrix. These breccias formed as an advancing flow ripped up fragments from the underlying flow's surface and mixed them with whatever sediments had been deposited on the short-lived depositional surface (Gathright, 1976).

Although these flows were erupted as basalt, they have since been affected by low-level metamorphism. Heat and pressure related to the formation of the Appalachian Mountains has

altered the composition and textures of the rock to form greenstone, which is the common name for metamorphosed basalt. While basalt consists primarily of plagioclase feldspar and pyroxene, this metamorphism encouraged the growth of minerals such as chlorite and epidote. Epidote replacement can be widespread, and results in a grainy, lime-green appearance, while chlorite growth produces a darker green color and a platier texture.

A common structure within the greenstone is cleavage, which is a series of planar, parallel fractures that can look very similar to sedimentary bedding. This structure develops during metamorphism, as pressures on the rock start to create small fractures, while the mica-like mineral chlorite grows and aligns itself with these fractures, creating a platy texture similar to that of slate. In general, the cleavage planes found within the Catoctin Formation dip eastward at around 45-60 degrees, and as such are very distinct from the near-horizontal orientation of the lava flows themselves.

Another common structure within the greenstone is columnar jointing, which is a fracture pattern formed as the molten lava cooled on the surface. Lava, like most substances, contracts as it cools and hardens. As it does so, a series of angular fractures can develop, usually at 120 degree angles to one another, creating a hexagonal pattern within the rock. These fractures can extend many meters vertically, producing what appear to be a series of tall, polygonal columns within the rock that can be over a meter wide. Much of the columnar jointing in the park is poorly developed or preserved, but a few locations contain spectacular examples of this distinctive feature.

Metamorphism and hydrothermal activity within the Catoctin have resulted in locally common metal deposits, including iron and copper. These can be seen as mineral growths within fractures, or within the greenstones themselves. During historic times, these deposits were targeted for small-scale prospecting and mining operations, including the small mine and furnace located high on Stony Man Mountain in the early 20th century.

Chilhowee Group Metasediments

The Chilhowee consists of three formations, closely related to one another but generally distinct in appearance and depositional environment. Deposition of these rocks apparently began shortly after the cessation of Catoctin volcanism, and continued as the advancing Iapetus Ocean covered the area (Badger, 1999). The Chilhowee grades from sandstone/conglomerate (Weverton Fm) into sandstone/siltstone/shale (Hampton Fm) into quartzite (Erwin Fm), and ends where a thick sequence of dolomite and limestone (Tomstown Fm) overlies it (Morgan et al., 2004).

<u>Weverton Formation</u>

After Catoctin volcanism had ended, and the lava flows had cooled, rivers and streams re-established drainage patterns over the new landscape. The first evidence of this transition comes in the Weverton Formation, which consists of coarse clastic sedimentary deposits, including some conglomerates, representing the initial movement and deposition of debris by rivers

(Gathright, 1976). The Weverton can generally be recognized by the presence of large quartz pebbles within sandstone, and is only 31-152m thick (Morgan et al., 2004).

Hampton Formation

Overlying the Weverton sandstones is a thick (600m) unit of sandy shale and siltstone, comprising the Hampton Formation (Morgan et al., 2004). These rocks have been largely metamorphosed into phyllite, a platy low-grade metamorphic rock. The original lithology records the presence of lagoons, marshes, or other mixed-energy shallow-water environments at the time of deposition. It is likely that, as the Iapetus Ocean advanced, the landscape began to flood behind a series of barrier islands, similar to the modern environment found today along the southeast Atlantic and Gulf Coasts. Within the thick sequence of shales and siltstones, several beds of quartzite occur, which likely represent barrier island/beach environments formed during minor changes in sea level (as sea level fluctuates, the coastline moves inland and seaward, leaving shoreline deposits at various places within the stratigraphic record) (Gathright, 1976).

Erwin Formation

As the Iapetus Ocean continued to advance, the inland lagoons and bays gradually transitioned to beachfront property, and silts and shales gave way to quartz sand dunes, beaches, and barrier islands. The Erwin Formation is dominated by beds of clean, pure white quartz sand, now hardened into a very resistant quartzite by later metamorphism. These quartzites often preserve original sedimentary structures, such as layering and cross-bedding, that record their beach/dune environment. The Erwin quartzites also commonly contain remnant trace fossils called “skolithos”, which are preserved burrows from an early form of worm. These fossils appear as thin, straight, tube-like structures within the rock, and are often extremely prevalent throughout the rock. The Erwin is not entirely quartzite, but rather a series of quartzite beds separated by less resistant layers of siltstone and shale which are rarely found as exposed bedrock. As in the Hampton Formation, this sequence represents the continued minor fluctuations in sea level during the overall advance of the Iapetus (Gathright, 1976).

Appendix D. Bedrock-influenced geomorphic patterns in SHEN.

The following descriptions and interpretations draw on the author's personal observations and experiences, as well as previous work by Gathright (1976), Connors (1988), and Badger (1999).

General bedrock patterns

The bedrock geology of SHEN is a controlling factor in the location and physical character of open rock exposures, as well as in the general morphology of the landscape. In the North and Central Districts of the park, the ridgeline is generally capped by greenstone lava flows that dip eastward. Thus, many open rock exposures in this lithology are found at high elevation, facing generally westward (e.g. Stony Man and Hawksbill Mountains). Where significant exposures occur on the east side of the ridge, they are generally associated with deep slot canyons incised into the greenstone layers by streams (e.g. Little and Big Devil's Stairs, Whiteoak Canyon). In the southern portion of the North District, the greenstone layers dip west as well, producing a similar texture on the western side of the park (Jeremy's Run, Overall Run).

In the North and Central Districts, basement rocks are generally found at lower elevations, underlying the greenstones, and so are less likely to produce significant open rock exposures. Significant exceptions to this rule are found where faulting has thrust the basement rocks over the greenstones (e.g. Pinnacle Ridge/Mary's Rock), where similar faults separate basement rock areas into solitary summits (e.g. Old Rag and Oventop Mountains), or where the original paleotopography of the pre-Catoctin land surface has preserved an especially high point (e.g. Hogback Mountain).

While the North and Central Districts are relatively similar in their bedrock geology and structures, the South District is distinctly different. Here, the Chilhowee Group has not yet been eroded away, and the orientation of the rock sequence dips strongly to the west, so that the younger rocks are exposed to the west. Thus, the dominant bedrock of this district is the Chilhowee, and most of the ridgelines and valleys are formed in this lithology. The Catoctin is still present along the eastern slope of the main ridge, and the basement rocks are mostly deep in valleys or outside the park boundary.

General structural patterns

Large-scale geologic structures significantly influence the location and shape of the Blue Ridge in Shenandoah. As discussed above, several large faults run through the park, along which thick sequences of bedrock were thrust and stacked atop one another, creating ridges and peaks that would not otherwise exist (e.g. Mary's Rock and Pinnacles). In addition, the actual traces of these faults are often areas of accelerated weathering, since fault activity tends to grind up and weaken bedrock in the area. Thus, these faults create gaps and valleys (e.g. Thornton Gap, Berry & Weakley Hollows) that may isolate certain peaks (e.g. Old Rag and Oventop). Several smaller faults cut across the main ridge, perhaps influencing the development of gaps at these locations (e.g. Fishers Gap and Hawksbill Gap).

At a smaller scale, physical structures such as joints, foliation, and cleavage provide planes of weakness along which weathering processes act to shape rock exposures. Where such structures are oriented parallel to the surrounding slope, longer, linear, more sheer rock exposures may be expected. Where such structures are oriented against the surrounding slope, isolated, protruding outcrops of rock may be more likely. In addition, the presence and quantity of ledges (prime vegetation habitat) is directly related to the presence and nature of such geologic structures; cleavage and layering in particular are conducive to ledge formation.

Basement rocks

In general, most granitic-type rocks will erode into smooth, rounded landforms due to the relative uniformity of their mineral textures and the processes of spheroidal weathering and exfoliation. The former acts to chemically break down minerals (especially those found in granitic rocks) in exposed areas, thus rounding off any sharp corners and producing the smooth, rounded knobs and boulders found at places like Old Rag Mountain. Exfoliation occurs when a bedrock area slowly expands and contracts due to temperature changes; the subtle flexing that occurs under these conditions creates curved fractures by which rounded slabs of rock break off. This process is especially common in fine-grained, structureless crystalline rocks, where it produces an onion-like surface texture of smooth, rounded rock faces with multiple layers of curved fractures parallel to the surface.

Where jointing is present, the joints create natural planes of weakness for such weathering processes to focus on, resulting in a series of rounded blocks, boulders, and distinct knobs, all bounded by joints. Where strong foliation is present, these rounded surfaces may take on some of the orientation of that foliation, and make the exposure appear platy or oblong. Where these structures are both present, they interact to form complicated rounded, polygonal rock exposures. Where they are absent or minor, the rocks tend to form smooth, expansive rock faces unbroken by any other feature (and exfoliation is likely dominant).

In SHEN, the basement rocks tend to erode faster than the overlying Catoctin greenstones. This factor, in combination with the relative lack of structures (compared to the dominant planar flows in the Catoctin), results in basement rock areas generally being steeper, more rugged, and containing deeply incised ravines and valleys. It is often easy to see the contact between the Catoctin and the underlying basement rocks from afar simply by looking for the point along a slope where deep ravines and narrow ridges suddenly develop below an upper areas that is smoother and more gently sloping.

Catoctin Formation

The Catoctin Formation creates a unique landscape where it is present. Individual lava flows tend to be more resistant to erosion than the fractured, brecciated contact zones between flows. This results in a staircase-like topography, where cliffs and/or steeper terrain form within individual flows, while flatter topographic benches develop along the contacts between flows. Structurally, the flows are most commonly near-horizontal, dipping up to 20 degrees (though

many other orientations do occur). These factors combine to produce a landscape in which the gentler slopes of Catoctin areas form smooth, gently dipping planes cut by occasional stream canyons, while opposite slopes are dominated by sheer cliffs and steep slopes formed by the upthrust faces of individual flows. This pattern is most commonly found in the Central and North Districts, where east-dipping flows produce west-facing cliffs.

It is not a coincidence that most of the major waterfalls within the park are located to the east, where streams draining the broad, smooth surfaces cut down into the stacked flows to create sequential waterfalls at each boundary. Often within this landscape, the individual lava flows are exposed as parallel cliff/outcrop lines that angle sharply up the slope, due to the geometry of the steep canyon walls interacting with the gentle eastward dip of the flows. The result can be a "tilted staircase", where the topographic benches between flows become ramps ascending the slope, delineated by continuous lines of rock exposure that often stretch from top to bottom of the valley's sides (e.g. Rose River). In other canyons, the dip of the flows is gentle enough that a single flow can form a recognizable cliff line throughout the canyon (e.g. Big Devil's Stairs).

The Catoctin can form very diverse rock exposures. The most common formation is the "staircase" pattern of cliffs and ledges discussed above, but boulder fields, isolated outcrops, and angled slopes of bedrock are all present within SHEN. The individual texture of each flow (amount of cleavage and fractures, columnar jointing, mineral composition, geographic location) varies widely, and so the landscape can change dramatically from one slope to another. A common way to distinguish one lava flow from the next is to note the change in character of the landscape and bedrock exposures across a certain vertical distance.

The Chilhowee Group

The metasediments of the Chilhowee Group form a distinct terrain, despite the diverse nature of the rocks within this group. Quartzite in particular is very hard, strong rock, and difficult to erode. However, most areas underlain by the Chilhowee have also been significantly deformed by tectonic activity, and the quartzites generally reacted to these pressures by breaking rather than deforming. Thus, most quartzite areas are laced with fractures along which weathering processes operate, resulting in large, unstable cliff areas and widespread boulder fields formed from the crumbling bedrock. Large-scale folds in the bedrock are also common, visible as arch-shaped white quartzite cliffs shaping the mountains (e.g. Rocky Mountain).

The siltstones, shales, and other more fine-grained rocks of the Chilhowee are more easily eroded, and are less likely to form bedrock outcrops. The combination of hard, resistant quartzite layers and easily eroded silty layers results in a very rugged landscape in which ridges are held up by quartzite while steep slopes and deep ravines are eroded into the other rocks. Thus, the South District has a much more rugged, undulating appearance than elsewhere in the park, created by the numerous sharp ridges and narrow valleys created by these processes. At the very western edge of the Blue Ridge, the Erwin Formation takes one last plunge into the earth, creating a steep rampart of topography that ends abruptly in the much softer limestones and dolomites of the Shenandoah Valley.

Appendix E. Glossary of geologic terms and mineral compositions

Table of Contents

Terms Specific to This Report…….…..….56

General Geologic Terms……..……..57

Rock Types…….…...……59

Geologic Structures…….…...…60

Common or Important Minerals in SHEN…….…….....61

The following definitions are adapted from Blatt & Tracy (1999), Deer et al., (1966), Gathright (1976), and Parker (1994), as well as personal knowledge and experience from the author.

Terms Specific to This Report

Basement Rock – A general descriptive term for the complex set of igneous and metamorphic rocks, 1-1.2 billion years in age, that underlie the Blue Ridge in Shenandoah and the surrounding region. Used in this report in favor of the old "Pedlar Formation" designation; see that entry for details.

Catoctin Formation – A unit of greenstone lava flows that extends from southern Pennsylvania through Maryland and portions of Virginia, erupted onto the surface around 570 million years ago.

Chilhowee Group – A group of three related metasedimentary formations deposited over the Catoctin Formation. Chilhowee rocks are predominately found in the South District, with minor occurrences in the Central and North Districts.

Cliff – In this report, a specific type of exposure morphology. See Figure 2 or Appendix D for definition.

Erwin Formation – This uppermost unit of the Chilhowee Group is known for its thick, white quartzite beds that dominate ridgelines in the South District. These layers commonly form sheer cliffs and large, open boulder fields on the steep flanks of narrow ridges.

Exposure – See Open Rock Exposure.

Face – In this report, a specific type of exposure morphology. See Figure 2 or Appendix D for definition.

Hampton Formation – This central unit of the Chilhowee Group is composed primarily of fine-grained metasandstones and phyllites, commonly containing a strong, planar cleavage structure that appears similar to layering. The unit also contains several distinct quartzite beds that are similar in appearance to the Erwin Formation, though darker in color.

Ledge – In this report, a specific type of exposure morphology. See Figure 2 or Appendix D for definition.

Open rock exposure – Any area of bedrock or talus area that is mostly open to the sun, i.e. not shaded or obscured by tree canopy, shrubs, or soil. Lichen coverage is not considered in this definition.

Outcrop – A general term used for any exposed bedrock area. In this report, a specific type of exposure morphology. See Figure 2 or Appendix D for definition.

Pedlar Formation – An old collective designation for the complex set of igneous and metamorphic rocks, 1-1.2 billion years in age, that underlie the Blue Ridge in Shenandoah and the surrounding region. This term has fallen out of favor among some geologists in recent years as further work establishes how diverse this suite of rocks really is. In this view, "Formation" implies too much shared history and character. In this report, the term "basement rock" is used instead to avoid controversy.

Terms specific to this report (continued).

Social trail – Any trail, path, or route created or maintained by humans, but not sanctioned, recognized, or maintained by authorities. Commonly found leading from official trails to overlooks, campsites, or other areas of interest to visitors.

Talus – A general term for loose rock on a slope (see Talus, General Geologic Terms). Also, in this report, a specific type of exposure morphology. See Figure 2 or Appendix D for definition.

Weverton Formation – This is the lowermost unit of the Chilhowee Group, deposited directly onto the final Catoctin Formation lava flow. The formation is most commonly composed of metasandstone, quartzite, and some pebble/cobble beds, and represents the onset of erosion and river system development once the Catoctin eruptions had ceased.

General Geologic Terms

Amygdule/Amygduloidal – A texture found in volcanic rocks, in which previously formed vesicles are filled in by mineral deposits after the rock has cooled. These are very common in concentrated zones 1-2 meters thick near the tops of lava flows within the Catoctin Formation. Quartz is by far the most common filler mineral, with epidote and chlorite present in some cases.

Bedrock – General term referring to any solid rock that remains fully attached to the earth (i.e. not soil, river sediments, or loose boulders). It does not refer only to the lowest in a sequence of rocks, but to any and all that fit the above definition.

Boulder field – see Talus.

Charnockite – A specific type of granitic rock where pyroxene is the dominant dark-colored mineral rather than biotite. Generally unusual, it is common in parts of Shenandoah.

Crystalline – A rock texture composed of fully intergrown mineral crystals, rather than individually cemented grains. Typical of igneous rocks, this texture can also be found in some metamorphic rocks (if the minerals have been deformed enough to grow together) and sedimentary rocks (if the minerals chemically grew together in the first place, e.g. limestone and chert). Can be identified by observing minerals closely to determine whether they are intergrown or cemented by some independent substance.

Formation – When used as a noun, any unit of bedrock or associated units that are locally classified together as part of the interpretation of their geologic history. Formations do not have to be the same rock type, but generally share similar histories. For example, the Catoctin Formation contains both volcanic and metasedimentary rocks, but these are classified together based on a shared origin and history, and to distinguish them from other, less related rocks.

Geochemistry – Relating to the chemical composition of rocks and/or minerals.

Geomorphology – In general, the study of the Earth's surface and the processes that shape the landscape (distinct from studying the bedrock underlying that landscape). As an adjective, can be used to refer to the character of a certain landscape, e.g. "the geomorphology of that river valley". This latter usage is often interchangeable with Morphology, though the latter also implies a smaller scale area.

General Geologic Terms (continued).

Igneous – Any rock formed by the cooling and solidification of molten rock, whether underground or on the Earth's surface.

Lithology – The general composition and/or classification of a particular rock or rock unit.

Metamorphic – Any rock formed through the physical and/or chemical alteration of a pre-existing rock to the point that it becomes distinct from the original rock. Metamorphism refers to the process of these changes, and the prefix Meta- can be attached to most rock types to indicate that metamorphism has occurred, especially if the effects were not strong and the rock retains many of its original features (e.g. metabasalt).

Mineral – Any naturally occurring, solid substance with a known chemical composition and crystal structure. Minerals are most easily thought of as individual crystals that make up a rock (some rocks are made up entirely of crystals of a single mineral type, e.g. limestone {calcite}).

Morphology – Referring to the physical character or shape of a rock, exposure, or landcsape. Similar to Geomorphology, but generally describing a smaller scale, e.g. "the morphology of this cliff".

Paleotopography – A landscape present at some past time in Earth's history, usually different from that seen today. This may be directly observed from the shape and nature of contacts between rock layers, or inferred from sedimentary deposits collected elsewhere.

Plate tectonics – The slow movement of solid portions of the Earth's crust (plates), interacting to form mountains, oceans, volcanoes, and all other features of the Earth's surface.

Sedimentary – Any rock formed by the physical collection and cementation together of individual mineral grains (e.g. sandstone), or the chemical growth of minerals at or near the earth's surface (e.g. some limestones, cherts, and cave formations).

Structures – Any physical feature other than minerals present in a rock. Structures may be internal and integral to the rock, such as layering and foliation, or may be imposed upon the rock, such as cleavage, joints, and faults.

Talus – Loose rock fragments accumulated on a slope. Generally used to describe areas where these fragments are dominating the slope, at the expense of soil or vegetation growth. Usually, but not always, associated with a bedrock cliff or other exposure from which the fragments have eroded. Also referred to as Boulder Field. Also used in this report as a specific type of exposure morphology; see Figure 2 for definition.

Tectonic – Adjective referring to the actions or results of Plate Tectonics, e.g. "tectonic activity creating mountains" refers to the collision of crustal plates to form topography.

Vesicle/Vesicular – A texture formed in volcanic rocks, consisting of empty cavities created from gas bubbles present in the cooling rock. In Shenandoah, these are rarely found as true vesicles (empty), but generally as Amygdules, where the cavity has been filled by mineral deposits.

Appendix E. (continued).

Rock Types

Basalt – A dark-colored volcanic rock composed primarily of the minerals plagioclase, pyroxene, and olivine. Generally erupted from volcanoes or rift areas, forming fluid lava flows that cool on the surface of the earth. Individual crystals are small and rarely visible, due to the rapid cooling of the lava above ground. Can be used as an adjective describing the general mineral composition of a rock; e.g. basaltic.

Breccia – A sedimentary rock formed from angular fragments of other rocks, mixed together and cemented by other minerals. This often reflects a landslide or other active erosional process. A volcanic breccia is formed when lava flows or other volcanic processes rip up and collect rock fragments into a distinct unit. A conglomerate is similar, but contains mostly rounded fragments, generally reflecting an origin in river or stream gravels.

Conglomerate – See Breccia.

Gneiss – Any crystalline metamorphic rock containing a planar structure formed by alternating bands of similar mineral types. This banding forms during intense metamorphism, as individual minerals within the rock segregate themselves into bands containing other like minerals. This banding, or foliation, is distinct from the layering found in sedimentary rocks (in which minerals are deposited in place) or the foliation found in other metamorphic rocks such as schist or phyllite (in which the planar structure is formed by alignment of platy minerals such as micas). Can be used as an adjective describing any rock containing this banding structure (implying very intense metamorphism); e.g. gneissic.

Granite – A generally light-colored igneous rock composed primarily of quartz, orthoclase, and plagioclase, with lesser amounts of other minerals such as biotite, garnet, and pyroxene. Forms from molten rock which cools slowly underground into a solid, crystalline body; individual minerals are almost always visible. Can be used as an adjective describing the general mineral composition of a rock; e.g. granitic.

Greenstone – A rock formed by the low-grade metamorphism of basalt. Under these conditions, the original mineral composition of the basalt is altered to form the minerals chlorite, epidote, and actinolite. These new minerals give the rock a greenish tint; thus the name. This rock is also commonly referred to as metabasalt. Its physical appearance preserves many original features of the basalt, and is generally similar, except for the common green tinge, a slight trend toward being more coarse-grained, and the common presence of cleavage structures formed by alignment of chlorite crystals during the metamorphism.

Limestone – A sedimentary rock composed primarily of calcite, formed in marine environments from the detritus of living organisms. Limestone is generally white-grey and massive (little to no prominent layering or structures), and will react with hydrochloric acid to produce bubbles of carbon dioxide.

Quartzite – A metamorphic rock formed by heat and pressure acting on sandstone. The term specifically refers to rocks containing virtually all quartz (originating in a clean sandstone), where the individual sand grains have been fused together to form a very solid mass of pure crystalline quartz. A metamorphosed sandstone which contains significant amounts of mineral grains other than quartz would be a metasandstone.

Sandstone – A sedimentary rock formed primarily of sand grains cemented together. This rock most commonly reflects the presence of a beach, river, or dune at the time of its formation.

Rock Types (continued).

Sandstones vary from “clean” (containing virtually all quartz sand) to “dirty” (containing sand grains of many different minerals mixed together), the composition reflecting the age and energy of the original environment. A mature beach or dune is most likely to produce clean sandstone, while an actively eroding river is more likely to produce a dirty sandstone.

Shale – A sedimentary rock formed primarily of very fine silt and clay particles, forming thin layers along which the rock easily breaks. Generally, little to no individual minerals can be seen in shale, which appears most often as a solid grey-black, platy rock. This rock reflects an original environment of deep, calm water such as lakes and oceans, in which very fine sediments are able to settle to the bottom in thin layers.

Siltstone – A sedimentary rock compositionally between sandstone and shale, containing a mixture of fine-grained silt and clay minerals combined with coarser sand grains. This rock is quite variable in appearance, generally containing noticeable layering which still appearing grainy. This rock often reflects lagoon/delta environments, where both flowing and calm water can be found.

Geologic Structures

Banding – See Foliation.

Cleavage – A roughly planar fracture system within a rock, formed during metamorphism through the growth or realignment of platy minerals such as biotite or chlorite. Generally gives the rock a fractured, jagged appearance, and often cross-cuts internal structures such as layering or foliation. Similar in appearance to foliation in some rocks, but occurs as a set of semi-planar fractures imposed on the rock, and related to mineral orientations, rather than a planar structure internal to the rock. Distinct from joints in that cleavage is generally more unruly in appearance, closer-spaced, and smaller at the scale of each individual fracture plane. ALSO – A planar structure within certain minerals, related to the crystal structure of that mineral type. Common in platy minerals such as micas.

Columnar joints – These are a special subset of joints that occur in cooling igneous rock, generally lava flows or dikes. As the molten rock cools, it contracts, and under certain conditions will fracture into smooth joints at obtuse degree angles to one another, forming polygonal columns of rock from 10-100cm in diameter or larger. Although columnar joints are technically the fracture set, the term is often used to refer to the resulting polygonal column of rock. Columnar joints develop perpendicular to the surface constraining the molten rock; vertically in erupted lava flows, and in dikes perpendicular to the walls of the fracture containing the dike.

Dike – A narrow, generally planar, discrete body of igneous rock cutting through the mass of another rock. These form when underground molten rock follows joints or other fractures up into solid rock, and cools within the fracture. Dikes are distinct from veins in being generally bigger, more planar, and forming from cooled molten rock rather than minerals deposited by water.

Geologic Structures (continued).

Foliation – A planar structure within a rock, formed by alignment of minerals into distinct bands. This may take the form of very thin, platy surfaces formed by micas, or a more general banded texture formed by quartz, feldspar, or other minerals. Similar to cleavage, but internal to the rock rather than an imposed fracture system (see Cleavage). Similar to layering, but found in igneous or metamorphic rocks as an alignment or segregation of like minerals, rather than a series of independently formed layers of sediments.

Joint – A very planar fracture within a rock that shows no displacement on either side. Joints generally occur in parallel sets, all following the same orientation and spaced over 50cm apart. Joints are distinct from cleavage in being larger, more planar, spaced farther apart, and not being related to any mineral orientation or structures.

Layering – A planar structure within a rock, consisting of a discrete unit of sediments or minerals that share a common history of deposition or formation distinct from the layers above and below. Appears similar to foliation or banding, but layers form individually and consecutively during the formation of the rock itself, rather than collectively due to outside pressures or forces (as in foliation). Most common in sedimentary rocks, though certain igneous and volcanic rocks may form a crude layering as they cool and solidify.

Vein – A small, narrow mineral deposit within a rock, generally formed underground by water intruding into fractures in the rock and depositing dissolved minerals into the fracture. Veins often contain deposits of unusual or valuable minerals, collected and concentrated by heated and pressurized water deep underground. Distinct from dikes in being mineral deposits rather than cooled igneous rock, and generally being much smaller and less planar.

Common or Important Minerals in SHEN

Actinolite – $Ca_2(Fe, Mg)_5Si_8O_{22}(OH)_2$ – A dark green mineral commonly formed during metamorphism of basaltic rocks. Actinolite can form somewhat fibrous, elongated crystals that may occur in veins within greenstone.

Biotite – $K(Mg_3,Fe_3)AlSi_3O_{10}(OH)_2$ – One of many mica minerals that form thin, platy sheets with highly reflective surfaces. Biotite is usually dark brown to black, and forms thin flakes primarily within igneous rocks.

Chlorite – $(Fe,Mg,Al)_6(Si,Al)_4O_{10}(OH)_8$ – A dark green mica mineral commonly formed during metamorphism of basaltic rocks. Chlorite, like other micas, forms a thin, platy crystal structure, and will often align itself into planes under pressure, creating a strong cleavage structure within the rock. This is common in greenstone areas of Shenandoah.

Epidote – $Ca_2Al_2FeSi_3O_{12}(OH)$ – A lime/pistachio green mineral commonly formed during metamorphism of basaltic rocks. Epidote replacement is very common in the Catoctin Formation greenstones, and ranges from producing a light green tinge to solid masses of pistachio green rock meters in diameter. Areas with a great deal of epidotization often appear grainy or even sandy compared to the finer grained greenstone nearby. Epidote can also be found in a more crystalline form in amygdules or other small pockets of mineral growth. In

Common or Important Minerals in SHEN (continued).

addition, it may form in granitic rocks during local metamorphism (such as the intense heat generated by a lava flow covering the rock), producing the pink-and-green rock unakite.

Feldspar – A general term for a large family of common aluminosilicate minerals (their structure is based on a framework of silicon, aluminum, and oxygen). There are two main classes of feldspar; plagioclase and orthoclase, both of which are found in Shenandoah. These two are often difficult to tell apart in the field; in Shenandoah, orthoclase is often white-pink, while plagioclase is often white-grey. Both may fracture into planar, reflective surfaces and form blocky crystals. In igneous rocks, where they are most commonly seen, individual crystals may grow many centimeters in diameter. Orthoclase is found chiefly in granitic rocks, particularly the Old Rag Granite, while plagioclase is common throughout the granitic gneisses of the Basement Rocks and as a main constituent of basalt/greenstone. Either may be found in small quantities as mineral fragments in sedimentary rocks.

Garnet – $(Fe,Mg,Ca,Mn)_3Al_2Si_3O_{12}$ – A common accessory mineral in granitic rocks, rarely found in abundance but often present in minor amounts. Garnet can take on a wide range of colors, but is mostly commonly dark red to maroon, and appears as small red spots within granite.

Olivine – $(Mg,Fe)_2SiO_4$ – A common ferromagnesian (see Pyroxene) mineral in dark-colored low-silica rocks such as basalt. Olivine is never found together with quartz, which is common in lighter-colored, high-silica rocks such as granite. Olivine is generally dark green, though it is rarely seen as a visible crystal in Shenandoah.

Orthoclase – $KAlSi_3O_8$ – One of two common feldspar types (with plagioclase), containing potassium (K). Orthoclase is found mainly in granitic rocks, particularly the Old Rag Granite. For more on distinguishing orthoclase from plagioclase, see Feldspar.

Plagioclase – $NaAlSi_3O_8$ – $CaAl_2Si_2O_8$ - One of two common feldspar types (with orthoclase), containing variable amounts of sodium (Na) and calcium (Ca). Plagioclase is common in granitic rocks, as well as basalt/greenstone. For more on distinguishing plagioclase from orthoclase, see Feldspar.

Pyroxene – $MgSiO_3$ – FeSiO3 (with associated Na, Ca, and others possible). A general term for a broad and diverse group of dark-colored ferromagnesian minerals (their structure is based on iron and magnesium in a framework of silicon and oxygen). Pyroxenes are generally black, and form small, blocky crystals within igneous rocks. They are an important part of basalt/greenstone, but are less common in granitic rocks, where Biotite is a more common dark mineral.

Quartz – SiO_2 – Very common, clear-white mineral. Usually forms no specific crystal shape, and breaks in random, curved fashion without flat, reflective surfaces. Has a glassy or waxy shine and is often partially translucent. Can be stained a number of different colors by minor impurities, but generally solid white to milky/clear. Most prominent in sandstone, quartzite, and granite; also found in veins and amygdules within greenstone.

Appendix F. ROMP geologic site reports

C02	Bettys Rock……..	5 pages
C03	Big Devils Stairs……..……....	8 pages
C04	Blackrock Central District……...	6 pages
C05	Blackrock South District…….	7 pages
C07	Browntown Valley Overlook ……..	7 pages
C08	Calvary Rocks / Chimney Rock……...	8 pages
C10	Crescent Rock Overlook……..	7 pages
C11	Crescent Rock South……	6 pages
C12	Dean Mountain Ridge……..	5 pages
C13	Dickey Hill……...	5 pages
C14	Dickey Ridge ……..	5 pages
C15	Franklin Cliffs North……	8 pages
C16	Franklin Cliffs Overlook……..	7 pages
C17	Franklin Cliffs South……	7 pages
C18	Goat Ridge……...	6 pages
C19	Gooney Manor Overlook…….	7 pages
C20	Halfmile Cliff……..	7 pages
C21	Hawksbill N slope outcrops…….	13 pages
C22	Hawksbill summit…….....	8 pages
C23	Hightop…….	6 pages
C24	Hogback Mtn spur……	8 pages
C27	Little Devils Stairs……...	8 pages
C28	Little Stony Man……..	9 pages
C29	Loft Mountain summit…….	7 pages
C31	Marys Rock……..	7 pages
C32	Millers Head…….	8 pages
C34	Nakedtop Upper East Slope…….	7 pages
C35	North Marshall summit……	7 pages
C36	Old Rag southside……	8 pages
C37	Old Rag summit east……	11 pages
C38	Oventop……	8 pages
C39	Overall Run Falls south……	6 pages
C40	Pass Mountain……..	7 pages
C41	Pinnacles……...	9 pages
C42	Powell Gap cliff ……..	6 pages
C44	Rocky Mountain……...	8 pages
C45	Sawlog Ridge……...	7 pages
C46	South Marshall cliff…….	7 pages
C47	Stony Man summit……...	10 pages
C49	Trayfoot Saddle boulderfields E……..	6 pages
C50	Upper Devils Ditch……...	8 pages
C60	Hawksbill N slope talus……	8 pages
C62	Old Rag summit west……...	7 pages
C63	Overall Run Falls north……	8 pages
C64	Brown Mountain……..	8 pages
C65	Trayfoot Saddle boulderfields W…….	7 pages
C66	Field Hollow Cliff……	9 pages
C67	Bearfence……..	9 pages
C68	Rose River……	8 pages
C69	Whiteoak Canyon…….	7 pages

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C02 - Bettys Rock

Site Code: C02
Site Name: Bettys Rock
Data Collector Butler, Eric
Date Studied: 16-Jun-05

Polygon Centroid: **E:** 728074 **N:** 4272018
UTM (Zone 17 NAD83)
Dimensions (m): 100 x 150 (GIS est.)
Elevation Range (ft): 3600 to 3680

Physical Characteristics

Location Acces

Park at Crescent Rock Overlook (south of Milepost 44) and take the marked Betty's Rock trail 500m north. This is an easy, mostly level trail that terminates on the upper ledge of the outcrop.

Physical Description:

Betty's Rock consists of a single outcrop of rock, jutting out from the surrounding slope. An open ledge at the top slopes gently east to merge with the surrounding topography, while the west side drops about 6m over several small ledges to the forest floor. The outcrop is entirely surrounded by forest; though some talus is present on the sides and base of the outcrop, it is virtually all under the trees. The access trail leads directly onto the top of the outcrop, and most of this upper ledge is cleared and gravelly.

Vegetation: Moderate

The outcrop is surrounded by thick forest. At the top this consists of low, dense growth which can be hard to push through, while at the base it is open forest. A few thickets are present, but can be avoided. Given that the only real exposure is on the outcrop itself, the vegetation is not a major issue.

Human Effects

Impacts: Heavy

The site is accessed by a well-trodden trail, which leads directly over the upper ledge on the outcrop. The vegetation here is set back at least one meter, with the ledge reduced to gravel and bare rock with isolated pockets of plants remaining. Several small social trails lead off into the woods to the east, but do not appear to go anywhere. The flanks and base of the exposure are less impacted, and it is likely that most human visitation is confined to the open overlook at the top.

Access Easy

The site is located only a few hundred meters from a parking lot on Skyline Drive, with a trailhead sign specifically guiding visitors to Betty's Rock. The trail is wide, mostly flat, and well-maintained.

Geologic Characteristics

Lithology:

Rock Type Greenstone

Betty's Rock is composed of Catoctin Formation greenstone, a grey-green metabasalt that is very fine grained with variable amounts of epidote present. Quartz-filled vesicles and veins are present. Although there are several ledges at different elevations on the outcrop, there is no evidence of separate lava flows, and it seems most likely that the entire outcrop is contained within one flow. There is some minor flow bedding present within the basalt that contributes to some ledge formation.
An unusual feature of this exposure is occasional pockets of very epidote-rich material, sometimes almost a meter wide. These areas appear more coarse-grained and crystalline than the surrounding greenstone, with a lime/pistachio green color. Parallel fractures are common within these pockets, and some can look almost sedimentary. These pockets are likely the result of local hydrothermal alteration, in which hot, mineral-rich fluids percolating through the greenstones replaced the existing minerals with epoidote (a common alteration mineral in greenstone) and quartz. It is not clear whether these small areas have any influence on local plant or lichen growth, but similar features are found elsewhere in the park, including the lower cliff at Loft Mountain.

Structure:

The greenstone here contains a fairly well-developed cleavage, which dips to the east at around 35 degrees. This structure is not prevalent throughout the outcrop, but where present, it affects the formation of ledges and helps protect pockets of developing soil behind the slope of the cleavage. There is a regular joint set oriented around 100 degrees, as well as many fractures which do not appear to follow any specific trend.

C02 - Bettys Rock (continued...)

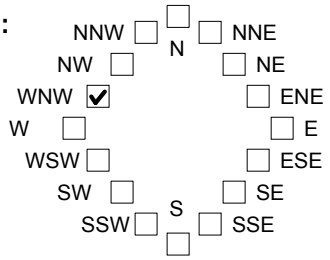
Other:

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	0.0	50.0	0.0	40.0	10.0	100
Max relief(m):	0	10	0	1	10	

Maximum Slope: 25 **Texture:** Fractured

Aspects:



Setting:

The dominant geomorphic agent here is the widespread cleavage, which produces regular planes of weakness along which slabs of rock can crack off. The steep slope of the cleavage also forms numerous ledges, both at the top of the outcrop and along the sides, by creating a protected pocket between the slope of the cleavage plane and the face of the outcrop. It is not clear why there is such a pronounced outcrop in this particular place, but it may be due to the dominant joint set, which provides an obvious control on the north and south extent of the outcrop. Betty's Rock is high on a fairly exposed knob, and there was likely a much larger outcrop here in the past, which has since weathered down along joint faces and cleavage planes to leave behind a core of resistant rock.

Stability: Stable

Despite the prevalent fractures, the outcrop is quite solid, and there are no loose slopes or other unstable terrain.

GPS Points

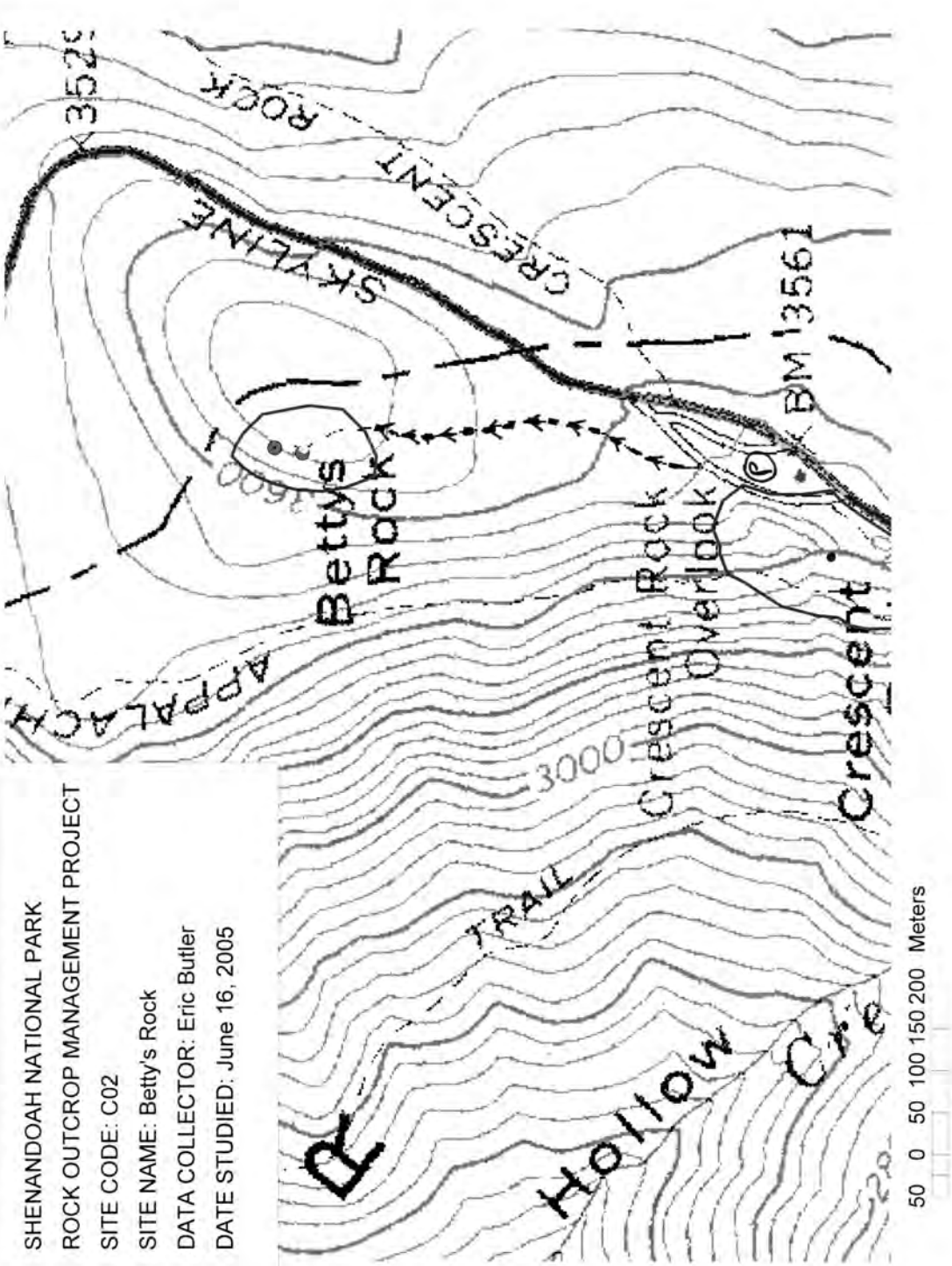
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
6/16/2005	G059-C02	728075	4272053	3680	Northern extent of exposure
6/16/2005	G060-C02	728069	4272020	3680	Southern extent of exposure

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
6/16/2005	G059-C02	SHEN_C02_G_20050616_001.jpg	200	Butler, Eric	Pod of epidotized greenstone; note parallel fracturing that mimics layers
6/16/2005	G059-C02	SHEN_C02_G_20050616_002.jpg	200	Butler, Eric	View south across top of exposure
6/16/2005		SHEN_C02_G_20060216_001.JPG		Butler, Eric	View of site through zoom lens from Hawksbill summit

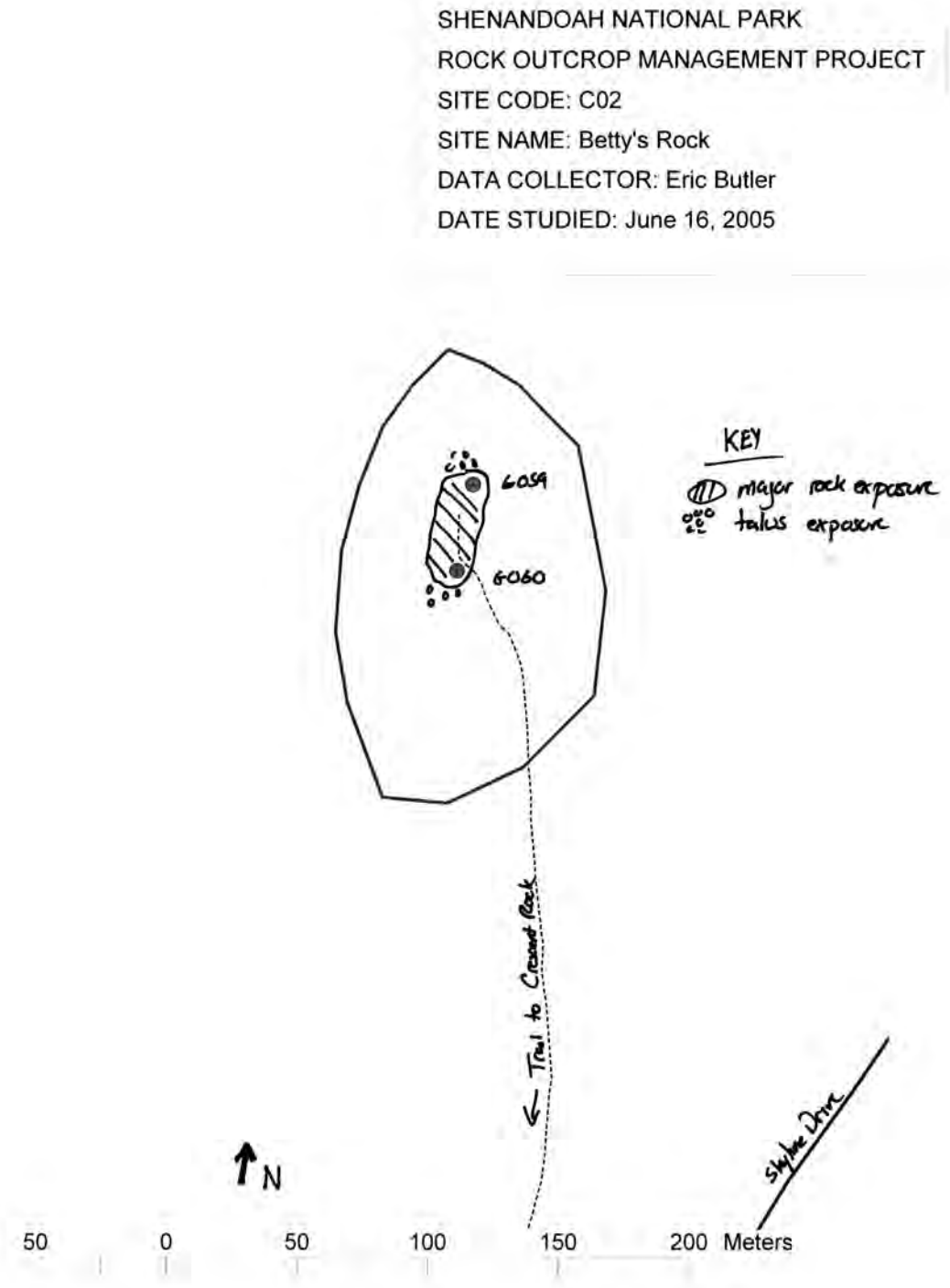
C02 - Bettys Rock (continued...)

Area sketch map



C02 - Bettys Rock (continued...)

Detail sketch map



C02 - Bettys Rock (continued...)



SHEN_C02_G_20050616_001.jpg Azmuth: 200

Pod of epidotized greenstone; note parallel fracturing that mimics layers



SHEN_C02_G_20050616_002.jpg Azmuth: 200

View south across top of exposure



SHEN_C02_G_20060216_001.JPG Azmuth:

View of site through zoom lens from Hawksbill summit

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C03 - Big Devils Stairs

Site Code: C03
Site Name: Big Devils Stairs
Data Collector Butler, Eric
Date Studied: 08-Sep-06

Polygon Centroid: **E:** 742012 **N:** 4293351
UTM (Zone 17 NAD83)
Dimensions (m): 120 x 850 (GIS est.)
Elevation Range (ft): 1360 to 2120

Physical Characteristics

Location Acces

Park at the lot for Gravel Springs Gap (milepost 17.5), and hike 450m down the gravel road toward Gravel Springs hut. At the elbow of the first switchback, take a short cutoff trail to the Bluff Trail, rather than continuing down the road to the hut. Follow the Bluff Trail appx. 2km east; the trailhead for the Big Devils Stairs Trail will turn off to the south shortly after crossing the stream which feeds into Big Devils Stairs canyon. Follow this trail south another 700m to reach the top of the main cliff line within the site. The trail runs along the cliff-top ledges in the northern section of the site, but then curves east to follow the gentler slope of the ridgetop.

Physical Description:

This site covers the east side of a deep, narrow slot canyon oriented nearly due south. The stream is confined between significant, continuous cliffs on both sides of the canyon. On the east side, one tall, continuous line of cliffs runs the entire length of the site, with only one small break. There is a thin set of ledges atop this cliff line, and some scattered ledges lower down, but overall it forms a sheer dropoff for its entire length, as does its counterpart on the west side of the canyon. There is a second line of bedrock exposure just above the top of this cliff, set back a few tens of meters, but this line is intermittent and rarely open, so it is mostly not mapped for this survey. Toward the south end of the site, as the canyon wall curves east into the broader nose of the ridge, the cliff line slowly fades away and becomes forested, before disappearing altogether.

Vegetation: Open

The forest behind the clifftop is mostly open forest, with some scattered thick growth along the ledges. Rarely is there any barrier to navigation.

Human Effects

Impacts: Mild

In the short area where the trail follows the cliff-top ledges, the usual impacts are present (stripped soil, etc.) but these do not appear heavy. Through most of the site, little evidence of visitation was found. Once the trail leaves the clifftop, the remainder of the site appears untouched.

Access Difficult

It is a long hike down to even the first cliff-top exposures, with a great deal of elevation to gain on the way back up. This is a dead-end trail, as there is no access from the boundary, and it is doubtful that too many visitors put in the time and energy necessary to reach this site. Those who do very likely stop at the first cliff exposures along the trail, and do not continue farther down the trail or cliff line.

Geologic Characteristics

Lithology: **Rock Type** Greenstone

This site is dominated by a single greenstone lava flow from the Catoctin Formation, though others are present within the site boundary. This flow forms the large, near-continuous cliff line that defines both sides of the canyon, with other flows above and below it (this major flow appears to be about 10m thick, with at least one more flow below forming the larger overall cliff). There is a thick (at least several meters) zone of contact rock capping this flow and the cliff line, variably consisting of volcanic breccia, amygdaloidal greenstone, and greenstone containing abundant fragments of ripped-up and metamorphosed sediments. The latter is more common to the north, while the breccias are more common to the south. Above this flow, a second, thinner flow forms a smaller line of cliffs and outcrops in the woods; this flow contains more cleavage and tends to appear jagged, while the major flow contains more columnar jointing and tends to appear more solid. The base of the major flow, as observed within the talus chute at G276, is marked by an amygdaloidal zone at the top of the next flow down. This basal flow could not be directly observed due to the terrain, but is also like about 10m thick, judging from the overall height of the cliff exposures in this

C03 - Big Devils Stairs (continued...)

area.

Structure:

Columnar jointing is apparently present within the main flow, judging from exposures on the west side of the canyon. However, in the one place where the flow's stratigraphy could be directly observed, the talus chute at G276, none could easily be identified. What joints are present are not prevalent, and there are few other fractures within the generally massive and stable rock. This flow in particular seems to be very resistant to erosion. Overall, the lava flow sequence appears to be dipping very gently to the south in this area, as judged both from the gradual descent of the cliff top to the south, and the angle of the sequential cliffs observed on the west side of the canyon.

Other:

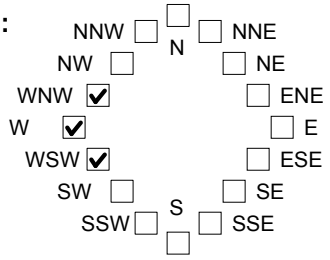
Though outside the site boundary, there is a feature of interest worth noting nearby. North of the site, a small area of granitic rock appears on the surface within the greenstone that dominates the rest of the region. This granitic pocket is first entered where the Bluff Trail crosses the stream, and the northern portion of the Big Devils Stairs trail continues through it before eventually crossing back into the greenstone again before reaching the open rock exposures. This pocket of granitic material likely represents an old high point in the pre-Catoctin landscape, a hill around which the lava flows lapped, and which is now re-exposed by current erosion. Similar patterns are found at Hogback Mountain and Whiteoak Canyon. This does not directly affect the site, but is worth documenting.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	60.0	10.0	0.0	30.0	0.0	100
Max relief(m):	20	5	0	1	0	

Maximum Slope: 35 **Texture:** Rough

Aspects:



Setting:

This site conforms to a pattern common to greenstone areas on the east side of the Central and North Districts. Through most of these areas, the lava flows dip gently (10-20 degrees) to the south and/or east, creating fairly smooth slopes that descend gradually from the ridgeline. Where these gentle slopes are cut by significant streams, deep canyons tend to form with linear cliffs and waterfalls where the erosion cuts through individual lava flows. Here, the dip angle of the lava flows must be fairly low, as the cliff lines are clearly near-horizontal with only a gentle down-grade to the south. The cliffs here are formed from a sequence of resistant lava flows, at least three of which can be clearly identified in the matching exposures on the west side of the canyon. The entire length of the site is dominated by one especially thick, resistant flow, and all open areas are formed or affected by this unit.

The canyon here is unusually deep and narrow, as compared to other similar features within the park such as Little Devils Stairs and Whiteoak Canyon. The significant lava flows present here do not contain many fractures or other planes of weakness (what columnar jointing is present is not well-developed), and so the flows are likely very resistant to physical weathering. Thus, although the stream has cut a deep canyon, the resulting cliffs have not eroded back significantly, and so retain the sheer cliff lines and narrow ledges that are present today. This resistance may also be related to something in the composition of the rock, but that could not be determined in a field survey. It is worth noting that the site appears to be unusually sparse, botanically, and so perhaps the same mineralogical/chemical different that makes these flows especially resistant is also affecting the ecology of the area. This is only speculation, however.

Stability: Stable

The major cliff line here has few fractures, and appears to be very stable everywhere observed.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
9/8/2006	G274-C03	741961	4293622		First overlook along trail; ledge area atop major cliff line
9/8/2006	G275-C03	741957	4293537		Continuation of open ledges accessed by trail atop major cliff line

C03 - Big Devils Stairs (continued...)

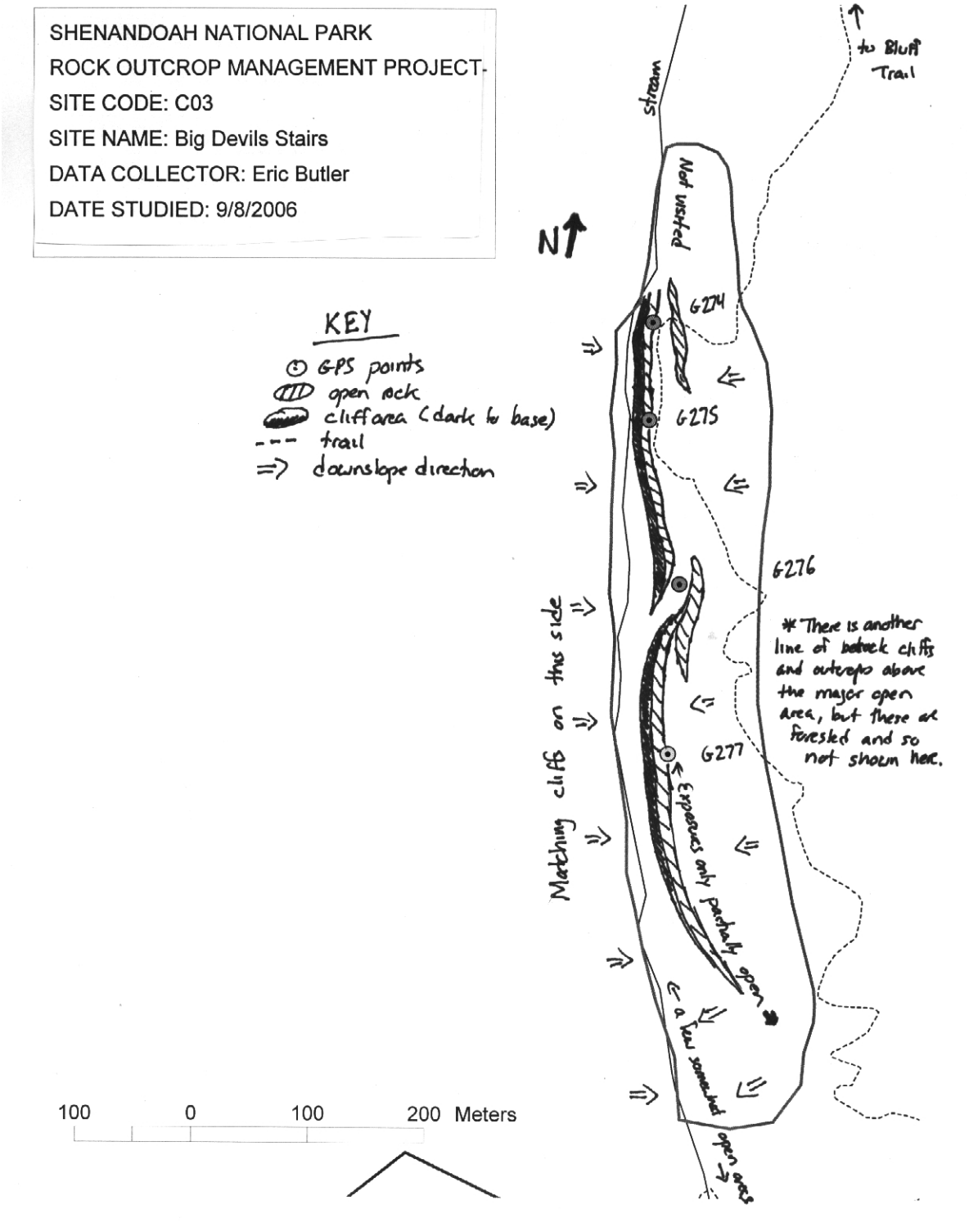
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
9/8/2006	G276-C03	741984	4293395		Steep notch eroded into otherwise continous cliffs; allows descent belo
9/8/2006	G277-C03	741974	4293248		Semi-open ledges atop cliff; from here south, exposures slowly blend

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
9/8/2006	G274-C03	SHEN_C03_G_20060908_001.jpg	210	Butler, Eric	View from ledges along trail, acros to cliffs on opposite side of canyon. Large cliff at base of sequence likely correlates to the same large cliff the photographer is
9/8/2006	G274-C03	SHEN_C03_G_20060908_002.jpg	210	Butler, Eric	Typical narrow ledges along top of major cliff
9/8/2006	G274-C03	SHEN_C03_G_20060908_003.jpg		Butler, Eric	Fragments of chert and/or metamorphosed sediment within the greenstone on these ledges.
9/8/2006	G275-C03	SHEN_C03_G_20060908_004.jpg	325	Butler, Eric	Multiple ledges along angled cliff; no reasonable access to these areas
9/8/2006	G275-C03	SHEN_C03_G_20060908_005.jpg	350	Butler, Eric	Cliff/ledge complex along major cliff line at this site. This is typical of the exposures here.
9/8/2006	G275-C03	SHEN_C03_G_20060908_006.jpg	240	Butler, Eric	Zoomed view across canyon at corresponding cliffs on west side; note apparent columnar jointing within this flow, implying the same feature is present here, though
9/8/2006		SHEN_C03_G_20060908_007.jpg		Butler, Eric	Volcanic breccia south of G275; this unit caps the major cliff for most of its length, though with quite variable thickness, composition, and quality
9/8/2006		SHEN_C03_G_20060908_008.jpg	350	Butler, Eric	Partially open ledges atop cliff line at G277; from here south the rock exposures are generally less open than to the north
9/8/2006	G277-C03	SHEN_C03_G_20060908_009.jpg	350	Butler, Eric	Typical view of clifftop in this area, with trees obscuring much of the upper ledges
9/8/2006	G277-C03	SHEN_C03_G_20060908_010.jpg		Butler, Eric	Evidence of an intrepid bear recently in the area
9/8/2006		SHEN_C03_G_20060908_011.jpg		Butler, Eric	Excellent exposure of volcanic breccia at top of cliff line, south of G277
9/8/2006		SHEN_C03_G_20060908_012.jpg		Butler, Eric	Excellent exposure of volcanic breccia at top of cliff line, south of G277

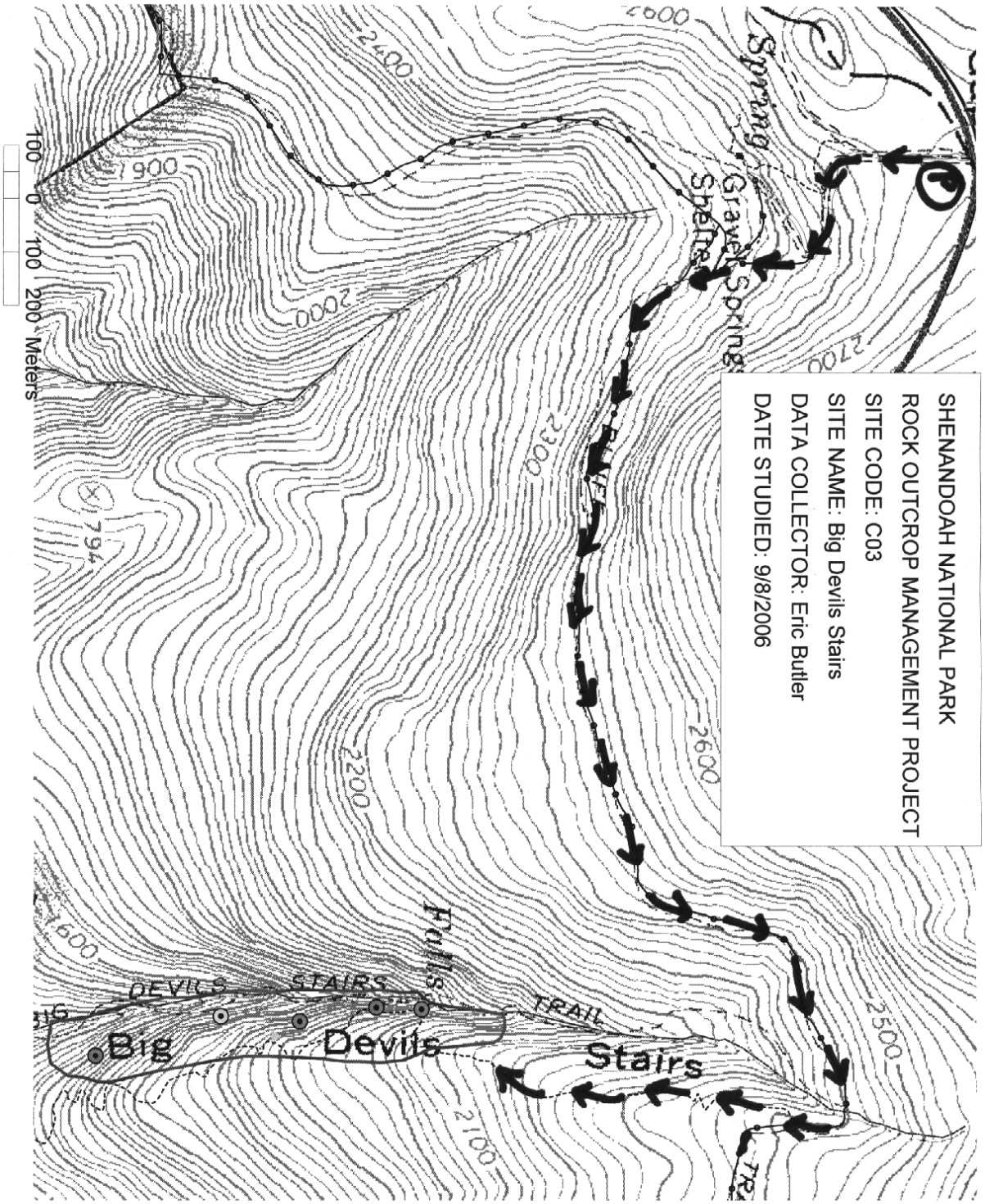
C03 - Big Devils Stairs (continued...)

Detail map



C03 - Big Devils Stairs (continued...)

Area map



C03 - Big Devils Stairs (continued...)



SHEN_C03_G_20060908_001.jpg Azmuth: 210

View from ledges along trail, acros to cliffs on opposite side of canyon. Large cliff at base of sequence likely correlates to the same large cliff the photographer is standing on.



SHEN_C03_G_20060908_002.jpg Azmuth: 210

Typical narrow ledges along top of major cliff



SHEN_C03_G_20060908_003.jpg Azmuth:

Fragments of chert and/or metamorphosed sediment within the greenstone on these ledges.



SHEN_C03_G_20060908_004.jpg Azmuth: 325

Multiple ledges along angled cliff; no reasonable access to these areas

C03 - Big Devils Stairs (continued...)



SHEN_C03_G_20060908_005.jpg Azmuth: 350

Cliff/ledge complex along major cliff line at this site. This is typical of the exposures here.



SHEN_C03_G_20060908_006.jpg Azmuth: 240

Zoomed view across canyon at corresponding cliffs on west side; note apparent columnar jointing within this flow, implying the same feature is present here, though not accessable.



SHEN_C03_G_20060908_007.jpg Azmuth:

Volcanic breccia south of G275; this unit caps the major cliff for most of its length, though with quite variable thickness, composition, and quality



SHEN_C03_G_20060908_008.jpg Azmuth: 350

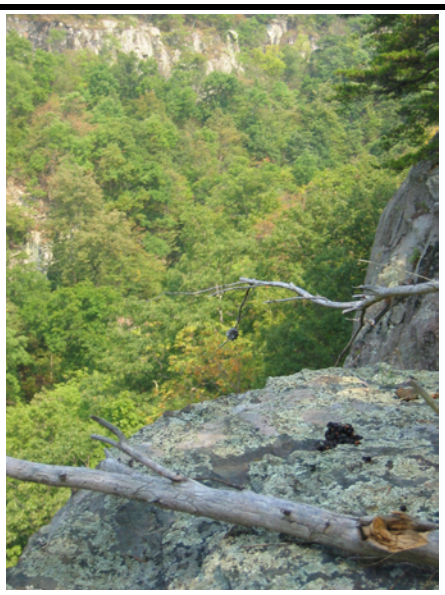
Partially open ledges atop cliff line at G277; from here south the rock exposures are generally less open than to the north

C03 - Big Devils Stairs (continued...)



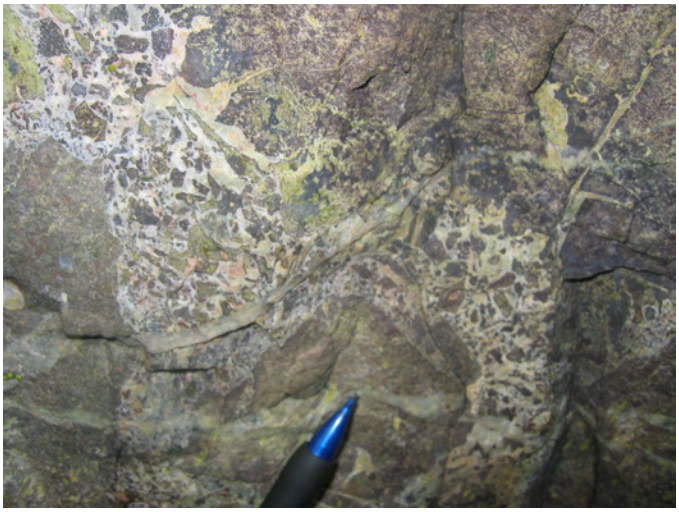
SHEN_C03_G_20060908_009.jpg Azmuth: 350

Typical view of clifftop in this area, with trees obscuring much of the upper ledges



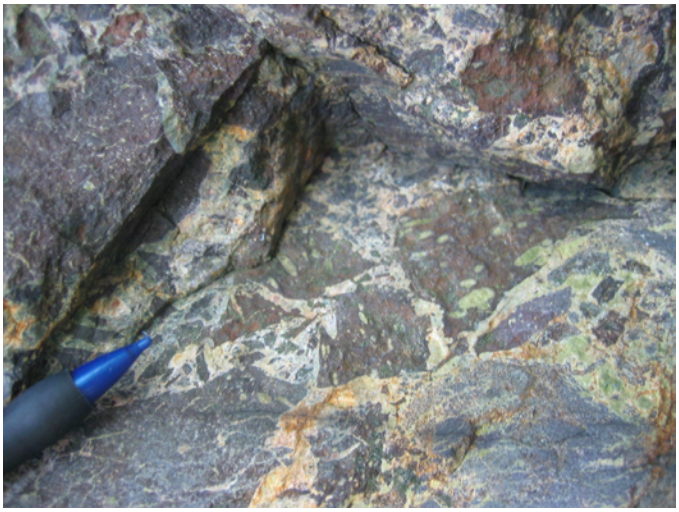
SHEN_C03_G_20060908_010.jpg Azmuth:

Evidence of an intrepid bear recently in the area



SHEN_C03_G_20060908_011.jpg Azmuth:

Excellent exposure of volcanic breccia at top of cliff line, south of G277



SHEN_C03_G_20060908_012.jpg Azmuth:

Excellent exposure of volcanic breccia at top of cliff line, south of G277

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C04 - Blackrock Central District

Site Code: C04
Site Name: Blackrock Central District
Data Collector Butler, Eric
Date Studied: 14-Jun-05

Polygon Centroid: **E:** 722808 **N:** 4267437
UTM (Zone 17 NAD83)
Dimensions (m): 50 x 250 (GIS est.)
Elevation Range (ft): 3480 to 3680

Physical Characteristics

Location Acces

Park in lot to west of Big Meadows Lodge. A large interpretive sign marks the trailhead to the Blackrock "summit", which is about 100m from the parking lot. Follow this trail to the top, an open rock knob that marks the beginning of the site. From here, the site extends down and to the west.

Physical Description:

This site consists of two levels of cliffs with associated talus. The summit is the highest point on the upper cliff, which ends just to the northeast and extends about 100m to the southwest. The Appalachian Trail (AT) runs along the base of this cliff and its talus slopes. Halfway through the site, to the SW, this upper cliff peters out into a broad, flat area along which the AT runs, and new cliffs and talus appear further west, below and on the other side of the AT. These exposures continue to the southwest and eventually merge with the slope again. The rock exposures range from sheer cliffs >10m high to small outcrops in the woods.

Vegetation: Open

There are a few thickets on the lower talus slopes, but most of the site is open forest and vegetation is not a significant barrier.

Human Effects

Impacts: Heavy

The summit area is heavily stripped and trampled, and the rocks appear slightly polished. There are numerous social trails leading down slopes and along ledges within the upper cliffs, and trash and bottles are common at the base and in the talus. In contrast, the lower set of cliffs is not as accessible, save a few overlooks reached by social trail from the Appalachian Trail, and are a more pristine contrast to the upper cliffs.

Access Easy

This site is very easily accessed from the Big Meadows Lodge and cabins, and has a large interpretive sign at the head of the trail leading to the summit. This trail connects to the AT, which bisects the site and offers additional access.

Geologic Characteristics

Lithology: **Rock Type** Greenstone

The rocks here are entirely Catoctin Formation greenstones, which are strongly magnetic here and commonly interfere with compass work. There are two separate lava flows within the site, which create the two levels of cliffs that are bisected by the Appalachian Trail (AT). The upper flow is fine-grained, and rich in epidote, which gives it a lime green cast, especially on fracture surfaces. Toward the base of this flow, the rock becomes more iron-rich and has some preserved flow layering. The lower flow, while not as well exposed, is very similar in appearance to the upper and is not easily distinguished, although it does seem to contain less epidote. The boundary between these flows is marked to the north by a narrow break in slope, along which the AT was built. Toward the center of the site, where the upper set of cliffs fades away, there is a large flat plateau in the woods; this is the top of the lower flow, whose cliffs begin to occur below the AT beyond this point to the SW. The boundary is marked by a very distinctive deposit of red, vesicular breccia which cannot be found in place, but covers the forest floor on this plateau. It is not seen along the base of the upper cliffs, along the AT, but appears again at the very northern end of the site, near the cabins. In between, it is likely covered by the raised path of the AT.

Structure:

There is a single joint set oriented roughly E-W visible in the upper flow, but more commonly the rocks contain chaotic fractures that do not follow any clear orientation. On several surfaces defined by joints, sheared mineral deposits (slickensides), mostly in epidote, show that some motion occurred along these planes.

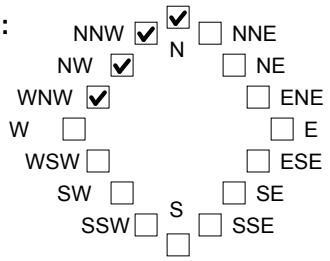
Other:

C04 - Blackrock Central District (continued...)

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	50.0	10.0	0.0	20.0	20.0	100
Max relief(m):	15	5	0	1	10	

Aspects:



Maximum Slope:

Texture: Rough

Setting:

Aerial photographs show what appears to be one, large cliff extending along the axis of the site from NE to SW. On the ground, the geologic evidence suggests that there are in fact two different lava flows forming this site, oriented near-horizontally rather than tilted, as the photographs suggest. This interpretation is based on the presence of vesicular breccia on the ground between the two sets of cliffs, although there is no actual bedrock exposure of this unit. On the ground, the flat plateau in the SE ends abruptly to the north as the ground rises up to form the upper cliffs, which is consistent with one lava flow eroding off the surface of another below it. See attached map for a sketch illustrating how this contact is interpreted. Both flows are fractured enough to have produced extensive talus slopes below the cliffs, although the bedrock is currently very stable in appearance.

Stability: Stable

The rock is quite solid, and the talus is not overly steep or unstable.

GPS Points

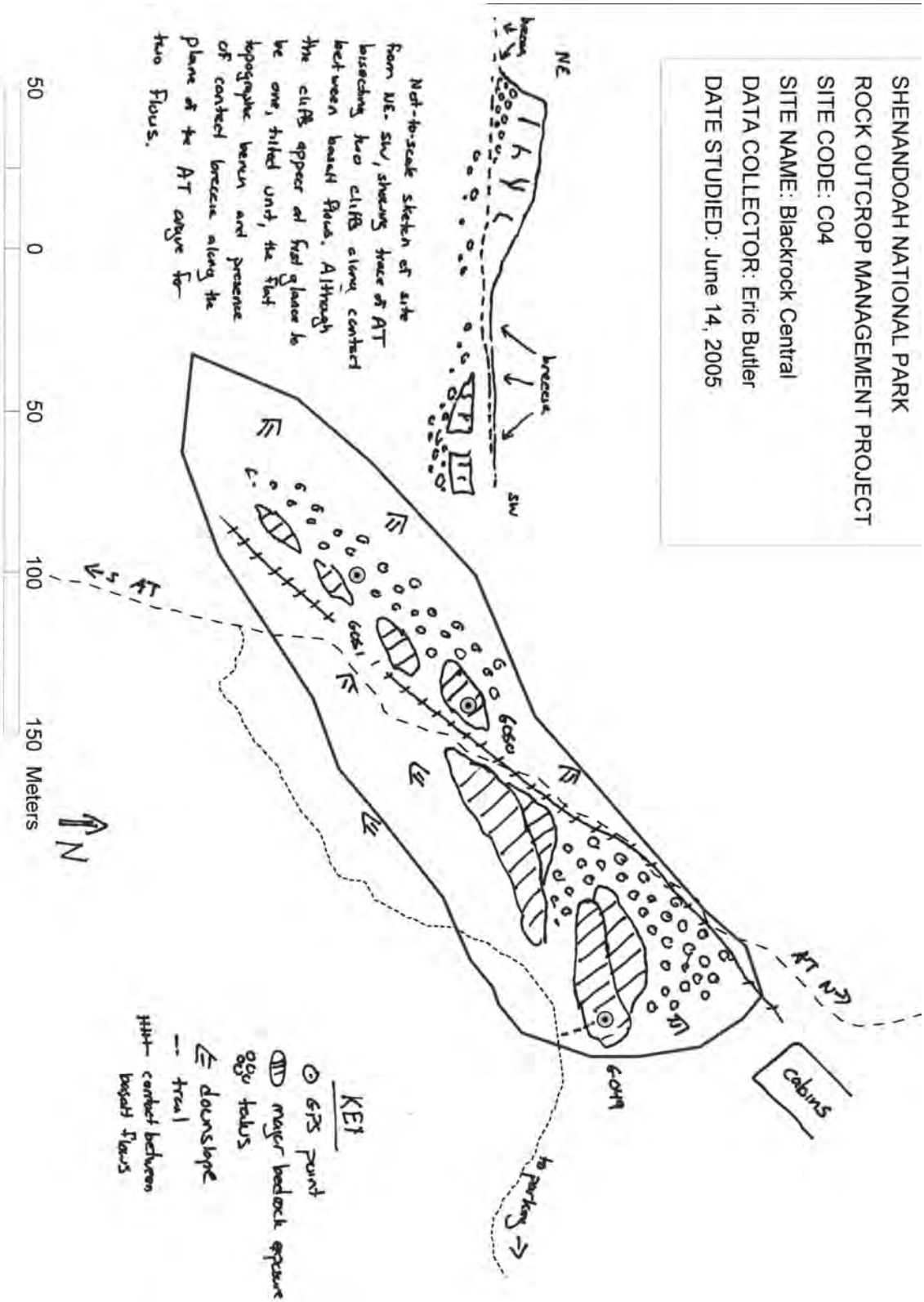
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
6/14/2005	G049-C04	722906	4267479	3660	Top of site, where trail from cabins ends
6/14/2005	G050-C04	722808	4267436	3600	Crossing of AT, first outcrop of talus
6/14/2005	G051-C04	722768	4267402	3590	Middle of talus, lower level, occurrence of rare raspberry

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
6/14/2005	G049-C04	SHEN_C04_G_20050614_001.jpg	55	Butler, Eric	Upper outcrop, looking along minor joint set
6/14/2005	G049-C04	SHEN_C04_G_20050614_002.jpg	70	Butler, Eric	Open, stripped ledges on upper outcrop
6/14/2005		SHEN_C04_G_20050614_003.jpg		Butler, Eric	Example of contact breccia between flows
6/14/2005	G050-C04	SHEN_C04_G_20050614_004.jpg	180	Butler, Eric	Closeup of vesicular greenstone in contact debris
6/14/2005	G050-C04	SHEN_C04_G_20050614_005.jpg		Butler, Eric	Outcrop and talus of lower level

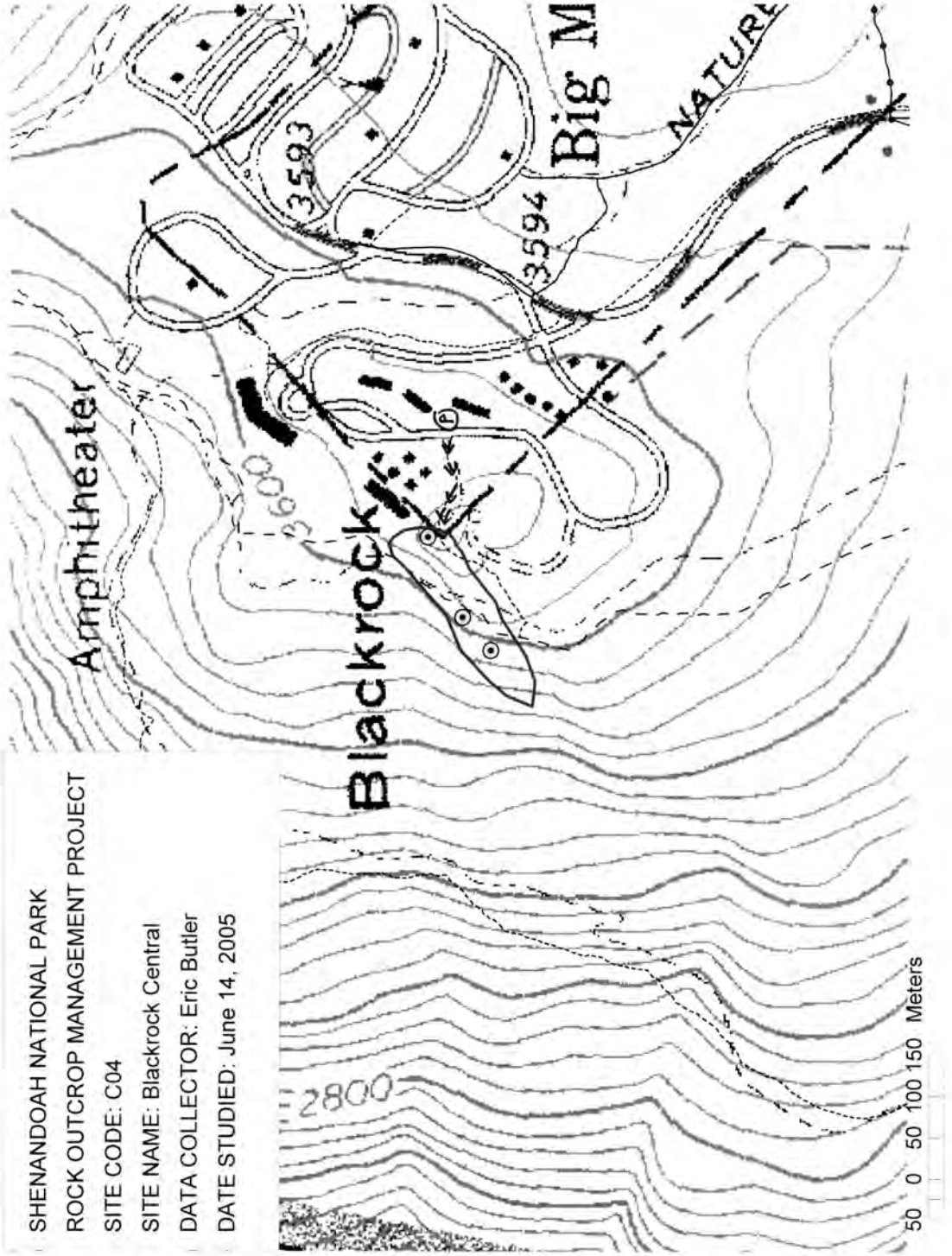
C04 - Blackrock Central District (continued...)

Detail sketch map



C04 - Blackrock Central District (continued...)

Area sketch map



C04 - Blackrock Central District (continued...)



SHEN_C04_G_20050614_001.jpg Azmuth: 55

Upper outcrop, looking along minor joint set



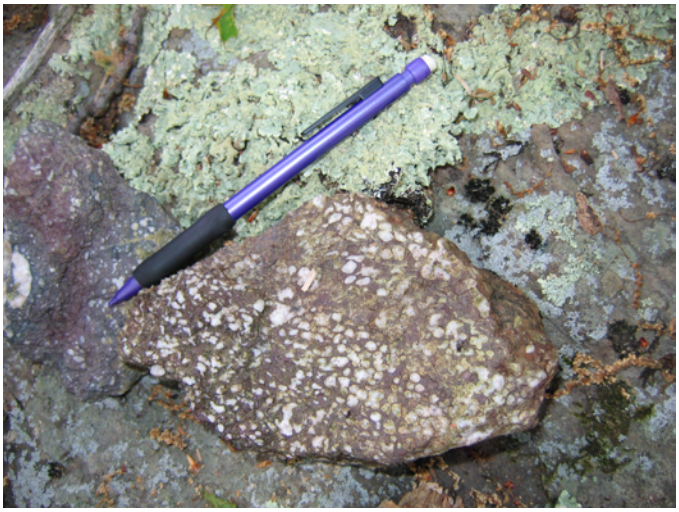
SHEN_C04_G_20050614_002.jpg Azmuth: 70

Open, stripped ledges on upper outcrop



SHEN_C04_G_20050614_003.jpg Azmuth:

Example of contact breccia between flows



SHEN_C04_G_20050614_004.jpg Azmuth: 180

Closeup of vesicular greenstone in contact debris

C04 - Blackrock Central District (continued...)



SHEN_C04_G_20050614_005.jpg Azmuth:

Outcrop and talus of lower level

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C05 - Blackrock South District

Site Code: C05
Site Name: Blackrock South District
Data Collector Butler, Eric
Date Studied: 26-Jul-05

Polygon Centroid: **E:** 697779 **N:** 4232680
UTM (Zone 17 NAD83)
Dimensions (m): 240 x 250 (GIS est.)
Elevation Range (ft): 2880 to 3080

Physical Characteristics

Location Acces

Park at Blackrock Summit Parking Area, just north of Milepost 85. Follow trail from lot about 700m to reach open boulder field. Note that there are several near-parallel trails here which can be confusing; check maps and follow signs posted at intersections. From the parking lot, follow the trail (an old road) to a trail junction with the Appalachian Trail (AT), and take the AT south from here. For the next few hundred meters southwest, the AT and the road are parallel and only a few meters apart, but soon the AT will swing more westerly and the road will curve more southerly. The AT will soon reach the open boulder field of the site; it then loops around the open rock knob of the summit trail before heading back east to rejoin the old road. Turn left here to return to parking.

Physical Description:

This site consists of a large, open boulder field that caps a ridge and extends down both sides. While there are several small areas of bedrock remaining in place, the vast majority of the site is composed of steep slopes covered in large, angular boulders up to several meters long. The high point is a knob of bedrock and talus 5-10m above the trail, from which the slope descends on three sides. Though the overall slope ranges between 25-35 degrees, local stacking of the boulders can create steeper slopes up to 45 degrees. Patches of trees and other vegetation divide the site in places, though these areas of vegetation are still underlain by boulders. In addition, the boulders continue down slope in all directions from the open areas, and are simply covered by encroaching trees. A few pockets of semi-open talus occur within the forest down slope from the main open exposures, and may be of interest

Vegetation: Open

There is little to no vegetation on the open boulders. While some dense forest has encroached onto the boulders along the edges and in a few other places, creating interesting transition zones, few areas of thick vegetation need to be entered to gain access to open rock.

Human Effects

Impacts: Moderate

Human impact is difficult to assess here, as the vast majority of the site consists of open boulders covered only in variable amounts of lichen. It is likely that humans have been impacted these communities, as the boulders are a very tempting scramble, and numerous written guides encourage visitors to climb the talus to reach the knob's summit. Some interesting comparisons could be made of lichen and plant distributions above and below the AT, as it is much less likely that significant amounts of people explore the boulders below the trail level.

Access Easy

This site is a short, nearly level walk from a well-marked parking area. Numerous guidebooks, signs, and other sources describe Blackrock as an excellent place to visit. The AT loops around three sides of the knob's summit, providing obvious and easy access to the boulders.

Geologic Characteristics

Lithology: **Rock Type** Quartzite

The bedrock and boulders are composed of quartzite, a metamorphosed sandstone. In this case, the quartzite formed from very clean, well-sorted quartz sand, very likely from a shallow marine/beach environment. Later metamorphism resulted in the individual sand grains being "baked" and fused into a very hard, very resistant rock. Original sedimentary features are still preserved within the rock, including bedding planes and cross-bedding, a feature resembling angled beds which forms in dunes and/or ripples. The rock is almost entirely quartz, though the slightly bluish gray color must result from some minor impurities. This quartzite bed has been assigned to the Hampton Formation, which is composed mostly of siltstones and shale.

C05 - Blackrock South District (continued...)

Stratigraphically above this unit is the Erwin Formation, which is composed mostly of quartzites similar to the rocks here. The two can be distinguished partly by color, as Erwin quartzites tend to be very white, while this unit of Hampton quartzite is a much darker grey-blue color. Although some of this color is related to the lichen growths on the rock surface, the color of a freshly broken face is still noticeably different from that of Erwin rocks.

Structure:

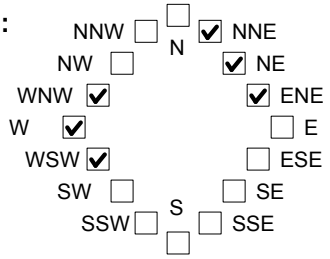
What little bedrock remains in place is heavily fractured, which in turn creates the very angular boulders. The bedding planes dip gently to the northwest at around 25 degrees, creating some flat tables of bedrock when this plane intersects with the slope.

Other:

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	0.0	10.0	0.0	0.0	90.0	100
Max relief(m):	0	2	0	0	60	

Aspects:



Maximum Slope: 45 **Texture:** Fractured

Setting:

Quartz is a very stable mineral at the earth's surface, and when fused together in a dense rock like quartzite, is virtually impermeable to small-scale physical and chemical weathering. Within the park, distinct beds of quartzite occur within thicker units of other, less resistant sedimentary rocks, and so tend to form large cliffs and boulder fields that dominate the surrounding slopes. These boulders have their source in the widespread fracturing of the bedrock, which occurred during the regional deformation and folding associated with the formation of the Appalachian Mountains. Although quartzite is generally very resistant, the heavy fracturing makes it susceptible to large-scale physical weathering processes such as the freeze-thaw cycle, which exploit the fractures to create masses of large, angular boulders that are otherwise still quite stable. At Blackrock, a unit of quartzite happens to cap the local ridge, and has mostly crumbled into boulders that wrap around the ridge and extend down slope in several directions. This same unit can be traced across to Trayfoot Mountain by looking for similar occurrences of large boulder fields sourced in the same rock. These large boulder fields, and many smaller ones, may be directly related to periglacial processes active during the last ice age, at which time extreme climate conditions would have accelerated physical weathering processes such as the freeze-thaw cycle.

It is worth noting that as one travels away from the central knob, whether down slope or across slope, the average size of the boulders gradually diminishes. This pattern seems to correlate inversely with the thickness of vegetation, so that the boundaries of tree growth coincide with the disappearance of the largest boulders, and an average rock size of 10-50cm. This pattern is likely due to the source of the boulders, the exposed bedrock atop the knob. The largest pieces can travel only so far from their source, and will slowly continue to fracture into smaller pieces via continued cycles of freeze-thaw. These smaller pieces may have an easier time moving down slope by filtering through larger pore spaces, and being transported by large storms. Thus the exposed top remains dominated by large boulders with little soil, while the fringes with their smaller clast size become increasingly more habitable for colonizing species.

Stability: Loose

The site is predominately loose block of variable size. In general, areas of larger blocks seem to be more stable compared to areas with blocks below 1m in diameter, though any given block may shift underfoot. Most parts of the site are relatively stable to walk on, however.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
7/26/2005	G103-C05	697815	4232630	3120	Summit of talus fields within site
7/26/2005	G104-C05	697842	4232709	3000	Corner of northern talus field
7/26/2005	G105-C05	697793	4232786	2920	Corner of northern talus field
7/26/2005	G106-C05	697675	4232726	2900	Base of talus along southern trail

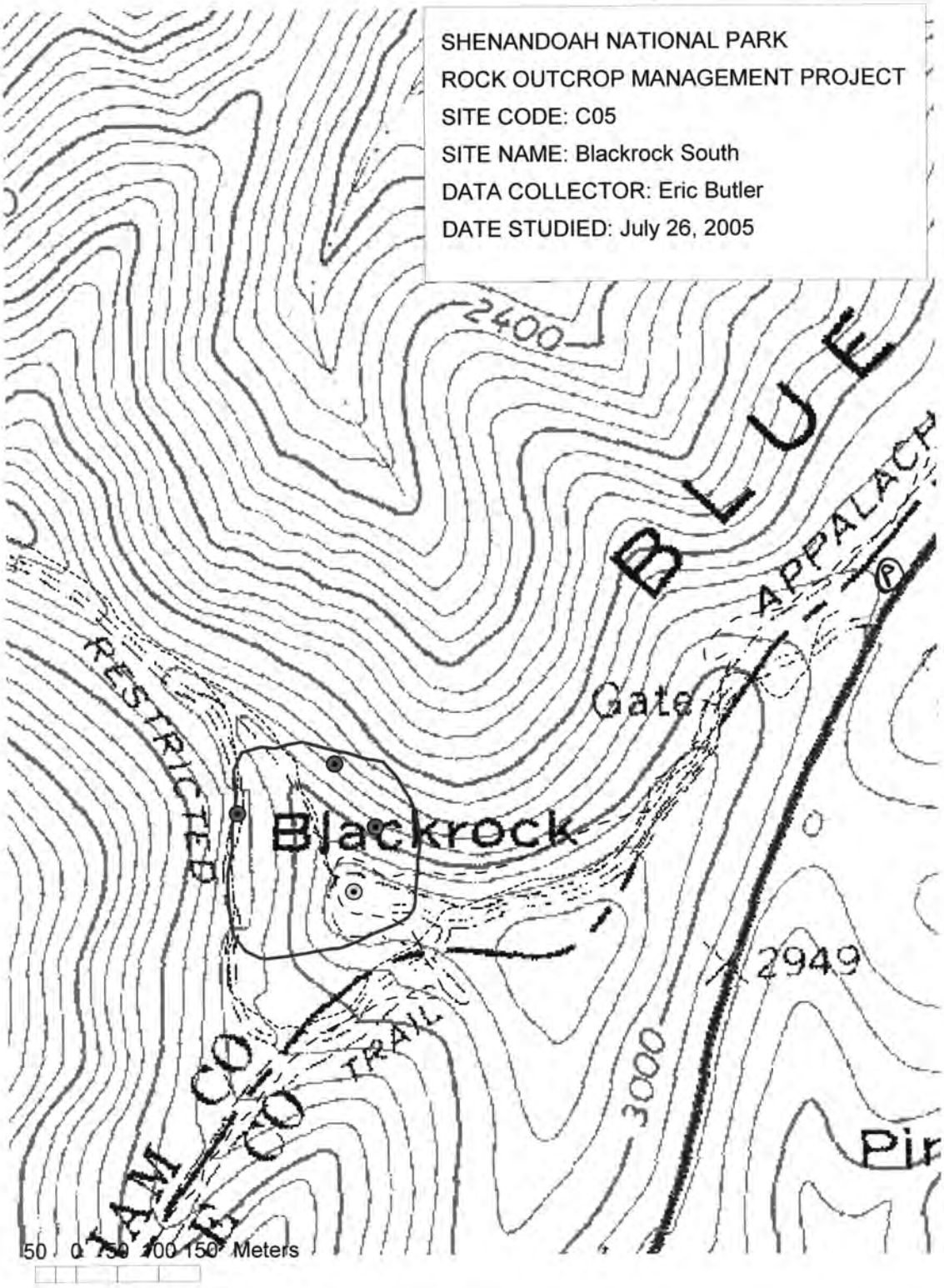
C05 - Blackrock South District (continued...)

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
7/26/2005	G103-C05	SHEN_C05_G_20050726_001.jpg	20	Butler, Eric	Summit talus, with in-place rock to left. Looking along joint plane.
7/26/2005	G104-C05	SHEN_C05_G_20050726_002.jpg	180	Butler, Eric	Looking upslope near G104, showing change in rock tripe abundance from shade to open
7/26/2005	G104-C05	SHEN_C05_G_20050726_003.jpg	270	Butler, Eric	Typical talus, with in-place bedrock outcropping on top of ridge
7/26/2005		SHEN_C05_G_20050726_004.jpg	90	Butler, Eric	Cross-bedded layer within quartzite, pencil for scale - taken at site centerpoint
7/26/2005		SHEN_C05_G_20050726_005.jpg	90	Butler, Eric	Closeup of cross-bedded quartzite shown in photo #004 - taken at site centerpoint

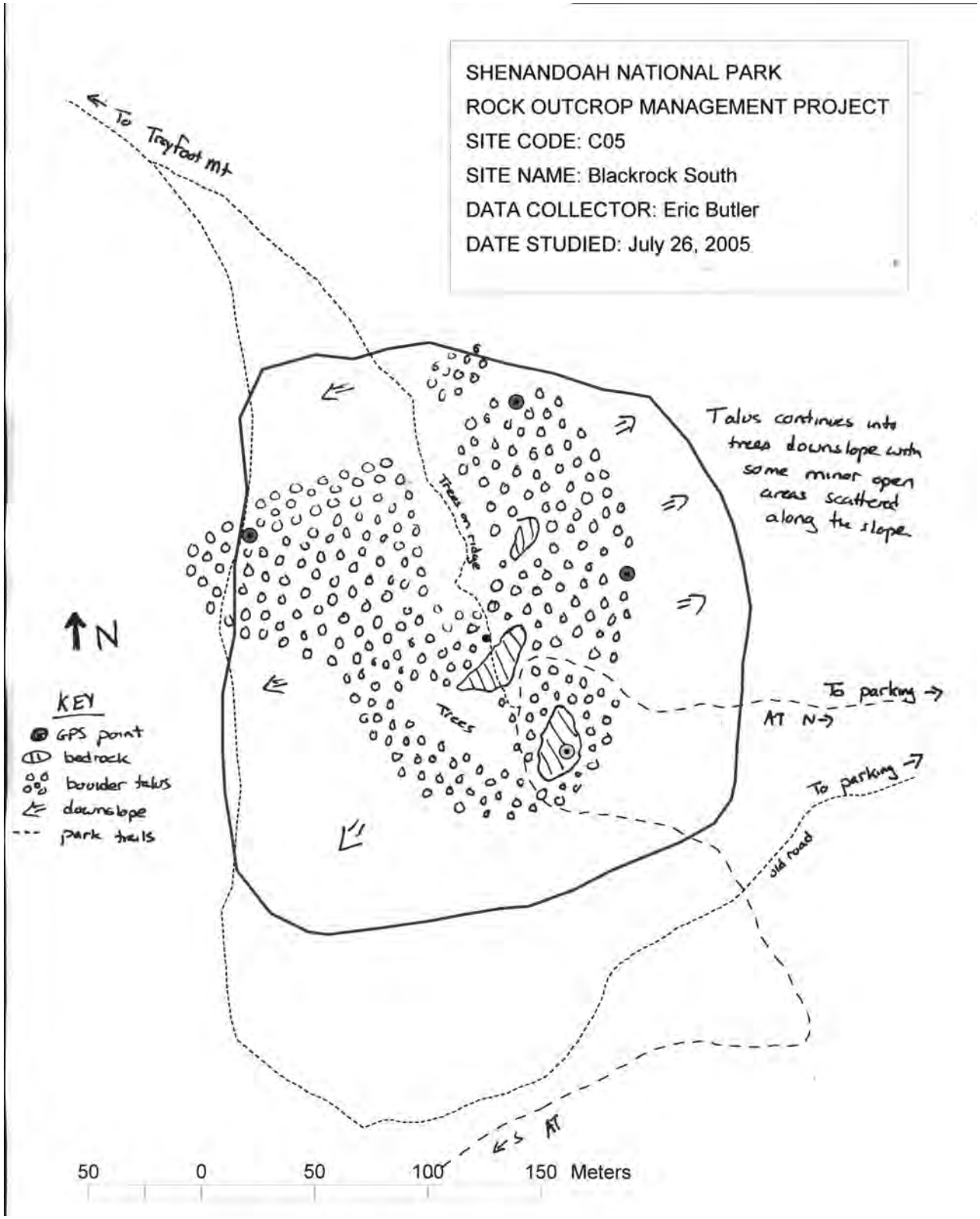
C05 - Blackrock South District (continued...)

Area sketch map



C05 - Blackrock South District (continued...)

Detail sketch map



C05 - Blackrock South District (continued...)



SHEN_C05_G_20050726_001.jpg Azmuth: 20

Summit talus, with in-place rock to left. Looking along joint plane.



SHEN_C05_G_20050726_002.jpg Azmuth: 180

Looking upslope near G104, showing change in rock tripe abundance from shade to open



SHEN_C05_G_20050726_003.jpg Azmuth: 270

Typical talus, with in-place bedrock outcropping on top of ridge



SHEN_C05_G_20050726_004.jpg Azmuth: 90

Cross-bedded layer within quartzite, pencil for scale - taken at site centerpoint

C05 - Blackrock South District (continued...)



SHEN_C05_G_20050726_005.jpg Azmuth: 90

Closeup of cross-bedded quartzite shown in photo #004 - taken at site centerpoint

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C07 - Browntown Valley Overlook

Site Code:	C07	**Polygon Centroid:**	**E:** 743170 **N:** 4296888
Site Name:	Browntown Valley Overlook		UTM (Zone 17 NAD83)
Data Collector	Butler, Eric	**Dimensions (m):**	220 x 350 (GIS est.)
Date Studied:	28-Jun-05	**Elevation Range (ft):**	2400 to 2660

Physical Characteristics

Location Acces

Park at Browntown Valley Overlook (Milepost 15) and hike northwest down the slope for about 300m to reach the first rock exposures in the upper level of the site. The initial descent off Skyline Drive is very steep and unstable, after which the route is gently sloping and forested, with variable nettles but no real barriers to navigation.

Physical Description:

This site consists of two sets of rock exposures at distinct topographic levels. Above 2600', the landscape is gently sloping and fully forested. At 2600', a break in slope occurs that is marked by discontinous, sloping rock outcrops and/or steeper soil/talus slopes. For the next 100' down, the slope descends steeply and is punctuated by outcrops of variable size, most of which are under full forest cover. Around 2500', the slope levels out and leads to a set of very large, sheer cliffs (up to 30m) that extend along this level with steep talus and soil slopes dividing them. At the base of these lower cliffs, the landscape returns to sloping forest cover.

At the south end of the site, multiple springs appear around 2600', feeding into a braided system of channels that plunge down over a series of outcrops and small cliffs. This section is extremely steep and thickly vegetated, including numerous deadfall, and can be very difficult to negotiate. The rocks are wet and lushly vegetated, and may be of interest biologically, even though they are not open to the sun.

Vegetation: Moderate

There is a unique and very interesting vegetation pattern at this site. The gentler slopes directly above both levels of rock exposure seem extremely dry, with little understory. Where the slope steepens, the vegetation changes noticeably to a moister environment, including abundant nettles (see map for illustration of this pattern). The rock exposures themselves are generally very bare, especially the ledges above the lower cliffs, and overall the site resembles the vegetation pattern found on sedimentary rock or granite, rather than metabasalt. Thick laurels are common around the cliffs, and can make navigation difficult. The surrounding slopes are forested and generally have very little understory that interferes with navigation, as described above.

Human Effects

Impacts: Pristine

There is no evidence of human visitation here, although the physical appearance of the ledges above the lower cliff unit could easily be taken for human impact. These ledges, unlike most similar sites, are mostly bare rock for several meters away from the cliff, with little established vegetation. If a trail led to this location, or there were any other sign of human use, these ledges might look heavily impacted. However, the remoteness of this site (see ACCESS) and the lack of any other evidence suggests that this is due to other factors such as the unusual dryness of the surrounding environment (see VEGETATION). The lower cliffs do have climbing potential, but are covered in thick mats of lichen that are undisturbed.

Access Remote

Although this site is only 300m of easy hiking from Skyline Drive, it seems unknown to visitors. It is located downslope through thick forest, in an area with no nearby trails, and is not visible from any vantage within the park. The park boundary is below the site, with no access points there either. Although the access from Browntown Valley Overlook is over a gentle slope, the precipitous initial descent off SD, together with very thick vegetation along the road, would certainly discourage exploration. No visitor would have any reason to hike or explore in this area.

Geologic Characteristics

Lithology: **Rock Type** Greenstone

The site is located on several flows of Catoctin Formation greenstone. Flow bedding is common throughout the site, generally

C07 - Browntown Valley Overlook (continued...)

10-50cm thick, especially in the upper unit. These flows are iron-rich, weathering to a deep red-brown on exposed surfaces. The greenstones are generally dark grey and very fine-grained. There are two similar units of vesicular breccia that mark flow boundaries, whose thickness is difficult to determine and may be anywhere from 1-5m. These occur at the base of both major topographic breaks in slope. The large cliffs at the base of the site change composition about halfway down, where a unit of columnar joints (see STRUCTURE) truncates at a rubbly, sandy-looking unit with 5-10m of greenstone beneath it. In a nearby location, this level was marked by a thin (50cm), wavy layer of sediments that closely resembled a stream deposit. This section was difficult to study up-close due to its location halfway up the cliff, but it may mark another flow boundary.

Structure:

There are several occurences of columnar jointing within the site, one within each major unit. In the upper unit, these are visible in several small outcrops, tilting out of the ground. In the lower unit, a set of columnar joints is visible partway up the large cliff, especially in one location where an overhang makes the hexagonal bases especially visible. These joints do not appear to form a continuous unit across the site, but appear in certain places only.

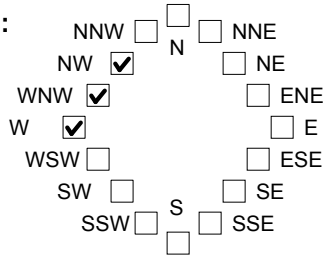
Other:

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	40.0	30.0	0.0	20.0	10.0	100
Max relief(m):	30	10	0	2	10	

Maximum Slope: 35 **Texture:** Rough to smooth

Aspects:



Setting:

There are two obvious cliff/outcrop levels within the site, separated by sloping topographic benches. Based on topography and morphology alone, it seems clear that there are two corresponding lava flows creating these benches. This interpretation is supported by the presence of vesicular breccia at the base of each cliff/outcrop unit, a common marker of the boundary between lava flows. However, it is possible that the lower cliff unit is in fact composed of two different flows. The presence of a rubbly/sandy layer roughly halfway up the cliff, which corresponds with the lower truncation of columnar jointing and a slightly different lithology below, suggests that a more subtle flow boundary is present here. It is possible that these two flows erupted very close to each other in time, without developing a more significant boundary, and so behave as one flow at a large scale. It is also possible that this boundary, or the rocks directly above it, are more resistant than average and so resist the erosional that normally produces a “staircase” pattern between multiple flows. If there are indeed two separate flows within this cliff unit, they do not greatly affect the morphology of the landscape, and so this question is more academic than practical.
The ecology of the site is unusual, in terms of how barren and dry the slopes are compared to most basaltic areas within the park. One possibility, though unprovable, is related to the existence of a large network of springs and channels at the south end of the site. In this scenario, these springs are draining groundwater laterally from the slopes farther north, producing a dry, northern “upland” and a wet, southern set of seeps. As groundwater moves downslope to the west, it is diverted into these seeps, eventually leaving the thinner soils near the cliff edges much drier than usual, but leaving areas in mid-slope more moist. If this is not the explanation for the dry ecology, it is unclear what other factors might be affecting the vegetation to produce this unusual community on greenstone.

Stability: Stable

The bedrock exposures are very solid, without any extensive fracturing or loose blocks. Steep, talus-dominated slopes are rare within the site, and most slopes are a mixture of soil and smaller rocks that is not difficult to negotiate.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
6/28/2005	G076-C07	743153	4296817	2580	Outcrop on upper level
6/28/2005	G077-C07	743147	4296742	2580	Beginning of springs
6/28/2005	G078-C07	743099	4296790	2480	Southern exposure on lower flow
6/28/2005	G079-C07	743078	4296799	2400	Basal outcrop of boundary rocks - near break in slope

C07 - Browntown Valley Overlook (continued...)

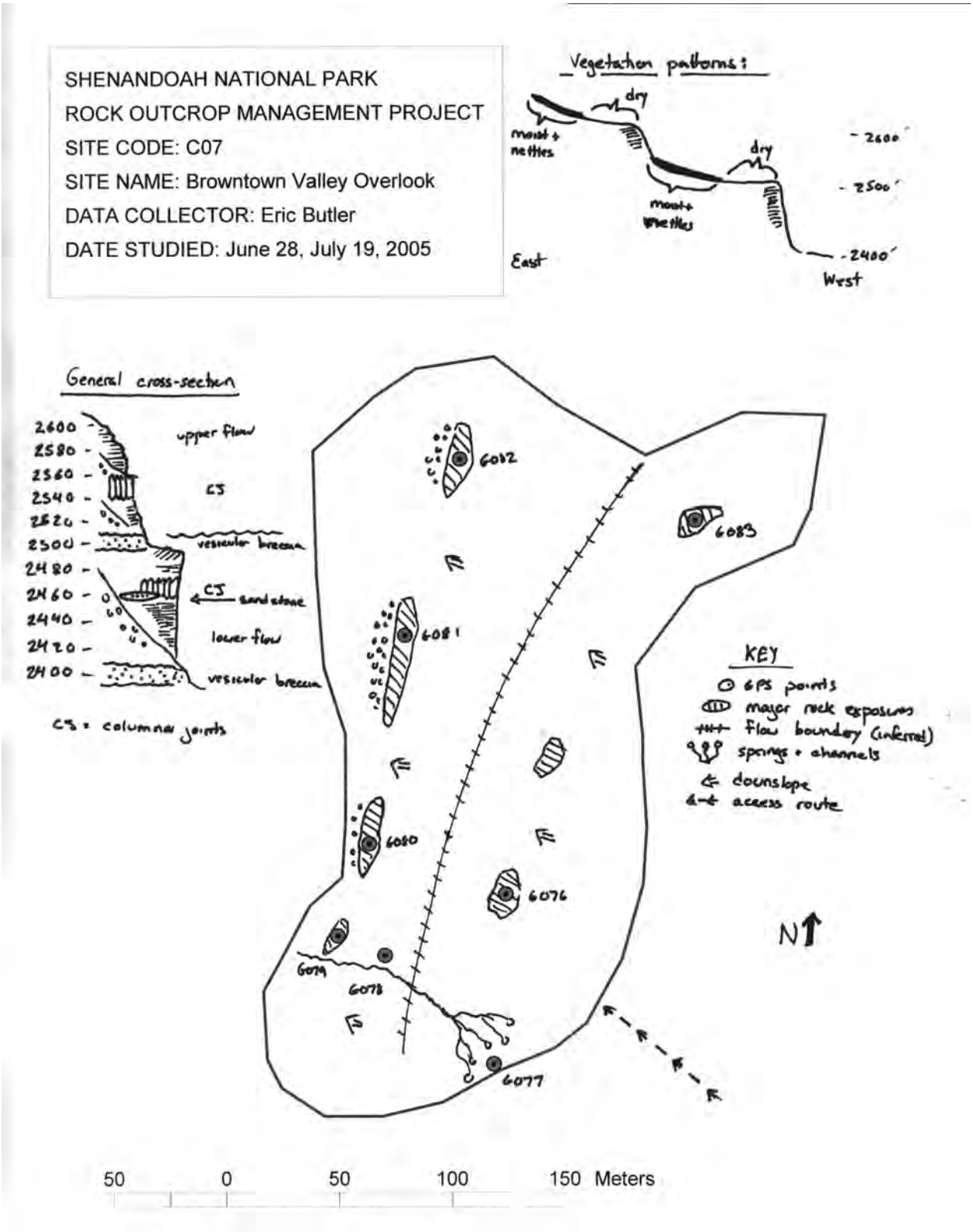
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
6/28/2005	G080-C07	743092	4296840	2500	Top of major cliff at lower level
6/28/2005	G081-C07	743108	4296933	2440	Base of cliff along lower level
6/28/2005	G082-C07	743133	4297012	2520	Northern cliff of lower level
6/28/2005	G083-C07	743237	4296984	2660	Exposure on upper level, isolated to NE

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
6/28/2005		SHEN_C07_G_20050628_001.jpg	45	Butler, Eric	Cleavage in lower unit and fresh face
6/28/2005		SHEN_C07_G_20050628_002.jpg	20	Butler, Eric	Large sheer cliff in lower unit
6/28/2005		SHEN_C07_G_20050628_003.jpg	0	Butler, Eric	Dry, open forest above lower cliffs
6/28/2005		SHEN_C07_G_20050628_004.jpg	200	Butler, Eric	Top of cliff – open ledge
6/28/2005		SHEN_C07_G_20050628_005.jpg	25	Butler, Eric	Open, rubbly outcrop about 50m NE of G076

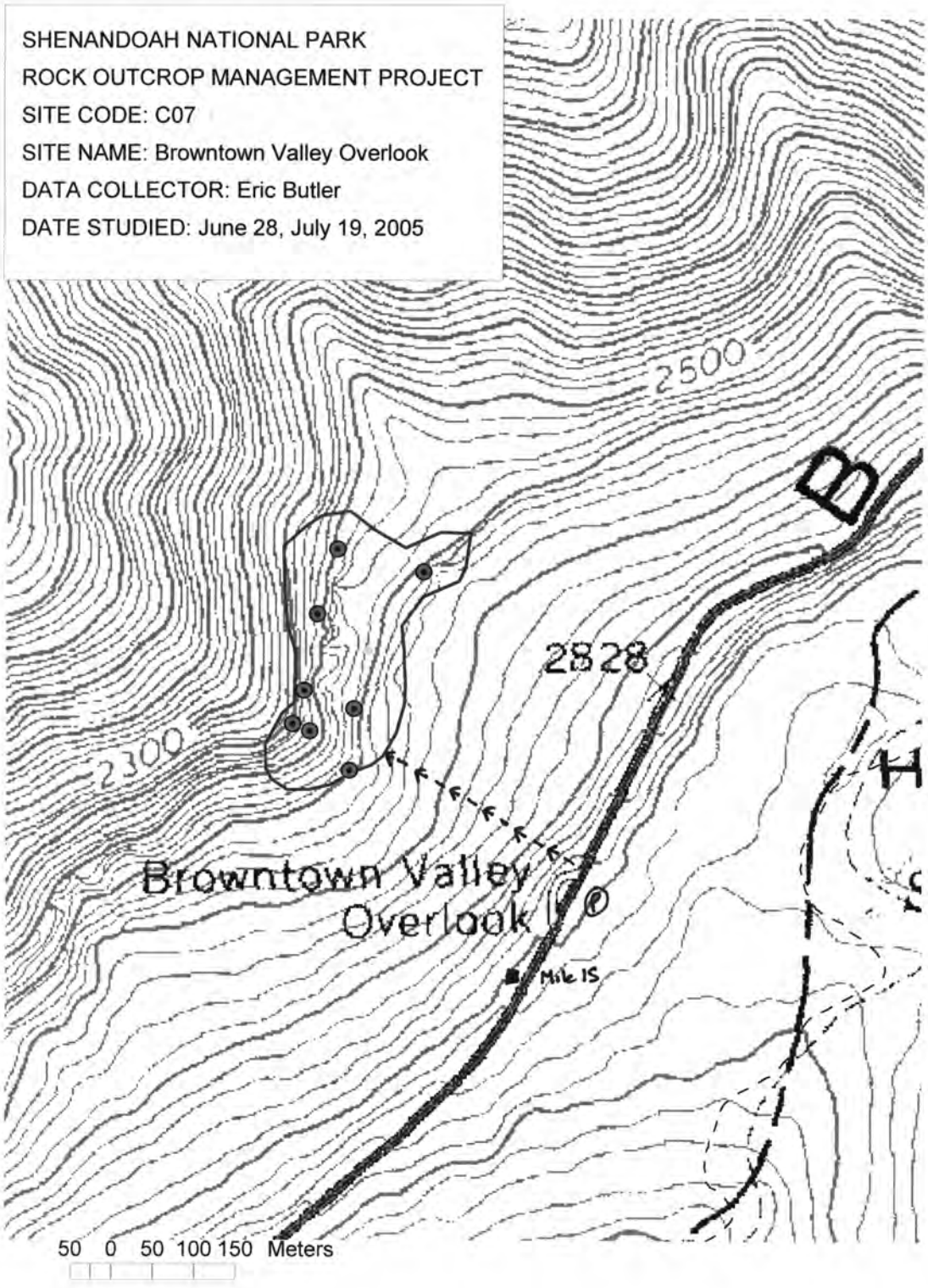
C07 - Browntown Valley Overlook (continued...)

Detail sketch map



C07 - Browntown Valley Overlook (continued...)

Area sketch map



C07 - Browntown Valley Overlook (continued...)



SHEN_C07_G_20050628_001.jpg Azmuth: 45

Cleavage in lower unit and fresh face



SHEN_C07_G_20050628_002.jpg Azmuth: 20

Large sheer cliff in lower unit



SHEN_C07_G_20050628_003.jpg Azmuth: 0

Dry, open forest above lower cliffs



SHEN_C07_G_20050628_004.jpg Azmuth: 200

Top of cliff – open ledge

C07 - Browntown Valley Overlook (continued...)



SHEN_C07_G_20050628_005.jpg Azmuth: 25

Open, rubbly outcrop about 50m NE of G076

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C08 - Calvary Rocks - Chimney Rock

Site Code:	C08	**Polygon Centroid:**	**E:** 694937 **N:** 4228724
Site Name:	Calvary Rocks - Chimney Rock		UTM (Zone 17 NAD83)
Data Collector	Butler, Eric	**Dimensions (m):**	680 x 460 (GIS est.)
Date Studied:	21-Aug-06	**Elevation Range (ft):**	2520 to 2880

Physical Characteristics

Location Acces

Park at Riprap Trail parking, just before Milepost 90. Take Appalachian Trail north appx. 650m to trail junction with Riprap Trail. Turn left (west) onto trail and follow 1100m down through saddle to reach steeply sloping boulderfield at edge of site. From here trail loops around north end of boulderfield to reach upper ridge.

Physical Description:

This site consists of two separated open rock areas. The larger expanse is a long, narrow ridge running SW to NE, with moderate to steep dropoffs along both sides. This ridge rises in the middle to form the summit of Calvary Rocks. Narrow, steep boulder fields run along the base of this ridge, alternating between open and vegetated. The northeastern end is steeper to the NW, while the southwestern end is steeper to the SE.

Downslope and to the NW of Calvary Rocks, a large cliff wraps around the ridge to form the Chimney Rock area (the namesake is an almost free-standing quartzite pillar which has broken from the main cliff). This near-continous cliff has a large, open boulder field at its base, with very large (car-sized) fragments in places.

Vegetation: Dense

The area is thickly vegetated in laurels and scrubby oaks, though navigation along most of the open rock areas is reasonable. Little real bushwhacking is needed to access the open rock areas.

Human Effects

Impacts: Mild

Visible human impacts are limited to a few places directly along the trail, where obvious overlooks are available. Some soil stripping and lichen removal are visible, but no trash or further disturbance was present. Several possible old campsites may be present in the woods near Chimney Rock. Most of the site is pristine.

Access Difficult

Accessing this site requires hiking nearly 2km with a great deal of elevation change in both directions. A sign at the parking lot directs hikers to the site.

Geologic Characteristics

Lithology: **Rock Type** Quartzite

The site is underlain by white-pink quartzite of the Erwin Formation. The original clean quartz sandstone has been highly metamorphosed, and most grains are fully fused into a massive, resistant rock. Very few layering or other original structures can be identified, though a sample along the trail to the site preserves excellent cross-bedding.

There appear to be two units of quartzite along the Calvary Rocks ridge, though they are visually indistinguishable. This interpretation is based on the clear map and outcrop pattern in which two parallel lines of exposure are present along much of the ridge, one higher than the other. It is unclear which of the two units correlates to Chimney Rock, but it is likely the upper one, as there is no evidence for any significant quartzite bedrock directly above this location.

Structure:

The bedrock here is highly fractured along planes generally developed parallel to the ubiquitous skolithos burrows (see below). These burrows act as a strong perforation that results in fractures near to 90-degree angles and very planar. The orientation of the bedrock varies within the site; along the Calvary Rocks ridge the rocks are dipping around 65 degrees to the NW, while further west at Chimney Rocks the bedrock is nearly flat. With virtually no layering visible, these orientations were determined by

C08 - Calvary Rocks - Chimney Rock (continued...)

observation of skolithos orientation (the original burrows form vertically).

Other:

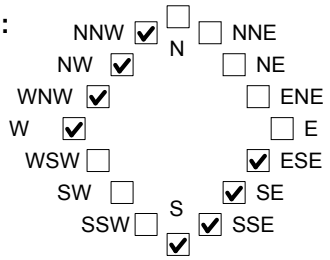
Skolithos, a type of fossilized worm burrow, is omnipresent within the bedrock here. These burrows are interpreted to form in sands within a shallow beach environment, and are excellent indicators of a layer's orientation (see above). These trace fossils most commonly appear as long, linear tubes within the rock, though metamorphism may partially alter them to appear as simple streaks that are often discolored by iron.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	10.0	30.0	0.0	50.0	10.0	100
Max relief(m):	15	15	0	2	5	

Maximum Slope: 25 **Texture:** Fractured

Aspects:



Setting:

There are two primary factors affecting the exposures within this site. First and foremost, the common skolithos burrows create perforations that influence the regular, parallel fractures forming at near-90-degree angles. Second, there appears to be a large bedrock fold running through the site that influences the angled nature of the open rock areas. Along the Calvary Rocks ridge, the quartzite layers are dipping steeply to the NW, creating a series of angled ledges and dropoffs in both directions that often create an almost staircase-like pattern, though often too steep to easily negotiate. Further down and to the west, at Chimney Rock the quartzite appears to be horizontal, and thus a more typical vertical cliff/ledge complex has formed there.

In addition, the quartzite here is very homogenous and resistant to erosion, due in large part to the metamorphism which fused the quartz grains into a solid mass. Thus the fractures (likely related to the stresses of mountain-building) are the main factor in eroding and shaping the landscape, as they offer an obvious conduit for winter, water, and frost action. It seems likely that periglacial effects were felt strongly here, as has been suggested at other exposed quartzite sites such as Blackrock. This short period of intense weathering conditions may help explain why much of the site appears to have crumbled in place, but does not show further signs of active erosion at a large scale.

Stability: Loose

The bedrock is heavily fractured here, and many larger blocks are not as stable as they appear. Loose talus is abundant and easy to shift. Deep cracks within the bedrock isolate several tall spires of uncertain stability.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
8/21/2006	G242-C08	695206	4228926	2800	NE end of high, narrow open ridge
8/21/2006	G243-C08	694942	4228701	2880	Summit at Calvary Rocks, high point of long open ridge
8/21/2006	G244-C08	694709	4228853	2680	Top of Chimney Rock accessed by trail

Site Photos

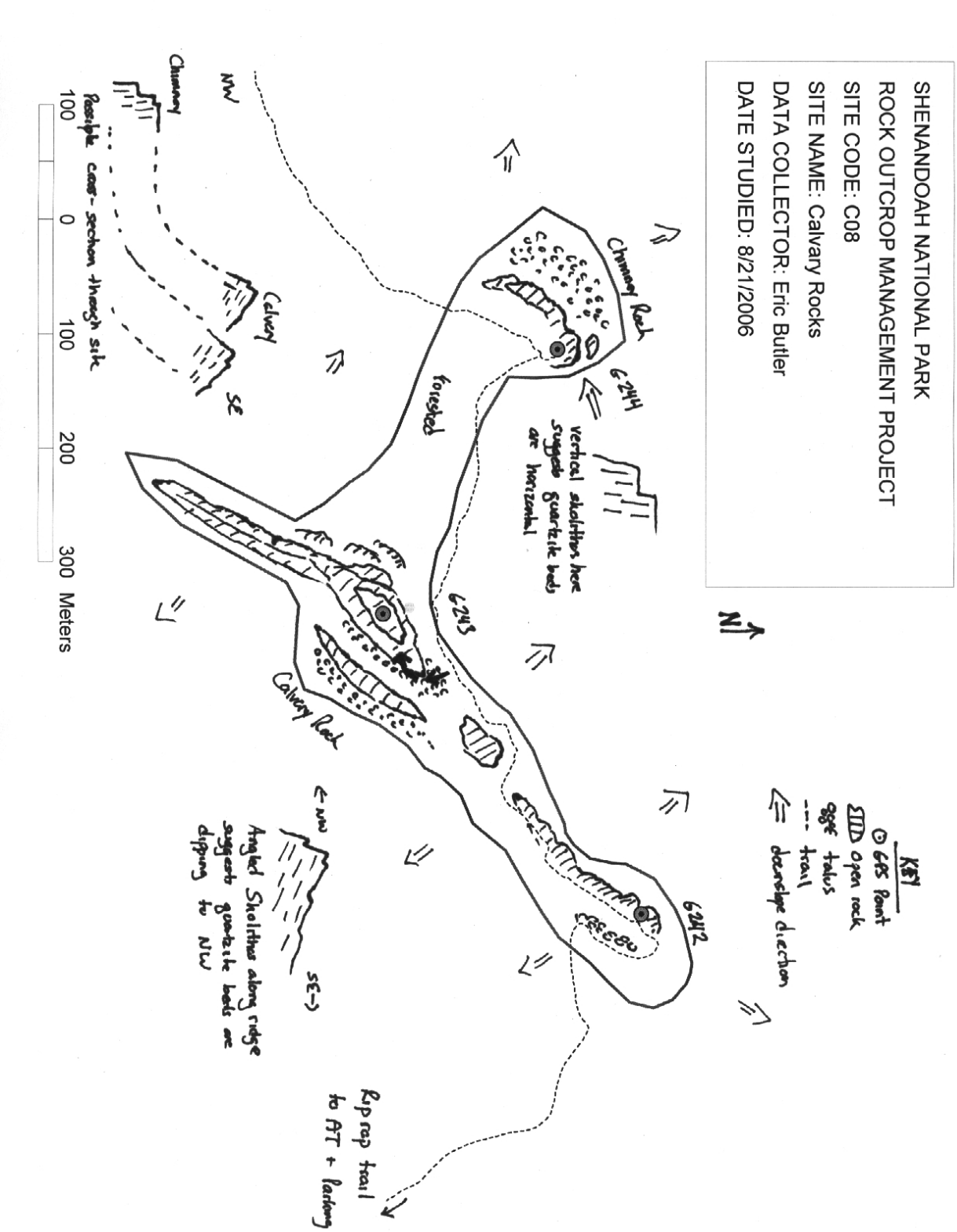
Image Date	GPS Point	File Name	Azmuth	Taken By	Description
8/21/2006	G242-C08	SHEN_C08_G_20060821_001.jpg	225	Butler, Eric	Boulder field along trail on SE side of long ridge
8/21/2006	G242-C08	SHEN_C08_G_20060821_002.jpg	15	Butler, Eric	Fractured outcrop - note abundant skolithos burrows dipping to right (SE); dip of rock bed is to left (NW)
8/21/2006	G242-C08	SHEN_C08_G_20060821_003.jpg	225	Butler, Eric	Typical impacts along trail
8/21/2006	G242-C08	SHEN_C08_G_20060821_004.jpg	225	Butler, Eric	Asymmetric outcrop/ledge complex along ridge - steep dropoff to right (NW) and gentler slopes to left (SE)

C08 - Calvary Rocks - Chimney Rock (continued...)

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
8/21/2006	G243-C08	SHEN_C08_G_20060821_005.jpg	250	Butler, Eric	Open rock outcrops and ledges at summit
8/21/2006	G243-C08	SHEN_C08_G_20060821_006.jpg		Butler, Eric	Closeup of well-preserved skolithos burrow
8/21/2006	G244-C08	SHEN_C08_G_20060821_007.jpg	335	Butler, Eric	Boulderfield below and to west of Chimney Rock
8/21/2006	G244-C08	SHEN_C08_G_20060821_008.jpg	75	Butler, Eric	Vertical exposures with ledges; compare to photo 4
8/21/2006	G244-C08	SHEN_C08_G_20060821_009.jpg	330	Butler, Eric	Large boulders at western end of Chimney Rock boulderfield
8/21/2006	G244-C08	SHEN_C08_G_20060821_010.jpg		Butler, Eric	Closeup of vertical skolithos at Chimney Rock
8/21/2006	G242-C08	SHEN_C08_G_20060821_011.jpg		Butler, Eric	Closeup of angled skolithos along ridge; burrows dip to right (SE) showing bedrock dip to left (NW)
8/21/2006		SHEN_C08_G_20060821_012.jpg		Butler, Eric	Closeup of cross-bedding structure in loose rock along trail

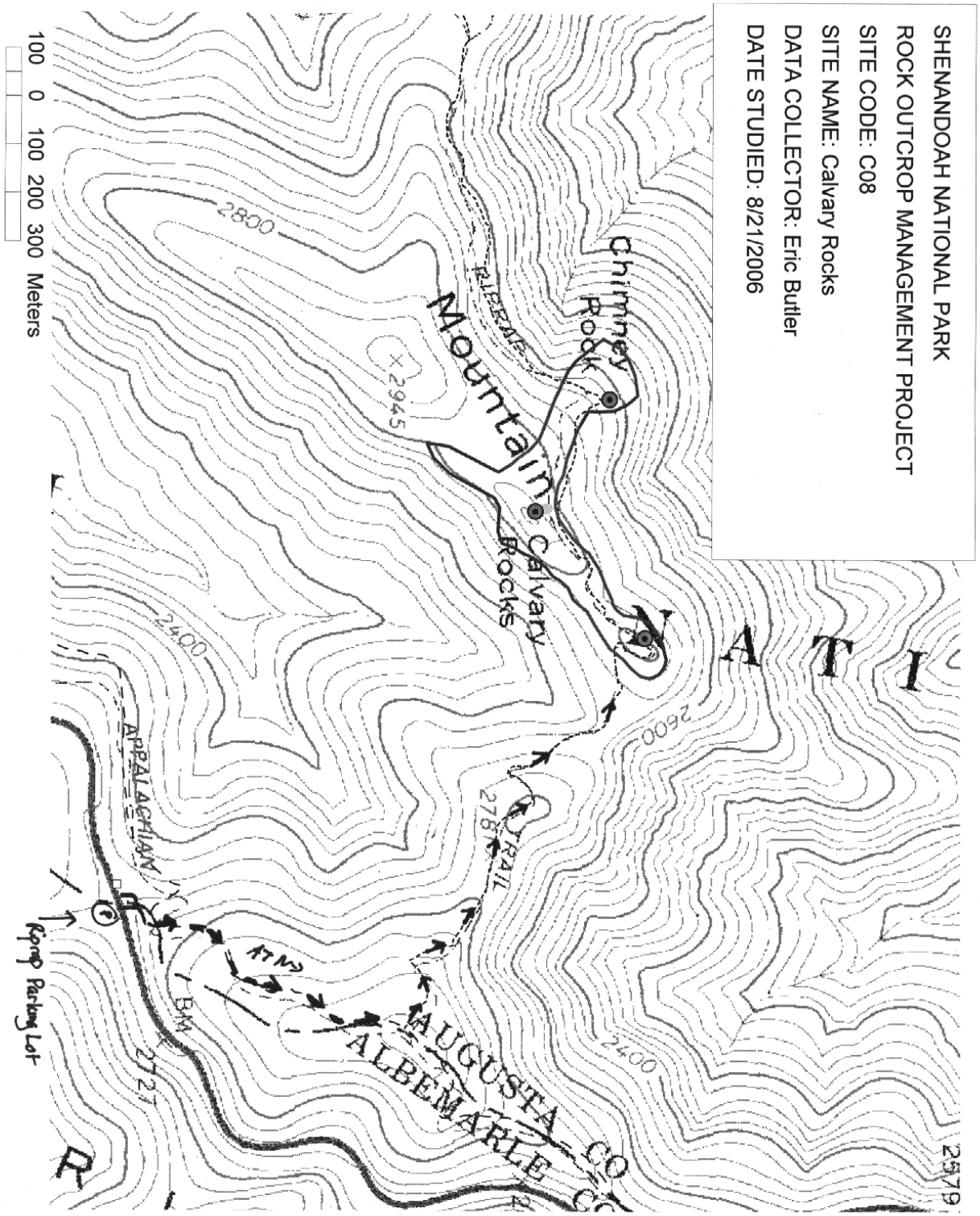
C08 - Calvary Rocks - Chimney Rock (continued...)

Detail map



C08 - Calvary Rocks - Chimney Rock (continued...)

Area map



C08 - Calvary Rocks - Chimney Rock (continued...)



SHEN_C08_G_20060821_001.jpg Azmuth: 225

Boulder field along trail on SE side of long ridge



SHEN_C08_G_20060821_002.jpg Azmuth: 15

Fractured outcrop - note abundant skolithos burrows dipping to right (SE); dip of rock bed is to left (NW)



SHEN_C08_G_20060821_003.jpg Azmuth: 225

Typical impacts along trail



SHEN_C08_G_20060821_004.jpg Azmuth: 225

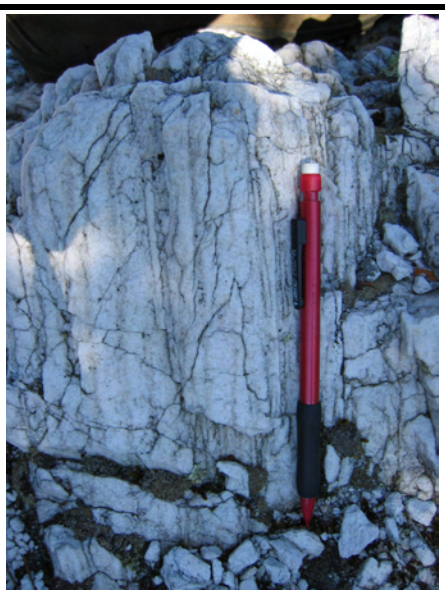
Asymmetric outcrop/ledge complex along ridge - steep dropoff to right (NW) and gentler slopes to left (SE)

C08 - Calvary Rocks - Chimney Rock (continued...)



SHEN_C08_G_20060821_005.jpg Azmuth: 250

Open rock outcrops and ledges at summit



SHEN_C08_G_20060821_006.jpg Azmuth:

Closeup of well-preserved skolithos burrow



SHEN_C08_G_20060821_007.jpg Azmuth: 335

Boulderfield below and to west of Chimney Rock



SHEN_C08_G_20060821_008.jpg Azmuth: 75

Vertical exposures with ledges; compare to photo 4

C08 - Calvary Rocks - Chimney Rock (continued...)



SHEN_C08_G_20060821_009.jpg Azmuth: 330

Large boulders at western end of Chimney Rock boulderfield



SHEN_C08_G_20060821_010.jpg Azmuth:

Closeup of vertical skolithos at Chimney Rock



SHEN_C08_G_20060821_011.jpg Azmuth:

Closeup of angled skolithos along ridge; burrows dip to right (SE) showing bedrock dip to left (NW)



SHEN_C08_G_20060821_012.jpg Azmuth:

Closeup of cross-bedding structure in loose rock along trail

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C10 - Crescent Rock Overlook

Site Code: C10
Site Name: Crescent Rock Overlook
Data Collector Butler, Eric
Date Studied: 02-Aug-05

Polygon Centroid: **E:** 727942 **N:** 4271387
UTM (Zone 17 NAD83)
Dimensions (m): 140 x 280 (GIS est.)
Elevation Range (ft): 2380 to 3540

Physical Characteristics

Location Acces

Park at Crescent Rock Overlook (south of Milepost 44). A short trail leads south from the overlook to the top of Crescent Rock. To access the cleared viewshed area, take the Betty's Rock trail north from the overlook, then turn left a few meters into the woods onto a cutoff trail that leads down to the Applachian Trail (AT) at the base of the cleared viewshed. The base of Crescent Rock can be accessed by climbing upslope from the AT; in addition, just south of Crescent Rock, a narrow talus/soil slope descends from Skyline Drive and provides another route of access to ledges along the face of Crescent Rock.

Physical Description:

The dominant feature here is Crescent Rock, a very large cliff that protrudes from the slope just west of Skyline Drive. Although this cliff appears sheer from a distance, it contains numerous small ledges which support quite a bit of plant growth along both axes of the exposure. A social trail leads from the top of the cliff down to several ledges along the north end of the exposure. Below this cliff, a steep, mostly forested talus/soil slope with numerous small outcrops leads down to a topographic bench on which the Appalachian Trail (AT) is built. Below the AT are more small cliffs and outcrops, but these remain fully forested to the limits of the site boundary. Just north of Crescent Rock, there is a large cleared viewshed area below the roadside overlook along Skyline Drive, which is thickly vegetated but contains numerous small outcrops and a small line of cliffs just below the overlook wall. North of the cleared viewshed, beyond the site boundary, another line of large cliffs begins, but these are mostly forested and offer little open ledge area. Within the viewshed, toward the south end, a small spring runs over the cliff and forms a wet, seepy area that drains down the slope into the forest below the AT.

Vegetation: Dense

The top of Crescent Rock and surrounding slopes are generally thickly vegetated with laurel and low trees. Within the cleared viewshed, thick grasses and other growth make movement difficult in places, particularly as they obscure the variable talus beneath. Below the AT the forest is more open, but there are no significant exposures.

Human Effects

Impacts: Heavy

Crescent Rock is obviously very heavily visited. The upper ledges, and those reached by social trail, are mostly stripped of soil and are either bare or gravelly. There is numerous graffiti scratched into the rock, and near G115 there are drill holes and concrete patches remaining from a former staircase/platform. In the talus/soil slopes below Crescent Rock, there are numerous broken bottles and other debris presumably thrown from the top. The areas below the overlook, while less obviously impacted, still contain human debris and evidence of visitation.

Access Easy

This site is located directly at a signed Skyline Drive overlook, with other obvious signs pointing the way along a wide, level trail to Crescent Rock, only tens of meters from the parking lot. During the day, a steady stream of cars visits the overlook.

Geologic Characteristics

Lithology:

Rock Type Greenstone

The Crescent Rock area is underlain by greenstone of variable composition. In general, the rock is fine-grained and green-grey, with a subtle layering that dips around 20 degrees to the east. This layering is most prominent in a 30'-40' thick zone near the top of Crescent Rock, and can be clearly identified as an area that is much sheerer, and contains fewer ledges, than the areas above and below which are more cleavage-dominated. This area also contains an especially high amount of epidote. Around 3440' (near the base of Crescent Rock), a unit of dark, very finely layered rock appears, which contains many pockets and veins of dark, metallic material. This unit appears deformed, and may represent an ash or sediment bed.

C10 - Crescent Rock Overlook (continued...)

Structure:

Columnar joints occur at certain levels, especially between 3460'-3480', and around 3400'. These are not laterally continuous at these levels, however. Cleavage is common, dipping steeply to the southeast, and forms platy, protruding ledges where present.

Other:

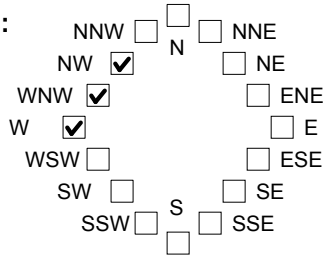
There are numerous loose blocks of vesicular breccia among the talus within the overlook viewshed, but none can be found in place. Several similar pieces are present in the trees between parking areas of the overlook, but are not found on the higher slopes to the east. No obvious contact material can be found in the slopes or bedrock below Crescent Rock, though the dark, metallic, layered unit around 3440' may represent a basal contact if it is an ash/sediment bed.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	50.0	10.0	0.0	20.0	20.0	100
Max relief(m):	40	3	0	2	10	

Maximum Slope: 35 **Texture:** Rough

Aspects:



Setting:

Crescent Rock is apparently formed from a single, thick lava flow. There are no identifiable contacts or boundaries along the cliff face. The distinct topographic bench directly above the cliff, upon which Skyline Drive and the overlook are built, is typical of those formed between flows, though very little contact material such as vesicular basalt or breccia can be found. The distinct layered, metallic unit near the base of Crescent Rock appears to be an ash bed or sedimentary unit, which would constrain the lower boundary of this flow. While this interpretation is uncertain, the location of this unit at the base of the cliff and its unique appearance provide a useful marker in the absence of other evidence. The presence of a similar unit at the base of the cliff line just south of here, in C11 (Crescent Rock South), also encourages this interpretation.

Crescent Rock is a dominating feature that protrudes from a landscape otherwise marked by smaller, intermittent lines of cliffs and outcrops, and it is not clear what factors have contributed to the formation of such a large and unusual exposure in this particular location. There are no obvious joints or faults that constrain the north and south extent of the cliff, and there does not appear to be any appreciable change in the bedrock composition in the surrounding exposures. The cliff is not even located on the most protruding portion of the slope. It may be that past erosional processes, acting on past topography and now-vanished geologic factors, may have created a long-gone feature which influenced the formation of today's Crescent Rock.

On the other hand, the physical texture of the exposures here is directly linked to changes in the structure and composition of the rock. Areas dominated by the sharply dipping cleavage produce angled, ledgy exposures that create numerous areas of habitat. Where this cleavage is less dominant, and layering is more prevalent, the rock is smoother and sheerer. This different may also be related to the high epidote content of this area, which seems to make the rock more solid and resistant. The intermittent columnar joints also appear to create a more rugged, ledgy texture as they interact with the cleavage. In many cases these are poorly preserved and not immediately evident, but their existence is a factor.

Stability: Moderate

The bedrock is very solid; though the cleavage provides planes of weakness, it is not pervasive enough to generate many loose pieces. The lower slopes can be very loose and slippery, particularly some of the talus/soil chutes below Crescent Rock, where this material funnels between smaller outcrops in the forest. Most of the talus immediately surrounding Crescent Rock and other exposures seems relatively stable.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
8/2/2005	G114-C10	728016	4271494	3520	Northern end of cleared viewshed for overlook
8/2/2005	G115-C10	727960	4271377	3520	North extent of impacted ledges on Crescent Rock; below top ledges
8/2/2005	G116-C10	727950	4271318	3540	South extent of impacted ledges on Crescent Rock
8/2/2005	G117-C10	727927	4271344	3400	Base of Crescent Rock/top of talus, also location of columnar joints
8/2/2005	G118-C10	727936	4271246	3520	Southeast corner of site along Skyline Drive, where cleared viewshed

C10 - Crescent Rock Overlook (continued...)

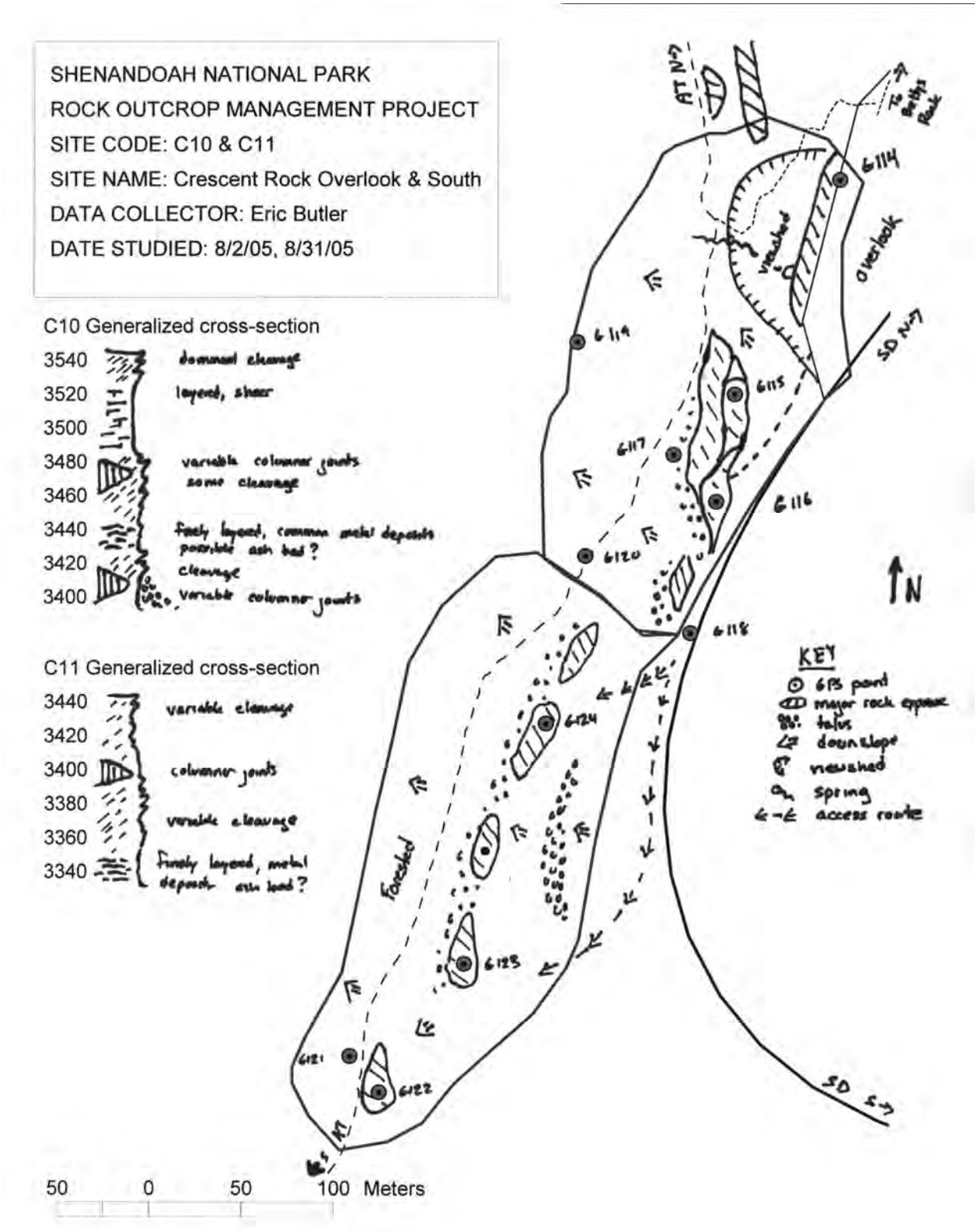
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
8/2/2005	G119-C10	727875	4271405	3320	Forested outcrops below AT, on site boundary
8/2/2005	G120-C10	727879	4271288	3380	South boundary of site along AT

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
8/2/2005	G114-C10	SHEN_C10_G_20050831_001.jpg	160	Butler, Eric	View across cleared viewshed for overlook
8/2/2005	G116-C10	SHEN_C10_G_20050831_002.jpg	0	Butler, Eric	Upper impacted ledges of Crescent Rock
8/2/2005	G115-C10	SHEN_C10_G_20050831_003.jpg	180	Butler, Eric	Crescent Rock cliff with vegetated ledges at different levels
8/2/2005	G115-C10	SHEN_C10_G_20050831_004.jpg		Butler, Eric	View down to lower impacted ledges below G115, north end of Crescent Rock
8/2/2005	G116-C10	SHEN_C10_G_20050831_005.jpg		Butler, Eric	Rock graffitti from 8/5/05 on upper ledges of Crescent Rock
8/2/2005	G115-C10	SHEN_C10_G_20050831_006.jpg		Butler, Eric	Metallic deposits within greenstone, near base of cliff below G115
8/2/2005	G117-C10	SHEN_C10_G_20050831_007.jpg		Butler, Eric	Tilted columnar joints along AT near base of Crescent Rock
2/16/2006		SHEN_C10_G_20060216_001.JPG		Butler, Eric	View of site through zoom lens from Hawksbill summit

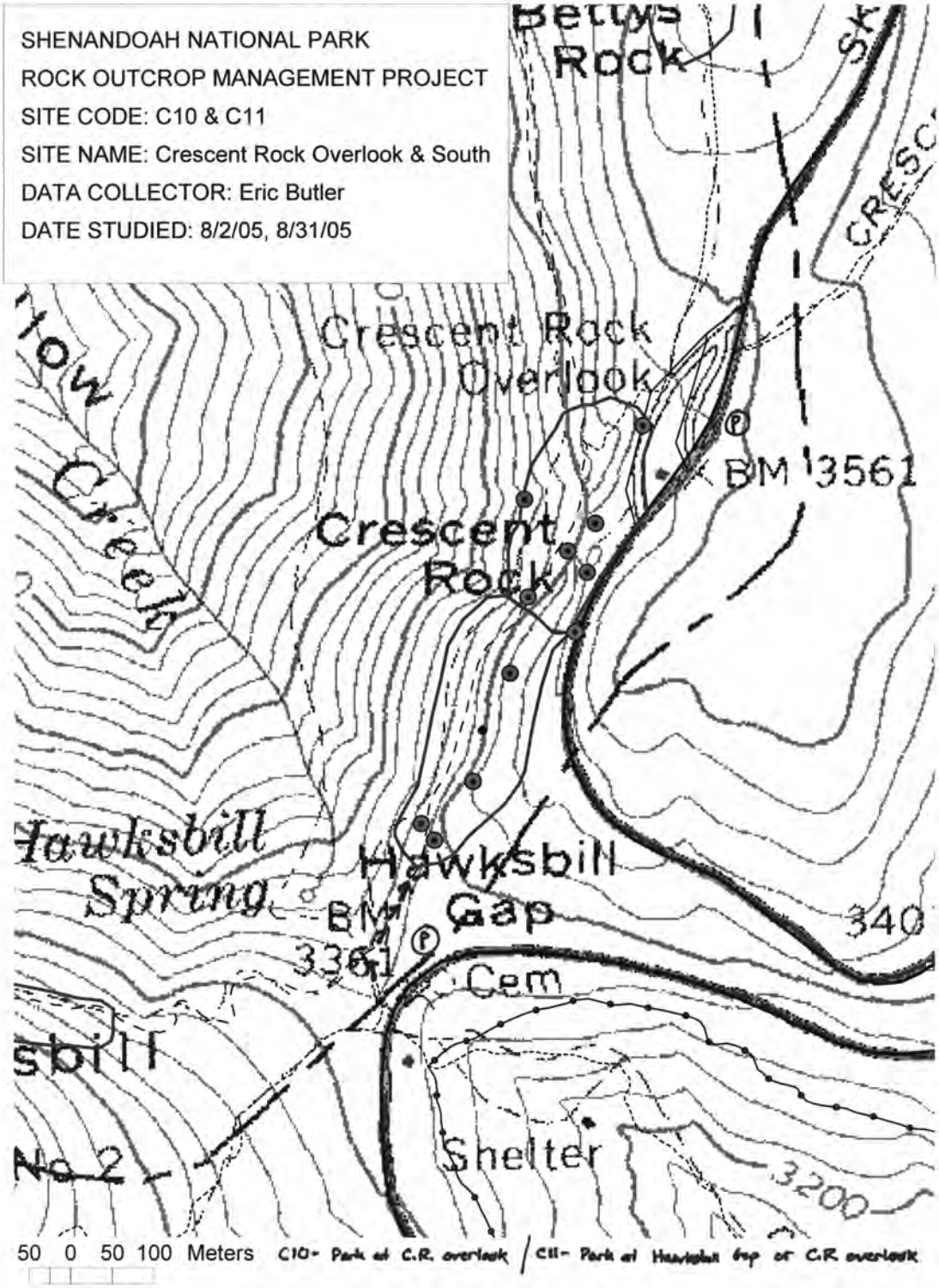
C10 - Crescent Rock Overlook (continued...)

Detail sketch map



C10 - Crescent Rock Overlook (continued...)

Area sketch map



C10 - Crescent Rock Overlook (continued...)



SHEN_C10_G_20050831_001.jpg Azmuth: 160

View across cleared viewshed for overlook



SHEN_C10_G_20050831_002.jpg Azmuth: 0

Upper impacted ledges of Crescent Rock



SHEN_C10_G_20050831_003.jpg Azmuth: 180

Crescent Rock cliff with vegetated ledges at different levels



SHEN_C10_G_20050831_004.jpg Azmuth:

View down to lower impacted ledges below G115, north end of Crescent Rock

C10 - Crescent Rock Overlook (continued...)



SHEN_C10_G_20050831_005.jpg Azmuth:

Rock graffitti from 8/5/05 on upper ledges of Crescent Rock



SHEN_C10_G_20050831_006.jpg Azmuth:

Metallic deposits within greenstone, near base of cliff below G115



SHEN_C10_G_20050831_007.jpg Azmuth:

Tilted columnar joints along AT near base of Crescent Rock



SHEN_C10_G_20060216_001.JPG Azmuth:

View of site through zoom lens from Hawksbill summit

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C11 - Crescent Rock South

Site Code: C11
Site Name: Crescent Rock South
Data Collector Butler, Eric
Date Studied: 02-Aug-05

Polygon Centroid: **E:** 727825 **N:** 4271127
UTM (Zone 17 NAD83)
Dimensions (m): 130 x 340 (GIS est.)
Elevation Range (ft): 3280 to 3480

Physical Characteristics

Location Acces

There are several options for accessing this site. One is to park at Crescent Rock Overlook (south of Milepost 44), take the cutoff trail to the Appalachian Trail (AT), which leaves from the Bettys Rock trail just north of the overlook, then hike the AT a short distance south. Another is to park at Crescent Rock Overlook and walk south along Skyline Drive past Crescent Rock itself, and past the short cleared viewshed along the drive. Where the forest returns, turn west into the woods and follow the gentle slope to the northern exposure; alternatively, continue along Skyline Drive until the road swings to the east, then turn west into the woods and follow the gentle slope to the southern exposures. A third option involves parking at Hawksbill Gap, a bit further south, and following either the AT north to the base of the site, or cutting up through the gentle slope in the woods to reach the top of the southern exposures. All of these options involve easy walks along trails and/or mostly open forest and gentle slopes. There is a very gentle slope behind and above these cliffs, so that walking along them is very easy.

Physical Description:

This site consists of a single line of cliffs, stretching south from the major exposure at Crescent Rock (C10). The escarpment is continuous, though the cliffs have occasional breaks that separate individual exposures. These cliffs begin just south of Crescent Rock, and end near Hawksbill Gap, where the slope gentles and wraps east into the gap. The ledges atop these cliffs are mostly open, and in places are almost meadow-like. Where the main line of cliffs ends (G123), the slope descends to a smaller exposure whose base is directly along the Appalachian Trail (AT). Otherwise, a talus/soil slope continues along the base of the cliffs into the forest between the cliffs and the AT. In the woods above the cliffs, between the upper ledges and the AT, a rampart of talus about 5m high extends for some distance, fading back into the slope to the north and south.

Vegetation: Moderate

With a few exceptions, the forest above and to the east of the cliffs is open and easy to walk through, although some of the trees are low and require stooping. The talus slopes below the cliffs are more thickly vegetated.

Human Effects

Impacts: Moderate

Although no social trails lead directly to the site from outside areas, there is evidence of trails leading along the cliffs, and some of the ledges appear impacted. In addition, a recent-looking fire pit was discovered in one of the meadow-like areas just above the cliffs, and some trash can be found in the area.

Access Easy

The Appalachian Trail (AT) runs along the base of this escarpment, offering easy access in several places along talus/soil slopes that can be scrambled up to reach the cliffs. Above the cliffs, some vague social trails lead through the grassy areas behind the ledges, though these do not seem to directly connect to any access point. Although no signs or trails lead to this site, and it is not directly visible from Skyline Drive, it is very close to the AT and two heavily used parking areas, and the gentle, open forest slopes leading to it are easy for visitors to explore.

Geologic Characteristics

Lithology:

Rock Type Greenstone

This area is underlain by greenstone of variable composition, very similar to the rock found at Crescent Rock Overlook (C10). In general, the rock is fine-grained and green-grey, with a variable amount of cleavage. The solid, layering-dominated rock seen near the top of Crescent Rock does not seem to be present here. Around 3340', along the Appalachian Trail near the south end of the site, a unit of dark, very finely layered rock appears, which contains many pockets and veins of dark, metallic material. This unit appears deformed, and may represent an ash or sediment bed. This is very similar to a unit found near the base of Crescent Rock, to the north.

C11 - Crescent Rock South (continued...)

Structure:

Columnar joints are common, though generally poorly preserved. Subtle to dominant cleavage is the major structure in these cliffs, creating ledgy exposures where present.

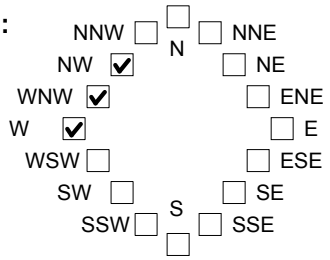
Other:

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	70.0	0.0	0.0	20.0	10.0	100
Max relief(m):	10	0	0	2	5	

Maximum Slope: 35 **Texture:** Rough

Aspects:



Setting:

This site appears to be contained within a single lava flow. The continuous line of cliffs, with topographic benches above and below, is a typical exposure pattern. The stratigraphy here requires comparison to Crescent Rock, immediately to the north, and raises the question of whether these cliffs are the same lava flow as Crescent Rock, or a flow immediately below. It is difficult to correlate these two sites on the ground, as intervening talus slopes and lack of connecting outcrop obscures the relationship.

The stratigraphy of these flows is very similar to that of the lower portion of Crescent Rock, particularly the presence near the base of both exposures of a distinct layered unit with metallic deposits. In addition, both exposures have a clear zone of columnar jointing 20'-40' above this layered unit. Based on the stratigraphy, it seems possible that these southern cliffs are in fact an extension of the same flow that forms Crescent Rock, and for some reason the upper portion of the flow is not present here. This missing upper unit may be represented by the linear rampart of talus which is found in the woods above the cliffs, but below Skyline Drive.

On the other hand, these cliffs are topographically significantly lower than Crescent Rock, their tops reaching 3440' (roughly the same elevation as the base of Crescent Rock), and correlating the bases of both flows would require a significance gain in elevation along the length of the site. If these two sites are composed of the same flow, the significant topographic bench above the southern cliffs would lead directly into the middle of Crescent Rock, the center of an apparently single flow.

This question, while intriguing, does not directly affect the nature of the rock exposures or plant habitat within the site. The single line of cliffs is clearly itself contained within a single lava flow, and the combination of cleavage and sporadic columnar jointing creates ledgy exposures on which plants can grow. The broad ledges and topographic bench atop these cliffs are the result of a significant structural change within the rocks, whether an actual flow boundary or a major compositional change within a larger flow.

Stability: Moderate

The bedrock is very solid; though the cleavage provides planes of weakness, it is not pervasive enough to generate many loose pieces. The lower slopes can be very loose and slippery, particularly some of the talus/soil chutes below Crescent Rock, where this material funnels between smaller outcrops in the forest. Most of the talus immediately surrounding Crescent Rock and other exposures seems relatively stable.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
8/2/2005	G121-C11	727752	4271015	3340	Base of open rock along AT
8/2/2005	G122-C11	727768	4270995	3400	Top of cliff with knob of columnar joints
8/2/2005	G123-C11	727814	4271065	3440	Open exposures along clifftop; meadow with fire pit
8/2/2005	G124-C11	727858	4271196	3440	Open exposures along clifftop

Site Photos

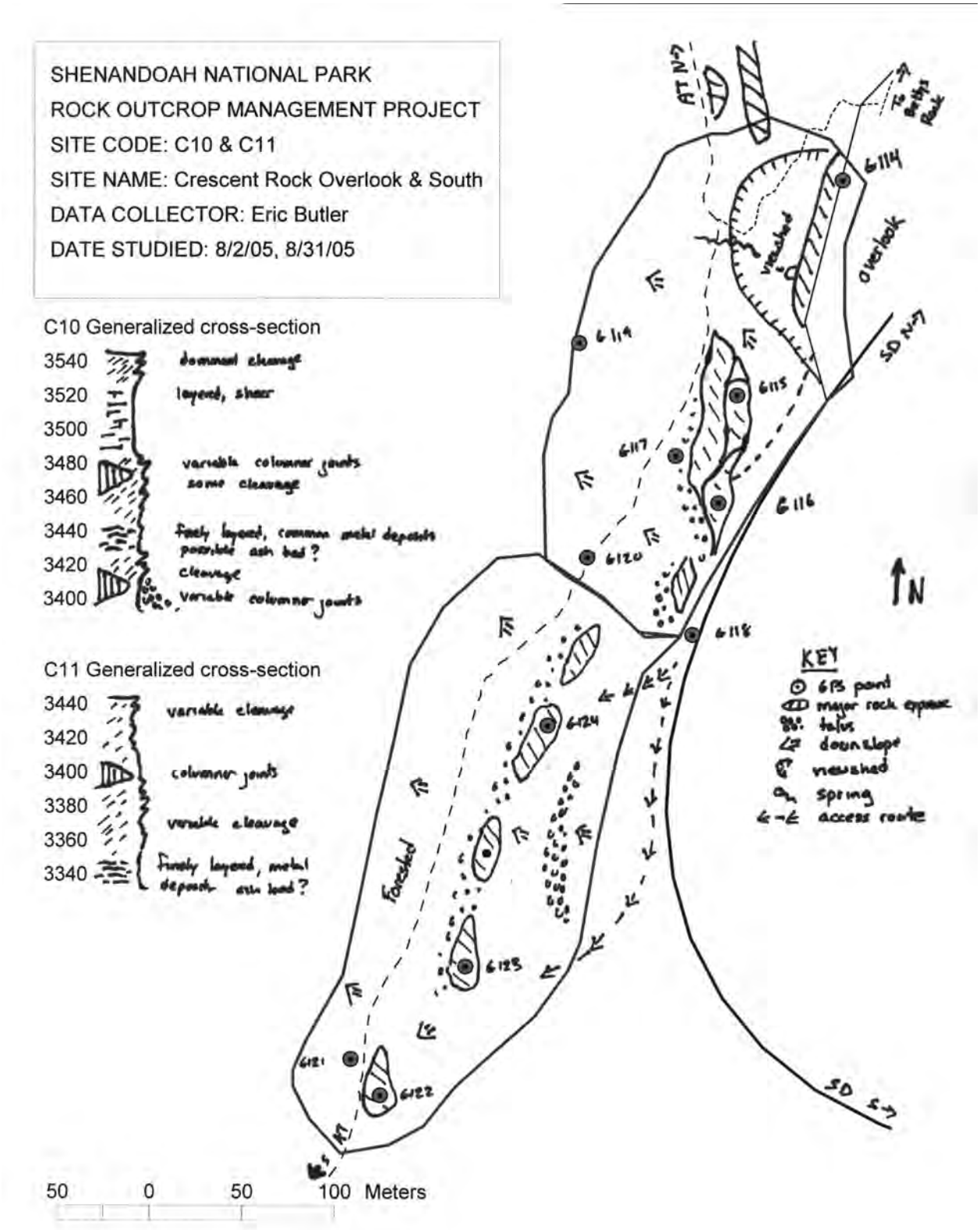
Image Date	GPS Point	File Name	Azmuth	Taken By	Description
8/2/2005	G123-C11	SHEN_C11_G_20050831_001.jpg	260	Butler, Eric	Fire pit in grassy area along cliff ledges (ledges in background)

C11 - Crescent Rock South (continued...)

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
8/2/2005	G123-C11	SHEN_C11_G_20050831_002.jpg	210	Butler, Eric	Broad open ledges with vegetation
8/2/2005	G123-C11	SHEN_C11_G_20050831_003.jpg	30	Butler, Eric	Cliff/ledges with dominant cleavage
8/2/2005	G122-C11	SHEN_C11_G_20050831_004.jpg	235	Butler, Eric	Knob of columnar joints and surrounding ledge

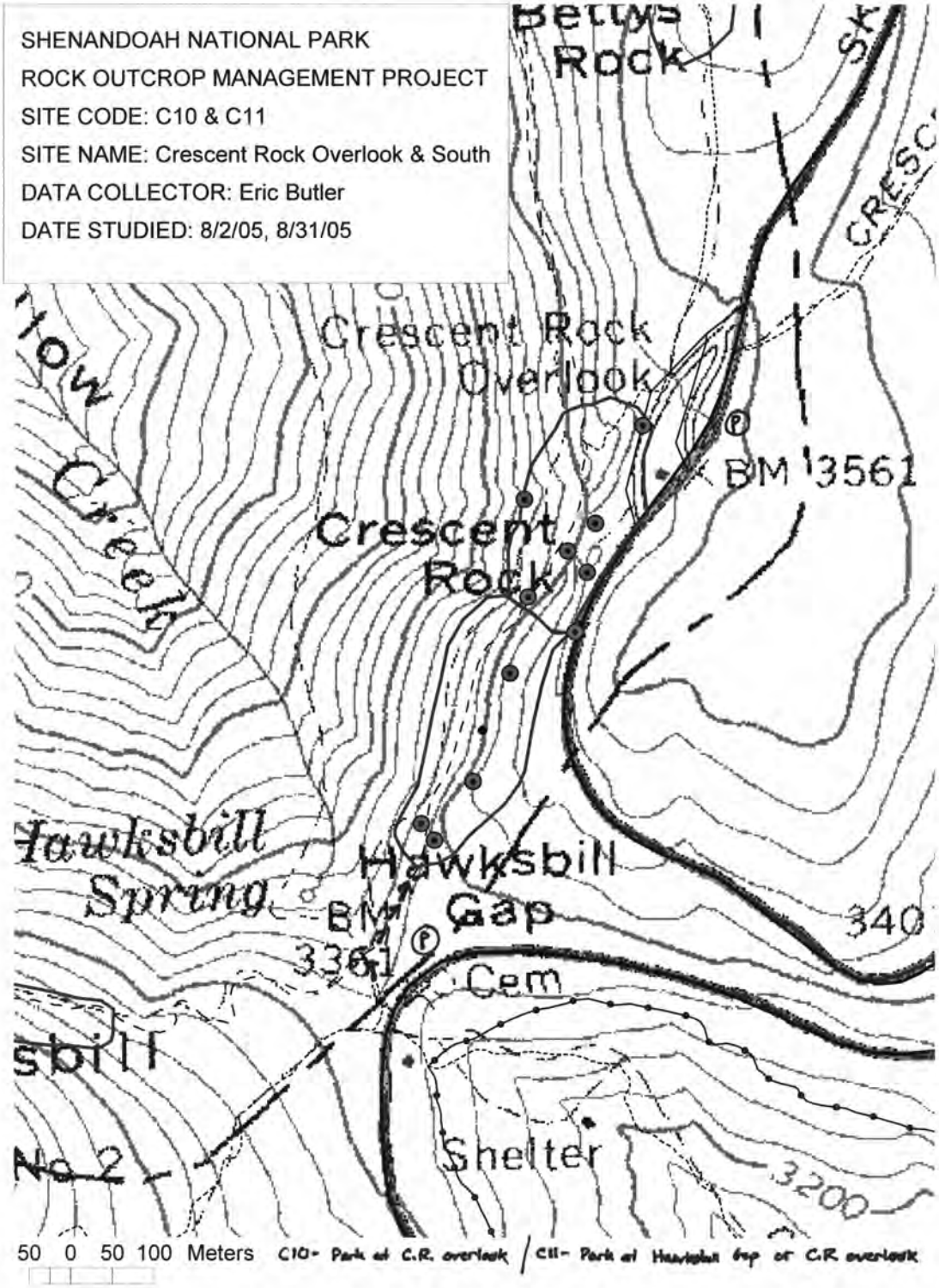
C11 - Crescent Rock South (continued...)

Detail sketch map



C11 - Crescent Rock South (continued...)

Area sketch map



C11 - Crescent Rock South (continued...)



SHEN_C11_G_20050831_001.jpg Azmuth: 260

Fire pit in grassy area along cliff ledges (ledges in background)



SHEN_C11_G_20050831_002.jpg Azmuth: 210

Broad open ledges with vegetation



SHEN_C11_G_20050831_003.jpg Azmuth: 30

Cliff/ledges with dominant cleavage



SHEN_C11_G_20050831_004.jpg Azmuth: 235

Knob of columnar joints and surrounding ledge

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C12 - Dean Mountain Ridge

Site Code: C12
Site Name: Dean Mountain Ridge
Data Collector Butler, Eric
Date Studied: 06-Jul-05

Polygon Centroid: **E:** 716911 **N:** 4252477
UTM (Zone 17 NAD83)
Dimensions (m): 100 x 350 (GIS est.)
Elevation Range (ft): 3200 to 3280

Physical Characteristics

Location Acces

About 700m west of Skyline Drive, between Milepost 61-62. Just south of Bald Face Mountain Overlook, a small gravel road leads through a locked gate to a gravel pit with space for parking. Hike WNW through gently sloping woods over the summit of Dean Mt to find site on west-facing slope.

Physical Description:

This site consists of scattered rock outcrops, most only a few meters tall, in two clusters at the north and south ends of the site. In between these clusters is about 100m of gently sloping forest. In both clusters, the tallest outcrop is at the base of the site, with smaller outcrops scattered above.

Vegetation: Open

The access route and site are mostly fully forested with open under story, though there are some thick nettles along the access. Navigation through the site is not in any way hampered by vegetation.

Human Effects

Impacts: Pristine

The access route passes a small cemetery at the end of the gravel pit, but there are no trails leading to the site and no indication of any human visitation.

Access Remote

Although the site is relatively close to Skyline Drive, there is no indication of its existence, no trails nearby, and no reason for any visitor to bushwhack 700m to reach it. The Dry Run Falls fire road passes below the site, but none of the rock exposures are large or open enough to be visible from this road, and it would be a 500’ vertical climb to reach the site.

Geologic Characteristics

Lithology:

Rock Type Greenstone

All exposures within the site are composed of Catoctin Formation metabasalt. The rock is lighter in color here than in some parts of the park, appearing light-medium grey on a freshly broken surface. It is very fine-grained and shows little evidence of internal structures such as flow bedding.

Structure:

There is a dominant cleavage in most outcrops within the site, producing a strong planar texture that dips steeply to the east. The cleavage is less developed toward the base of the site, where several larger outcrops are more massive.

Other:

Below the site boundary at G087, several boulders in a talus field are composed of volcanic breccia that indicates a flow boundary, although their provenance is unclear.

Geomorphic Characteristics

C12 - Dean Mountain Ridge (continued...)

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	0.0	60.0	0.0	30.0	10.0	100
Max relief(m):	0	10	0	1	1	

Maximum Slope:

Texture: Rough

Aspects:

N ☐ NNE ☐ NE ☐ ENE ☐ E ☐ ESE ☐ SE ☐ SSE ☐ S ☐ SSW ☐ SW ☐ WSW ☐ W ☑ WNW ☑ NW ☐ NNW ☐

Setting:

The steeply dipping cleavage is the dominant geomorphic agent here, producing planes of weakness along which platy boulders are formed. The eastward dip of the cleavage, into the slope, produces outcrops which jut out from the surrounding slope, as well as slightly protected ledges at the top and bottom where soil can form. It seems likely that all exposures within the site are from one lava flow, given the homogeneity of the scattered outcrops and lack of evidence to the contrary. The larger drop-offs found at the base of both outcrop clusters may be the result of more resistant greenstone at the base of this flow.

Stability: Stable

Despite the dominant cleavage, the outcrops are quite solid. The few occurrences of talus are low-slope and easy to walk on.

GPS Points

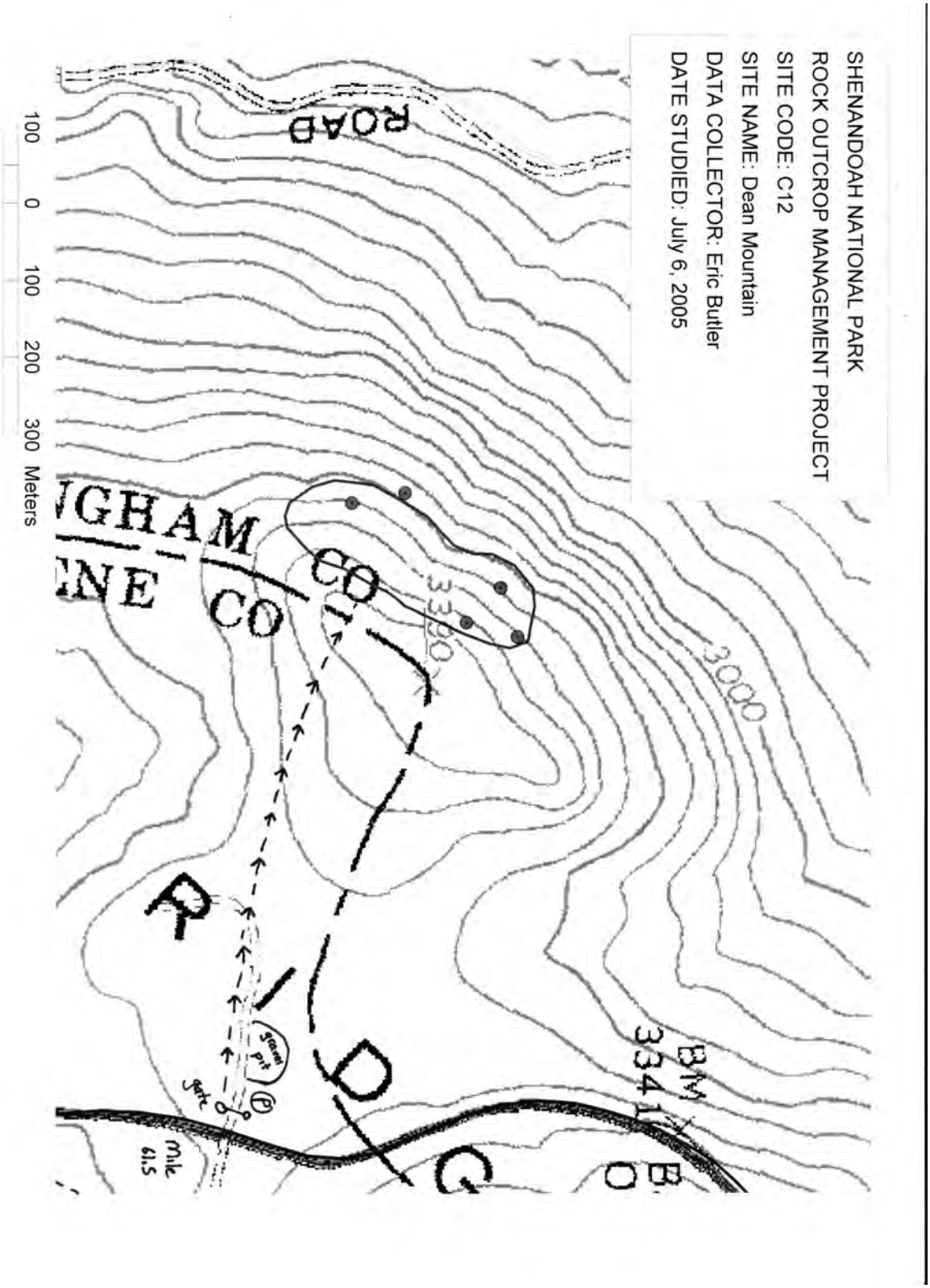
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
7/6/2005	G084-C12	716988	4252550	3320	Upper outcrop with typical steeply dipping cleavage
7/6/2005	G085-C12	717007	4252617	3280	Northernmost outcrop
7/6/2005	G086-C12	716942	4252595	3240	Outcrop 5m tall
7/6/2005	G087-C12	716818	4252470	3200	Isolated outcrop below site boundary
7/6/2005	G088-C12	716831	4252401	3240	Largest outcrop in site, appx. 10m high

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
7/6/2005	G084-C12	SHEN_C12_G_20050706_001.jpg	10	Butler, Eric	Typical outcrop with steeply dipping cleavage
7/6/2005	G086-C12	SHEN_C12_G_20050706_002.jpg		Butler, Eric	Possible rare plant, later determined not to be so

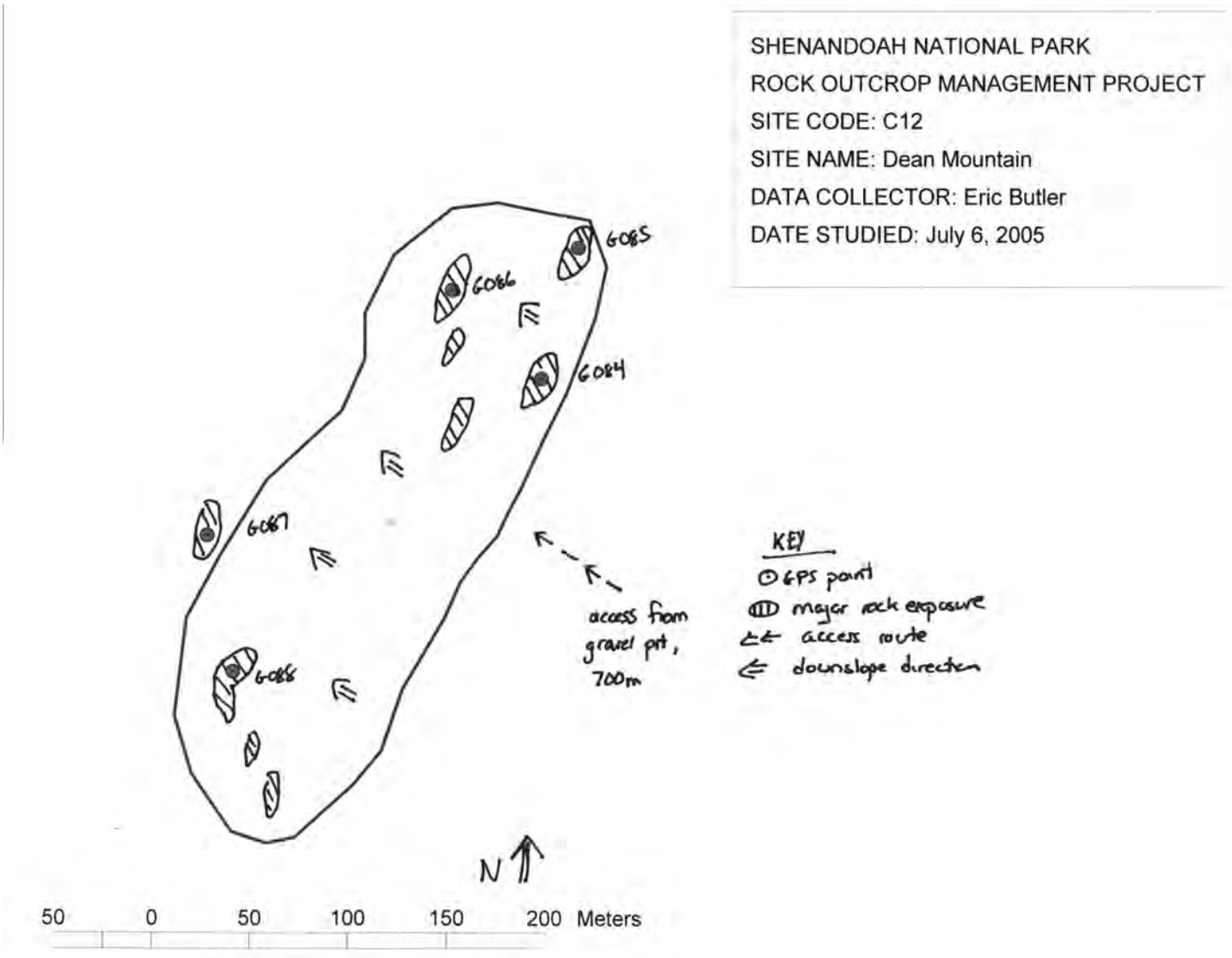
C12 - Dean Mountain Ridge (continued...)

Area sketch map



C12 - Dean Mountain Ridge (continued...)

Detail sketch map



C12 - Dean Mountain Ridge (continued...)



SHEN_C12_G_20050706_001.jpg Azmuth: 10

Typical outcrop with steeply dipping cleavage



SHEN_C12_G_20050706_002.jpg Azmuth:

Possible rare plant, later determined not to be so

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C13 - Dickey Hill

Site Code: C13
Site Name: Dickey Hill
Data Collector Butler, Eric
Date Studied: 21-Jun-05

Polygon Centroid: **E:** 742112 **N:** 4304117
UTM (Zone 17 NAD83)
Dimensions (m): 260 x 540 (GIS est.)
Elevation Range (ft): 1500 to 1920

Physical Characteristics

Location Acces

This site is located 400m SW of Signal Knob Overlook, down a forested slope. Access is through woods at north end of overlook, to avoid cleared viewshed thickets, then hike SW down slope. Around 2000', an old road leads south, gradually descending to around 1900', and this provides a relatively easy route toward the site.

Physical Description:

This site consists of two exposed bedrock areas at roughly the same elevation, separated by about 150m of forested slope. Both exposures are similar, with a series of small cliffs 1-3m high separated by wide, thickly vegetated ledges, creating a staircase-like topography. Access to the intermediate benches between cliffs can be difficult, as they are separated by drops just far enough to provide a barrier, and it is best to hunt for a break in the cliffs. Toward the base of the exposure, 1-2 larger cliffs appear, with a maximum height around 10m. Below this level, the slope is gentler and fully forested again, as above the exposures. A few open talus fields occur among and below the cliff/ledge complexes, but most of the talus is in forest or under thick vegetation. One notable exception is a large, linear talus field 20m x 100m that extends directly downslope between the two exposure areas. This field parallels a pronounced raised rib in the slope which can be clearly seen on a topographic map.

Vegetation: Dense

Though the approaches to the site are through open, mature forest, the exposure areas are densely vegetated and can be difficult to negotiate. Thick grasses, fallen logs, vines, and briars all contribute to the barriers.

Human Effects

Impacts: Pristine

There is no evidence of any human visitation here. There is an old, abandoned road running along the top of the site boundary around 1900', but it is heavily overgrown. No compaction, trash, trails, or any other human sign are present.

Access Remote

Although the site is very close to Skyline Drive, it is completely hidden from view. There are no trails or other indicators of its existence, and it is located in an area where few visitors would think to explore. In addition, the slope below most of SD in this area is a cleared viewshed, with dense thickets further discouraging off-road exploration down the steep slope.

Geologic Characteristics

Lithology: **Rock Type** Greenstone

The site is entirely greenstone of the Catoctin Formation. It is very fine-grained, green-grey, and fairly iron-rich, generally weathering to a rusty brown. At the top of the exposures vesicles are common, and the rock contains more epidote than elsewhere. Some areas appear to contain remnant flow bedding. Although there are at least three distinct benches divided by cliffs within the exposures, the bedrock contains no evidence that these are separate basalt flows.

Structure:

There are no obvious joint sets within the site, but columnar joints are common. Evidence of these can be found intermittently throughout the site, but they are most common and well-developed toward the base of the exposures, especially in the larger, bottom cliffs. The columns are generally vertical, perpendicular to the near-horizontal orientation of the basalt flows, and appear to help control the erosion of the bedrock.

Other:

There is one site at the very base of the northern exposure where horizontal columnar joints are exposed in a sheer cliff around 10m high. This is very unusual, especially as vertical columns can be found within bedrock a short distance to the south. This cliff may in fact be a very large, loose block that has broken away from the slope and tilted 90 degrees, with the space in

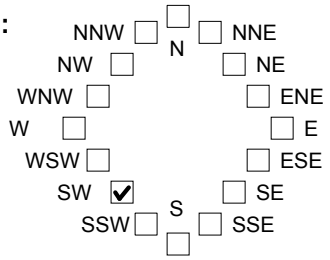
C13 - Dickey Hill (continued...)

between filled by talus, soil, and thick vegetation. This interpretation could not be confirmed in the field. While the columnar jointing helps control the formation of cliffs higher in the site, the base of this cliff is forested and holds no plant communities, so the unusual orientation here does not seem particularly relevant.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	40.0	0.0	0.0	40.0	20.0	100
Max relief(m):	10	0	0	2	30	

Aspects:



Maximum Slope:

Texture: Rough

Setting:

The two separated areas of exposure appear to both originate in the same basalt flow. Both areas have the same staircase-like cliff/ledge pattern, the bedrock erodes in similar ways, and no significant lithologic difference can be identified. In addition, both exposures are at roughly equivalent elevations, and are the only notable cliff areas in the surrounding topography. Beyond the site boundaries, other outcrops and small cliffs appear at similar elevations along the slope, and are likely also related to this cliff-forming unit.

There is no easy explanation for the long, linear talus field located between the two exposures. There is no cliff or other source above the talus, and no obvious constraining topography around it. One possibility is a minor fault trending E-W, similar to others in the park, that would heavily fracture the rocks and produce such a linear feature, but there is no other exposure or evidence to support this idea. Another possibility is that this talus field is simply a small remnant of much larger fields that have been swallowed by forest and soils, but the boundaries here appear fairly sharp and the surrounding slopes do not seem rocky enough, even accounting for soil development. In addition, this talus field appears to have a convex cross-section that protrudes from the surrounding slope, which implies that this is a unique feature rather than simply a remnant of a larger feature. Another possibility is that this talus field is a remnant of a rock glacier, which is a periglacial feature formed when large amounts of talus move downslope in an icy matrix that behaves similarly to a regular glacier. This mechanism has been proposed for quartzite boulder fields in the South District, and could certainly have acted here as well.

Stability: Moderate

The bedrock is solid and not heavily fractured, other than the columnar jointing, but the surrounding talus and soil slopes are steep and very loose. A loosened rock can easily roll tens of meters before stopping.

GPS Points

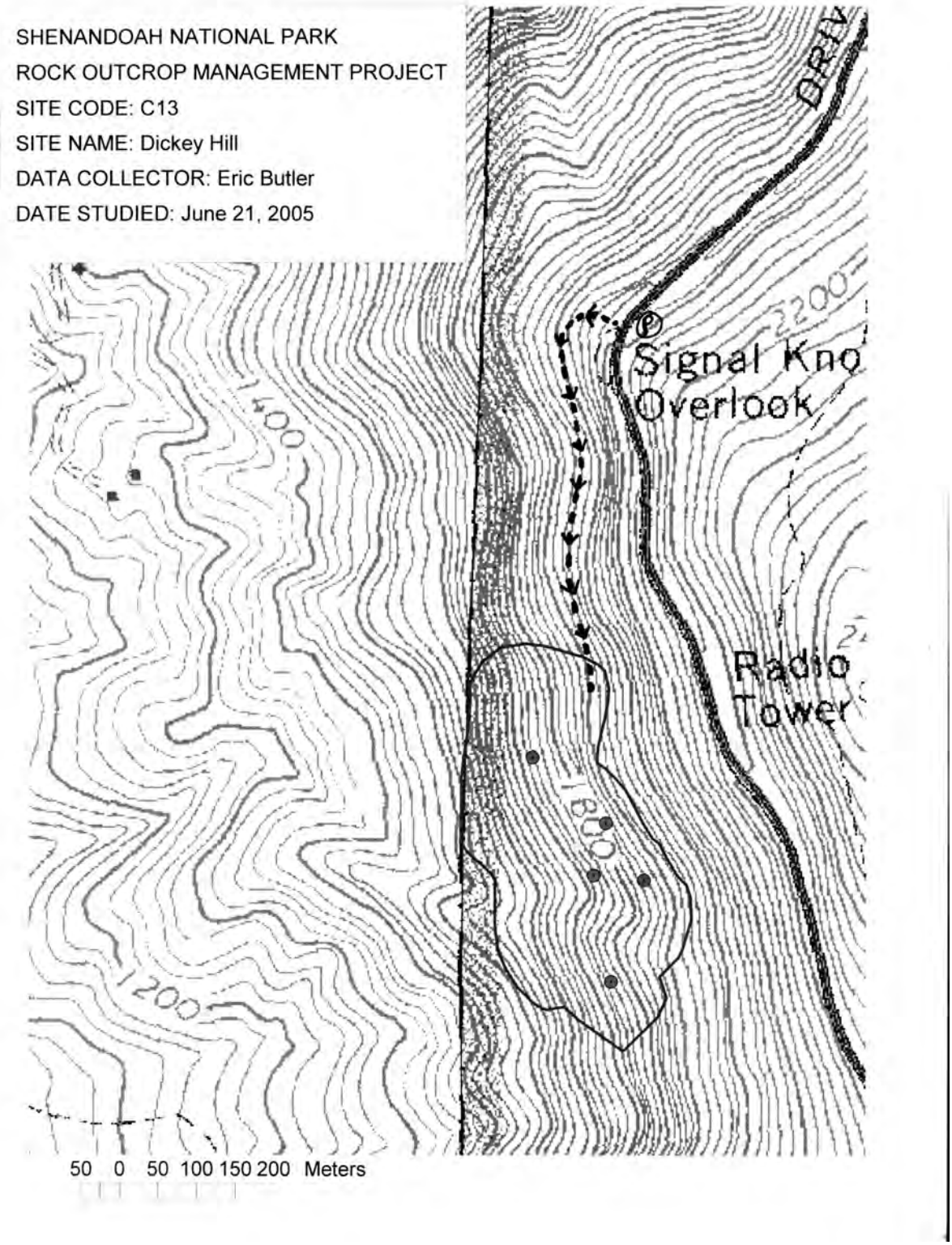
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
6/21/2005	G066-C13	742056	4304233	1720	Top of ledgy cliff at NW of site
6/21/2005	G067-C13	742136	4304081	1720	Base of long, linear talus field
6/21/2005	G068-C13	742201	4304075	1840	Top of long, linear talus field
6/21/2005	G069-C13	742158	4303944	1740	Southern extent of rock exposure
6/21/2005	G070-C13	742151	4304148	1820	Higher elevation rock exposure

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
6/21/2005	G066-C13	SHEN_C13_G_20050621_001.jpg	160	Butler, Eric	View of horizontal columnar joints in cliff – possible rotated loose block? Below G066
6/21/2005	G068-C13	SHEN_C13_G_20050621_002.jpg	270	Butler, Eric	Top of major talus field, looking downslope to west
6/21/2005	G070-C13	SHEN_C13_G_20050621_003.jpg	340	Butler, Eric	General view of heavily vegetated, ledgy outcrops

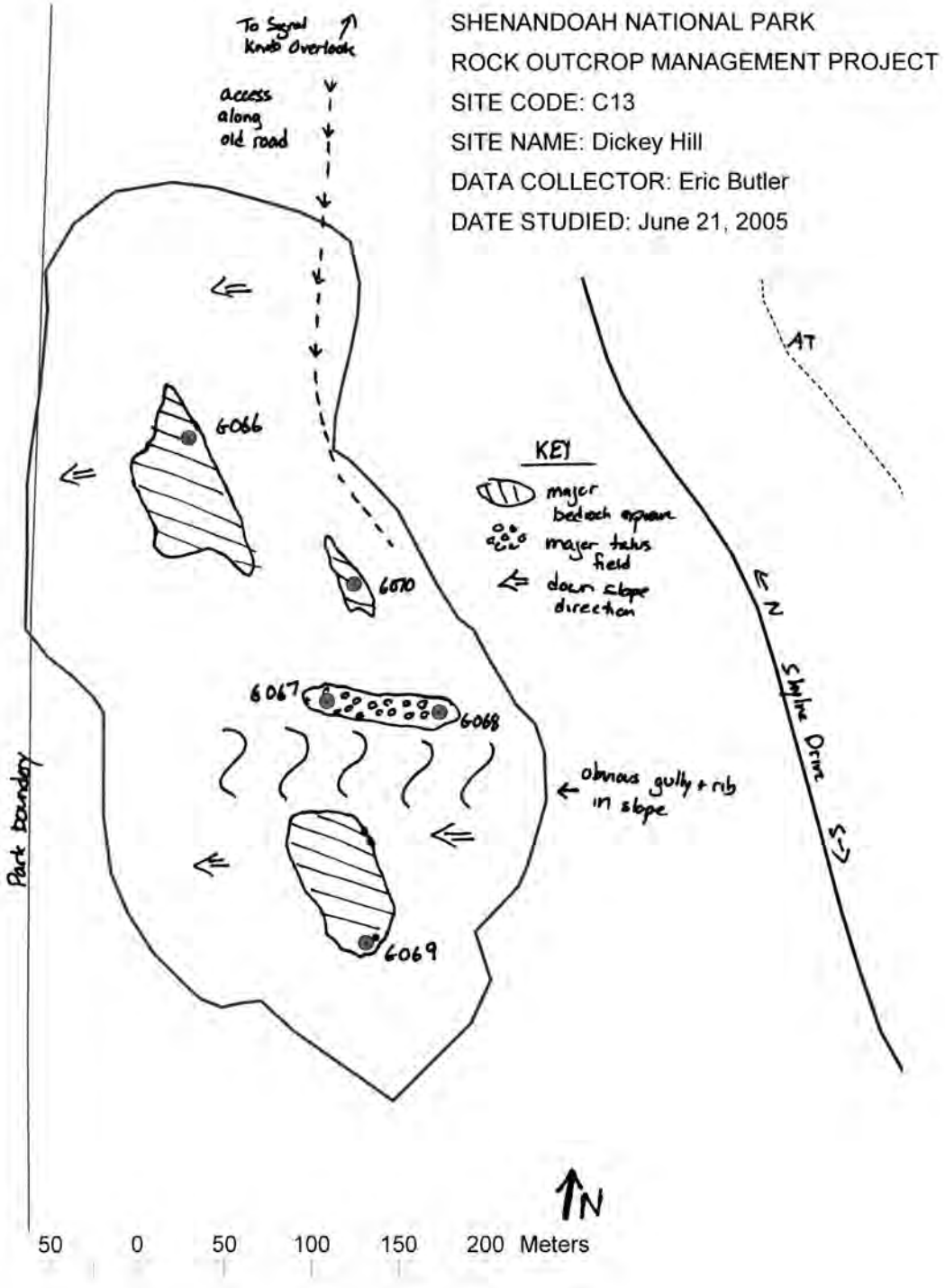
C13 - Dickey Hill (continued...)

Area sketch map



C13 - Dickey Hill (continued...)

Detail sketch map



C13 - Dickey Hill (continued...)



SHEN_C13_G_20050621_001.jpg Azmuth: 160

View of horizontal columnar joints in cliff – possible rotated loose block? Below G066



SHEN_C13_G_20050621_002.jpg Azmuth: 270

Top of major talus field, looking downslope to west



SHEN_C13_G_20050621_003.jpg Azmuth: 340

General view of heavily vegetated, ledgy outcrops

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C14 - Dickey Ridge

Site Code: C14
Site Name: Dickey Ridge
Data Collector Butler, Eric
Date Studied: 07-Jun-05

Polygon Centroid: **E:** 741857 **N:** 4306612
UTM (Zone 17 NAD83)
Dimensions (m): 180 x 310 (GIS est.)
Elevation Range (ft): 1640 to 1700

Physical Characteristics

Location Acces

About 100 vertical feet down slope from Skyline Drive, approximately 700m northwest of Dickey Ridge Visitors Center. North of the Visitor's Center, park along Skyline Drive just before the next stone wall & cleared viewshed, and hike 200m west, angling down slope. The site is just below the bottom of the cleared Skyline Drive viewshed.

Physical Description:

This site consists of an open clearing surrounded by forest. The slope is steep (around 35 degrees) and is composed of an even mix of open rock outcrops and vegetated talus. The clearing is dotted with small trees but is mostly thick grass and other low vegetation covering most of the surface that is not bare bedrock. At the base of the open site, a small cliff extends intermittently across the slope and marks the transition from open vegetation back into forest.

Vegetation: Open

Surrounding forest has very little undergrowth, with a few thicker patches along the edges of the clearing. Within the exposures, the vegetation is thick but low, and does not hamper movement.

Human Effects

Impacts: Pristine

There is no evidence that humans visit this site. There are several deer trails in the surrounding forest, but they do not connect to Skyline Drive or any other human access point.

Access Remote

Although the site is very close to Skyline Drive and Dickey Ridge Visitor's Center, it is invisible from the road. It is located down a steep, forested slope with no nearby parking, trails, or any evidence of its existence. There would be no reason for any visitor to venture near this area on foot.

Geologic Characteristics

Lithology:

Rock Type Greenstone

The site is predominately greenstone of the Catoctin Formation, mostly dark grey or green. On some freshly broken faces, crystals of plagioclase and olivine can be observed. There are occasional pockets of quartz and epidote, as well as veins of actinolite. Many outcrops have a rough, rubbly, almost step-like texture that may be the result of remnant bedding in the lava. Few internal structures are clearly visible, with the exception of some well-preserved flow bedding in an outcrop near the SW corner of the site.

Structure:

The bedrock is heavily fractured. At any specific location, a clear joint set may be observed, but there does not seem to be any dominant orientation of these fractures site-wide.

Other:

The greenstones here appear heavily weathered, most surfaces appearing dark red-orange from oxidation of iron-bearing minerals. Freshly broken faces commonly reveal deep weathering rinds, sometimes over 1cm thick. Exposed surfaces commonly have a rough, sandy feel, and a grainy look, which may be the result of preferential weathering of unstable minerals like pyroxene and olivine, leaving feldspars behind in relief.

The talus deposits commonly contain blocks of vesicular greenstone, exposures of which cannot be found anywhere in the bedrock of the site. These blocks appear to come from a line of outcrops 20m above the site, directly at the base of the cleared Skyline Drive viewshed, where in-place bedrock shows evidence of a contact between lava flows, including vesicles, jasper, and breccia.

C14 - Dickey Ridge (continued...)

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	0.0	40.0	0.0	0.0	60.0	100
Max relief(m):	0	3	0	0	20	

Aspects:

NNW ☐	☐ N	☐ NNE
NW ☐		☐ NE
WNW ☐		☐ ENE
W ☐		☐ E
WSW ☐		☐ ESE
SW ☐		☐ SE
SSW ☑	☐ S	☐ SSE

Maximum Slope:

Texture: Rough to fractured

Setting:

The exposures here are contained within a single greenstone lava flow. There is no evidence of a boundary between two flows within the bedrock, and clear exposures of boundary-type rocks just upslope constrain the top of this flow. The bottom of the flow may be marked by the small cliff at the lower edge of the site, although no obvious deposits prove this. The sloping, ledgy nature of the bedrock may be due to original layering within the basalt, as well as the chaotic fracturing that prevents the formation of linear cliffs. The surrounding topography may also play a role in resisting the development of larger cliffs; this site sits within a long, consistent slope, and there is no particular factor that would encourage erosion to develop anything more dramatic at this particular site.

The heavy chemical weathering of the bedrock surfaces suggests that these rocks have been exposed in-place for a long time; in other words, are not actively undergoing physical erosion in the same manner as a cliff. The surrounding forest contains similar patterns of small bedrock outcrops surrounded by talus slopes, although developing soil has partially buried these features. This site may be a remaining fragment of the Ice-Age landscape here, when vegetation was scarce and the mountain slopes were undergoing significant physical weathering from fluctuations in temperature, wind, ice, and water, producing slopes covered in talus and bedrock. It is not clear why this particular area has withstood the encroaching forest for so long; it may be the center of a once-larger area that is still actively shrinking, or perhaps the talus is thicker here and has retarded the development of soils appropriate for trees and larger vegetation.

Stability: Moderate

This depends greatly on the weather conditions. The talus is relatively stable, and the thick grasses and vegetation aid footing, but when wet this site is extremely slick.

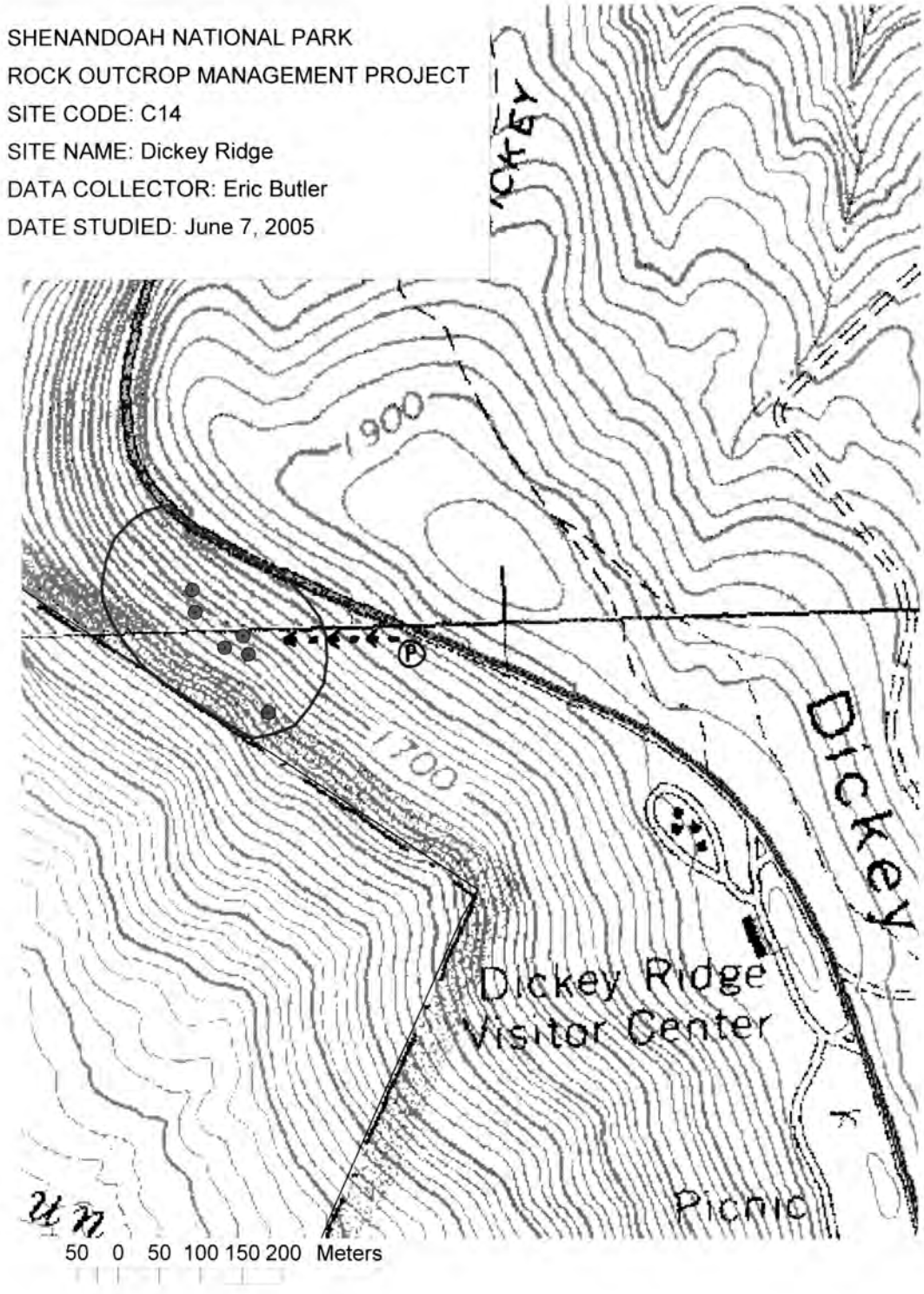
GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
5/24/2005	G016-C14	741923	4306502		
5/24/2005	G017-C14	741831	4306650	1710	NW corner of exposure
6/7/2005	G026-C14	741834	4306623	1668	SW corner of exposure
6/7/2005	G027-C14	741899	4306572	1646	Additional small cleared area
6/7/2005	G028-C14	741892	4306594	1644	NE corner of exposure
6/7/2005	G029-C14	741870	4306580	1595	SE corner of exposure

Site Photos

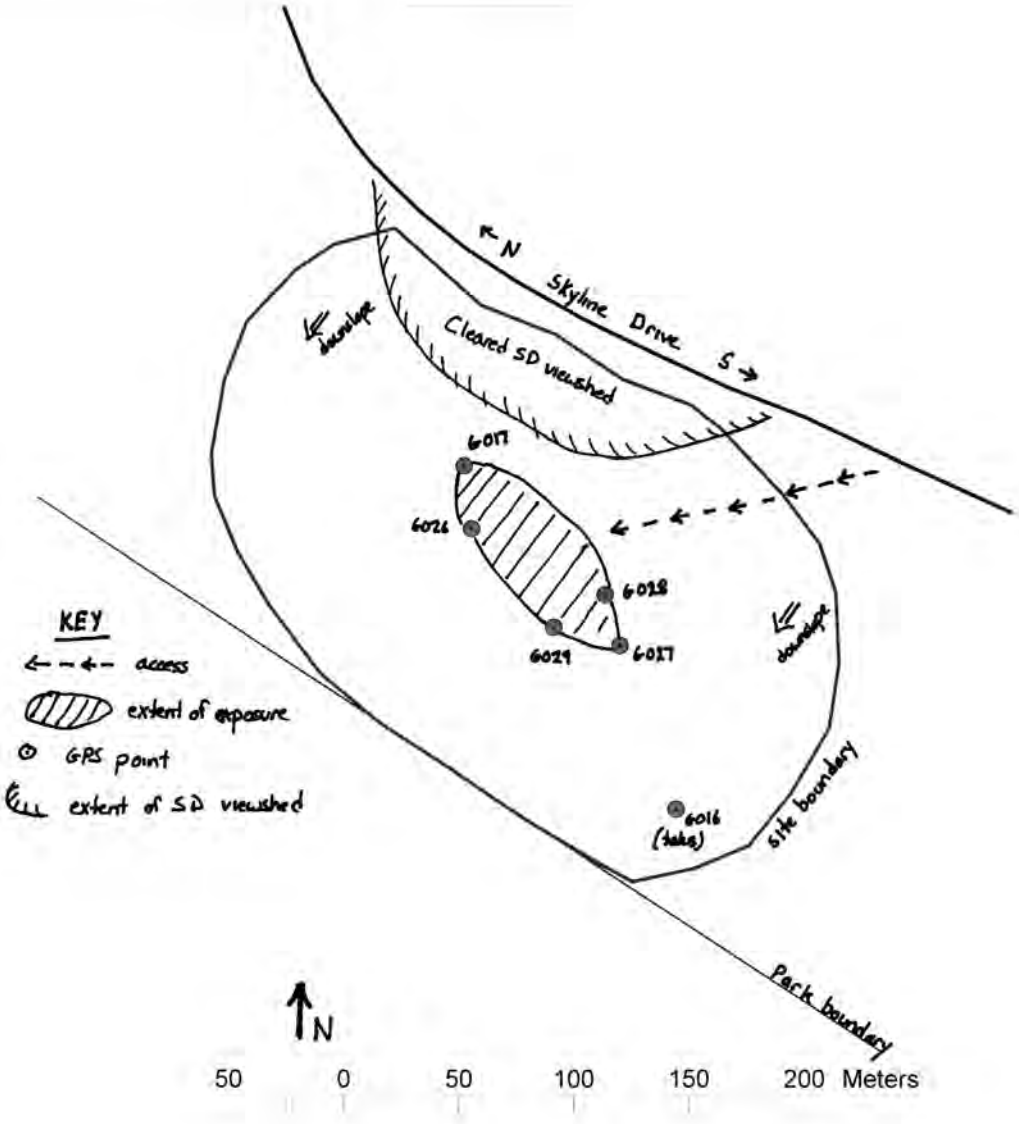
Image Date	GPS Point	File Name	Azmuth	Taken By	Description
6/7/2005	G026-C14	SHEN_C14_G_20050607_001.jpg		Butler, Eric	Original flow layering in greenstone – may have been altered by developmont of cleavage
6/7/2005	G026-C14	SHEN_C14_G_20050607_002.jpg		Butler, Eric	Closeup of fresh face from 001, showing greenstone texture & iron-covered veins/cleavages
6/7/2005		SHEN_C14_G_20050607_003.jpg	135	Butler, Eric	General view SE across site, showing steep slope and outcrops surrounded by vegetation

C14 - Dickey Ridge (continued...)

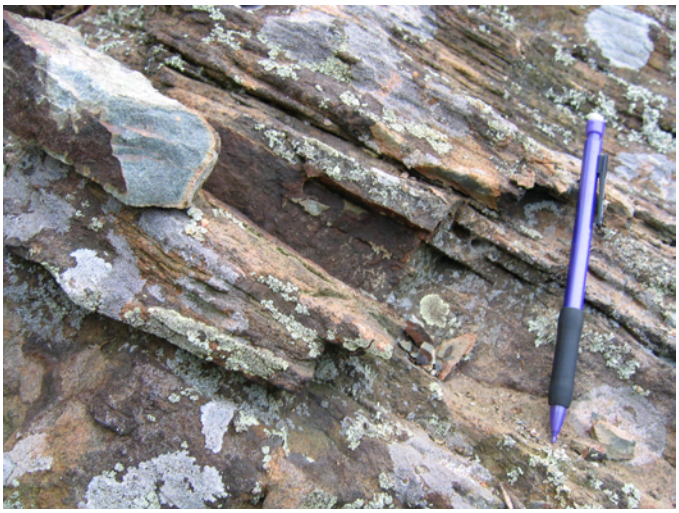


C14 - Dickey Ridge (continued...)

SHENANDOAH NATIONAL PARK
ROCK OUTCROP MANAGEMENT PROJECT
SITE CODE: C14
SITE NAME: Dickey Ridge
DATA COLLECTOR: Eric Butler
DATE STUDIED: June 7, 2005



C14 - Dickey Ridge (continued...)



SHEN_C14_G_20050607_001.jpg Azmuth:

Original flow layering in greenstone – may have been altered by developmont of cleavage



SHEN_C14_G_20050607_002.jpg Azmuth:

Closeup of fresh face from 001, showing greenstone texture & iron-covered veins/cleavages



SHEN_C14_G_20050607_003.jpg Azmuth: 135

General view SE across site, showing steep slope and outcrops surrounded by vegetation

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C15 - Franklin Cliffs North

Site Code: C15
Site Name: Franklin Cliffs North
Data Collector Butler, Eric
Date Studied: 02-Feb-06

Polygon Centroid: **E:** 725148 **N:** 4269140
UTM (Zone 17 NAD83)
Dimensions (m): 130 x 500 (GIS est.)
Elevation Range (ft): 2960 to 3280

Physical Characteristics

Location Acces

There are two good access routes to this site. First, park at Franklin Cliffs Overlook (Milepost 49). From here, hike north along Skyline Drive about 300m, then turn north into the woods at a saddle. Continue north up a gentle slope to reach the upper cliffs at the south end of the site. Alternatively, park at Spitler Knoll Overlook (Milepost 48) and hike south along Skyline Drive about 400m, then leave the road and loop west below a small knob, entering the northern portion of the site through a gentle saddle. The site can also be approached along the Appalachian Trail from north or south, but this involves a significant ascent through steep, rugged, bouldery slopes, and is less efficient than approaches from higher elevations along Skyline Drive.

Physical Description:

This site is dominated by a single line of cliffs reaching 40m in height and stretching the length of the site nearly unbroken. These cliffs are angled noticeably up to the north, but form a continuous rock unit over the entire distance. Below this cliff line, the slope is steep, rugged, and thickly vegetated, making approaches from below difficult. Many smaller rock outcrops occur in this area, but these are not open. Above the major cliff line, a noticeable topographic bench extends about 10-20m east from the ledge tops for much of the site, angled up to the north. This bench provides an excellent access and transit route within the site, as it has little obstructing vegetation and few obstacles. There is another, smaller cliff line above and to the east of the main cliffs, reaching their height to the south and slowly dwindling to the north. These cliffs are mostly forested, although some ledges and talus are partially exposed, particularly to the south. The Appalachian Trail (AT) briefly touches the site boundary in the south, but remains at a relatively consistent elevation while the rock exposures climb steadily to the north, so that the AT is not a good access route for most of the site. To the east, the slopes are gentle and covered in open forest, so that they are generally very easy to navigate.

Vegetation: Moderate

Near the cliffs, and particularly beneath them, the vegetation can be very thick, including brambles and laurels. The forest along the east slopes, and the dividing bench, is more mature and open, and easy to navigate. The southern portion of the site, where the bench fades into rockier slopes, is also thickly vegetated in places

Human Effects

Impacts: Mild

Traces of social trails can be found in the woods and near the ledge tops, but these are not well developed or continuous. The ledges appear pristine, based on lichen and plant coverage, so any impact seems minimal. No trash, graffiti, or other signs of human use were found. No identifiable social trail leads to the site from an established trail or road, though any such route from the Appalachian Trail below would likely not be preserved due to the rockiness of that area. These cliffs are easily visible from Franklin Cliffs Overlook to the south, and so some visitors are likely inspired to investigate.

Access Moderate

Despite the site's proximity to both Skyline Drive and the Appalachian Trail, there is no direct and obvious access route from either of these. The easiest access routes to this site are along Skyline Drive and then through woods, where the cliffs are not visible until reached , and so these routes may not be the most intuitive to visitors. The more obvious route from the viewing point of Franklin Cliffs lies along the Appalachian Trail, but involves much more strenuous negotiation of steep, bouldery, thickly vegetated areas to reach the cliffs, and so likely provides some deterrent.

Geologic Characteristics

Lithology:

Rock Type Greenstone

The site is underlain by two typical greenstone lava flows, both fine grained and epidote rich. The two flows are not easily distinguished by lithology, but are clearly divided by a thick unit of volcanic breccia that occurs throughout the site, as well as a

C15 - Franklin Cliffs North (continued...)

distinct topographic bench separating the cliffs of the two flows.

Structure:

Columnar joints are completely dominant here; virtually every rock exposure is laced with these structures, creating a palisade-like appearance to the cliffs. In many places single joints extend, unbroken or altered, for 10-20m vertically. This is the thickest concentration of columnar joints within any ROMP site, and among the most concentrated of any area in the park. Although these structures are ubiquitous within the site, their formation and preservation vary, so that in most cases individual joints are not spectacular, though collectively they have a significant influence on the cliffs' morphology. The northern portion of the site, however (between G196-G197) contains well-formed and well-preserved occurrences of columnar joints (see photos 9-12). Most of these excellent examples are not easily accessible to visitors, though, as they occur within or below the cliffs in this area. While better examples of columnar jointing exist elsewhere in the park, those occurring here are some of the best found within any ROMP site.

Other:

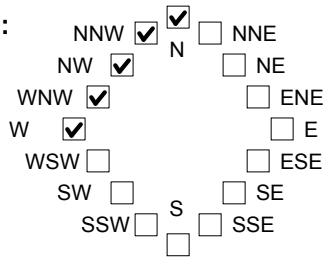
The volcanic breccia unit separating the two flows within this site is typical of those found in Shenandoah; a collection of reddish-brown fragments of vesicular basalt, cemented by a highly epidotized matrix. This unit is found in float and talus above the main cliffs in the south and north parts of the site, but cap the cliffs in the center of the site (around G195; see diagram on site map). In addition, this rock is very similar in appearance to a unit found capping the cliffs at Franklin Cliffs Overlook just to the south, and likely corresponds to those rocks.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	60.0	15.0	0.0	15.0	10.0	100
Max relief(m):	40	20	0	1	10	

Maximum Slope: 25 **Texture:** Fractured

Aspects:



Setting:

This site is dominated by a single lava flow 30-40m thick, with another, thinner flow above. These units are divided by a volcanic breccia layer 5-10m thick. The broad, open bench between the two cliff lines is typical of the topographic pattern formed throughout the park by successive lava flows, and the presence of the breccia within this bench and atop the lower cliff reinforces this interpretation. The distinct dip of the cliffs and bench down to the south is unusual, as the broader pattern in this area is for the lava flows to dip off to the east, but some localized folding must have occurred to create this pattern. It is also possible that the lava flowed down an originally angled land surface, and solidified at an angle, but this seems less likely. Careful measurements of the orientation of columnar joints to the orientation of the flow might be able to test this. The dip is very clearly illustrated by walking up the bench separating the flows, or by viewing the site from the west (see sketch on the site map). The rocks must also have an element of dip to the east, however, as the site does follow the usual pattern of rugged, steep topography to the west (where the lava flows protrude from the slope) and gently sloping terrain to the east (along the top of flows).□□□

□The rock sequence within this site is very similar to that found at Franklin Cliffs Overlook (C16), with a lava flow dominated by columnar joints capped by a thick epidotized breccia unit, and it is likely that both sites are formed by the same flow. Columnar jointing is more prevalent here, however.

□The columnar joints are certainly the dominant geomorphic factor within this site, creating numerous planes of weakness along which weathering processes can operate, peeling away individual columns of rock. Despite this apparent weakness, the large, sheer nature of the cliffs is also likely due to the joints, as their unusually long length and excellent formation actually serve to strengthen the rock in a way, forming unbroken pillars many meters high. Each individual pillar might collapse, but the overall cliff contains few horizontal planes of weakness along which it might crumble. Thus, long, sheer cliffs are formed, and weathering processes do not change the underlying nature of the rock.

□The presence of such ubiquitous jointing probably reflects a stable cooling period for the lava flow. If the flow was still moving as it cooled, was deformed during cooling, or otherwise disrupted, it is less likely that such long, linear, parallel columnar joints would have formed. Thus, the lava was likely undisturbed, perhaps after it flowed into a basin or other

C15 - Franklin Cliffs North (continued...)

protected area, and cooled in place.

Stability: Loose

The ubiquitous columnar joints create numerous planes of weakness, and the cliffs have a very fractured, crumbly appearance. Frequently free-standing or protruding pillars of rock are formed from these joints, and though the ledge areas atop the cliffs are solid and stable, but the same cannot be said of the cliff faces themselves.

GPS Points

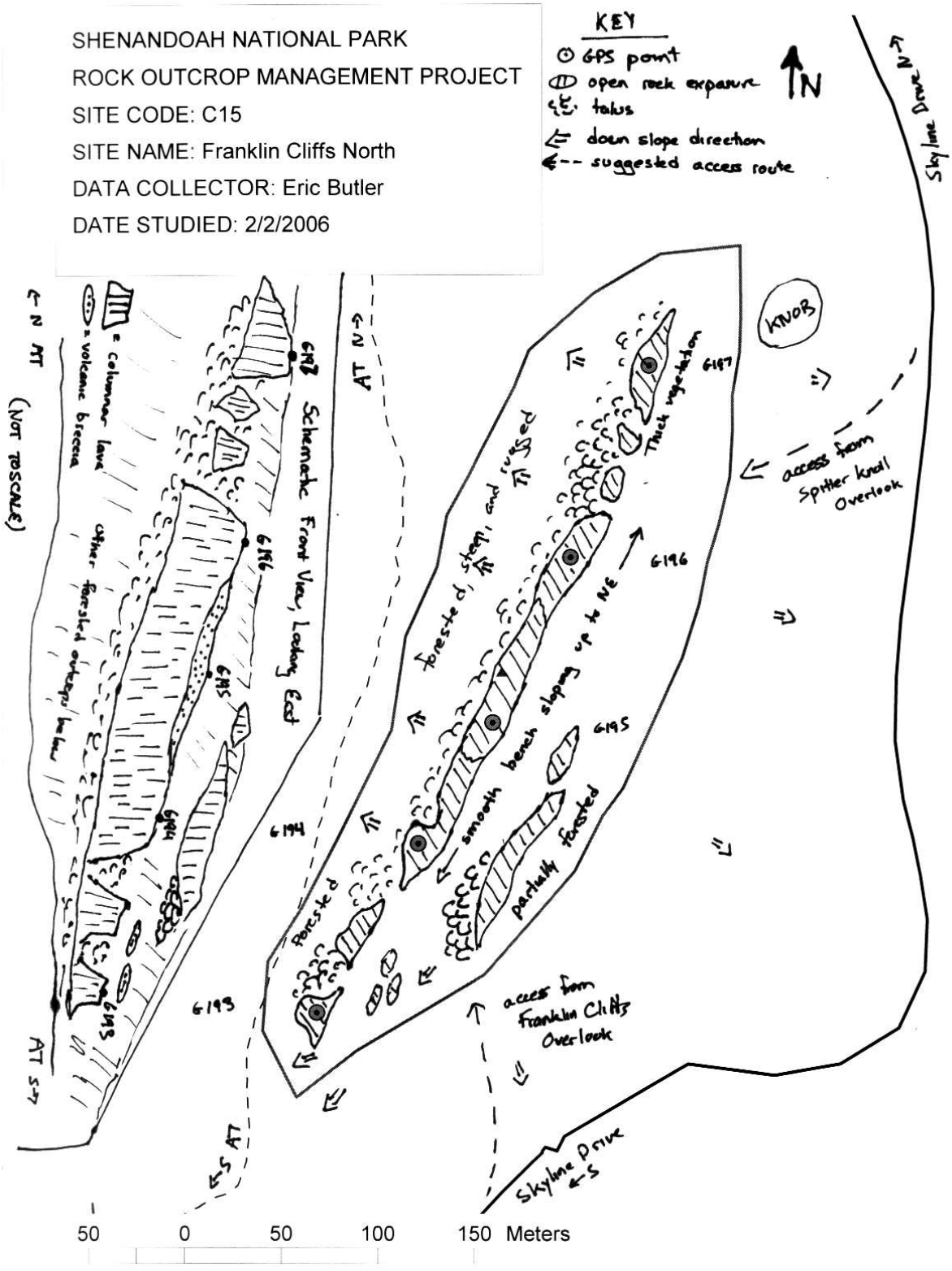
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
2/2/2006	G193-C15	725052	4268964	3080	Protruding outcrop with 20m relief, southernmost open rock exposure i
2/2/2006	G194-C15	725105	4269051	3120	Southern end of main cliff in site
2/2/2006	G195-C15	725143	4269113	3160	Clifftop ledges capped by volcanic breccia in this area
2/2/2006	G196-C15	725184	4269199	3200	Highest point on main cliff; northern end of cliff
2/2/2006	G197-C15	725225	4269297	3240	Isolated cliff, northernmost exposure in site

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
2/2/2006		SHEN_C15_G_20060202_001.jpg		Butler, Eric	Overall view of site, looking north from cliff area outside site to south
2/2/2006	G193-C15	SHEN_C15_G_20060202_002.jpg	35	Butler, Eric	View north toward higher portions of main cliff
2/2/2006	G193-C15	SHEN_C15_G_20060202_003.jpg	220	Butler, Eric	North side of outcrop, showing abundant columnar jointing controlling outcrop pattern
2/2/2006	G194-C15	SHEN_C15_G_20060202_004.jpg	30	Butler, Eric	View north of abundant columnar joints in cliff, creating spires and ragged exposures
2/2/2006	G194-C15	SHEN_C15_G_20060202_005.jpg	270	Butler, Eric	Pristine, vegetated ledge covered in lichens
2/2/2006	G194-C15	SHEN_C15_G_20060202_006.jpg	60	Butler, Eric	Abundant columnar jointing in cliff, and planar topographic bench above cliff defining a flow boundary
2/2/2006	G195-C15	SHEN_C15_G_20060202_007.jpg	0	Butler, Eric	Vegetated ledge area just south of G195
2/2/2006	G195-C15	SHEN_C15_G_20060202_008.jpg		Butler, Eric	Volcanic breccia in contact zone between flows, capping cliff near G195
2/2/2006	G197-C15	SHEN_C15_G_20060202_009.jpg	260	Butler, Eric	Protruding spire of columnar joints
2/2/2006	G197-C15	SHEN_C15_G_20060202_010.jpg		Butler, Eric	Columnar joints in cliff, controlling exposure pattern, south of G197
2/2/2006	G197-C15	SHEN_C15_G_20060202_011.jpg		Butler, Eric	Columnar joints protruding from ground south of G197
2/2/2006	G196-C15	SHEN_C15_G_20060202_012.jpg		Butler, Eric	Columnar joints in cliff, controlling exposure pattern, north of G196

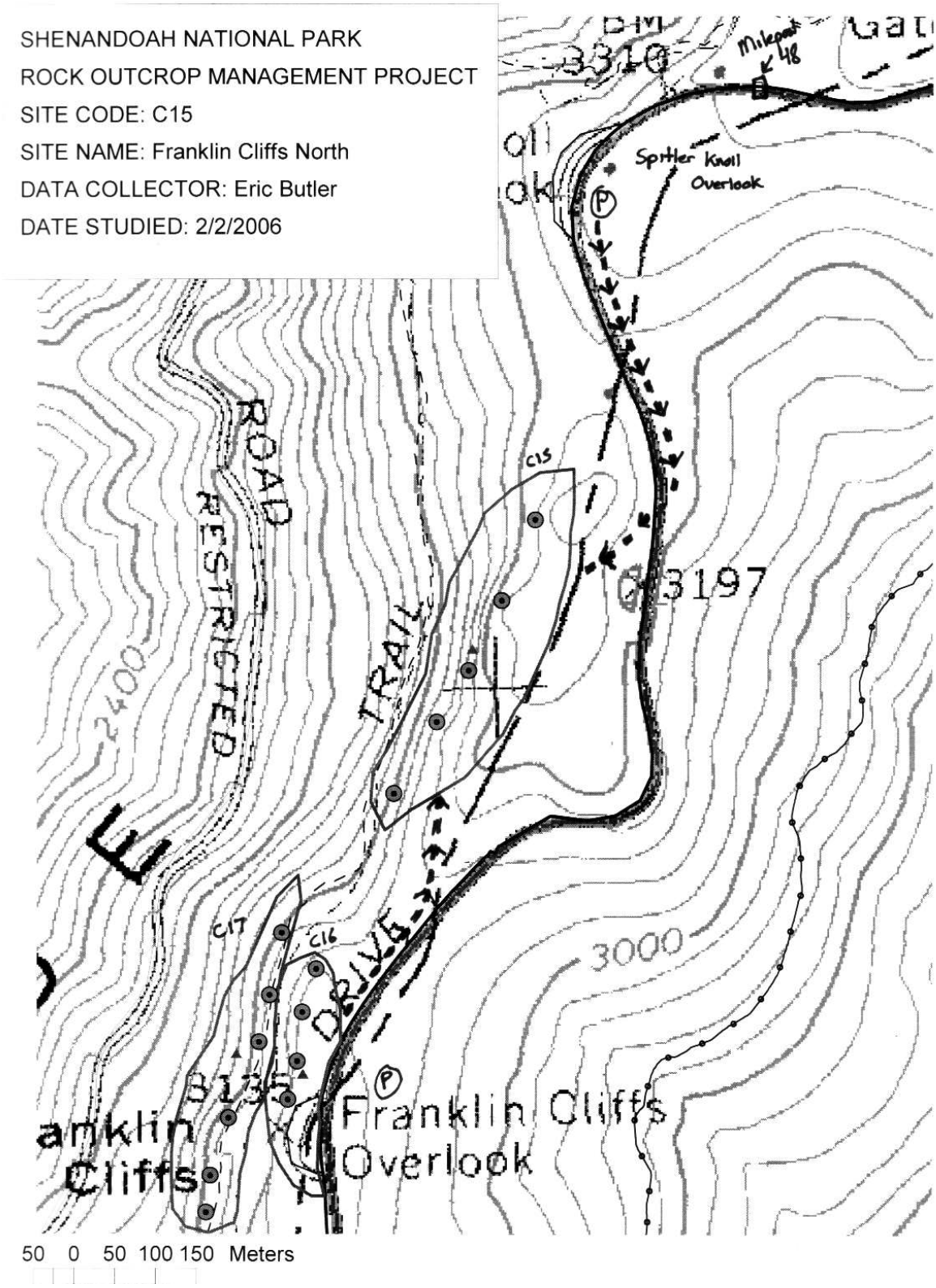
C15 - Franklin Cliffs North (continued...)

Detail sketch map



C15 - Franklin Cliffs North (continued...)

Area sketch map



C15 - Franklin Cliffs North (continued...)



SHEN_C15_G_20060202_001.jpg Azmuth:

Overall view of site, looking north from cliff area outside site to south



SHEN_C15_G_20060202_002.jpg Azmuth: 35

View north toward higher portions of main cliff



SHEN_C15_G_20060202_003.jpg Azmuth: 220

North side of outcrop, showing abundant columnar jointing controlling outcrop pattern



SHEN_C15_G_20060202_004.jpg Azmuth: 30

View north of abundant columnar joints in cliff, creating spires and ragged exposures

C15 - Franklin Cliffs North (continued...)



SHEN_C15_G_20060202_005.jpg Azmuth: 270

Pristine, vegetated ledge covered in lichens



SHEN_C15_G_20060202_006.jpg Azmuth: 60

Abundant columnar jointing in cliff, and planar topographic bench above cliff defining a flow boundary



SHEN_C15_G_20060202_007.jpg Azmuth: 0

Vegetated ledge area just south of G195



SHEN_C15_G_20060202_008.jpg Azmuth:

Volcanic breccia in contact zone between flows, capping cliff near G195

C15 - Franklin Cliffs North (continued...)



SHEN_C15_G_20060202_009.jpg Azmuth: 260

Protruding spire of columnar joints



SHEN_C15_G_20060202_010.jpg Azmuth:

Columnar joints in cliff, controlling exposure pattern, south of G197



SHEN_C15_G_20060202_011.jpg Azmuth:

Columnar joints protruding from ground south of G197



SHEN_C15_G_20060202_012.jpg Azmuth:

Columnar joints in cliff, controlling exposure pattern, north of G196

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C16 - Franklin Cliffs Overlook

Site Code: C16
Site Name: Franklin Cliffs Overlook
Data Collector Butler, Eric
Date Studied: 31-Aug-05

Polygon Centroid: **E:** 724941 **N:** 4268621
UTM (Zone 17 NAD83)
Dimensions (m): 70 x 300 (GIS est.)
Elevation Range (ft): 3060 to 3140

Physical Characteristics

Location Access

Park at Franklin Cliffs Overlook (Mile 49). There is a wide set of ledges topping a line of cliffs directly in front of the overlook, and an obvious social trail leads north from the overlook to follow an additional set of ledges. Behind these ledges is a nearly flat topographic bench which is very easy to walk along, providing good access to all exposures. At the north and south ends of the site, where the cliffs end, an easy slope leads through forest around to the base of the cliffs; several breaks in the cliffs give additional access within the site.

Physical Description:

This site consists of a single line of cliffs and associated upper ledges, beneath the overlook and stretching north for roughly 150m. These ledges are broad and open, and meet a distinct topographic bench that extends well to the east (Skyline Drive is built on this bench). Below the cliff line, a thick, nearly continuous talus field composed of blocks up to 1m in diameter extends downslope to a second bench, on which the AT runs. This talus is variably forested, with the most open area toward the north end of the site.

Vegetation: Open

Above the cliffs, the forest is open and very easy to traverse, and even the vegetation along the talus slopes is not difficult to negotiate. Vegetation poses little to no barrier here.

Human Effects

Impacts: Heavy

Most of the ledges appear heavily impacted; stripped of vegetation, mostly bare rock and soil, especially at the overlook itself. An obvious, gravelly social trail leads along most of the site; this fades toward the north, but even the northernmost ledges show signs of human presence. There are numerous instances of rock graffiti all along the site, and trash is common below the cliffs.

Access Easy

The open ledges begin at the overlook, which provides immediate access to visitors. Although no signs or maintained trails north from here, the continuing cliffs and ledges are quite visible from the overlook. A clear social trail begins at the north end of the overlook, leading onto the ledges to the north. The AT runs along the base of this escarpment, offering easy access in several places along talus/soil slopes that can be scrambled up to reach the cliffs.

Geologic Characteristics

Lithology:

Rock Type Greenstone

This area is underlain by greenstone, very fine-grained and epidote rich. There seems to be some flow layering here, but it is difficult to identify. There is some flow layering present, but overall the rock is very solid and unstructured, probably a result of the ubiquitous epidote mineralization. The base of this flow cannot be directly observed, due to thick talus deposits, but the lithology of the next set of cliffs down is noticeably different (see C17, Franklin Cliffs South).

Structure:

There is evidence of columnar joints throughout the cliffs, which may contribute to the rugged, uneven nature of the ledges, particularly at the overlook. Some minor cleavage is present, especially toward the upper few meters of the flow, where it interacts with the columnar jointing to help create a ledgy texture that fades away lower along the cliff. There is an identifiable joint set oriented at 150-330, but this is intermittent and does not appear to be a dominant factor.

Other:

There appears to be a thick unit of volcanic breccia capping the topographic bench above the cliff line. This is rarely found in

C16 - Franklin Cliffs Overlook (continued...)

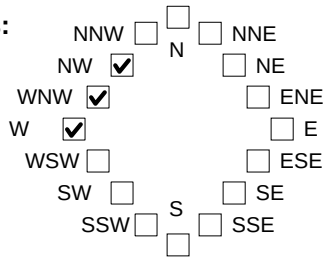
place, but more often as pieces of talus and float in the woods surrounding the overlook. The best examples are a large boulder at the north end of the overlook, and many pieces in the narrow strip of trees dividing the two paved portions of the overlook. This unit consists of angular fragments of red-purple vesicular basalt, 1-10cm in diameter, in a pale green epidotized matrix. A similar unit can be found capping the cliffs at C15 (Franklin Cliffs North), directly north of this site, and is likely related.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	50.0	0.0	0.0	30.0	20.0	100
Max relief(m):	10	0	0	2	10	

Maximum Slope: 25 **Texture:** Rough

Aspects:



Setting:

This site appears to be contained within a single lava flow. The continuous line of cliffs, with topographic benches above and below, is a typical exposure pattern. The top of this flow is marked by the presence of a thick, well-preserved volcanic breccia unit which can be identified in-place at the top of the cliffs, though it is more commonly found as float along the upper topographic bench. The thick talus deposits at the base of the cliffs obscures any boundary rock dividing this flow from the next, but the topographic bench at the base of the talus, as well as the noticeably different lithology below this level, make it clear that these cliffs represent the full extent of a single lava flow. The broad, somewhat angled ledges at the top of the cliffs are the result of some minor cleavage interacting with columnar jointing; lower on the cliffs, the cleavage fades and the columnar jointing, where present, is the dominant factor in the shape of the cliff. These joints also likely contribute to the development of the thick talus deposits that mantle the lower half of the cliff area.

Stability: Stable

The rock is very solid, with few large fractures or other planes of weakness. The talus is not overly steep and is generally easy to traverse. There is no observable danger of loose rock or shifting slopes.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
8/31/2005	G156-C16	724934	4268637	3140	South end of cliff located north of overlook
8/31/2005	G157-C16	724940	4268697	3140	North end of heavily impacted ledges
8/31/2005	G158-C16	724957	4268750	3140	North end of cliff located north of overlook
8/31/2005	G159-C16	724923	4268591	3120	North end of cleared overlook ledges

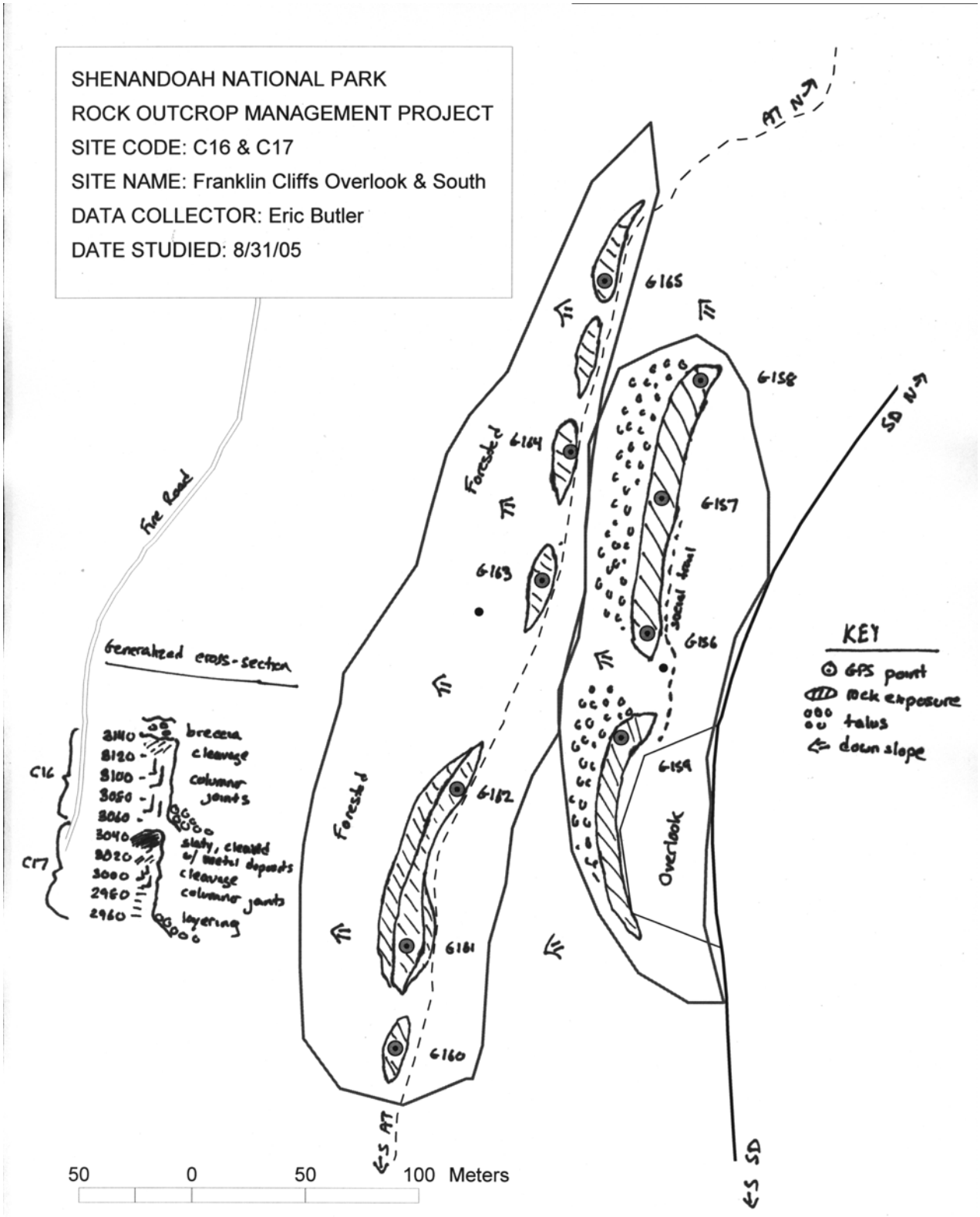
Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
8/31/2005	G156-C16	SHEN_C16_G_20050831_001.jpg	195	Butler, Eric	View of cleared overlook ledges from north
8/31/2005	G156-C16	SHEN_C16_G_20050831_002.jpg	15	Butler, Eric	Impacted ledges atop cliffs to north of overlook
8/31/2005	G157-C16	SHEN_C16_G_20050831_003.jpg		Butler, Eric	Rock graffiti on ledges north of overlook
8/31/2005	G157-C16	SHEN_C16_G_20050831_004.jpg		Butler, Eric	Rock graffiti on ledges north of overlook
8/31/2005	G157-C16	SHEN_C16_G_20050831_005.jpg	130	Butler, Eric	Poorly preserved columnar joints near base of cliff below G157
8/31/2005	G159-C16	SHEN_C16_G_20050831_006.jpg	155	Butler, Eric	Impacted ledges at cleared overlook
8/31/2005		SHEN_C16_G_20050831_007.jpg		Butler, Eric	Vesicular breccia with epidotized matrix, in patch of trees in parking area

C16 - Franklin Cliffs Overlook (continued...)

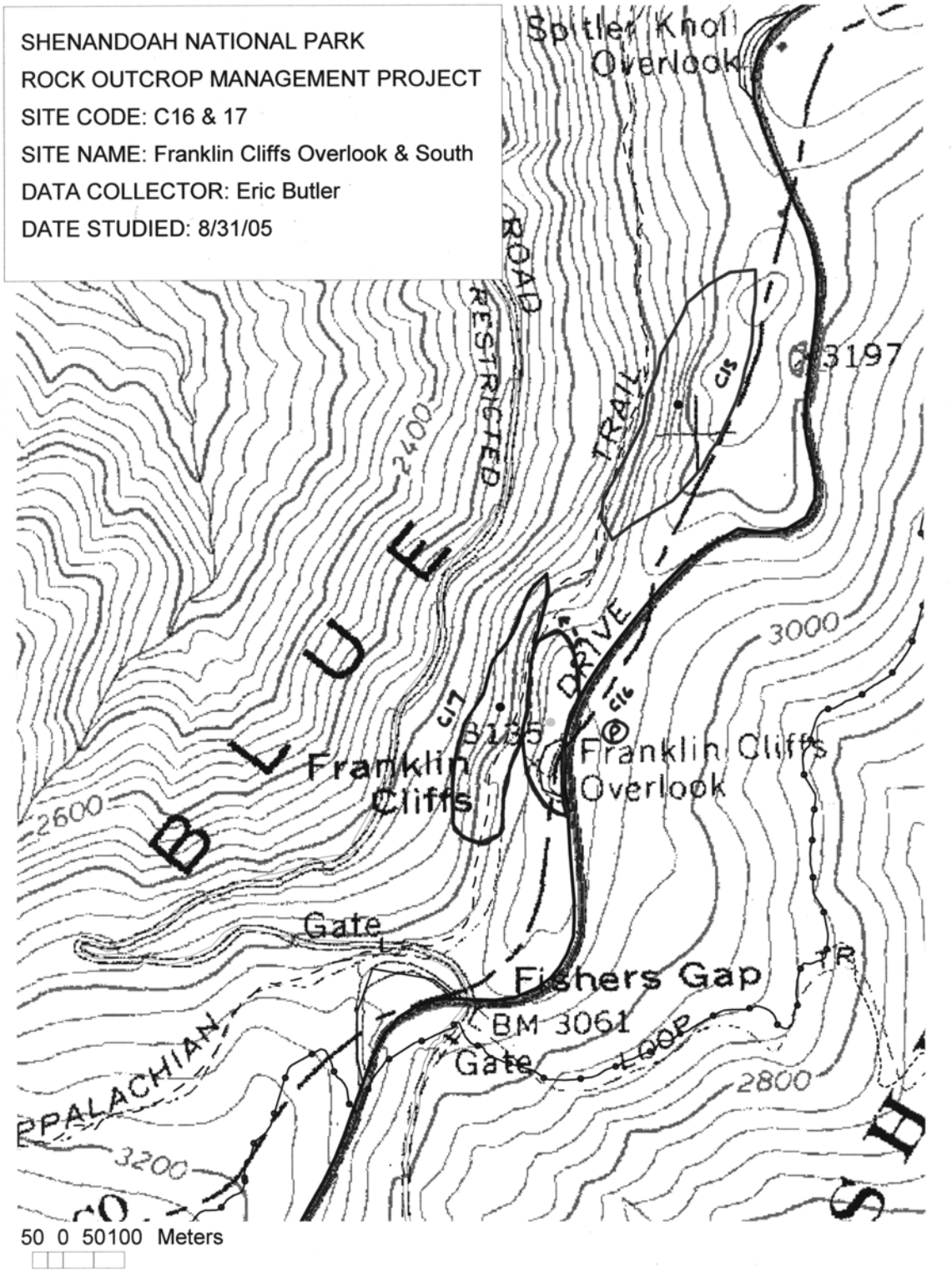
C16 - Franklin Cliffs Overlook (continued...)

Area sketch map



C16 - Franklin Cliffs Overlook (continued...)

Detail sketch map



C16 - Franklin Cliffs Overlook (continued...)



SHEN_C16_G_20050831_001.jpg Azmuth: 195

View of cleared overlook ledges from north



SHEN_C16_G_20050831_002.jpg Azmuth: 15

Impacted ledges atop cliffs to north of overlook



SHEN_C16_G_20050831_003.jpg Azmuth:

Rock graffiti on ledges north of overlook



SHEN_C16_G_20050831_004.jpg Azmuth:

Rock graffiti on ledges north of overlook

C16 - Franklin Cliffs Overlook (continued...)



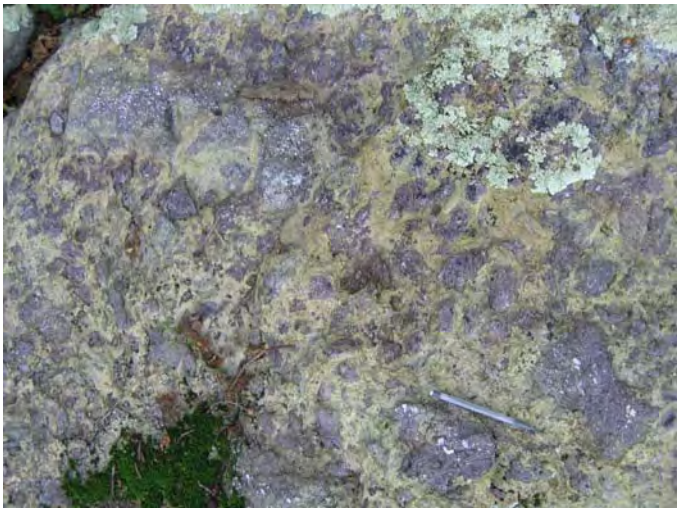
SHEN_C16_G_20050831_005.jpg Azmuth: 130

Poorly preserved columnar joints near base of cliff below G157



SHEN_C16_G_20050831_006.jpg Azmuth: 155

Impacted ledges at cleared overlook



SHEN_C16_G_20050831_007.jpg Azmuth:

Vesicular breccia with epidotized matrix, in patch of trees in parking area

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C17 - Franklin Cliffs South

Site Code: C17
Site Name: Franklin Cliffs South
Data Collector Butler, Eric
Date Studied: 31-Aug-05

Polygon Centroid: **E:** 724860 **N:** 4268646
UTM (Zone 17 NAD83)
Dimensions (m): 90 x 450 (GIS est.)
Elevation Range (ft): 2880 to 3060

Physical Characteristics

Location Acces

Park at Franklin Cliffs Overlook (Milepost 49. There is a line of cliffs directly below the parking area, composing site C16 (Franklin Cliffs Overlook). Below these cliffs and their associated talus, approximately 120' below the elevation of the parking lot, is a small topographic bench along which the Appalachian Trail (AT) runs. The exposures composing this site are located along the AT, just west and below the trail. To reach the AT from the parking lot, go around the northern or southern extent of the C16 cliffs, where the slopes are easy to follow down, or take the steeper, more thickly vegetated gap immediately north of the overlook. Either way, continue downslope to reach the AT, then follow that trail north and/or south to reach all the exposures. There are a great deal of small social trails leading off the AT, which provide access to most of the open rock areas.

Physical Description:

This site consists of a single, discontinuous line of cliffs, stretching the length of the site. There is a narrow topographic bench above these cliffs, on which the Appalachian Trail (AT) runs, and the slope drops off steeply below this. The cliffs are not continuous, but rather alternate with steep, forested soil/talus slopes, which provide difficult access to the base of the exposures. The best access to the base of the cliffs may be at the north end of the site, where the slope gentles and returns to more open forest. There is one large area of exposure at the south end of the site, then a section with little to no exposure in the middle, while the northern half of the site is a near-continuous line of smaller cliff exposures. All these exposures have some open ledge areas at their top, many of which have small social trails leading to them and are variably impacted. The cliffs tend to be ledgier near the top, then gradually become steeper and sheerer toward the base. In some places, especially at G161, the ledges extend more than halfway down the exposure before transitioning to a true cliff. Below this line of cliffs, the slope appears to be fully forested for the remaining extent of the site.

Vegetation: Thick

Along the Appalachian Trail, there is a generally thick wall of laurel and/or other thick vegetation that makes seeing or accessing the exposures difficult when there is not a social trail (which there usually is). The steep soil/talus slopes dividing the cliff exposures are equally heavily vegetated and difficult to traverse.

Human Effects

Impacts: Mild

It is clear that people visit these ledges, but it is difficult to assess the results here. Human impact appears confined to small overlook areas along ledges accessed by social trail from the Appalachian Trail. These ledges appear to have some stripping of soil, lichens, and vegetation, but do not appear heavily impacted for the most part. There are many unimpacted areas where social trails either do not access, or where the impact is confined to the smallest, uppermost portion of the exposure, leaving most of the exposure below looking untouched.

Access Moderate

Although these exposures are directly along the Appalachian Trail (AT) and generally very accessible by social trail, it is difficult to estimate how often individual areas are used. There is no direct access or trails from Franklin Cliffs Overlook leading to this area, and no indication at that overlook that any exposures of interest to visitors are below. The nearest access point to the AT is at Fishers Gap, 300m south, but here as well there are no signs or other indications that visitors should follow the AT north for any specific reason.

Geologic Characteristics

Lithology:

Rock Type Greenstone

This area is underlain by greenstone, probably of a single lava flow. At the top of the ledges, along the Appalachian Trail, there is a unit of dark, very platy rock with many fragments and/or veins of iron-rich material and sediment nodules. Below this unit,

C17 - Franklin Cliffs South (continued...)

the basalt grades from strong cleavage into a more solid, layered texture that extends to the base of the flow. The apparent flow layering creates numerous ledges, with an almost staircase-like texture, which becomes less prominent and more cliff-like toward the base. The rock is otherwise a very typical grey-green fine-grained greenstone.

Structure:

Columnar joints are intermittently preserved, especially toward the upper portion of the flow. Where present, they interact with the cleavage and layering to produce additional ledgy areas. The cleavage is strongest in the upper few meters of the flow, where it deeps steeply to the southeast and creates a jagged, platy texture beneath the uppermost ledges. Below this, the more gently dipping layering produces nearly level ledges that range from a few centimeters to nearly a meter in width.

Other:

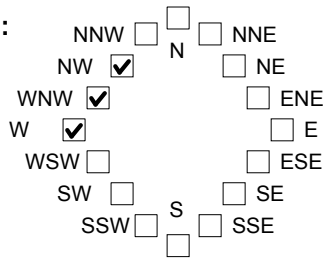
The platy, metal-rich unit at the very upper portion of the cliffs likely marks the boundary between this flow and the flow above it (composing C16, Franklin Cliffs Overlook). It is not clear whether this unit is a strongly cleaved volcanic breccia that has incorporated fragments of sedimentary and other rock, or whether it is a highly deformed bed of sedimentary rock.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	70.0	0.0	0.0	30.0	0.0	100
Max relief(m):	20	0	0	2	0	

Maximum Slope: 35 **Texture:** Rough

Aspects:



Setting:

This site appears to be contained within a single lava flow. The continuous line of cliffs, with topographic benches above and below, is a typical exposure pattern. Whether the platy, metallic unit at the top of the cliffs is a basaltic breccia or a deformed sedimentary bed (or a combination of both), it clearly marks a boundary between two flows. The character of these cliff exposures and their associated ledges depends greatly on where in the sequence the exposure is located. Near the top, sharp, angled, protruding ledges are associated with cleavage, while below the upper few meters of the flow a more gentle, staircase-like ledge pattern is associated with the near-horizontal flow layering and occasional columnar jointing. The discontinuous nature of the exposures, with numerous soil/talus slopes breaking up the cliff line, may be due to a set of joints that provide planes of weakness for erosion, although an obvious set of properly oriented joints was not observed elsewhere in the rock. However, a joint set oriented at 150-330 was observed in the cliff line above this one, and likely affects this site as well.

Stability: Moderate

The bedrock is generally solid, with few fractures or other planes of weakness. The steep slopes dividing intermediate cliff areas are fairly loose, but most of these do not need to be traversed. At either end of the cliff line, the slope gentles and is not overly loose.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
8/31/2005	G160-C17	724823	4268453	3000	Small exposure on social trail at south end of site
8/31/2005	G161-C17	724828	4268498	3020	Large, multi-level ledgy exposure reached by social trail from AT
8/31/2005	G162-C17	724850	4268568	3040	High open ledge reached by social trail from AT
8/31/2005	G163-C17	724888	4268660	3020	Open ledge reached by social trail from AT
8/31/2005	G164-C17	724900	4268718	3040	Open ledge reached by social trail from AT
8/31/2005	G165-C17	724915	4268794	3040	Northernmost open ledge reached by social trail from AT

Site Photos

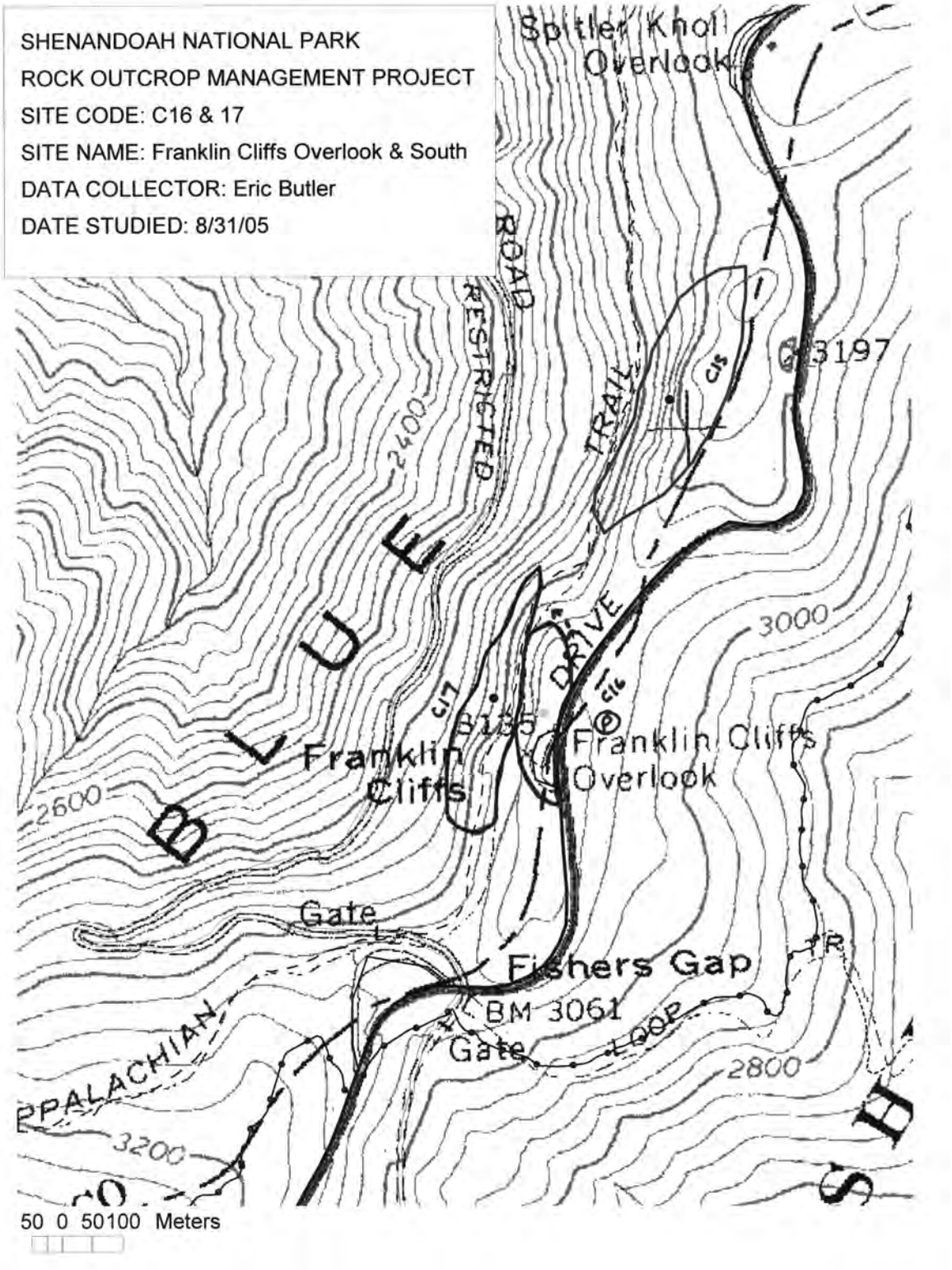
Image Date	GPS Point	File Name	Azmuth	Taken By	Description
8/31/2005	G161-C17	SHEN_C17_G_20050831_001.jpg	125	Butler, Eric	Ledgy exposures just below AT

C17 - Franklin Cliffs South (continued...)

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
8/31/2005	G162-C17	SHEN_C17_G_20050831_002.jpg	35	Butler, Eric	Vegetated, ledgy cliffs below AT
8/31/2005	G163-C17	SHEN_C17_G_20050831_003.jpg	25	Butler, Eric	Finely layered rock with metallic pockets & veins
8/31/2005	G164-C17	SHEN_C17_G_20050831_004.jpg	10	Butler, Eric	Ledges with strong cleavage
8/31/2005	G165-C17	SHEN_C17_G_20050831_005.jpg	5	Butler, Eric	Impacted ledges reached by social trail
8/31/2005	G165-C17	SHEN_C17_G_20050831_006.jpg	205	Butler, Eric	Impacted rocks – notice change in lichens from foreground to background

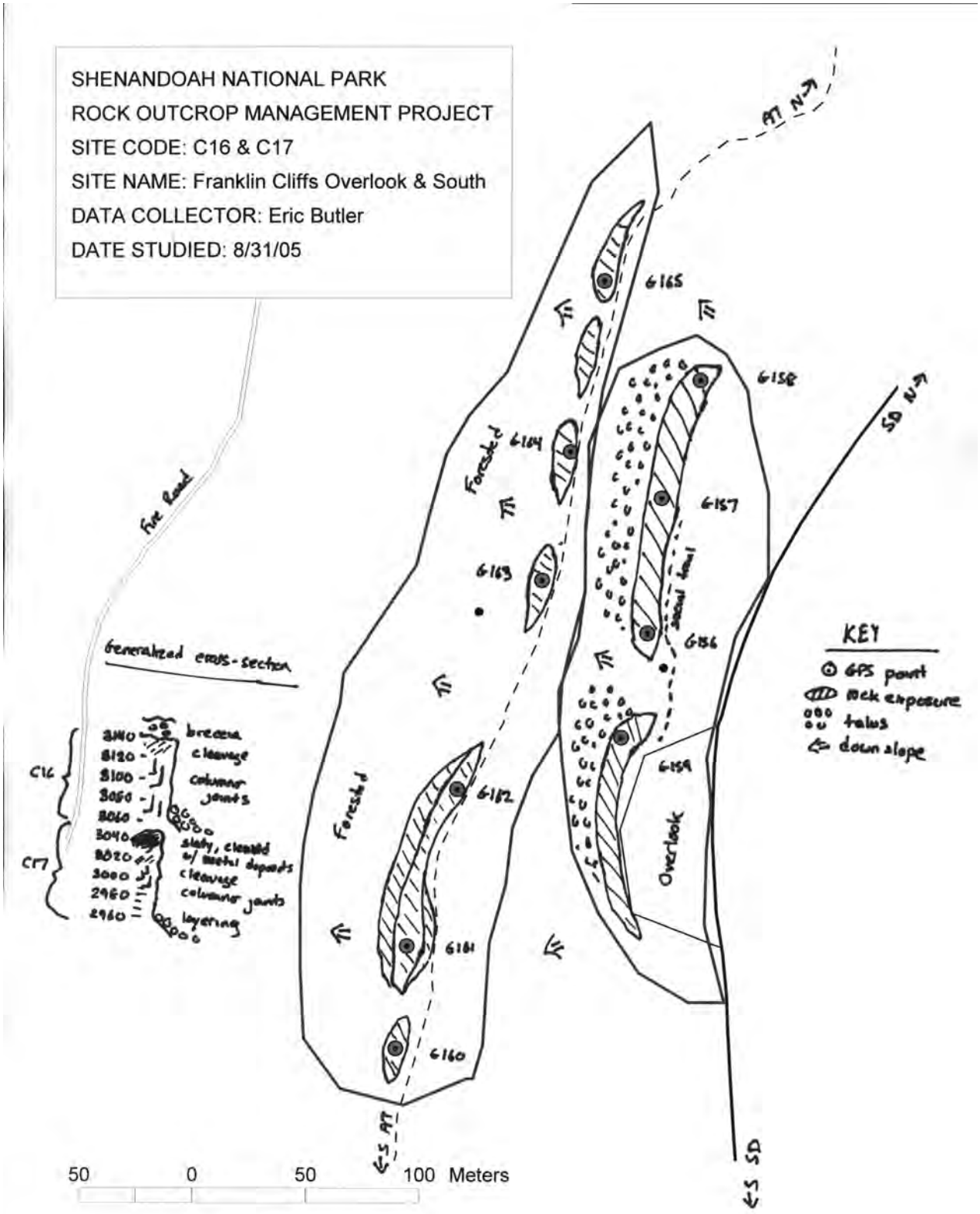
C17 - Franklin Cliffs South (continued...)

Detail sketch map



C17 - Franklin Cliffs South (continued...)

Area sketch map



C17 - Franklin Cliffs South (continued...)



SHEN_C17_G_20050831_001.jpg Azmuth: 125

Ledgy exposures just below AT



SHEN_C17_G_20050831_002.jpg Azmuth: 35

Vegetated, ledgy cliffs below AT



SHEN_C17_G_20050831_003.jpg Azmuth: 25

Finely layered rock with metallic pockets & veins



SHEN_C17_G_20050831_004.jpg Azmuth: 10

Ledges with strong cleavage

C17 - Franklin Cliffs South (continued...)



SHEN_C17_G_20050831_005.jpg Azmuth: 5

Impacted ledges reached by social trail



SHEN_C17_G_20050831_006.jpg Azmuth: 205

Impacted rocks – notice change in lichens from foreground to background

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C18 - Goat Ridge

Site Code: C18
Site Name: Goat Ridge
Data Collector Butler, Eric
Date Studied: 23-Aug-05

Polygon Centroid: **E:** 696092 **N:** 4222711
UTM (Zone 17 NAD83)
Dimensions (m): 250 x 570 (GIS est.)
Elevation Range (ft): 1400 to 1960

Physical Characteristics

Location Acces

This site is best accessed from outside the park. On the east side of the South District, take Virginia 810 to White Hall, then turn west onto 614. This road leads to Charlottesville Reservoir, at the junction of the North and South Forks of the Moormans River. Park in the open gravel area just west of the reservoir. Cross the North Moormans River just south of the parking area, then follow South Moormans Fire Road 1000m southwest until the road crosses the river at a shallow ford. Leave the road here and head WSW up and across the slope for 300m (400' vertical) to reach the first open clearing.

Physical Description:

This site consists of several open clearings, occurring at two different elevations within an otherwise forested area on a generally steep slope. The lower set of clearings consist of three narrow, vertically oriented openings dominated by smooth, sloping rock faces and some loose rock, covered by thick, grassy vegetation. The easternmost of these is by far the largest, while the other two are less than 10m across. The upper clearing is a long, horizontally oriented opening that stretches over 100m across the slope, also underlain by smooth rock faces and occasional loose rock. This clearing wraps around a change in the slope's orientation, and the rock exposures change character around this curve as well, becoming more protruding and cliff-like where the slope of the topography does not match the general slope of the rock faces. This area is also covered in grassy vegetation, though it appears different than the lower clearings. There are no bare talus slopes like those found in other areas of the park, but areas of loose rock do form a noticeable portion of the clearings, generally composed of small clasts and held in place by soil and vegetation. In addition, there are some noticeable outcrops of bedrock at other places within the site, but these are mostly under full canopy.

Vegetation: Open

The surrounding forest here consists of tall trees and very little undergrowth, very easy to traverse. Within the open clearings, the grasses and other vegetation are thick, but do not impede movement. Some portions of the slope below the site, which may be crossed en route, contain thicker vegetation that is more difficult to push through.

Human Effects

Impacts: Pristine

There is no evidence that people have visited this site. The vegetation is lush and undisturbed, and no trails lead near or within sight of the open areas.

Access Remote

This site is 300' vertical above the nearest trail, and is not visible from anywhere accessible to visitors. Reaching it requires a long hike up steep terrain, with no visible reward.

Geologic Characteristics

Lithology:

Rock Type Greenstone

The site is underlain by Catoctin Formation greenstone. In both clearings, the rock is fine-grained and grey-green in color. In the lower clearings, there is a very strong cleavage (see STRUCTURE) defined by chlorite, which creates a smooth, planar surface. In the upper clearing, the cleavage is not as pervasive, and the rock appears to contain less chlorite.

Structure:

There is a pervasive cleavage in the greenstones within the lower clearings, which dips southeast between 30-60 degrees. This structure is defined by the ubiquitous chlorite within the rock, which is a secondary mineral grown from alteration of the original basalt during metamorphism. There are virtually no other visible structures within the rock, such as fractures or jointing. In the upper clearing, the cleavage is not as pervasive, and the rock appears even more solid. There is one obvious joint orientation at

C18 - Goat Ridge (continued...)

150-330 degrees, but overall there are still few fractures or joints within the rock, other than the cleavage planes.

Other:

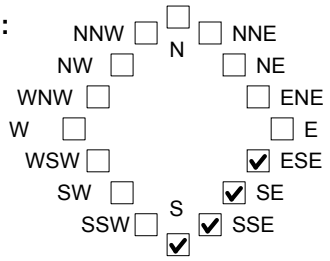
Similar to Sawlog Ridge (C45), the forested slope between the two levels of clearings is mostly underlain by a thick sequence of "boundary rock"; an assortment of vesicular basalt, breccia, purple-silver slate/phyllite, quartz-pebble conglomerate, and other mixed metabasaltic/metasedimentary rocks that define the boundary between two lava flows. These rocks, which are visually quite distinguishable from the regular flow basalt that underlies the open clearings, represent an unusually thick (up to 80'?) sequence; such a zone between two flows rarely exceeds a few meters in thickness. Clasts and talus deposits of this rock are extremely common along the surrounding forest slopes.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	0.0	20.0	50.0	20.0	10.0	100
Max relief(m):	0	2	5	1	5	

Maximum Slope: 40 **Texture:** Smooth

Aspects:



Setting:

This site, and the very similar Sawlog Ridge site (C45) nearby, are unusual Catoctin Formation sites in their aspect and physical character. Most open greenstone sites in the park are rough, fractured rock exposures, varying from sheer cliffs to protruding outcrops to large-clast talus slopes. Here, the greenstone creates smooth, rounded rock faces whose physical appearance is much more typical of granitic areas such as Old Rag Mountain or Mary's Rock. Several factors combine to produce this unique effect.

Through much of the Central and North Districts of the park, the Catoctin Formation caps the mountains, dipping gently eastward to produce a geomorphic pattern in which western slopes are steep and/or cliffy, while eastern slopes follow the surfaces of flows and are generally smooth and gently sloping, with little to no bedrock exposure. In the South District, however, this pattern begins to change, as the Catoctin gradually occurs lower in the topography, the overlying metasedimentary units begin to cap the mountains, and the entire sequence begins to dip west instead of east. In the Moormans River area, this results in the Catoctin being almost entirely covered to the west, instead being exposed along the eastern base of the mountains where its western dip protrudes from the slope.

This change is exacerbated by the unusual erosional pattern of the Moormans River, which has incised deep, narrow valleys along the trend of the mountains rather than across (as most rivers do), creating even steeper, southeast-facing slopes along the valleys of the North and South Forks of the Moormans River. One explanation for this trend may be the presence of a small fault creating a zone of fractured or otherwise weakened rock along which the rivers have eroded, or the rivers may be eroding along the surfaces of west-dipping lava flows.

The dominant internal structure here is the pervasive cleavage, which gives the greenstone a smooth, platy texture. The cleavage planes dip southeast, which is consistent with cleavage orientation through most of the park. However, the steep slopes underlain by greenstone generally face west, and so in these areas the southeastern dip of the cleavage produces sharp, jagged, upthrust-looking outcrops and cliffs. In the Moormans River area, this same cleavage orientation is instead nearly parallel with the general orientation and angle of the slope, and so produces exposures that are smooth, rounded, platy surfaces following the cleavage planes. In the absence of common fractures or joints, the resulting morphology is likely very difficult for soil to stick to, or trees to root into, thus creating areas that remain partially to fully open. This correlation is demonstrated best at Goat Ridge, where one clearing begins on an aligned slope, which then wraps west into a steep side drainage. The rock exposures continue, but begin to take on a much more cliff-like, protruding character as soon as the slope orientation has changed significantly.

A final factor may be soil movement or slumping. In a terrain underlain by such smooth rock slopes, any soil that forms may not be entirely stable. During large storms, the soil could liquefy and slump downslope, creating areas of clear, open bedrock that may remain open rather than reforming new soil. This is a possible explanation for why small clearings occur in certain places only, rather than across an entire slope. While no direct evidence of such a process could be observed in the field, it is a distinct possibility. Overall, open clearings appear to occur where the cleavage orientation and the slope orientation are most aligned, creating smooth rock faces that do not hold enough soil or talus to become and/or remain fully forested.

At both the Goat Ridge and Sawlog Ridge sites, open clearings appear to occur at two distinct topographic levels. These seem

C18 - Goat Ridge (continued...)

to correspond to two similar, highly cleaved lava flows, separated by a zone of volcanic breccia and metasediments up to 80' thick. This intermediate "boundary zone" does not contain cleavage (due to its very different composition), and in most places is much more rough, fractured, and rugged than the smooth, platy cleaved greenstones above and below it (thus not producing open rock faces).

Stability: Stable

The rock is quite solid, and where talus is present, it is generally small and held in place by vegetation or soil. The surrounding forest slopes seem more likely to be mobile than anything in the open clearings.

GPS Points

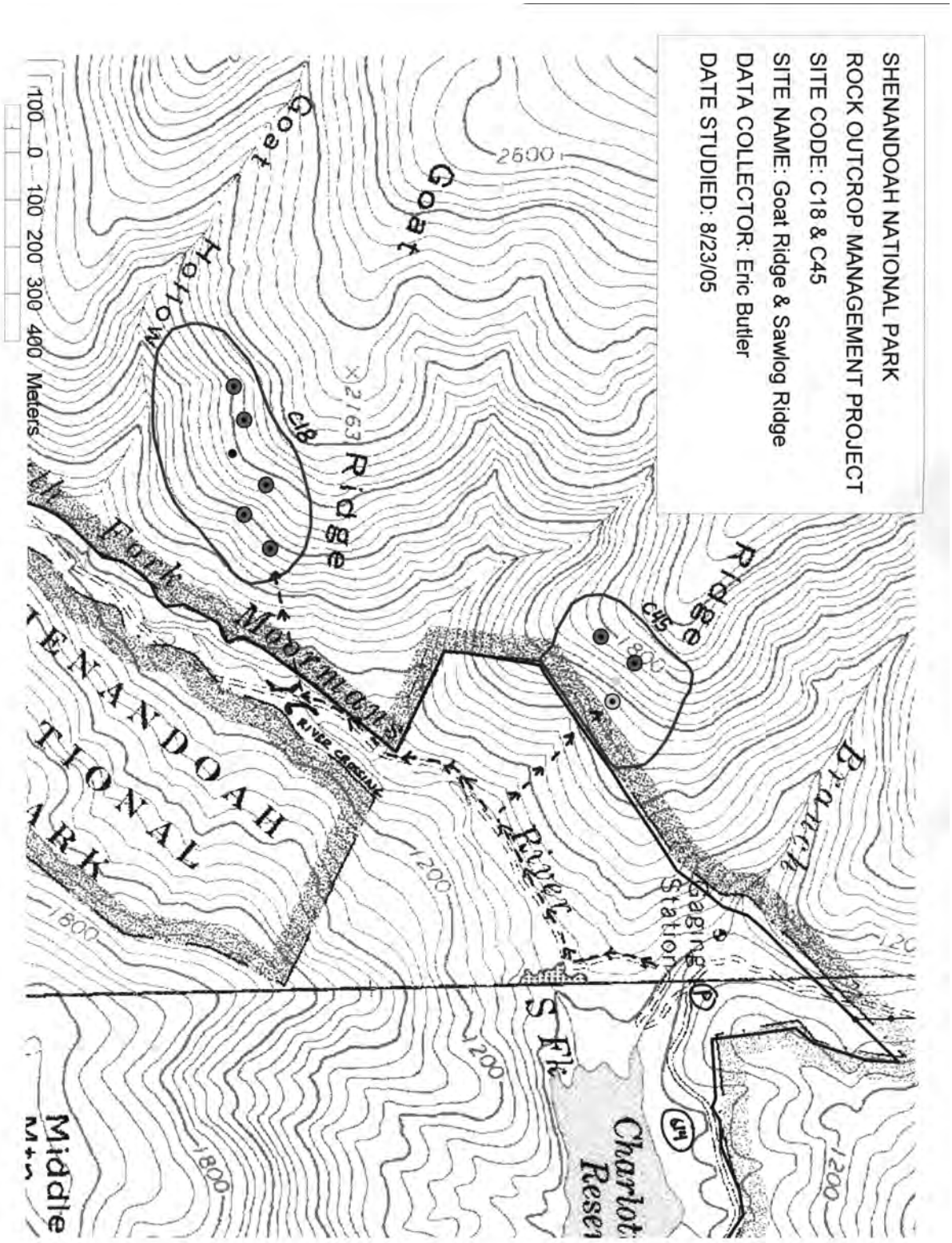
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
8/22/2005	G151-C18	696291	4222791	1560	Base of easternmost lower clearing
8/22/2005	G152-C18	696157	4222782	1760	Rock exposures in woods, semi-open; rare occurrence of "boundary ro
8/22/2005	G153-C18	696021	4222736	1940	Eastern end of long, linear upper clearing
8/22/2005	G154-C18	695951	4222715	1900	Western end of long, linear upper clearing
8/22/2005	G155-C18	696220	4222736	1640	Small clearing in lower level

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
8/23/2005	G151-C18	SHEN_C18_G_20050822_001.jpg	190	Butler, Eric	View across clearing, above G151
8/23/2005	G153-C18	SHEN_C18_G_20050822_002.jpg	45	Butler, Eric	Cleaved rocks protruding where slope and cleavage don't correspond
8/23/2005	G154-C18	SHEN_C18_G_20050822_003.jpg	260	Butler, Eric	View across large, sloping clearing, 20m east of G154
8/23/2005	G154-C18	SHEN_C18_G_20050822_004.jpg	80	Butler, Eric	View across large, sloping clearing

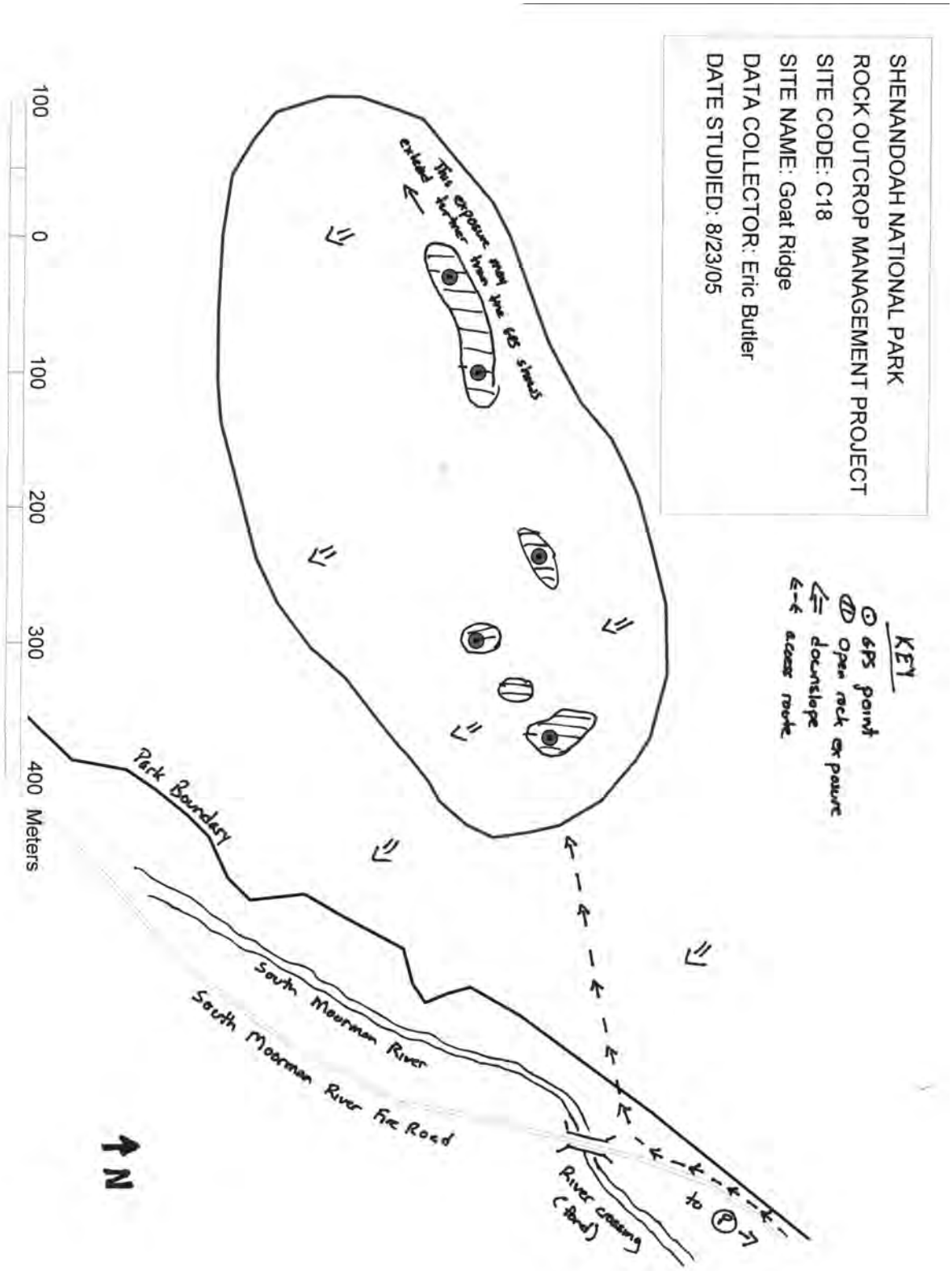
C18 - Goat Ridge (continued...)

Area sketch map



C18 - Goat Ridge (continued...)

Detail sketch map



C18 - Goat Ridge (continued...)



SHEN_C18_G_20050822_001.jpg Azmuth: 190

View across clearing, above G151



SHEN_C18_G_20050822_002.jpg Azmuth: 45

Cleaved rocks protruding where slope and cleavage don't correspond



SHEN_C18_G_20050822_003.jpg Azmuth: 260

View across large, sloping clearing, 20m east of G154



SHEN_C18_G_20050822_004.jpg Azmuth: 80

View across large, sloping clearing

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C19 - Gooney Manor Overlook

Site Code: C19
Site Name: Gooney Manor Overlook
Data Collector Butler, Eric
Date Studied: 06-Jun-05

Polygon Centroid: **E:** 742717 **N:** 4302274
UTM (Zone 17 NAD83)
Dimensions (m): 100 x 250 (GIS est.)
Elevation Range (ft): 1800 to 1920

Physical Characteristics

Location Acces

Site is immediately down slope from Gooney Manor Overlook, Milepost 7, North District. A gap in the stone wall leads to a steep, narrow trail that descends approximately 20' vertical to the center of an open cliff/ledge exposure.

Physical Description:

The defining feature here is an arc of cliffs at roughly the same elevation, somewhere between 1840' and 1900', though no single drop exceeds 40'. There are two major exposures; one running NW-SE for approximately 80m, and the other running SW-NE for approximately 60m. A vegetated talus/soil slope separates these cliffs so that one cannot be seen from the other. While the total drop in elevation over these cliffs is as high as 40', their surfaces are rough and ledged so that a sheer drop of >10' is rare. At the top of these cliffs, gently sloping ledges range from forested to open to bare, in general a few meters wide. Above this level, a steep, mostly vegetated slope leads up to Gooney Manor Overlook, with occasional small outcrops of bedrock present. Below the cliffs, and on either end of the site, are partially to fully forested talus/soil slopes with occasional bedrock outcrops. There are two small springs with semi-open vegetation just NW of the site boundary (see map).

Vegetation: Moderate

Some thickets on upper slopes are difficult to push through, but majority of site is reasonably passable.

Human Effects

Impacts: Moderate

While most of the site appears pristine in terms of vegetation cover and lack of trails, there is a great deal of trash scattered throughout the site. This consists primarily of broken and whole bottles of many vintages, found above, on, and below the cliffs. The only trampled and stripped location is the center of the western cliff, at the bottom of the access trail, but people have clearly been using the site on a regular basis.

Access Easy

Although the exposures are not directly visible from the road when leaves are on, the site is directly below an established overlook with a visible trail leading directly to the western cliff.

Geologic Characteristics

Lithology: **Rock Type** Greenstone

The site is predominately greenstone of the Catoctin Formation, mostly dark grey or green and very fine-grained. Small pockets of quartz and epidote are uncommon but present, as are empty vesicles. In a few places, near-horizontal original flow layering is preserved in beds ranging from 1cm to almost a meter. Many surfaces are weathered to a deep red-orange by oxidation of iron-bearing minerals.

Near the base of the site, generally around 1800' (below the cliffs), outcrops of granitic gneiss of the old Pedlar Formation appear. These rocks are white to pink, coarse-grained, and primarily composed of quartz and feldspars. They exhibit a strong foliation and are quite distinct from the dark volcanic rocks above. In several places the contact between the two units can be observed in the bedrock; otherwise it is inferred beneath soil and talus deposits dividing outcrops of the two. The gneiss does not form any open exposures, but is within the site boundary.

Structure:

The defining set of cliffs here is formed by a single lava flow of unclear thickness. This unit is generally very fractured and blocky-looking, forming rubbly, step-like cliffs rather than sheer drop-offs. No clear, consistent joint set can be identified across the site. It is unclear where the top of this flow lies; it may end anywhere from the top of the cliffs to somewhere in the vicinity of the overlook. Between the base of the cliffs and the gneiss contact, a darker, less fractured rock with a more regular joint set

C19 - Gooney Manor Overlook (continued...)

appears; this may be a separate flow but no contact is visible.

Other:

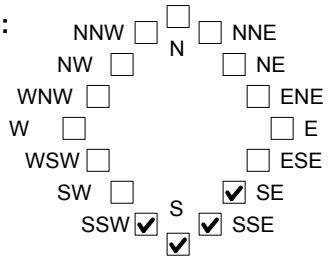
There are two small springs just NW of the site boundary (see map) that appear to originate in fracture systems within the basalt. They are partially open to the sun and may be of interest.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	40.0	20.0	0.0	30.0	10.0	100
Max relief(m):	10	2	0	1	3	

Maximum Slope: 20 **Texture:** Rough to fractured

Aspects:



Setting:

The dominant geomorphic control here is the single, near-horizontal lava flow that is the cliff-forming unit within the site. This is a common pattern within the park, as individual flows tend to create topographic benches with steep cliffs topped by near-horizontal ledges that support vegetation. The trend away from sheer drop-offs in favor of ledgy, step-like cliffs is probably due to the randomly fractured nature of the rock (with no consistent joint sets) and the presence of original flow bedding. The dominant cliffs occur at an exposed point within the surrounding topography, where the slope swings from west-facing to southeast-facing, which likely explains the presence of cliffs here rather than the forested talus fields that cover most of the surrounding topography.

Stability: Moderate

Small portions of the site are loose and/or wet, but most of surface is bedrock or stable talus.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
6/6/2005	G018-C19	742674	4302282		Base of footpath / center of western cliff
6/6/2005	G019-C19	742612	4302368		Spring NW of site boundary
6/6/2005	G020-C19	742613	4302326		Spring NW of site boundary
6/6/2005	G021-C19	742627	4302299	1800	Catoctin / Gneiss contact below western cliff
6/6/2005	G022-C19	742647	4302265	1800	Catoctin / Gneiss contact below western cliff
6/6/2005	G023-C19	742652	4302309		NW extent of western cliff
6/6/2005	G024-C19	742708	4302251		SE extent of western cliff
6/6/2005	G025-C19	742696	4302308		Top of footpath leading from overlook
6/7/2005	G030-C19	742789	4302253		E extent of eastern cliff
6/7/2005	G031-C19	742797	4302229		Catoctin / Gneiss contact below eastern cliff
6/7/2005	G032-C19	742740	4302227		W extent of eastern cliff

Site Photos

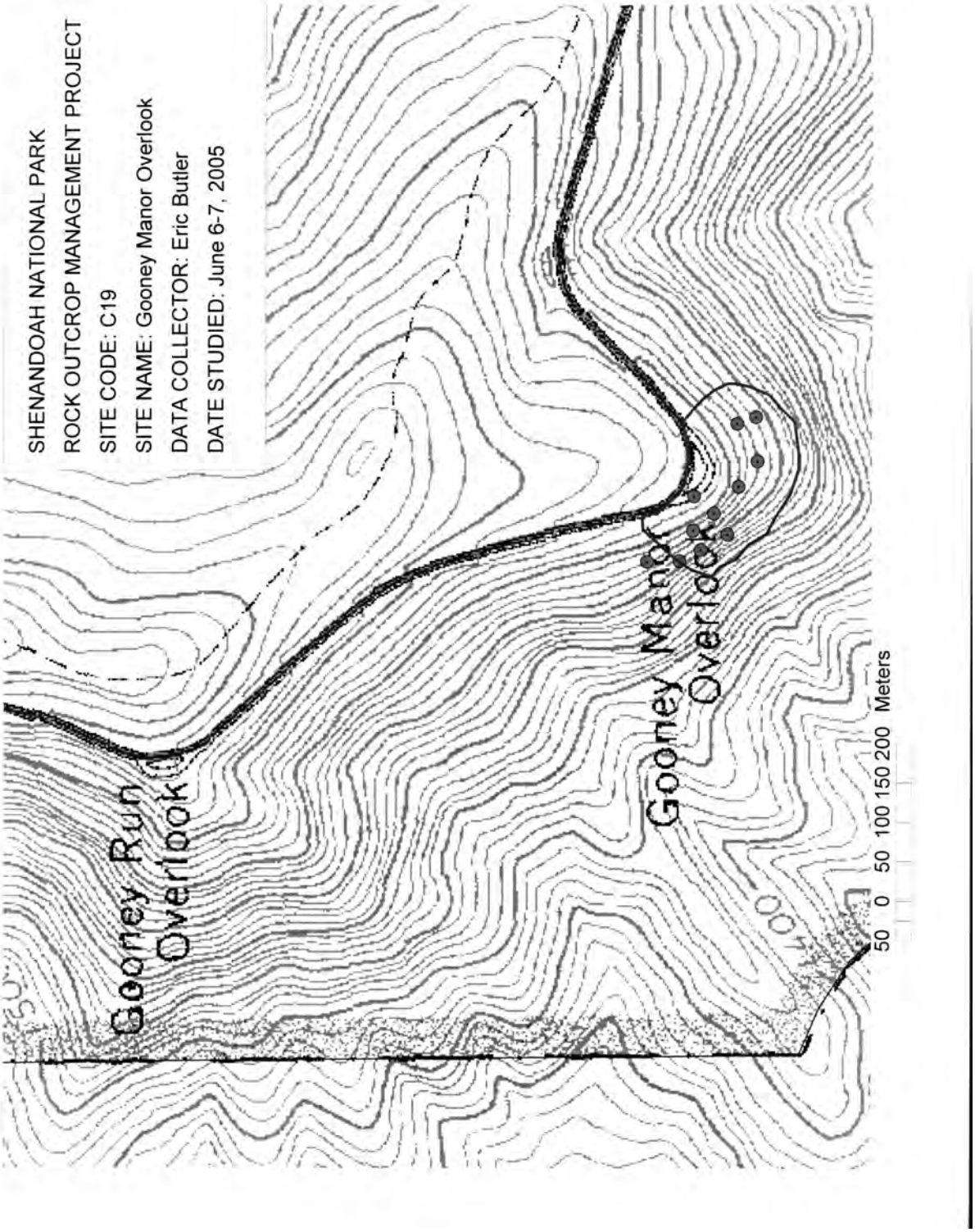
Image Date	GPS Point	File Name	Azmuth	Taken By	Description
6/6/2005	G018-C19	SHEN_C19_G_20050606_001.jpg	120	Butler, Eric	Spring with open vegetation NW of site boundary
6/6/2005	G019-C19	SHEN_C19_G_20050606_002.jpg	130	Butler, Eric	Spring with open vegetation on NW site boundary
6/6/2005		SHEN_C19_G_20050606_003.jpg		Butler, Eric	Typical exposure of basement gneiss, more rounded and smooth than basalt
6/6/2005		SHEN_C19_G_20050606_004.jpg		Butler, Eric	Typical exposure of greenstone cliff, very rough and fractured

C19 - Gooney Manor Overlook (continued...)

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
6/6/2005	G023-C19	SHEN_C19_G_20050606_005.jpg	145	Butler, Eric	Looking SE along top of western cliff

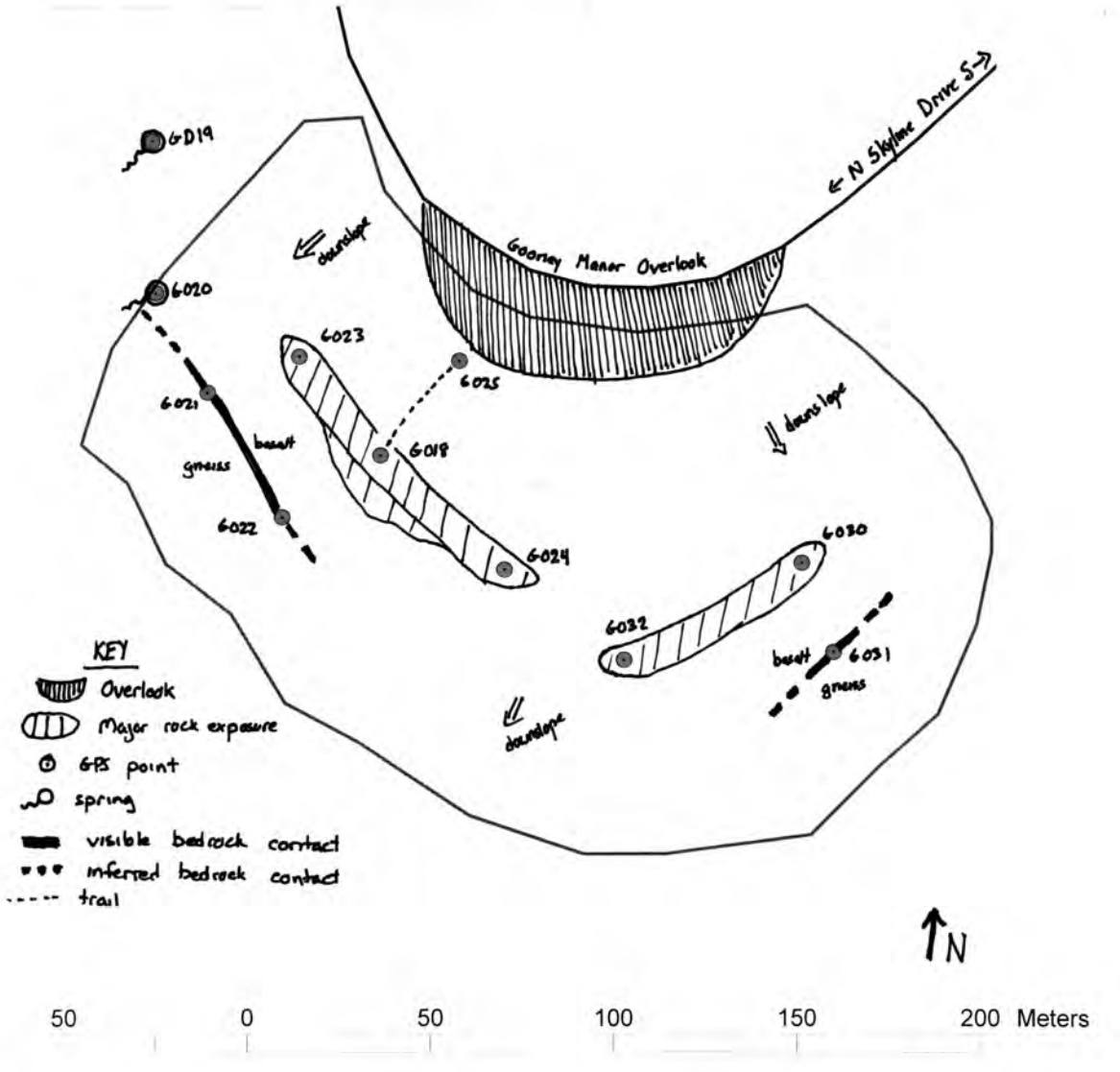
C19 - Gooney Manor Overlook (continued...)

Area sketch map



C19 - Gooney Manor Overlook (continued...)

Detail sketch map



C19 - Gooney Manor Overlook (continued...)



SHEN_C19_G_20050606_001.jpg Azmuth: 120

Spring with open vegetation NW of site boundary



SHEN_C19_G_20050606_002.jpg Azmuth: 130

Spring with open vegetation on NW site boundary



SHEN_C19_G_20050606_003.jpg Azmuth:

Typical exposure of basement gneiss, more rounded and smooth than basalt



SHEN_C19_G_20050606_004.jpg Azmuth:

Typical exposure of greenstone cliff, very rough and fractured

C19 - Gooney Manor Overlook (continued...)



SHEN_C19_G_20050606_005.jpg Azmuth: 145

Looking SE along top of western cliff

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C20 - Halfmile Cliff

Site Code: C20
Site Name: Halfmile Cliff
Data Collector Butler, Eric
Date Studied: 23-Aug-06

Polygon Centroid: **E:** 729788 **N:** 4269066
UTM (Zone 17 NAD83)
Dimensions (m): 1340 x 310 (GIS est.)
Elevation Range (ft): 1320 to 2280

Physical Characteristics

Location Acces

Park at the Lower Whiteoak Canyon parking lot, accessed from Berry Hollow outside the park. Follow the Whiteoak Canyon Trail appx. 170m to a junction with the Cedar Run Trail; follow this appx. 600m to a junction with the Cedar Run Link Trail (which cuts across to Whiteoak Canyon). This junction is roughly at the site boundary. From here, the easiest access is to turn upslope off the trail and climb a short distance to reach the first exposures and continue upslope from there (WARNING: Do not go too far NE of the site; the slope turns very rugged with abundant deadfall and loose rock in this direction). Alternatively, follow the trail through Cedar Run canyon to a point above the upper falls where you can cut back across the slope to reach the westernmost exposures. There is very little realistic access to the exposures from within the canyon, due to the ruggedness of the area.

Physical Description:

This site consists of a long expanse of steeply sloping land rising up from the narrow, rugged canyon of Cedar Run to near the top of the parallel ridge. At the southeast end, where the canyon widens, the site extends around the nose of the ridge and angles back northeast. Along the top of the site, the slopes are relatively gentle and the forest open, but towards the bottom of the site, near Cedar Run, the slopes become steep, rocky, and very rugged. At the northwest end of the site, the canyon becomes especially narrow and some outcrop areas surrounding the Upper Falls are too rugged to easily access.

This site contains two very different types of exposures. Within the southeast portion of the site, several exposures consist of sloping faces and outcrops at similar angles to the surrounding topography; these cover a wide area but are often partially vegetated. Along the rest of the site, the exposures take the form of multiple cliff lines topped by ledges, which angle up the slope nearly from top to bottom of the ridge. Some of these cliff lines remain within the forest, while others are partially open with grassy ledges and semi-open glens above them. Between these cliff lines, the landscape generally forms a sloping bench with open forest, which is usually very navigable. The cliffs are difficult to cross, however, and make lengthwise navigation difficult.

Vegetation: Moderate

Steeper slopes have some low, thick underbrush, but the forest here is generally open enough to cause no real barriers to navigation. The significant exceptions come near the Upper Falls, near the base of the canyon, and on the slopes along the nose of the ridge to the northeast of the lower site boundary; this latter area is especially dense with deadfall and briers.

Human Effects

Impacts: Pristine

There is no sign of any human presense or impact at these exposures. Given the difficulty involved in reaching most of the area, it is likely few visitors have ever reached the important portions of the site.

Access Remote

Although the trail technically runs through the site boundary, it does so deep in a rugged canyon, offering virtually no opportunities to cross Cedar Run and climb up to the exposures. A few parts of the cliffs are visible from the trail through the trees, but no means of access is present from these places. The only two realistic access points, from the trail junction below and from above the upper falls, offer no views or incentives to leave the trail, and indeed still involve a rugged climb and route to reach any open areas. In effect, the trail does not lead to or near any of the exposures within the site, and so it is classified as remote, as it has far more in common with truly remote sites than with others near trails.

Geologic Characteristics

C20 - Halfmile Cliff (continued...)

Lithology: **Rock Type** Greenstone

The bedrock here consists of a thick sequence of greenstone lava flows from the Catoctin Formation. There are likely at least five or six flows within the canyon, judging by the number of significant parallel cliff lines within the site, and possibly more. Although the flows change noticeably in character throughout the site, it is difficult in most places to precisely define the contact between each one, due to soil and talus cover and lack of sufficient exposure. Four common appearances were observed: (a) very platy, chlorite-rich, and dark green; (b) fine-grained and featureless other than columnar jointing; (c) fine-grained and blocky with significant quantities of lime-green epidote; (d) heavily cleaved, often with more iron content and thus a reddish surface.

Veins of epidote and quartz are common. In only one place was a specific contact between two flows observed within bedrock; most evidence of flow boundaries is geomorphic (benches or divisions between cliff units) or erosional (loose pieces of breccia, vesicular textures, or other evidence of contact areas).

Structure:

Cleavage and fracturing are common within the greenstone. The former is related to growth of platy chlorite minerals during deformation and produces ubiquitous near-parallel planes of weakness, while the latter is a more randomly distributed network of cracks along which blocks of bedrock erode. Columnar jointing is rare and poorly preserved within this site, but can be found in a few places.

Overall, it appears that the sequence of lava flows in this area has been tilted significantly to the east or southeast. This is shown most clearly by the regular, parallel cliff lines that angle NW-SE along the slope within the canyon, and the presence of contact material between these lines. Due to this orientation, as one travels NW through the site, one is actually descending through the sequence, despite gaining altitude in places.

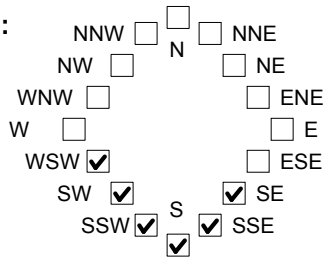
Other:

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	30.0	20.0	20.0	30.0	0.0	100
Max relief(m):	15	5	10	2	0	

Maximum Slope: 35 **Texture:** Rough

Aspects:



Setting:

The series of cliff lines angling across this site are formed from a series of east-dipping greenstone lava flows. Through most of the Central and North Districts, the lava flows dip to the east or southeast at gentle angles (estimated at 10-20 degrees by other sources). As in most other greenstone areas, the centers of flows tend to produce linear exposures across slopes, with topographic benches forming between flows. Where these flows protrude from west-facing slopes, they produce a near-horizontal staircase-like series of cliffs and benches, e.g. Stony Man and Mt Marshall. Where these flows are exposed within deeply incised canyons cutting across the dip of the flows, however, they produce angled cliff lines like those seen at Halfmile Cliff and Rose River. The flows are not dipping as steeply as the cliff lines, however; this is a geometric pattern created by the interaction between the topography and the underlying flow. Thus, as one walks west through the site, even while gaining elevation, one is slowly descending through the lava flow sequence with each cliff/outcrop line crossed.

At Halfmile Cliff, different lava flows are primarily distinguished by outcrop pattern (individual lines of cliffs, outcrops, and benches). Very few exposures preserve the contacts between flows, though amygdaloidal and brecciated fragments are common in loose rock on the slopes. All exposed bedrock here is fairly standard for greenstone areas, with no unusual textures or compositions.

The pattern of angled cliff lines does not hold at the southeast end of the site, though this is the exception that proves the rule. Here, at G250 and G251, the exposures form sloping faces and outcrops instead of cliffs, and follow the orientation of the slope rather than cutting across it. Considering the overall east or southeast dip of the lava flows, these final exposures are likely

C20 - Halfmile Cliff (continued...)

where the topography is now matching the orientation of the flows, and so smooth, sloping exposures are created. Almost certainly the flows underlying these areas connect to some of the cliff lines farther west, and simply create a different exposure pattern here due to the change in topography as the ridgeline wraps around to the east and northeast. The flows have not changed orientation; it is the change in the topography that is driving the change in exposure pattern. G250 and G251 might be compared to Goat Ridge (C18) and Sawlog Ridge (C45) which display a similar pattern of sloping faces where the topography and the flow orientation coincide.

Stability: Stable

Loose rocks are common in the surrounding forested slopes, but the bedrock exposures are generally quite solid; the cleavage and fracturing is not so strong or pervasive as to render the rock unstable.

GPS Points

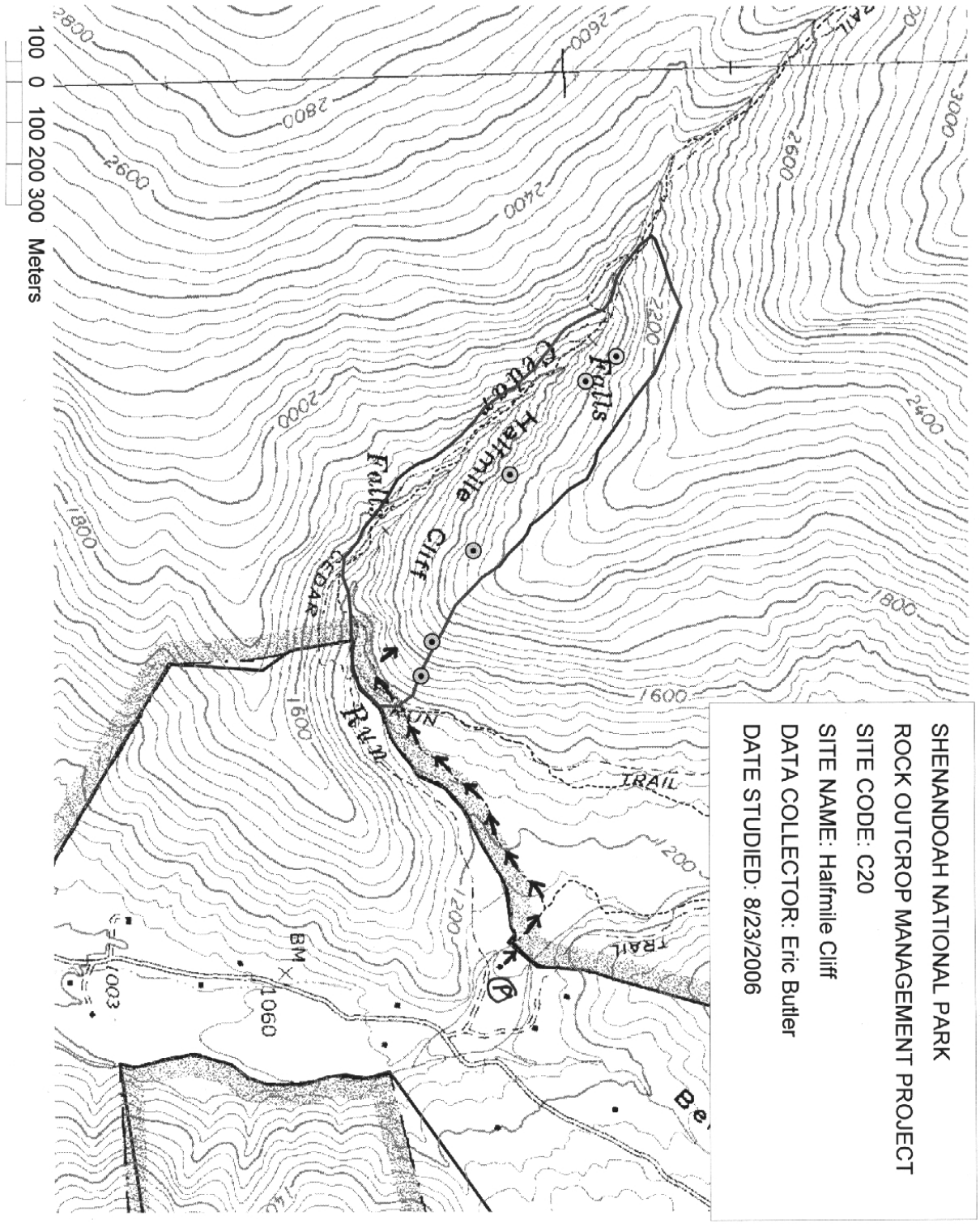
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
8/23/2006	G250-C20	730294	4268843	1520	Lower of two large, open face/cliff complexes at east end of site
8/23/2006	G251-C20	730210	4268870	1680	Upper of two large, open face/cliff complexes at east end of site
8/23/2006	G252-C20	729985	4268971	1920	Glade atop easternmost of many linear exposures angling up the slop
8/23/2006	G253-C20	729798	4269061	1920	Open ledges at center/top of very long, large cliff/ledge exposure near
8/23/2006	G254-C20	729567	4269247	1960	Glade above smaller linear exposure east of upper falls
8/23/2006	G255-C20	729506	4269322	2000	Part of westernmost exposures, above upper falls

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
8/23/2006	G250-C20	SHEN_C20_G_20060823_001.jpg	45	Butler, Eric	Vegetated faces sloping down to become cliff
8/23/2006	G252-C20	SHEN_C20_G_20060823_002.jpg	340	Butler, Eric	Cliff/ledge complex at G252, angling up slope
8/23/2006	G252-C20	SHEN_C20_G_20060823_003.jpg	35	Butler, Eric	Partially open glade at upper end of G252 exposure
8/23/2006	G253-C20	SHEN_C20_G_20060823_004.jpg	190	Butler, Eric	Ledges above long, large cliff centered on G253
8/23/2006	G253-C20	SHEN_C20_G_20060823_005.jpg	325	Butler, Eric	Looking down cliff at G253
8/23/2006	G253-C20	SHEN_C20_G_20060823_006.jpg	165	Butler, Eric	View along cliff top at G253
8/23/2006	G254-C20	SHEN_C20_G_20060823_007.jpg	155	Butler, Eric	Partially open glade above cliff at G254
8/23/2006	G255-C20	SHEN_C20_G_20060823_008.jpg		Butler, Eric	Open ledges above cliff

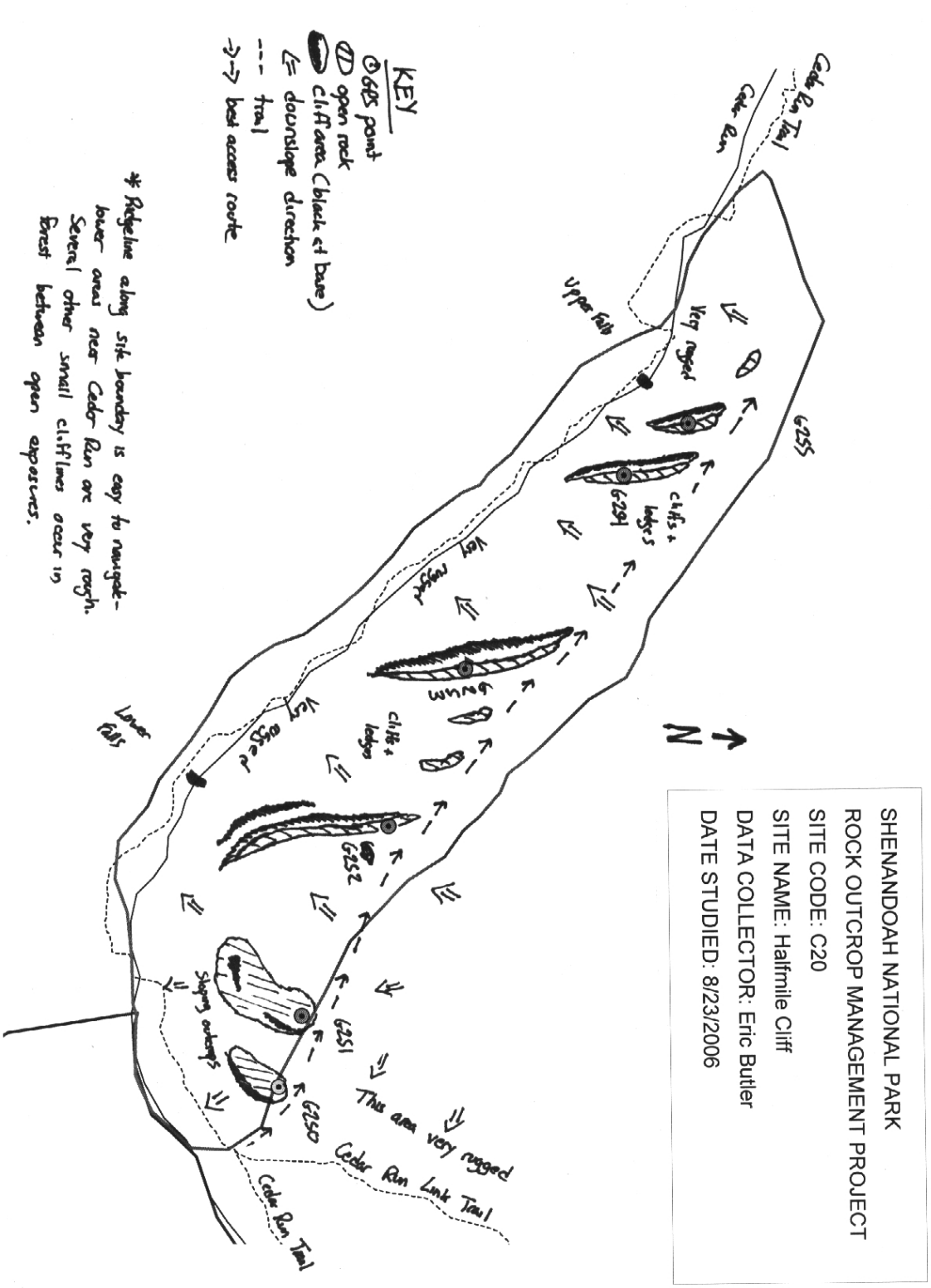
C20 - Halfmile Cliff (continued...)

Area map



C20 - Halfmile Cliff (continued...)

Detail map



C20 - Halfmile Cliff (continued...)



SHEN_C20_G_20060823_001.jpg Azmuth: 45

Vegetated faces sloping down to become cliff



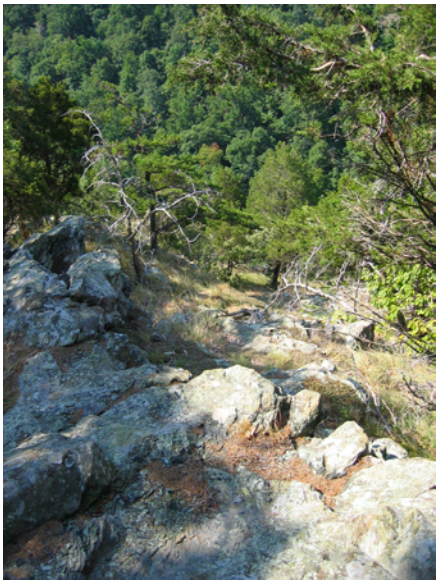
SHEN_C20_G_20060823_002.jpg Azmuth: 340

Cliff/ledge complex at G252, angling up slope



SHEN_C20_G_20060823_003.jpg Azmuth: 35

Partially open glade at upper end of G252 exposure



SHEN_C20_G_20060823_004.jpg Azmuth: 190

Ledges above long, large cliff centered on G253

C20 - Halfmile Cliff (continued...)



SHEN_C20_G_20060823_005.jpg Azmuth: 325

Looking down cliff at G253



SHEN_C20_G_20060823_006.jpg Azmuth: 165

View along cliff top at G253



SHEN_C20_G_20060823_007.jpg Azmuth: 155

Partially open glade above cliff at G254



SHEN_C20_G_20060823_008.jpg Azmuth:

Open ledges above cliff

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C21 - Hawksbill N slope outcrops

Site Code: C21
Site Name: Hawksbill N slope outcrops
Data Collector Butler, Eric
Date Studied: 01-Mar-06

Polygon Centroid: **E:** 727078 **N:** 4270765
UTM (Zone 17 NAD83)
Dimensions (m): 100 x 490 (GIS est.)
Elevation Range (ft): 3640 to 3960

Physical Characteristics

Location Access

This site can be accessed two different ways. To reach it from the top, park at the Upper Hawksbill parking lot, between MP 46 and 47. Follow the Hawksbill Trail along a gradual climb up the gentle southeast slope of the mountain for about 1.5km to reach the summit area. The last portion of this trail follows a gravel fire road. From the stone overlook at the summit, hike north along and then down the narrow ridge to reach a flat bench area that precedes the main cliffs of Hawksbill. To reach the site from the bottom, park at the Hawksbill Gap parking area (milepost 45.5) and follow a short connector trail to the Appalachian trail. Make sure not to follow the Hawksbill Trail, which begins from the same lot but leads to Hawksbill summit rather than the north slope via the AT. Once on the AT, hike south for about 400m, climbing steadily, until the trail begins to cross a series of linear talus slopes with views to the north and east. From here, climb up the talus slopes to reach the bases of the major Hawksbill cliffs.

Physical Description:

This site consists of many large rock exposures spread across the steep north face of Hawksbill Mountain. From afar, most of the exposures here look like sheer cliffs, but many are actually linear ridges or sloping outcrops that contain numerous ledges and are not too difficult to ascend or descend. In fact, many of the open rock areas are more stable and safer to navigate than the surrounding steep slopes covered in loose rock and slippery vegetation. Most of the exposures occur within two distinct bands stretching across the slope. The lower band contains larger and steeper exposures, including the one true cliff between G228 and G229, while the upper band contains more narrow, vertical outcrops with many ledges, primarily at G225-G227. Above this upper band of exposures are a few minor outcrops, and then a prominent topographic bench that marks the transition into C22 (Hawksbill Summit).

Vegetation: Dense

Many of the slopes surrounding these exposures are covered in thick growth, which can be very difficult to negotiate on steep and loose slopes.

Human Effects

Impacts: Mild

Despite the rugged nature of this site, definite signs of human visitation were observed. In early March, when the site was visited, recent footprints were clearly visible in snow banks near the top of the site. Several locations contained distinct patterns of parallel, linear scratches up to 5cm long, gouged into the rock surface and through lichens (see photos 11, 13, and 14). These patterns are most likely from ice-climbers' crampons; during the site visit a visitor was encountered who had ice-climbed within the site earlier in the winter, and was scouting the area for current conditions. These impacts make it clear that the outcrops and cliffs of this site are being accessed by visitors, and noticeable and long-lasting damage is being done to the bedrock (the crampon gouges are very noticeable and cannot be remediated). However, since these impacts were only observed in a few locations, and most of the site does not show evidence of impact, the rating is kept at "mild" as that most accurately reflects the overall condition of the site.

Access Remote

As discussed in IMPACTS above, it is clear that at least a few people are accessing this site despite the lack of trails or easy access directly to the rock exposures. In this case, however, it is relatively easy to get fairly close to the site, either via the Appalachian Trail from below or via the summit from above. It is not likely that the average visitor will reach the site, due to the topography and hiking distance involved, and the availability of easier views and experiences nearby. However, as the observed impacts appear related to climbing activity, the ruggedness of the surrounding landscape will provide less of a deterrent than usual for remote sites.

Geologic Characteristics

C21 - Hawksbill N slope outcrops (continued...)

Lithology: **Rock Type** Greenstone

This site is underlain by multiple greenstone lava flows of the Catoctin Formation. The rock exposures here primarily occur within two roughly horizontal bands stretching across the slope. The lower band, which contains the exposures marked by G222, G224, and the cliff marked by G228 and G299, appears to correlate to a single lava flow (this site's "lower flow"). This flow is marked primarily by abundant and well-formed columnar jointing, which is especially evident at G222 and G228. At G223, a long, horizontal outcrop of volcanic breccia appears to mark the base of the lower flow, although this unit does not visibly extend across the rest of the slope. Above this flow, between G227 and G228, a thick unit of volcanic breccia marks the transition to the next flow in the sequence (the "upper flow"). This flow forms the upper band of major rock exposure, the linear, ledgy outcrops of G225, G226, and G227. Here the rocks still contain abundant columnar jointing, though not as well formed as those below, and epidote is much more abundant, both in large distinct pods and within the general matrix of the rock. Above this upper band of exposures, a few subtle outcrops peek through the trees just below the large topographic bench that marks the base of the flow which forms Hawksbill's summit cliffs, part of site C22. It was not clear during this survey whether these outcrops are part of a smaller, separate flow, or simply the highest extent of the upper flow.

A study by Badger (1992) of lava flow stratigraphy in this area identified five total flows from the base of the sequence at the basement rock contact (flow 1) to the summit of Hawksbill Mountain (flow 5). The correlation between this study and Badger's work is not perfect, but a likely matchup is described here. Badger's second flow seems to fit the lower flow of this site, including containing "the best columnar jointing in the sequence". Above this, Badger's third flow still contains columnar jointing, but " numerous pods of epidosite…are prominent.", a good fit with the upper flow as described in this survey. Under this correlation, the possible separate flow above the upper flow becomes Badger's fourth flow, and the summit flow matches his fifth. Other arrangements are possible, but this seems the most likely without further field work to decide the issue (which is not directly relevant to ROMP and so is not the focus of this report).

Structure:

Columnar jointing seems to be the dominant structural feature here. Cleavage is present, but is not as prominent or well-developed as at other sites. Overall, the sequence of lava flows seems to be tilted off to the east at a gentle angle, which can be seen in the general shape of the mountain as well as in outcrop pattern in C22 (Hawksbill Summit).

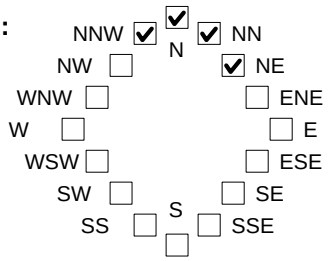
Other:

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	40.0	30.0	0.0	30.0	0.0	100
Max relief(m):	20	20	0	2	0	

Maximum Slope: 40 **Texture:** Fractured

Aspects:



Setting:

The rock exposures along Hawksbill's north face follow a pattern common within greenstone areas of the Central District in occurring along the west and north sides of the mountains, with a gentler slope descending to the south and east. This pattern is caused by the general southeastward tilt of the lava flow sequence, so that individual flows create steep slopes and rugged cliffs where they are thrust out of the ground, and create smooth, gentle slopes where their tilting surfaces match the topography. Within the exposures, columnar jointing appear to be the dominant structural factor affecting their formation and appearance. These tall, vertical fractures often create cliffs as at G228 and G229, are also instrumental in creating the linear, protruding outcrop ridges seen through much of this site.

This site is somewhat unusual in that its exposures are fairly fragmented, as compared to the more continuous cliff/outcrop areas of Hawksbill Summit, Stony Man, and other comparable high-elevation greenstone areas. No evidence that might explain this pattern was observed at the site. The presence of major cliffs and rock exposures on the north face of the mountain is also unusual, as in most comparable areas the sheer exposures are to the west, as dictated by the regional eastward dip of the lava

C21 - Hawksbill N slope outcrops (continued...)

flows. This anomaly may be explained by the presence of a small fault cutting across the mountains through Hawksbill Gap, which would likely accelerate and focus the erosion in this area and thus encourage the formation of steep slopes and sheer rock exposures here rather than to the west.

Stability: Moderate

Despite the abundant columnar jointing, most of the exposures are solid at a human time scale. However, the steep slopes and abundant loose material present a constant hazard.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
3/1/2006	G222-C21	727181	4270789	3640	Base of narrow cliff/ridge; defines one side of chute reportedly used by
3/1/2006	G223-C21	727123	4270792	3680	Western end of long horizontal outcropping of volcanic breccia
3/1/2006	G224-C21	727137	4270770	3740	Topographic bench between two significant rock exposures, separatin
3/1/2006	G225-C21	727118	4270753	3800	Center of large, open cliff/ledge complex with a great deal of rare plant
3/1/2006	G226-C21	727137	4270732	3840	Top of narrow cliff/outcrop extending down across two flows to meet G
3/1/2006	G227-C21	727036	4270793	3840	Center of tall, open cliff/ledge rock rib that corresponds to G225 in litho
3/1/2006	G228-C21	727039	4270821	3740	Western end of largest rock exposure in site; narrow chute in jointing c
3/1/2006	G229-C21	727082	4270824	3700	Eastern base of largest rock exposure; excellent columnar jointing alo
3/27/2006	G236-C21	727008	4270722	3960	Open ledge at edge of large flat bench, capping cliff/outcrop area at ve

Site Photos

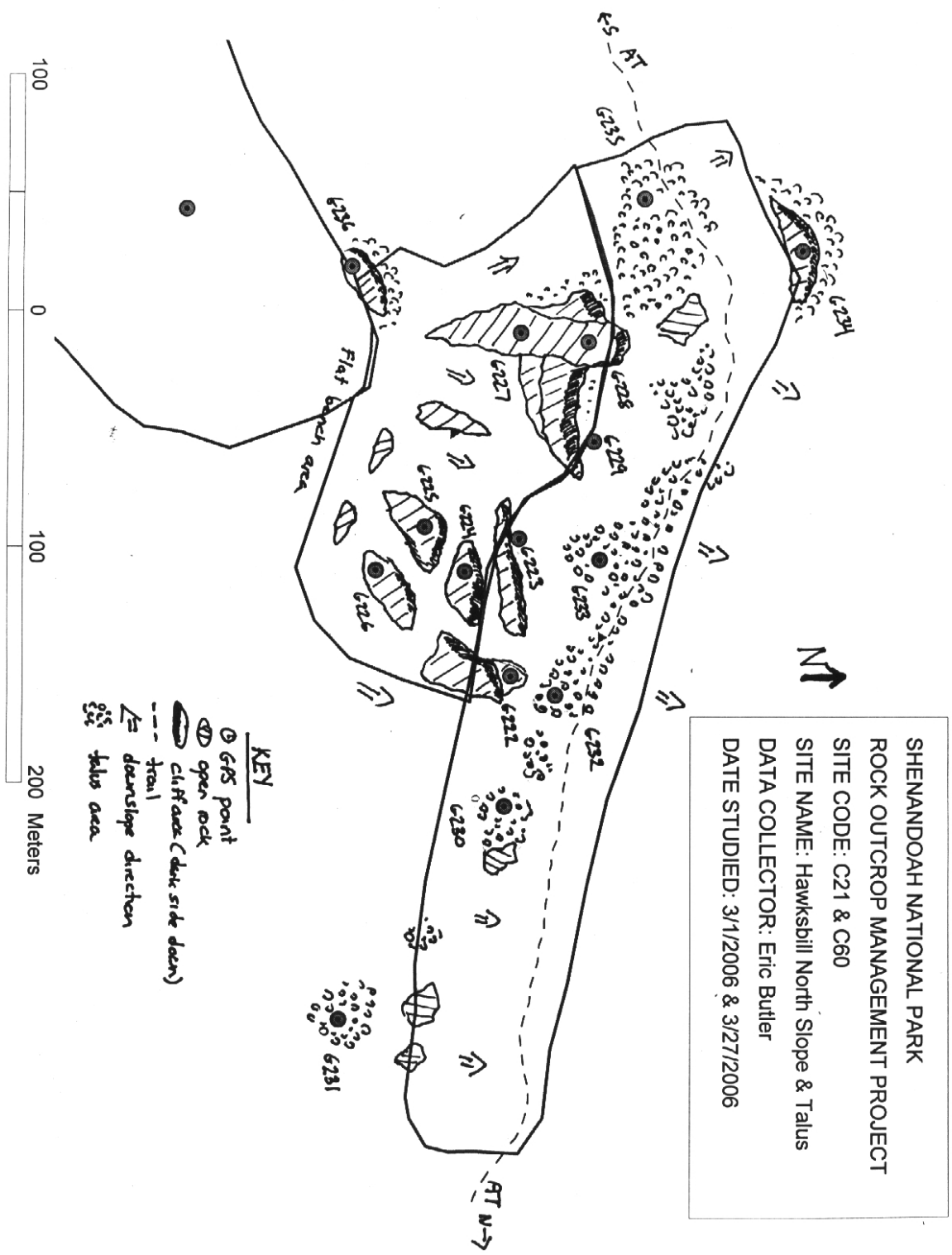
Image Date	GPS Point	File Name	Azmuth	Taken By	Description
3/1/2006		SHEN_C21_G_20050428_001.JPG		Butler, Eric	Wide view of summit cliffs taken from Crescent Rock
3/1/2006	G222-C21	SHEN_C21_G_20060301_001.jpg		Butler, Eric	Tilted columnar jointing at base of rock rib enclosing chute used for rock/ice climbing
3/1/2006	G222-C21	SHEN_C21_G_20060301_002.jpg		Butler, Eric	Thickly vegetated ledges formed from eroded tops of columnar joints
3/1/2006	G222-C21	SHEN_C21_G_20060301_003.jpg		Butler, Eric	Thickly vegetated ledges formed from eroded tops of columnar joints
3/1/2006	G222-C21	SHEN_C21_G_20060301_004.jpg		Butler, Eric	Icy cliff/ledges near top of chute, above G222 and east of G224. Area reportedly used for rock/ice climbing
3/1/2006	G224-C21	SHEN_C21_G_20060301_005.jpg		Butler, Eric	View from G224 of large cliff/ledge complex defined by G227 (upper left), G228 (on other side of cliff at center) and G229 (below ledges lower right)
3/1/2006	G224-C21	SHEN_C21_G_20060301_006.jpg		Butler, Eric	View down from G224 of rock rib defining climbing chute; G222 is at base, ice-climbing area is at lower right
3/1/2006	G224-C21	SHEN_C21_G_20060301_007.jpg		Butler, Eric	Slightly blurred view of very ledgy, heavily vegetated (many rare plants found here) exposures leading up to G225; note high epidote content of rocks here (lime
3/1/2006	G224-C21	SHEN_C21_G_20060301_008.jpg		Butler, Eric	View east toward G226, ledges atop small cliff where crampon marks were found
3/1/2006	G225-C21	SHEN_C21_G_20060301_009.jpg		Butler, Eric	Unidentified iron oxide mineral forming "skin" on rocks; likely originally formed in veins within rocks, which have since partially eroded away
3/1/2006	G225-C21	SHEN_C21_G_20060301_010.jpg		Butler, Eric	View down from G225 toward G224 (at break in slope) and climbing chute with G222 at base. Note high epidote content in this section, relative to rocks lower
3/1/2006	G225-C21	SHEN_C21_G_20060301_011.jpg		Butler, Eric	Closeup of epidote-rich, highly fractured rocks typical of this section
3/1/2006	G225-C21	SHEN_C21_G_20060301_012.jpg		Butler, Eric	Abundant rare plant huperzia growing on rock exposures near G225
3/1/2006	G226-C21	SHEN_C21_G_20060301_013.jpg		Butler, Eric	Deep, linear, near-parallel scratches in rock, presumed to be left by ice-climber's crampons; other scratches and footprints in snow found nearby
3/1/2006	G226-C21	SHEN_C21_G_20060301_014.jpg		Butler, Eric	Deep, linear, near-parallel scratches in rock, presumed to be left by ice-climber's crampons; other scratches and footprints in snow found nearby

C21 - Hawksbill N slope outcrops (continued...)

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
3/1/2006	G226-C21	SHEN_C21_G_20060301_015.jpg		Butler, Eric	Very ledgy, heavily vegetated area atop small cliff at G226; many rare plants found here.
3/1/2006	G226-C21	SHEN_C21_G_20060301_016.jpg		Butler, Eric	View down ledges and cliff at G226 toward lower rock rib bordering climbing chute; G222 is at base of this lower ridge
3/1/2006	G227-C21	SHEN_C21_G_20060301_017.jpg		Butler, Eric	Abundant vegetation growing on ledges fomed from eroded tops of columnar joints
3/1/2006	G227-C21	SHEN_C21_G_20060301_018.jpg		Butler, Eric	View down western edge of cliff toward G228;rock in foreground is thick unit of volcanic breccia separating two major flows within this site
3/1/2006	G227-C21	SHEN_C21_G_20060301_019.jpg		Butler, Eric	Closeup of epidotized volcanic breccia between G227 and G228
3/1/2006	G228-C21	SHEN_C21_G_20060301_020.jpg		Butler, Eric	Rare plant huperzia growing profusely in narrow chute descending western side of cliff near G228
3/1/2006	G228-C21	SHEN_C21_G_20060301_021.jpg		Butler, Eric	Beautifully formed and preserved columnar jointing below G228, near base of large cliff
3/1/2006	G228-C21	SHEN_C21_G_20060301_022.jpg		Butler, Eric	Good columnar jointing in cliff below G228
3/1/2006	G228-C21	SHEN_C21_G_20060301_023.jpg		Butler, Eric	Excellent columnar jointing at base of cliff below G228, west of G229

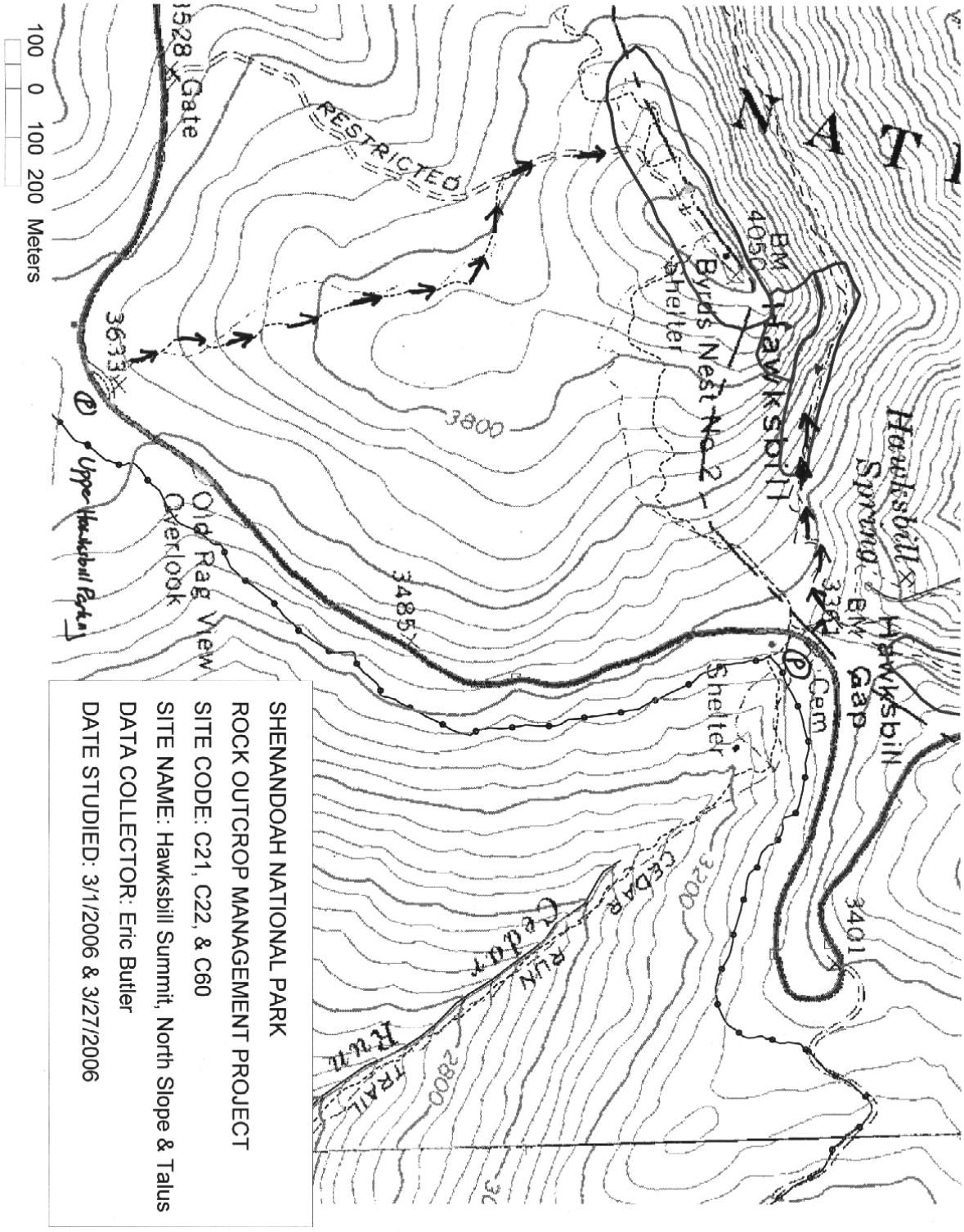
C21 - Hawksbill N slope outcrops (continued...)

Detail map



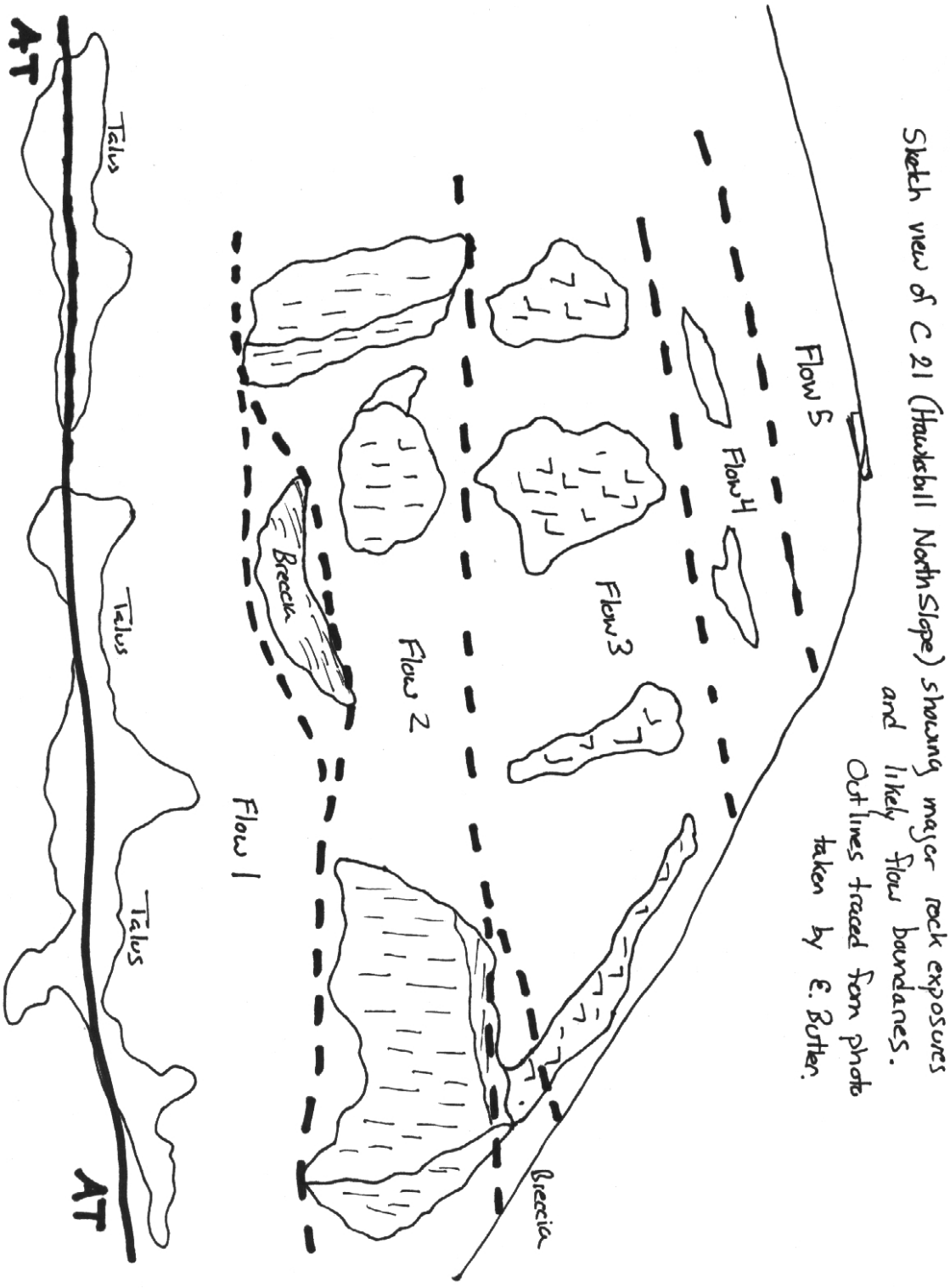
C21 - Hawksbill N slope outcrops (continued...)

Area map



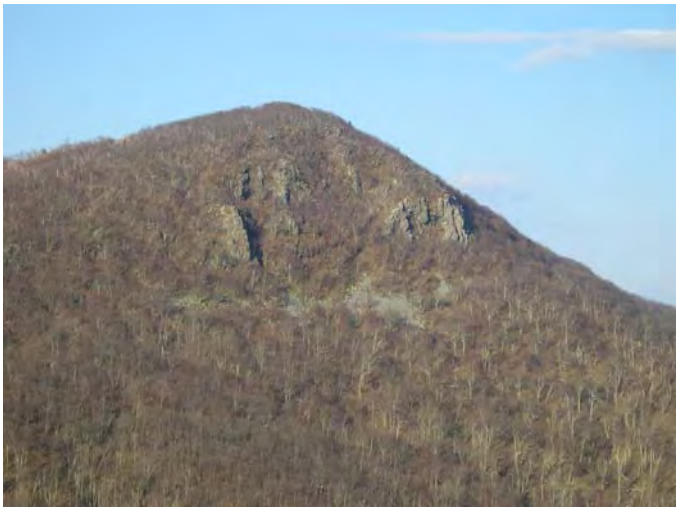
C21 - Hawksbill N slope outcrops (continued...)

Side view map



Sketch view of C 21 (Hawksbill North Slope) showing major rock exposures and likely flow boundaries. Outlines traced from photo taken by E. Butler.

C21 - Hawksbill N slope outcrops (continued...)



SHEN_C21_G_20050428_001.JPG Azmuth:

Wide view of summit cliffs taken from Crescent Rock



SHEN_C21_G_20060301_001.jpg Azmuth:

Tilted columnar jointing at base of rock rib enclosing chute used for rock/ice climbing



SHEN_C21_G_20060301_002.jpg Azmuth:

Thickly vegetated ledges formed from eroded tops of columnar joints



SHEN_C21_G_20060301_003.jpg Azmuth:

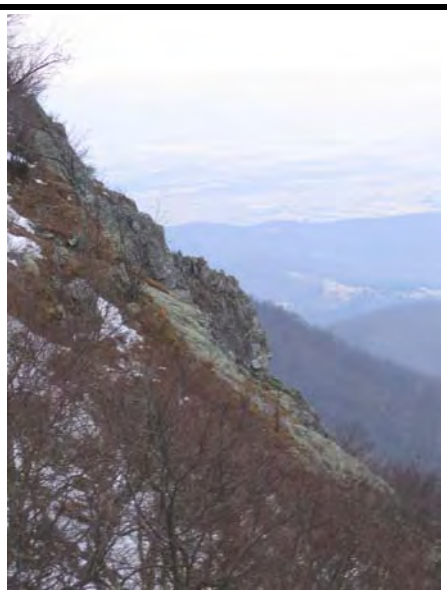
Thickly vegetated ledges formed from eroded tops of columnar joints

C21 - Hawksbill N slope outcrops (continued...)



SHEN_C21_G_20060301_004.jpg Azmuth:

Icy cliff/ledges near top of chute, above G222 and east of G224. Area reportedly used for rock/ice climbing



SHEN_C21_G_20060301_005.jpg Azmuth:

View from G224 of large cliff/ledge complex defined by G227 (upper left), G228 (on other side of cliff at center) and G229 (below ledges lower right)



SHEN_C21_G_20060301_006.jpg Azmuth:

View down from G224 of rock rib defining climbing chute; G222 is at base, ice-climbing area is at lower right



SHEN_C21_G_20060301_007.jpg Azmuth:

Slightly blurred view of very ledgy, heavily vegetated (many rare plants found here) exposures leading up to G225; note high epidote content of rocks here (lime-green color); columnar joints are not as well developed as lower areas

C21 - Hawksbill N slope outcrops (continued...)



SHEN_C21_G_20060301_008.jpg Azmuth:

View east toward G226, ledges atop small cliff where crampon marks were found



SHEN_C21_G_20060301_009.jpg Azmuth:

Unidentified iron oxide mineral forming "skin" on rocks; likely originally formed in veins within rocks, which have since partially eroded away



SHEN_C21_G_20060301_010.jpg Azmuth:

View down from G225 toward G224 (at break in slope) and climbing chute with G222 at base. Note high epidote content in this section, relative to rocks lower down.



SHEN_C21_G_20060301_011.jpg Azmuth:

Closeup of epidote-rich, highly fractured rocks typical of this section

C21 - Hawksbill N slope outcrops (continued...)



SHEN_C21_G_20060301_012.jpg Azmuth:

Abundant rare plant huperzia growing on rock exposures near G225



SHEN_C21_G_20060301_013.jpg Azmuth:

Deep, linear, near-parallel scratches in rock, presumed to be left by ice-climber's crampons; other scratches and footprints in snow found nearby



SHEN_C21_G_20060301_014.jpg Azmuth:

Deep, linear, near-parallel scratches in rock, presumed to be left by ice-climber's crampons; other scratches and footprints in snow found nearby



SHEN_C21_G_20060301_015.jpg Azmuth:

Very ledgy, heavily vegetated area atop small cliff at G226; many rare plants found here.

C21 - Hawksbill N slope outcrops (continued...)



SHEN_C21_G_20060301_016.jpg Azmuth:

View down ledges and cliff at G226 toward lower rock rib bordering climbing chute; G222 is at base of this lower ridge



SHEN_C21_G_20060301_017.jpg Azmuth:

Abundant vegetation growing on ledges fomed from eroded tops of columnar joints



SHEN_C21_G_20060301_018.jpg Azmuth:

View down western edge of cliff toward G228;rock in foreground is thick unit of volcanic breccia separating two major flows within this site



SHEN_C21_G_20060301_019.jpg Azmuth:

Closeup of epidotized volcanic breccia between G227 and G228

C21 - Hawksbill N slope outcrops (continued...)



SHEN_C21_G_20060301_020.jpg Azmuth:

Rare plant huperzia growing profusely in narrow chute descending western side of cliff near G228



SHEN_C21_G_20060301_021.jpg Azmuth:

Beautifully formed and preserved columnar jointing below G228, near base of large cliff



SHEN_C21_G_20060301_022.jpg Azmuth:

Good columnar jointing in cliff below G228



SHEN_C21_G_20060301_023.jpg Azmuth:

Excellent columnar jointing at base of cliff below G228, west of G229

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C22 - Hawksbill Summit

Site Code: C22
Site Name: Hawksbill Summit
Data Collector Butler, Eric
Date Studied: 27-Mar-06

Polygon Centroid: **E:** 726793 **N:** 4270562
UTM (Zone 17 NAD83)
Dimensions (m): 130 x 610 (GIS est.)
Elevation Range (ft): 3840 to 4040

Physical Characteristics

Location Acces

Park at the Upper Hawksbill parking lot, between Milepost 46 and 47. Follow the Hawksbill Trail along a gradual climb up the gentle southeast slope of the mountain for about 1.5km to reach the summit area. The last portion of this trail follows a gravel fire road. The summit can also be accessed by a trail from Hawksbill Gap, but this route is longer and much steeper.

Physical Description:

This site largely consists of a single long line of cliffs oriented NE to SW along the summit of Hawksbill. This mostly continuous line of exposures is broken in a few places by talus-filled gaps, through which access can be had to the base of the cliffs. Open ledges cap most of these, with varying amounts of vegetation growing out onto the ledges. The cliff line angles up slightly to the NE, so that the furthest NE extent forms the summit area, on which a stone observation platform has been built. Below this summit area, a narrow ridge leads to the northeast before ending above a flat topographic bench that serves as the transition into the steep cliffs of C21 (Hawksbill North Slope). A small open rock area right at the boundary between the two sites, at GPS point G236, has been assigned to C21 and so is not further discussed in this report. There is also a small, semi-open bedrock outcrop surrounded by talus to the southeast of the main cliff line, marked by point G239. This area may or may not be of interest to the project.

Vegetation: Dense

There is a great deal of thick, dense growths of laurel, oak, and other vegetation throughout the summit area, which can be very difficult to push through. This especially causes problems near the clifftop ledges, where it can obscure loose rock areas or make navigation difficult if not dangerous.

Human Effects

Impacts: Heavy

Most of the site shows evidence of heavy human traffic. The worst impact is near the true summit to the northeast, and diminishes somewhat to the southwest as the trails grow smaller and the attraction lessens. Near the summit, there is virtually no vegetation remaining, the soil is stripped away to pockets of bare gravel, and trash and graffiti are common. Southwest of Byrd's Nest Shelter, a trail parallels the cliff line, sometimes along the cliffs and sometimes swinging into the woods. Impacts in this area are directly related to the trail's location; the few somewhat mildly affected areas are found here, where the trail has left the cliffs for a moment. Wherever the trail is near, social trails lead to impacted overlook areas.

Access Moderate

Hawksbill Summit is not difficult to access, although the 1.5km hike and moderate amount of elevation gain do keep it from being easy. As the highest summit in Shenandoah, it is an obvious draw to visitors, and it is clear that human traffic here is heavy.

Geologic Characteristics

Lithology:

Rock Type Greenstone

Most of this site is underlain by a single greenstone lava flow of the Catoctin Formation. A study by Badger (1992) of lava flow stratigraphy in this area named this summit flow as the fifth from the base of the sequence. The greenstone here is typical of the Catoctin Formation, appearing fine-grained and dark grey to green with reddish surface staining from weathering iron. This flow is capped by well-preserved volcanic breccia, also noted by Badger, containing abundant amygdules of quartz and fragments of greenstone and various metasediments. This unit appears mostly in the woods downslope to the east of the cliffs, and divides Flow 5 from the thin and sparsely occurring (as described by Badger) Flow 6 above it, of which the outcrop at G239 is likely composed.

C22 - Hawksbill Summit (continued...)

Structure:

Columnar jointing is common in this unit, with various levels of quality and preservation on display within the summit cliffs. Cleavage planes are more prevalent toward the top of the flow, as is often the case in the Catoctin, and interact with the columnar jointing to create the very uneven and ledgy texture prevalent along this summit ridge. Overall, it appears that this flow and the rest of the greenstone sequence are tilted gently to the southeast, as is the regional pattern in the Central District. Thus the breccias and other contact rocks appear topographically below the summit, despite being stratigraphically above the summit cliffs.

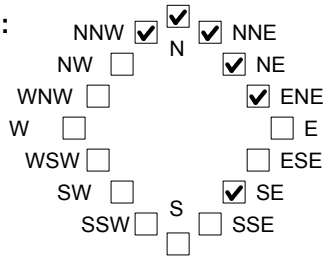
Other:

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	50.0	10.0	0.0	20.0	20.0	100
Max relief(m):	15	15	0	1	10	

Maximum Slope: 30 **Texture:** Fractured

Aspects:



Setting:

The cliffs along Hawksbill Summit follow a pattern common within greenstone areas of the Central District in occurring along the west and north sides of the mountains, with a gentler slope descending to the south and east. This pattern is caused by the general southeastward tilt of the lava flow sequence, so that individual flows create steep slopes and rugged cliffs where they are thrust out of the ground, and create smooth, gentle slopes where their tilting surfaces match the topography. Thus the hike from Upper Hawksbill Parking is gentle and easy (along the surface of the flows) whereas the hike from Hawksbill Gap is rugged and steep (up the protruding sequence of flows). This is also why the rocks at G239 are actually higher in the sequence of flows than those at the summit cliffs, despite being slightly lower in elevation. This general pattern is seen at Stony Man, Crescent Rocks, and many other sites within this region, and Hawksbill Summit is not unusual in this regard.

Within the cliffs themselves, columnar jointing is the dominant structural factor affecting the formation and appearance of the cliffs. This feature creates near-vertical fracture networks that help produce tall, sheer cliff faces as entire columns can peel away at once. Near the top of the flow, abundant cleavage planes at a much lower angle help to create the numerous ledges and pockets for soil that can support diverse vegetation in the area's natural state. The cliff itself is formed from the center of the flow, with the contact areas between the flows above and below being covered by talus and/or forming smoother benches that bracket the cliffs. This occurs because the greenstone within individual flows is far more homogenous and resistant to erosion than the diverse and jumbled rocks of most contact areas between flows.

Stability: Moderate

Most of the cliff and ledge areas are solid, but fractures are common enough that not all surfaces can be trusted.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
3/27/2006	G237-C22	726984	4270652	4040	Stone-built overlook at Hawksbill Summit, atop cliff line and narrow rid
3/27/2006	G238-C22	726892	4270619	4020	Partial gap in cliff line, with multiple vegetated ledges and access to tal
3/27/2006	G239-C22	726914	4270507	4000	Two parallel knobs/ridges of bedrock and talus; outside boundary, but
3/27/2006	G240-C22	726617	4270491	3920	Isolated knob of bedrock with impacted ledges; furthest west rock exp
3/27/2006	G241-C22	726724	4270538	3960	Open, impacted ledges along trail with abundant talus below

Site Photos

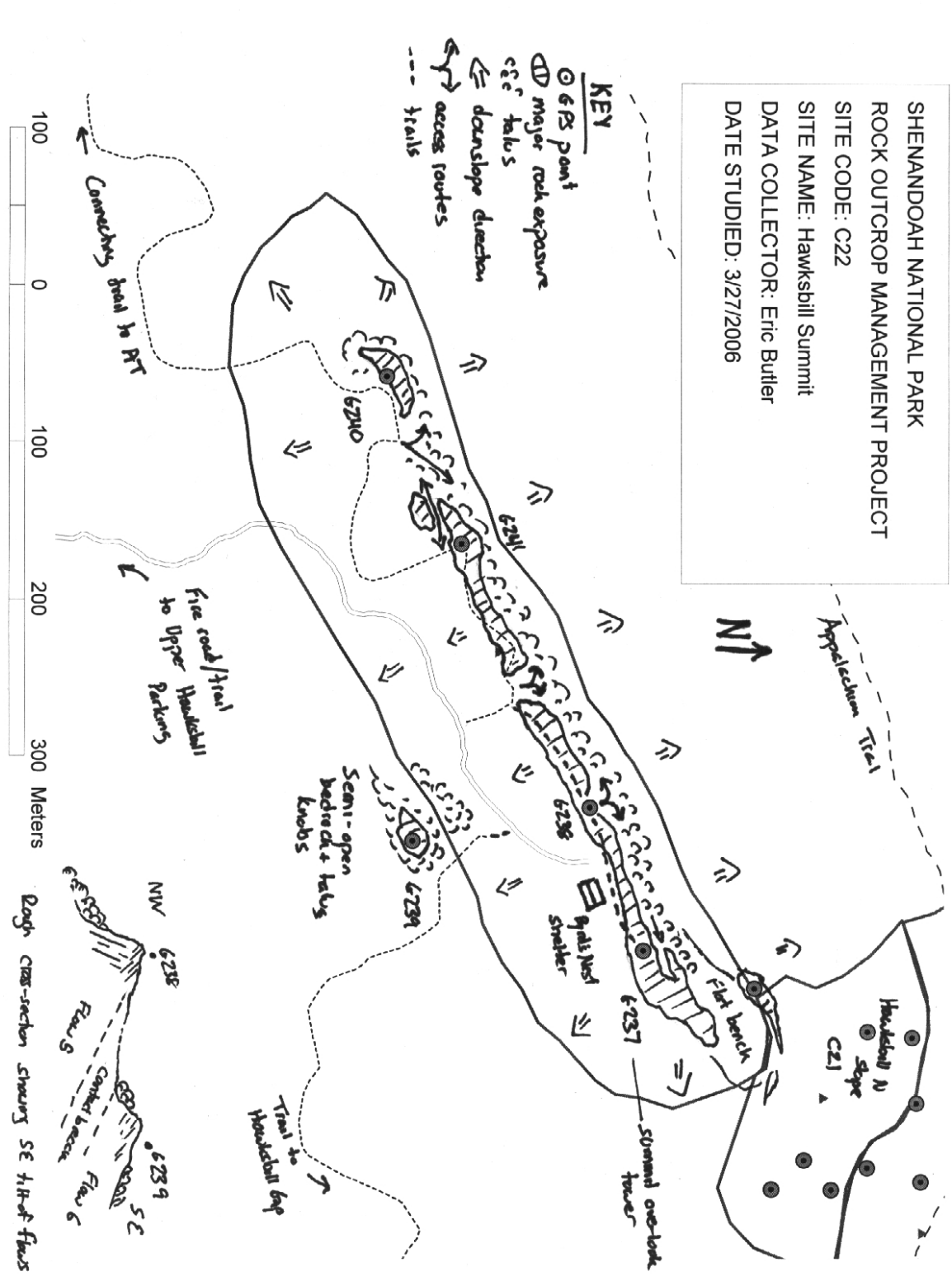
Image Date	GPS Point	File Name	Azmuth	Taken By	Description
3/27/2006		SHEN_C22_G_20060327_001.jpg	215	Butler, Eric	Flat bench northeast of summit ridge, with beginning of ridge in background behind trees (taken near GPS point G236, C21)

C22 - Hawksbill Summit (continued...)

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
3/27/2006	G237-C22	SHEN_C22_G_20060327_002.jpg	70	Butler, Eric	Top of summit ridge, northeast of stone overlook; social trails and some impact here
3/27/2006	G237-C22	SHEN_C22_G_20060327_003.jpg	55	Butler, Eric	Heavily impacted ledges along trail leading to stone overlook; soil and vegetated stripped, erosion along trail
3/27/2006	G237-C22	SHEN_C22_G_20060327_004.jpg	0	Butler, Eric	Significant erosion along side trail just southwest of summit overlook
3/27/2006	G237-C22	SHEN_C22_G_20060327_005.jpg	260	Butler, Eric	Impacted ledges and soil along clifftops southwest of summit overlook
3/27/2006	G237-C22	SHEN_C22_G_20060327_006.jpg	60	Butler, Eric	Impacted ledges and soil along clifftop, in front of Byrd's Nest shelter, southwest of summit overlook
3/27/2006	G238-C22	SHEN_C22_G_20060327_007.jpg	70	Butler, Eric	Columnar joints influencing shape and presence of cliff; note ledges developed on joint tops
3/27/2006	G238-C22	SHEN_C22_G_20060327_008.jpg	70	Butler, Eric	Numerous ledges along cliff below G239; this area can be traversed to the cliff base
3/27/2006	G238-C22	SHEN_C22_G_20060327_009.jpg	250	Butler, Eric	Numerous ledges along cliff below G239; this area can be traversed to the cliff base
3/27/2006	G240-C22	SHEN_C22_G_20060327_010.jpg	90	Butler, Eric	Impacted ledges atop small, isolated outcrop along trail below summit; farthest west exposure in site
3/27/2006	G241-C22	SHEN_C22_G_20060327_011.jpg	60	Butler, Eric	Open talus along cliff base at G241; typical of talus exposures found along entire length of cliffs within site
3/27/2006	G241-C22	SHEN_C22_G_20060327_012.jpg	240	Butler, Eric	Balsam fir growing among talus below cliffs

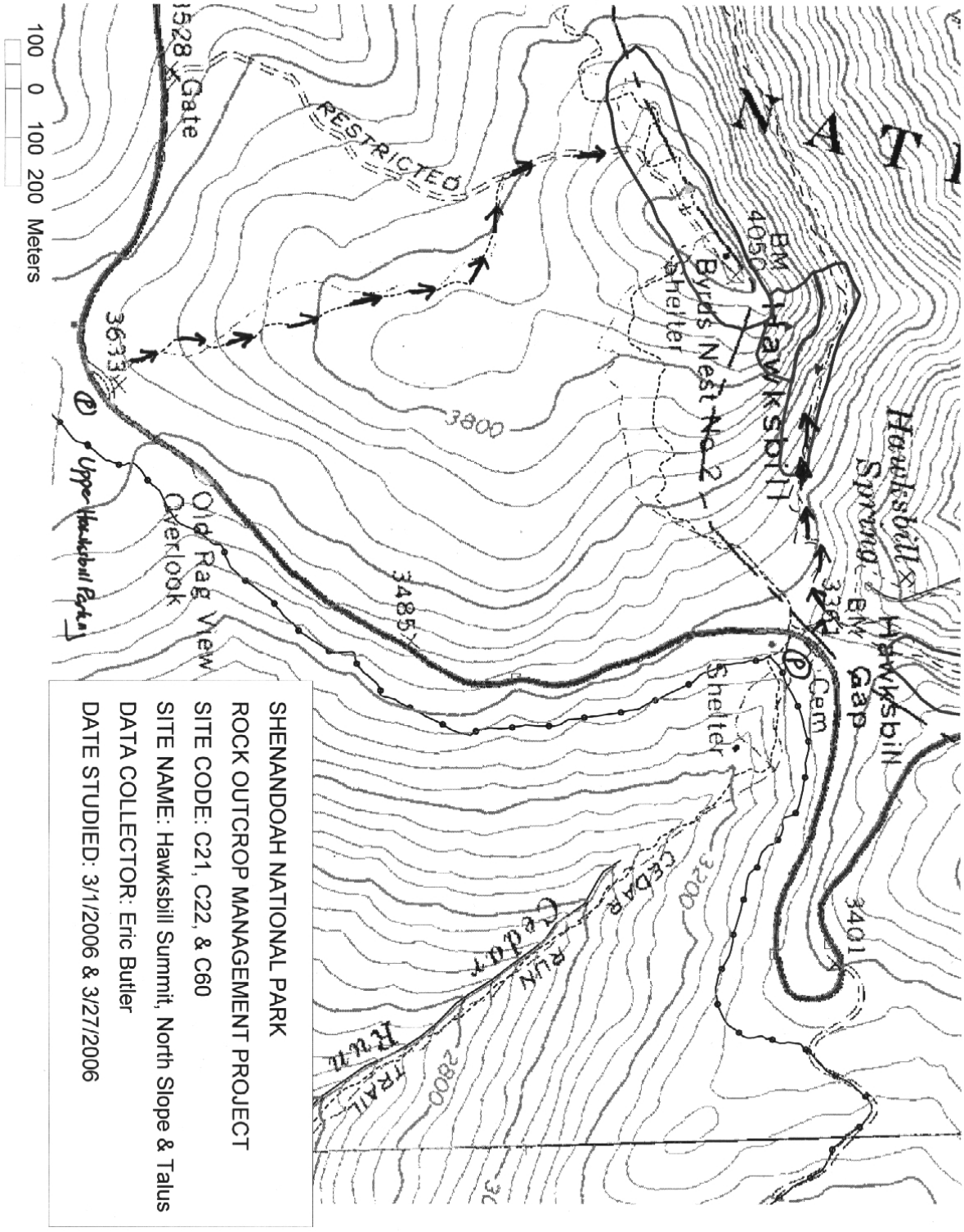
C22 - Hawksbill Summit (continued...)

Detail map



C22 - Hawksbill Summit (continued...)

Area map



SHENANDOAH NATIONAL PARK
ROCK OUTCROP MANAGEMENT PROJECT
SITE CODE: C21, C22, & C60
SITE NAME: Hawksbill Summit, North Slope & Talus
DATA COLLECTOR: Eric Butler
DATE STUDIED: 3/1/2006 & 3/27/2006

C22 - Hawksbill Summit (continued...)



SHEN_C22_G_20060327_001.jpg Azmuth: 215

Flat bench northeast of summit ridge, with beginning of ridge in background behind trees (taken near GPS point G236_C21)



SHEN_C22_G_20060327_002.jpg Azmuth: 70

Top of summit ridge, northeast of stone overlook; social trails and some impact here



SHEN_C22_G_20060327_003.jpg Azmuth: 55

Heavily impacted ledges along trail leading to stone overlook; soil and vegetated stripped, erosion along trail



SHEN_C22_G_20060327_004.jpg Azmuth: 0

Significant erosion along side trail just southwest of summit overlook

C22 - Hawksbill Summit (continued...)



SHEN_C22_G_20060327_005.jpg Azmuth: 260

Impacted ledges and soil along clifftops southwest of summit overlook



SHEN_C22_G_20060327_006.jpg Azmuth: 60

Impacted ledges and soil along clifftop, in front of Byrd's Nest shelter, southwest of summit overlook



SHEN_C22_G_20060327_007.jpg Azmuth: 70

Columnar joints influencing shape and presence of cliff; note ledges developed on joint tops



SHEN_C22_G_20060327_008.jpg Azmuth: 70

Numerous ledges along cliff below G239; this area can be traversed to the cliff base

C22 - Hawksbill Summit (continued...)



SHEN_C22_G_20060327_009.jpg Azmuth: 250

Numerous ledges along cliff below G239; this area can be traversed to the cliff base



SHEN_C22_G_20060327_010.jpg Azmuth: 90

Impacted ledges atop small, isolated outcrop along trail below summit; farthest west exposure in site



SHEN_C22_G_20060327_011.jpg Azmuth: 60

Open talus along cliff base at G241; typical of talus exposures found along entire length of cliffs within site



SHEN_C22_G_20060327_012.jpg Azmuth: 240

Balsam fir growing among talus below cliffs

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C23 - Hightop

Site Code:	C23	**Polygon Centroid:**	**E:** 713849 **N:** 4246040
Site Name:	Hightop		UTM (Zone 17 NAD83)
Data Collector	Butler, Eric	**Dimensions (m):**	140 x 220 (GIS est.)
Date Studied:	20-Jul-05	**Elevation Range (ft):**	3340 to 3560

Physical Characteristics

Location Acces

Park at Hightop Parking Area (Milepost 66.5) and follow Appalachian Trail south about 2km, with an 800' climb, to near summit of Hightop Mountain. Two social trails 80m apart lead to small rock exposures with views to the west; the site extends between and down from these.

Physical Description:

This site is dominated by a series of discontinuous rock outcrops which are variably vegetated. The top (east side) of the site slopes very gently down to the west, with the Appalachian Trail forming the rough boundary where the slope steepens. At around 3500'-3520', a series of jagged rock outcrops appear, jutting out from the descending slope. Some of these are open, and some are entirely within forest. Most of these outcrops are capped by rough, angular ledges, with fairly sheer, overhanging drop-offs to the west around 5m tall. Below this line of outcrops, smaller rock ledges and outcrops occur intermittently along the slope with no identifiable pattern, and are mostly under forest. Talus fields have formed beneath the larger outcrops, though all are forested with the exception of one below the largest exposure at G101. Around 3400', at or beyond the western site boundary, a series of large cliffs (15-20m) begins, capped by narrow, semi-vegetated ledges.

Vegetation: Moderate

The vegetation here is fairly variable, ranging from mostly open forest floor to scrubby oaks and laurel. The thickest vegetation and piles of deadfall occur in small pockets or zones that can generally be circumnavigated without too much trouble. One exception is along the top of the large cliffs, where the vegetation is consisently very thick and care must be taken when accessing the narrow open ledges behind the screen of vegetation.

Human Effects

Impacts: Moderate

Of the three major open exposures within the site, two are reached by social trails and are mostly stripped of vegetation and soil in comparison to more isolated areas. The cliff top ledges at the base of the site appear pristine.

Access Moderate

The site is directly and easily accessible from the Appalachian Trail, but getting there involves hiking several km and over 800' elevation gain from the parking area, where there are no interpretive signs or maps guiding visitors to climb Hightop. Several of the rock exposures are visible from Skyline Drive, but are not dramatic.

Geologic Characteristics

Lithology: **Rock Type** Greenstone

This site is entirely greenstone of the Catoctin Formation. The rocks are remarkably consistent in composition and physical texture throughout the site. They are fine grained and relatively light in color compared to other greenstones in the park, with even fresh faces appearing light grey, and weathering to a rusty red surface. There is a great deal of finely layered flow bedding within the rock, which where present creates small, flat benches that interact with the dominant cleavage (see below) to form ledgy outcrops. Between 3520', where the first outcrops begin, and 3400', where the top of the large cliffs appear, no visible changes in the rock or any form of flow boundary can be seen. In addition, the cliffs themselves are indistinguishable from the rocks above in both composition and structure.

The first evidence of a flow boundary is found at the base of the large cliffs, where an obvious unit of vesicular volcanic breccia crops out in a narrow ledge about 1m tall just below the cliff face. Below this is another, smaller drop-off of about 5m, at the base of which is another layer of similar breccia. These are the first occurrence of such rocks, however, and are not seen at higher elevations within the site boundary.

C23 - Hightop (continued...)

Structure:

The dominant structure here is a pervasive cleavage dipping around 45 degrees to the east. It is present nearly everywhere in the site, throughout the vertical section from 3520' to the upper portion of the large cliffs below. The cleavage does dissipate toward the base of this cliff, but elsewhere is the dominant factor in forming the ledgy, sharply angled outcrops in the site. The rocks are variably fractured throughout the site, though no obvious joint set or orientation can be identified.

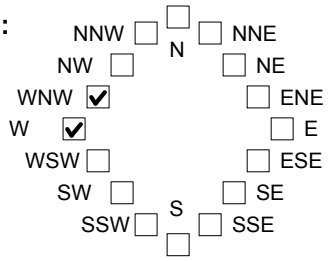
Other:

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	20.0	50.0	0.0	20.0	10.0	100
Max relief(m):	20	5	0	1	10	

Maximum Slope: 25 **Texture:** Fractured

Aspects:



Setting:

The pervasive cleavage in the rock is the dominant geomorphic factor affecting the shape and nature of rock outcrops here. The jutting, ledgy nature of the outcrops is a direct result of the angled cleavage planes, which create small ledges and pockets where soil can develop, especially when combined with the near-horizontal flow layering where present.

Within the almost 200' vertical sequence of rock within the site, no boundaries or changes in lithology were observed except for the vesicular breccia at the very base of the bottom cliff. It seems unlikely, however, that this entire sequence is composed of a single lava flow, and topographic features support this. The very top of the site is a fairly flat bench, which probably correlates to the top of a flow, which forms the dominant line of outcrops across the top of the site. Below these outcrops, the slope descends through isolated outcrops to a small topographic bench that leads to the ledges atop a large set of cliffs; this cliff is most likely a different, older flow, despite the lack of an obvious boundary, which may simply be a thin zone buried beneath the talus and soil of the slope where it cannot be identified.

It is possible that the lower, cliff-forming flow and the upper, outcrop-forming flow were formed in quick succession from the same source, which would preclude the formation of an obvious boundary between the two, and would explain their lithologic similarity. The similarity of the cleavage through both flows would also be explained by the similar origin and lithology, as two flows of the same composition would likely react to deformation in the same way.

Stability: Moderate

The bedrock is mostly stable, but in areas where cleavage is especially dominant, individual slabs can be quite loose and easy to dislodge. The surrounding slopes, while not especially steep, are often covered in talus that is very angular and can easily slide or rock from side to side. These issues are noticeable, but not common.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
7/20/2005	G100-C23	713878	4246098	3480	Northern exposure in site, below AT
7/20/2005	G101-C23	713832	4246000	3520	Large exposure reached by social trail from AT
7/20/2005	G102-C23	713789	4246055	3400	Top of large cliff at base of site

Site Photos

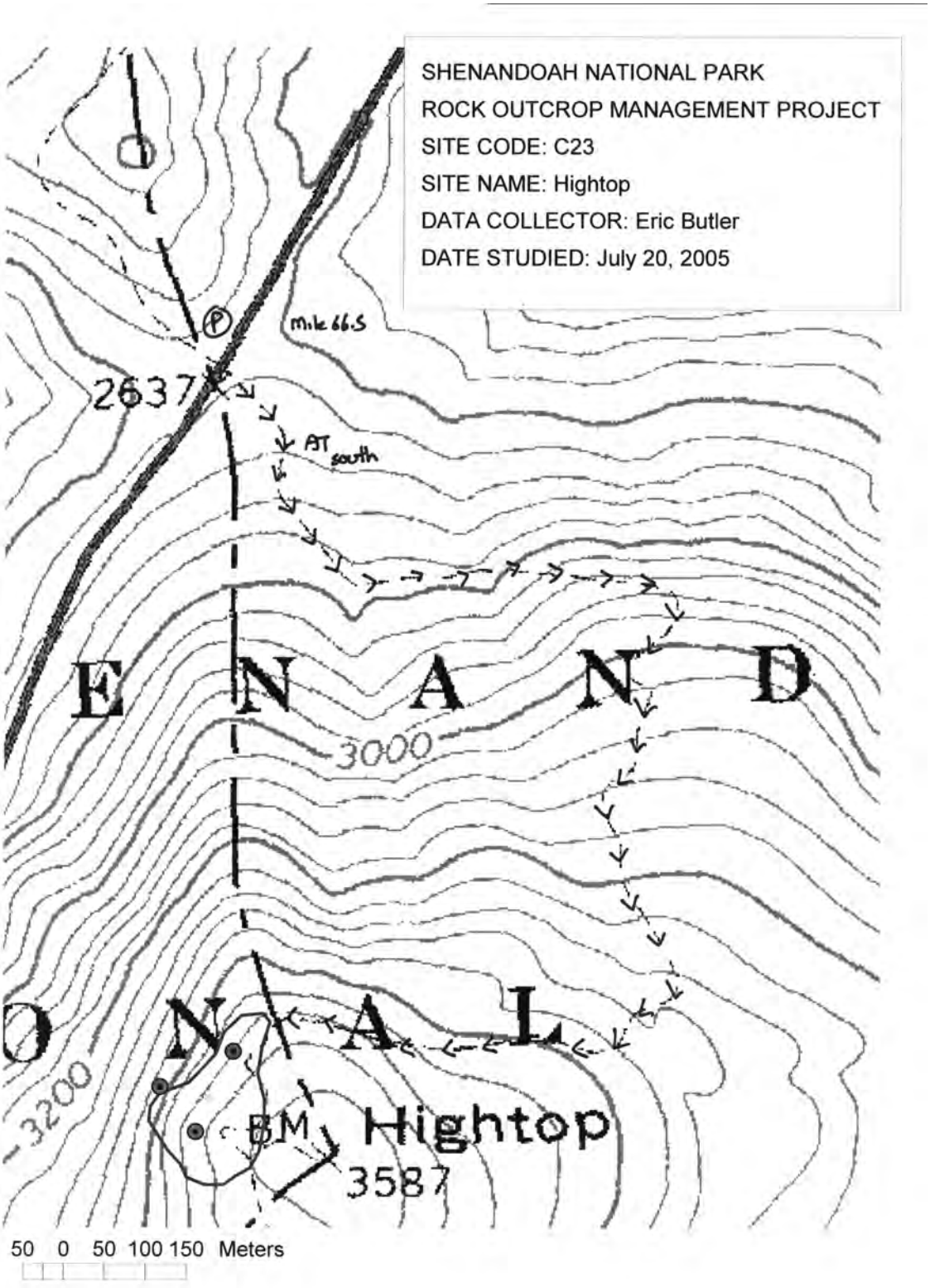
Image Date	GPS Point	File Name	Azmuth	Taken By	Description
7/20/2005		SHEN_C23_G_20050720_001.jpg	45	Butler, Eric	Outcrop with dominant cleavage
7/20/2005		SHEN_C23_G_20050720_002.jpg	110	Butler, Eric	Solidago Randii (lower left) on outcrop with cleavage and flow bedding
7/20/2005		SHEN_C23_G_20050720_003.jpg	70	Butler, Eric	Looking up talus toward G101; angular boulders from cleavage

C23 - Hightop (continued...)

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
7/20/2005		SHEN_C23_G_20050720_004.jpg	20	Butler, Eric	Top of lower cliff, dominant cleavage

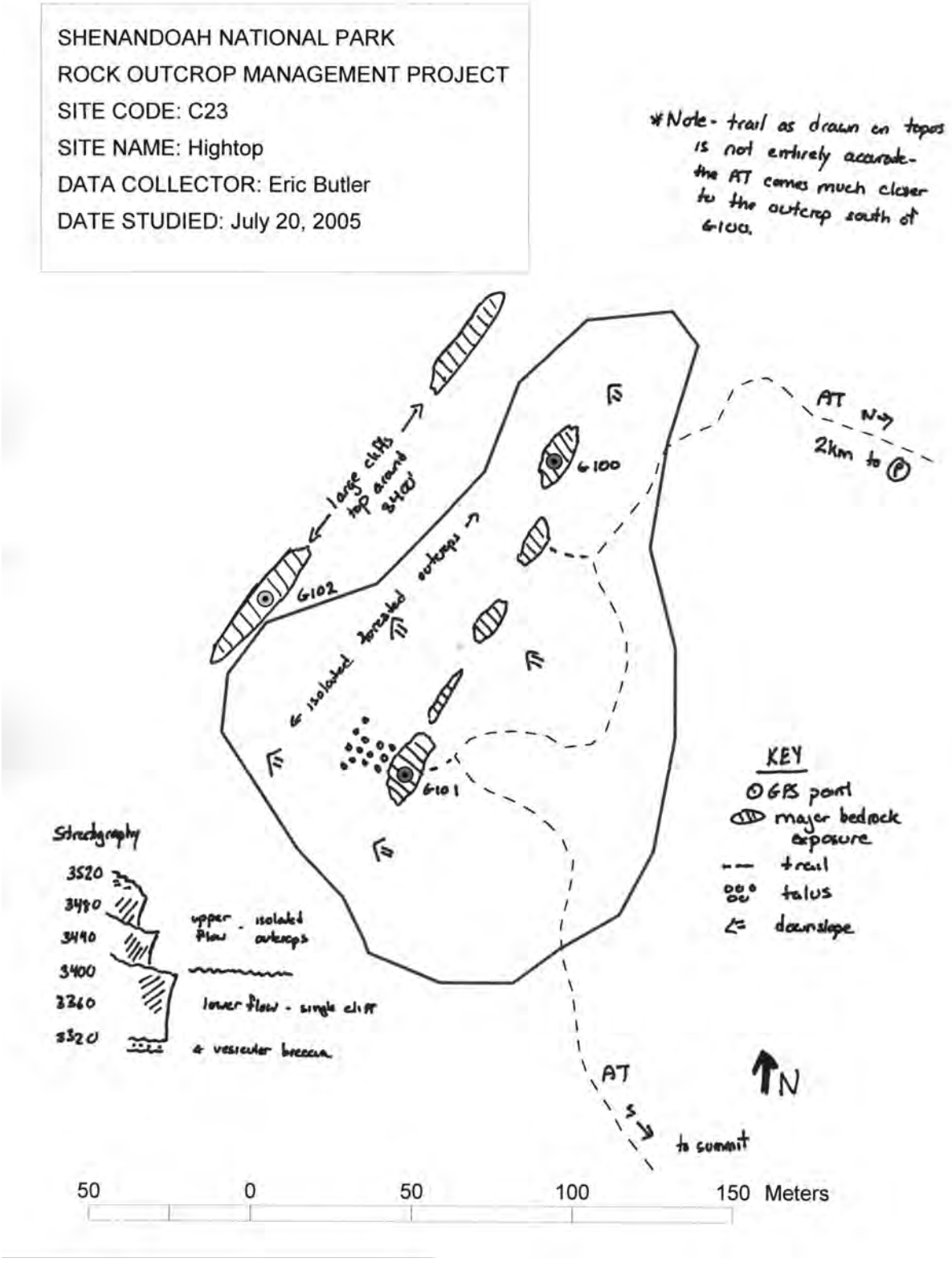
C23 - Hightop (continued...)

Area sketch map



C23 - Hightop (continued...)

Detail sketch map



C23 - Hightop (continued...)



SHEN_C23_G_20050720_001.jpg Azmuth: 45

Outcrop with dominant cleavage



SHEN_C23_G_20050720_002.jpg Azmuth: 110

Solidago Randii (lower left) on outcrop with cleavage and flow bedding



SHEN_C23_G_20050720_003.jpg Azmuth: 70

Looking up talus toward G101; angular boulders from cleavage



SHEN_C23_G_20050720_004.jpg Azmuth: 20

Top of lower cliff, dominant cleavage

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C24 - Hogback Mtn spur

Site Code: C24
Site Name: Hogback Mtn spur
Data Collector Butler, Eric
Date Studied: 17-Aug-05

Polygon Centroid: **E:** 736767 **N:** 4294703
UTM (Zone 17 NAD83)
Dimensions (m): 180 x 690 (GIS est.)
Elevation Range (ft): 2100 to 3000

Physical Characteristics

Location Acces

About 800m NNE from Hogback Overlook (Milepost 21), along the side of a steep, narrow stream drainage. Park at lot just south of Hogback Overlook, and head NNE downhill through mostly open forest for 700m to reach a large wooded plateau. Follow this plateau to its very northeastern tip, where a narrow ridge descends ENE. The site follows the top of this ridge, and the slope to the south, from 3000' down to 2100'. Whenever possible, remain on the spine of the ridge rather than cutting across slope, as the steep slopes in the southwestern portion of the site boundary are wet, unstable, thickly vegetated, and very difficult to traverse. Along the ridge crest, travel is much easier, along mostly open forest with some laurel thickets; follow this route at least until the major rock exposures begin. The ridge crest is also by far the easiest route to return by.

Physical Description:

This slope is located along a steep, south-facing slope above a small drainage. The ridge crest from top to bottom is fairly dry, with lots of rock debris and mostly open forest, generally steep but easy to traverse. Along the lower (eastern) half of the site, the slope is mostly open, with angled rock faces and some dropoffs, and scattered vegetation growing in cracks and ledges. Below the crest, and west of the rock exposures, the slope has apparently been hit by storms and/or other disturbances, as much of the canopy is gone and the area is a mass of thick vegetation and loose, thin, and wet soils, which are very difficult to traverse. There are no exposures of note in this area. To the west and east of the main zone of open rock, scattered small rock exposures can be found within the forest.

The ridge crest descends along a series of "knobs" that form cliffs and/or talus deposits 5-10m high, wrapping around the ridge but forested to the north and open to the south. Some of these can be descended directly, and others must be walked around. Past G144, the slope below the ridge crest becomes mostly open rock faces that can be crossed or accessed from various locations. There is a very common joint set (see STRUCTURE) oriented around 110-290 that creates a series of angled, soil-filled chutes that provide steep, but good access to various levels of rock; the most useful one leads from G144-G145. This joint set also forms several prominent rock ribs that protrude from the surrounding slope, the largest of which is located at G146.

Vegetation: Dense

Along the ridge crest, vegetation varies from occasional thick laurels to mostly open forest. Along the lower slopes, anywhere that is not open rock is very dense and difficult to traverse. Much of the western and southern slopes seem to be very impacted, and have lots of new growth that severely restricts movement.

Human Effects

Impacts: Pristine

There is no sign that humans have visited or disturbed this site.

Access Remote

Although this site is somewhat visible from Skyline Drive, its location far down a steep, narrow drainage precludes any easy access. There are no trails leading anywhere in the vicinity, and the landscape is very rugged. It is a long descent from Skyline Drive, and would be a long ascent from the bottom, although there is no public access from that direction either.

Geologic Characteristics

Lithology: **Rock Type** Granitic gneiss

The site is underlain by various granitic gneisses from the old Pedlar Formation. The mineralogic composition of these rocks changes frequently on the meter-scale, making it difficult to define a specific unit or set of units within the site. The most common composition is a white-grey, coarse-grained, quartz/feldspar gneiss with a weak foliation defined by narrow bands of mafic minerals, probably pyroxene. Some plagioclase crystals can be several centimeters in diameter. Very minor amounts of garnet and/or biotite mica can be seen in this unit. Less commonly, in some areas pyroxene is rare to nonexistant, and biotite is

C24 - Hogback Mtn spur (continued...)

the dominant mafic mineral. There are small pockets of a composition similar to Old Rag Granite (blue-grey quartz and orthoclase feldspar). In addition, there are areas of rock which appear very weathered, containing a great deal of iron mineralization and purple-silver staining, as well as being much less resistant than usual. These weathered, iron-rich zones may represent hydrothermal alteration along fractures during Catoctin volcanism, or they may represent more recent weathering activity (or possibly both).

Structure:

There is a dominant joint orientation at 110-290 that defines much of the rock exposures within the site. These joints commonly form narrow, soil-filled chutes, along with raised rock ribs, all with smooth, vertical rock walls. Other, less prevalent joints combine to form angular ledges and blocks in places. The foliation, which varies from strong to almost non-existant, generally strikes along 045-135, dipping around 45-60 degrees to the southeast.

Other:

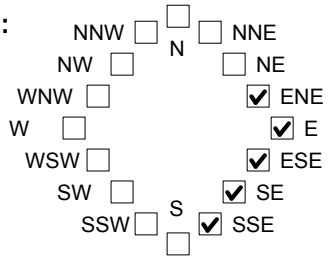
In several places, scattered blocks of black-green, tan-weathering basalt can be found on the surface, usually in a roughly linear zone near the ridge crest. These likely represent basaltic dikes intruded around the time of the Catoctin volcanism, although the bedrock trace of these dikes seems to be buried beneath the gneissic talus that armors the ridge crest.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	10.0	20.0	60.0	0.0	10.0	100
Max relief(m):	10	5	20	0	5	

Maximum Slope: 40 **Texture:** Smooth

Aspects:



Setting:

The exposure pattern here is controlled by three factors; the dominant joint set, the foliation within the rocks, and the weathering properties of granites in general. The joint set creates a series of large planar fractures along which the rocks break and weather, creating the common ribs, chutes, and smooth walls that are very noticeable in person. The foliation, dipping to the southeast, corresponds roughly to the overall orientation of the slope, and so creates an angled, planar surface. Exfoliation, a process common in granites in which planar or gently curved slabs of rock slowly peel away from a face, has likely also been active on these faces, probably exploiting the planes of weakness provided by the foliation.

It is interesting that no comparable large, open rock faces appear to have formed on the opposite (north) sides of the surrounding ridges and slopes. The southeast-dipping foliation does not align with the north-facing slope on the other side of this narrow valley, and on the north-facing slope across the ridge. Thus, even though there may be ledges, cliffs, and other bedrock exposures in these areas, smooth, sloping faces do not occur, and so talus and soil are able to accumulate, allowing growth of thicker vegetation. It is only where the foliation (exposed by the narrow, deep incision of this particular drainage) meets the slope angle and orientation, that smooth, open rock faces occur that do not hold talus or soil and thus remain unvegetated.

Stability: Stable

The rock exposures themselves are very stable and easy to traverse, as is the majority of the ridge crest. The only loose material is found in several of the joint-set chutes, and in the heavily vegetated slopes to the southwest, which do not contain any appreciable exposures and should be avoided.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
8/17/2005	G141-C24	736433	4294524	3000	Small rock exposure at edge of plateau, just outside site boundary
8/17/2005	G142-C24	736529	4294707	2800	Beginning of semi-open talus on ridgetop
8/17/2005	G143-C24	736605	4294751	2660	Top of rock knob/dropoff on ridgetop
8/17/2005	G144-C24	736701	4294776	2580	Top of rock knob on narrow ridge
8/17/2005	G145-C24	736746	4294738	2400	Along western edge of open rock face, between cliff and sloping face

C24 - Hogback Mtn spur (continued...)

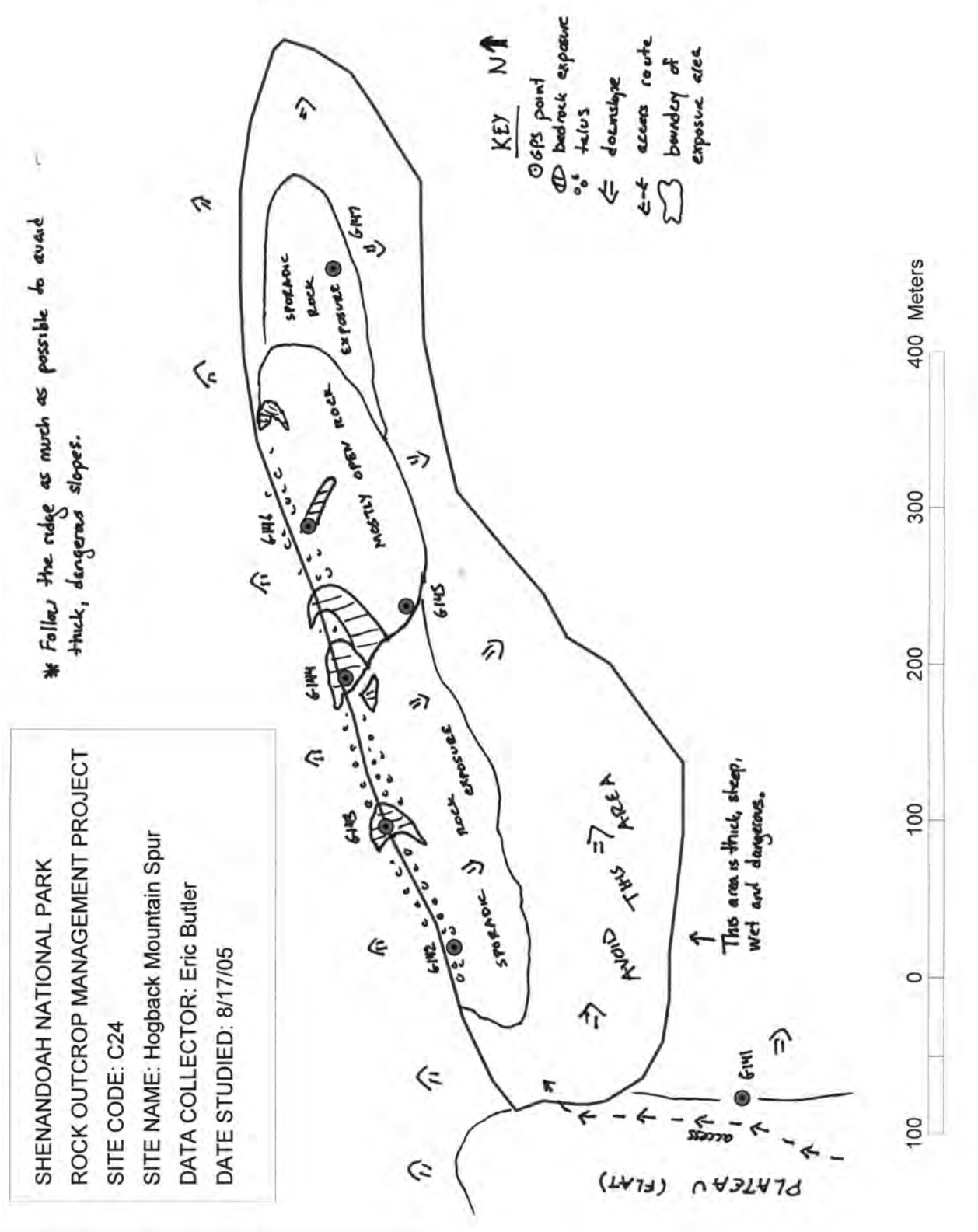
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
8/17/2005	G146-C24	736798	4294800	2460	Large rock rib protruding from slope along joint plane
8/17/2005	G147-C24	736963	4294784	2240	Beginning of transition from open rock into forested slope to east and

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
8/17/2005	G144-C24	SHEN_C24_G_20050817_001.jpg	290	Butler, Eric	Typical semi-open rock face with conifer
8/17/2005	G144-C24	SHEN_C24_G_20050817_002.jpg		Butler, Eric	Typical granite gneiss (background) with iron-stained fragment (foreground)
8/17/2005	G145-C24	SHEN_C24_G_20050817_003.jpg	110	Butler, Eric	Joint face oriented 100, with minor joints creating steps, 10m NW of G145
8/17/2005	G145-C24	SHEN_C24_G_20050817_004.jpg	50	Butler, Eric	Sloping rock face with plant growth, roughly oriented along foliation
8/17/2005	G145-C24	SHEN_C24_G_20050817_005.jpg	50	Butler, Eric	Sheer cliff beginning above G145 and wrapping north to ridgetop
8/17/2005	G145-C24	SHEN_C24_G_20050817_006.jpg	70	Butler, Eric	Typical open rock face with plant growth, roughly oriented along foliation
8/17/2005	G146-C24	SHEN_C24_G_20050817_007.jpg	110	Butler, Eric	Rock rib defined by joint plane (vertical) and foliation (angled SE)
8/17/2005	G146-C24	SHEN_C24_G_20050817_008.jpg	215	Butler, Eric	Sloping rock face with conifers, east of and below G146
8/17/2005		SHEN_C24_G_20050817_009.jpg	25	Butler, Eric	Wide view of site from Hogback Overlook (Skyline Drive)
8/17/2005		SHEN_C24_G_20050817_010.jpg	25	Butler, Eric	Closeup view of rock exposures from Hogback Overlook (Skyline Drive)

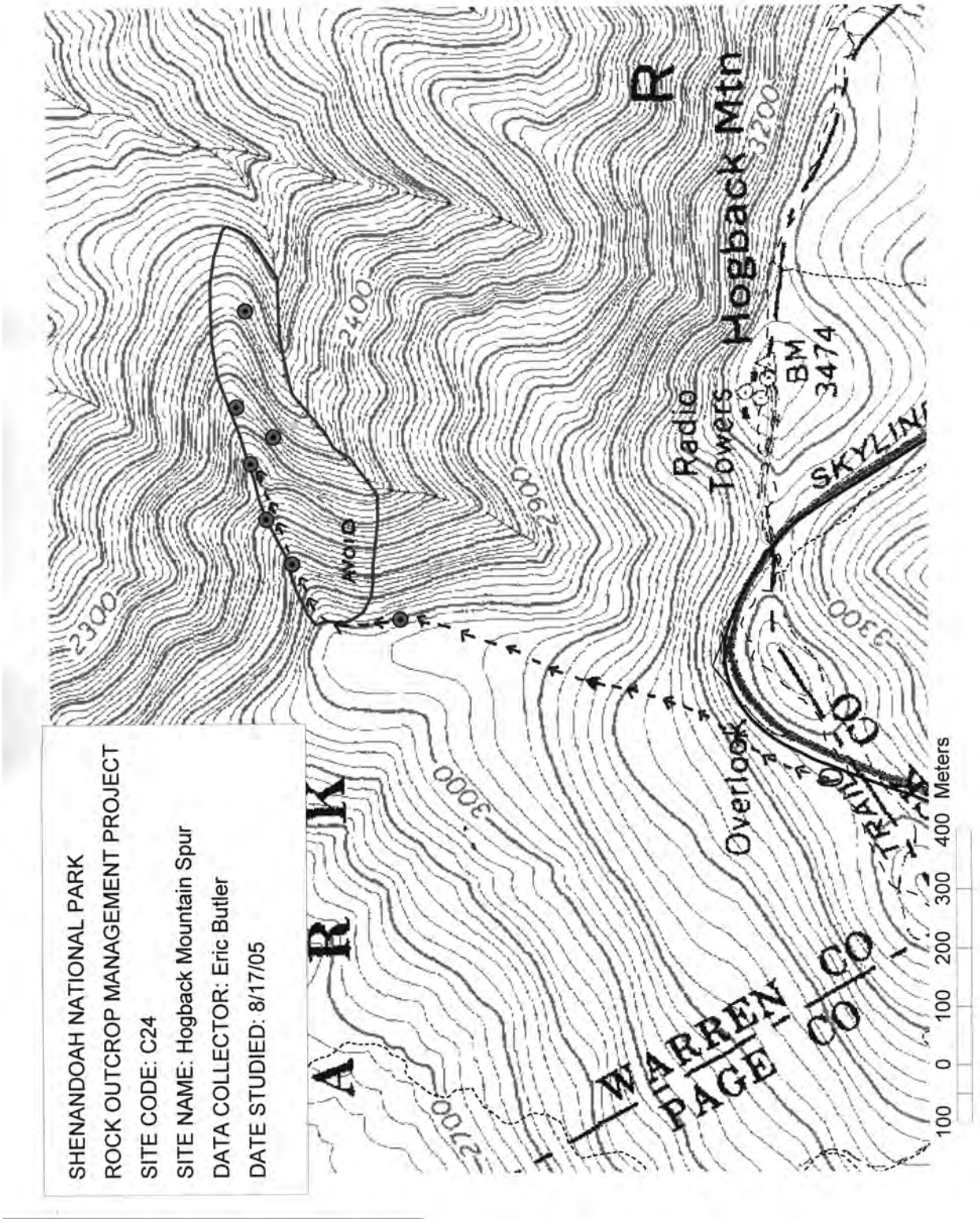
C24 - Hogback Mtn spur (continued...)

Detail sketch map



C24 - Hogback Mtn spur (continued...)

Area sketch map



C24 - Hogback Mtn spur (continued...)



SHEN_C24_G_20050817_001.jpg Azmuth: 290

Typical semi-open rock face with conifer



SHEN_C24_G_20050817_002.jpg Azmuth:

Typical granite gneiss (background) with iron-stained fragment (foreground)



SHEN_C24_G_20050817_003.jpg Azmuth: 110

Joint face oriented 100, with minor joints creating steps, 10m NW of G145



SHEN_C24_G_20050817_004.jpg Azmuth: 50

Sloping rock face with plant growth, roughly oriented along foliation

C24 - Hogback Mtn spur (continued...)



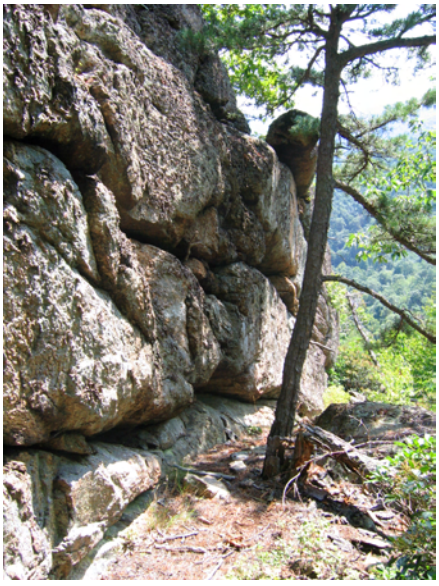
SHEN_C24_G_20050817_005.jpg Azmuth: 50

Sheer cliff beginning above G145 and wrapping north to ridgetop



SHEN_C24_G_20050817_006.jpg Azmuth: 70

Typical open rock face with plant growth, roughly oriented along foliation



SHEN_C24_G_20050817_007.jpg Azmuth: 110

Rock rib defined by joint plane (vertical) and foliation (angled SE)



SHEN_C24_G_20050817_008.jpg Azmuth: 215

Sloping rock face with conifers, east of and below G146

C24 - Hogback Mtn spur (continued...)



SHEN_C24_G_20050817_009.jpg Azmuth: 25

Wide view of site from Hogback Overlook (Skyline Drive)



SHEN_C24_G_20050817_010.jpg Azmuth: 25

Closeup view of rock exposures from Hogback Overlook (Skyline Drive)

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C27 - Little Devils Stairs

Site Code: C27
Site Name: Little Devils Stairs
Data Collector Butler, Eric
Date Studied: 06-Sep-06

Polygon Centroid: **E:** 737971 **N:** 4292325
UTM (Zone 17 NAD83)
Dimensions (m): 190 x 640 (GIS est.)
Elevation Range (ft): 1800 to 2560

Physical Characteristics

Location Acces

Use the Keyser Run Fire Road, just south of Milepost 19. The trailhead is 1.6km down the fire road; either park at the lot near Skyline Drive, or drive down the road if a gate key is available. Take the Little Devils Stairs trail about 900m, down a series of switchbacks into the canyon, and past the first falls. When the switchbacks end, cross the stream and climb the opposite slope to the NE to reach the first exposures. Alternatively, the site may be accessed from the bottom, outside the park, by hiking in 1.6km from the Little Devils Stairs parking lot at the end of Virginia 614, then climbing up the steep slope to reach the southern most exposures. Access to the open areas on the upper slope is limited to the northern and southern ends of the site, as much of the canyon's interior is lined with very large, sheer cliffs that confine the trail along Keyser Run.

Physical Description:

This site consists of a long, steep slope along the east side of a deep canyon carved by Keyser Run. Much of the slope consists of open to forested talus, but several areas of significant open bedrock exposure also occur. These consist mostly of linear cliffs topped by ledges, though smaller outcrops do occur. The most unique area occurs near the center of the site, where a large open glade has formed on a steep bedrock slope, with cliffs and outcrops below and nearby. Much of the lower, western portion of the site was not visited, due the steep, rugged nature of the area and time constraints on the field group present.

Vegetation: Dense

Vegetation can be very thick along the steeper slopes, as well as along the flatter bench atop the ridge east of the site. The most open forest can be found just below the break in slope roughly along the eastern site boundary, and access along this route is reasonable. Several cliff areas are mostly obscured in thick vegetation.

Human Effects

Impacts: Mild

Significant impacts were present at one location, the small open face at G262 where a fire ring and rock graffiti were found. Otherwise no impacts or signs of human presence were noted throughout the remainder of the large open areas.

Access Difficult

To access this site, a visitor must hike 2-3km with significant elevation change along the trail, then climb and traverse more difficult terrain off-trail. Most of the exposures are not visible from the trail, which remains confined within the canyon for much of its length and does not offer easy access to any open areas.

Geologic Characteristics

Lithology:

Rock Type Greenstone

This site is underlain by multiple greenstone lava flows of the Catoctin Formation. Individual flows were difficult to distinguish consistently throughout the site, but the scale of the site and the exposure patterns makes it clear that many different layers are present. For example, judging from exposure patterns, the descent from G262 to G264 crosses at least 3 flows, but these could not be consistently distinguished lithologically. Horizontally, it could not be determined visually whether the exposures at G265 and G266 correlate to anything exposed at G263 and G264; the flows are too similar, and the overall flow orientation is not clear. Most open rock areas consisted of typical greenstone, fine-grained and dark colored while weathering to a rusty red on the surface. Epidote replacement is common throughout the flows. Few distinct flow boundaries were observed, typically being obscured in talus or vegetation, and offering loose rock as their only evidence. One exception occurs at G264, where a 2m-thick section of epidotized volcanic breccia is found above a smooth bedrock surface that likely reflects the top of the underlying flow. This unit could not be traced for any distance in the bedrock however. At the southern end of the site, at G266, the greenstone contains many large (<40cm) rounded pockets of quartz and epidote within the otherwise smooth, fine-grained lava. This is an interesting texture, though not really relevant to the formation of the cliffs there.

C27 - Little Devils Stairs (continued...)

Structure:

Columnar jointing is common, though rarely well-formed. Random fracturing in addition to the joints is widespread, and only at the uppermost exposure within the site (G262) is the bedrock smoother and more massive. The overall orientation of the lava flow sequence is unclear here; at G264 several smooth, tilted surfaces suggesting the top of a flow dip to the southwest, but the larger-scale exposure patterns within the site suggest a more southeasterly orientation. The smooth surfaces at G264 (photo 006) are unusual in greenstone, which usually does not form such flat, almost sedimentary-looking surfaces.

Other:

A distinct unit of especially volcanic rock appeared consistently within loose rock near the ridge crest for much of the site's length, though never in-place. This unit consisted of vesicular lava and breccia, much of which was very rough and fresh-looking, with mostly open vesicles (rather than mineral-filled amygdules). In the course of this project, no other area visited has contained such a distinctly volcanic rock, which is reminiscent of much more recent and active activity than the Catoctin is usually associated with. Was there perhaps a vent very near this location, allowing these unusual structures to be formed and preserved? This unit never appeared in-place, and played no role in the formation or nature of open rock exposures, and so is of intellectual interest only.

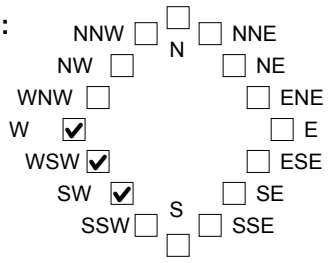
Also, the cliffs and talus at the base of the canyon (as seen from the trail) preserve excellent specimens of columnar jointing that are far better formed and preserved than those found in the open exposures at higher elevations. These lower, sheer cliff areas were not otherwise visited due to time and topographic restraints, but these features are worthy of notice.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	30.0	20.0	10.0	30.0	10.0	100
Max relief(m):	20	5	5	2	20	

Maximum Slope: 35 **Texture:** Rough

Aspects:



Setting:

This site conforms to a pattern common to greenstone areas on the east side of the Central and North Districts. Through most of these areas, the lava flows dip gently (10-20 degrees) to the south and/or east, creating fairly smooth slopes that descend gradually from the ridgeline. Where these gentle slopes are cut by significant streams, deep canyons tend to form with linear cliffs and waterfalls where the erosion cuts through individual lava flows. Here, the dip angle of the lava flows must be fairly low, as the cliff lines mostly run parallel to the slope and do not significantly cut up across it (as at Halfmile Cliff, for example). The rock exposures here are unusually truncated, however, in that most do not seem to form the continuous line of cliff/outcrop usually associated with greenstone areas. What cliffs do form are often tall, but not especially long. The ubiquitous fracturing within most of the bedrock here may play a role in this, generally allowing the bedrock more quickly, so that exposures crumble into talus relatively quickly. This possibility also helps explain the widespread talus covering most of the slopes within the site, though most of this talus is forested and thus not of direct interest to ROMP.

The common columnar jointing and other fracturing throughout the bedrock here also influences the shape of the bedrock exposures that do occur. The cliffs and outcrops are covered in ledges, even in the more sheer areas. This fracturing has also influenced the formation of non-cliff areas, such as the large glade near G264, where broken columnar joints create a steep, staircase-like expanse of small outcrops and ledges ascending the slope. The only real exception to this trend is at G262, where a small, smooth, gently sloping open rock face occurs. This location is very different from the rest of the site, and given its location at the top of the ridge, is likely formed from a more massive, unfractured flow as compared to the underlying sequence. In general, it appears that the ubiquitous fracturing within this site has created large areas of talus with the remaining cliff and outcrop areas rich in ledges developed from these fractures and joints.

One unusual feature of note is the large, linear talus-filled chute that separates two cliffs below G263. This chute does not follow any of the other structural features in the area, but by its very nature is difficult to study. There may be a small fault here, or a large joint along which the bedrock has eroded. No evidence of anything unusual could be found in the bedrock at the top

C27 - Little Devils Stairs (continued...)

of this chute.

Stability: Loose

This rating reflects the talus slope at G261 and the large glade area north of G263 and G264. This latter region is very steep and contains much fractured and loose rock which moves easily underfoot. The more established cliff/ledge areas are more stable.

GPS Points

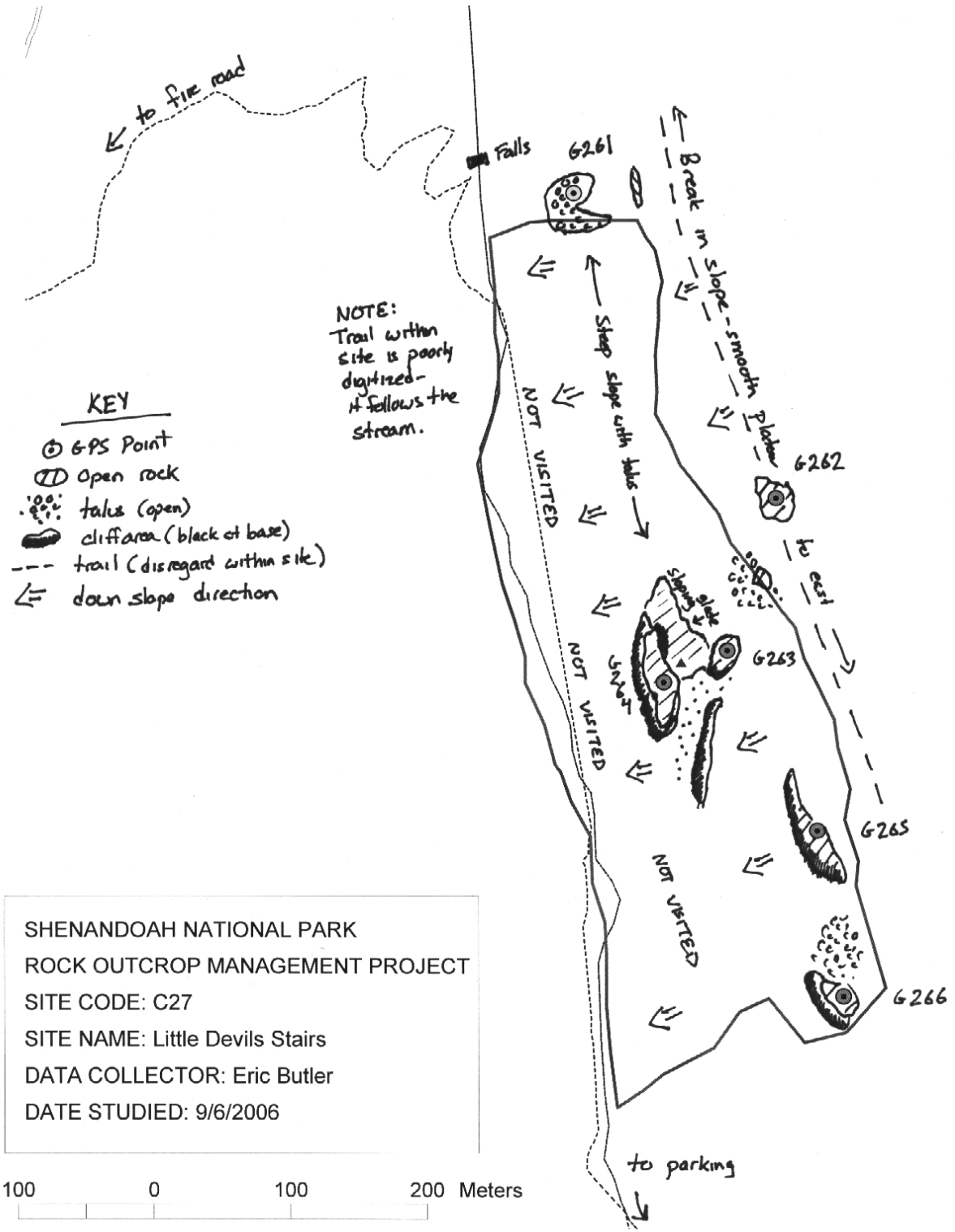
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
9/6/2006	G261-C27	737893	4292673	2480	Open talus area just north of site boundary, above and to east of falls
9/6/2006	G262-C27	738041	4292447	2560	Small, gently sloping open rock face at break in slope, outside bounda
9/6/2006	G263-C27	738005	4292334	2440	Steep, narrow outcrop at top of narrow talus chute dividing two large cl
9/6/2006	G264-C27	737959	4292311	2400	Top of large cliff below broad glade area stretching up to the north
9/6/2006	G265-C27	738070	4292201	2360	Top of open cliff/ledge area near southeast end of site
9/6/2006	G266-C27	738089	4292079	2200	Isolated cliff/ledge area at far SE corner of site

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
9/6/2006	G261-C27	SHEN_C27_G_20060906_001.jpg	230	Butler, Eric	View down steep open talus slope
9/6/2006	G262-C27	SHEN_C27_G_20060906_002.jpg	170	Butler, Eric	Gently sloping open rock face in greenstone
9/6/2006	G262-C27	SHEN_C27_G_20060906_003.jpg		Butler, Eric	Graffiti scratched into rock surface near fire ring at G262
9/6/2006	G263-C27	SHEN_C27_G_20060906_004.jpg	180	Butler, Eric	View across grassy ledges atop outcrop at G263
9/6/2006	G263-C27	SHEN_C27_G_20060906_005.jpg	45	Butler, Eric	Steep, narrow outcrop below ledges at G263
9/6/2006	G264-C27	SHEN_C27_G_20060906_006.jpg	150	Butler, Eric	Angled slab with smooth top; possibly top of lava flow?
9/6/2006	G264-C27	SHEN_C27_G_20060906_007.jpg	350	Butler, Eric	Large, steeply sloping glade with abundant ledges and small outcrops, north of G263 and G264
9/6/2006	G264-C27	SHEN_C27_G_20060906_008.jpg		Butler, Eric	Columnar jointing in small cliff at base of glade area, above larger cliff below.
9/6/2006	G264-C27	SHEN_C27_G_20060906_009.jpg		Butler, Eric	Thick outcrop of volcanic breccia atop ledges; unit is isolated and does not extend to north
9/6/2006	G264-C27	SHEN_C27_G_20060906_010.jpg	150	Butler, Eric	Edge of G264 cliff, with next cliff across talus chute visible in background
9/6/2006	G265-C27	SHEN_C27_G_20060906_011.jpg	230	Butler, Eric	Grassy ledges at G265
9/6/2006	G266-C27	SHEN_C27_G_20060906_012.jpg	190	Butler, Eric	Large, steep cliff and ledges

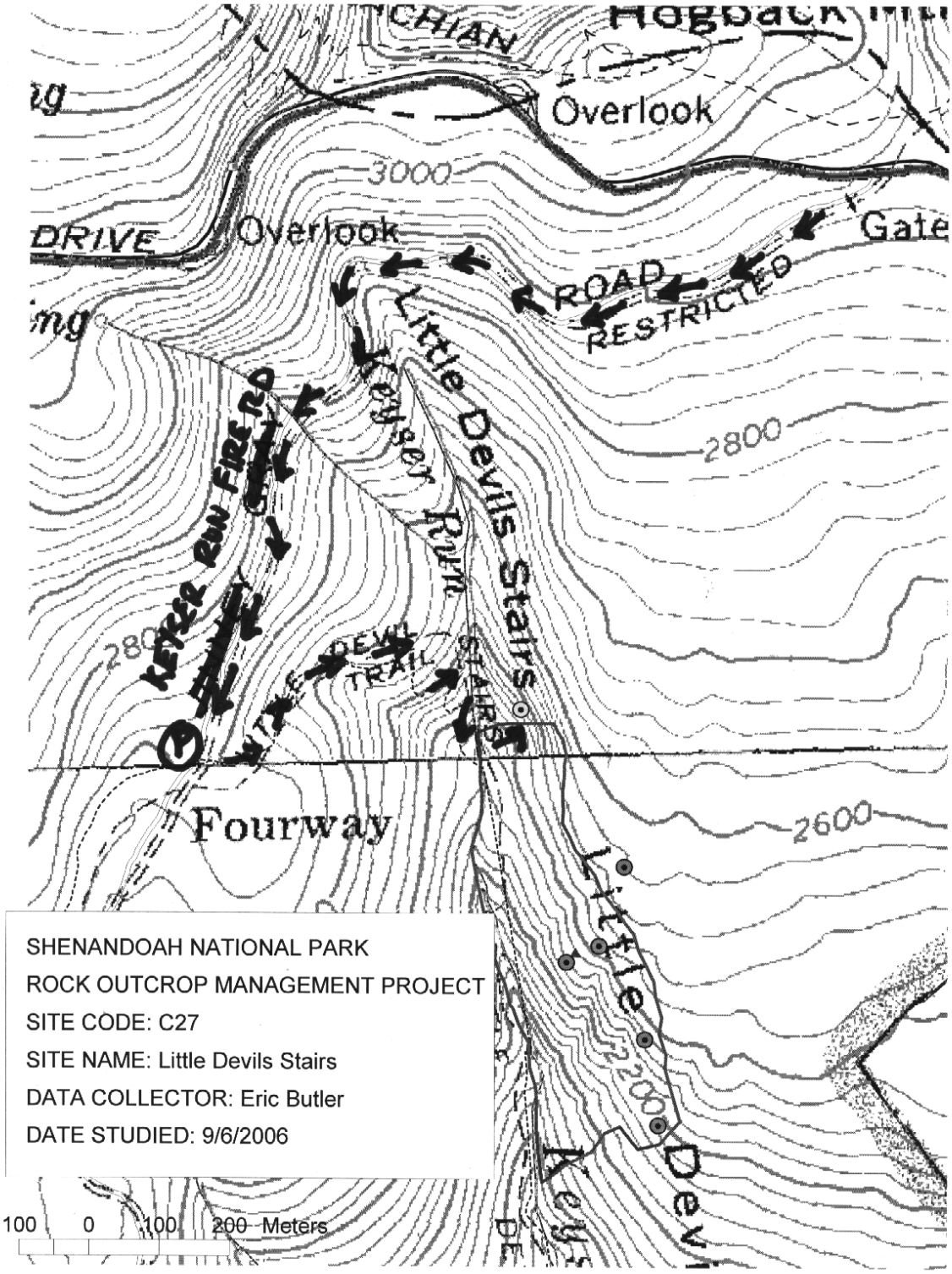
C27 - Little Devils Stairs (continued...)

Detail map



C27 - Little Devils Stairs (continued...)

Area map



C27 - Little Devils Stairs (continued...)



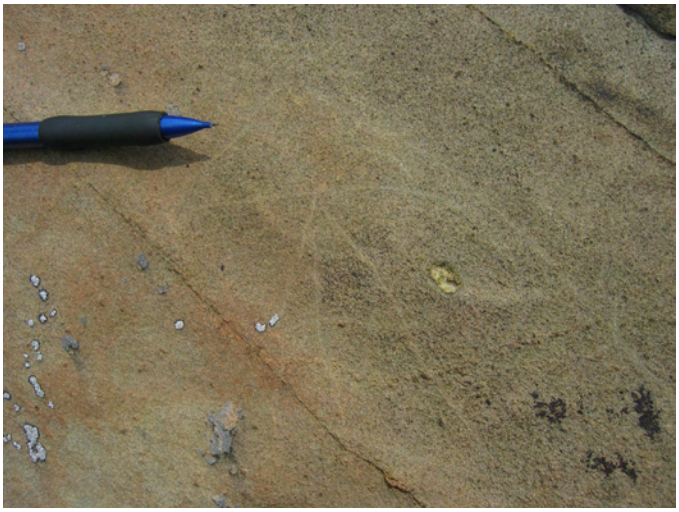
SHEN_C27_G_20060906_001.jpg Azmuth: 230

View down steep open talus slope



SHEN_C27_G_20060906_002.jpg Azmuth: 170

Gently sloping open rock face in greenstone



SHEN_C27_G_20060906_003.jpg Azmuth:

Graffiti scratched into rock surface near fire ring at G262



SHEN_C27_G_20060906_004.jpg Azmuth: 180

View across grassy ledges atop outcrop at G263

C27 - Little Devils Stairs (continued...)



SHEN_C27_G_20060906_005.jpg Azmuth: 45

Steep, narrow outcrop below ledges at G263



SHEN_C27_G_20060906_006.jpg Azmuth: 150

Angled slab with smooth top; possibly top of lava flow?



SHEN_C27_G_20060906_007.jpg Azmuth: 350

Large, steeply sloping glade with abundant ledges and small outcrops, north of G263 and G264



SHEN_C27_G_20060906_008.jpg Azmuth:

Columnar jointing in small cliff at base of glade area, above larger cliff below.

C27 - Little Devils Stairs (continued...)



SHEN_C27_G_20060906_009.jpg Azmuth:

Thick outcrop of volcanic breccia atop ledges; unit is isolated and does not extend to north



SHEN_C27_G_20060906_010.jpg Azmuth: 150

Edge of G264 cliff, with next cliff across talus chute visible in background



SHEN_C27_G_20060906_011.jpg Azmuth: 230

Grassy ledges at G265



SHEN_C27_G_20060906_012.jpg Azmuth: 190

Large, steep cliff and ledges

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C28 - Stony Man: Little Stony Man

Site Code:	C28	**Polygon Centroid:**	**E:** 729162 **N:** 4276036
Site Name:	Stony Man: Little Stony Man		UTM (Zone 17 NAD83)
Data Collector	Butler, Eric	**Dimensions (m):**	200 x 380 (GIS est.)
Date Studied:	06-Sep-05	**Elevation Range (ft):**	3280 to 3600

Physical Characteristics

Location Acces

Park at the Little Stony Man parking lot (Milepost 39) and take a short connecting trail from the lot to meet the Appalachian Trail (AT). Follow the AT south for about 600m, climbing about 200', to reach a trail junction between the AT and the Passamaquoddy Trail (PT). To reach the top of the site, follow the AT another 300m until the trail reaches open ledges atop the upper cliffs. Alternatively, follow the PT 150m to reach an open ledge atop the lower cliff (the "PT overlook" referred to below, at G169). Both trails are steep and rocky in places but are well-maintained and easy to follow.

Physical Description:

The site consists of two cliff levels divided by a narrow topographic bench along which the Passamquoddy Trail (PT) runs for the length of the site. The upper cliffs are about 30m high, near-vertical, and are divided into two distinct exposures, separated by several narrow, talus-filled chutes. There is a small rock rib separating these chutes, with some open ledge area at the top. The Appalachian Trail (AT) runs along the top of the northern upper cliff, then turns east, but an obvious social trail (possibly the trace of the old AT) leads south to provide good access to the southern upper cliff. One of the intermediate chutes offers good access between the AT and the PT via a well-developed social trail leading down the talus. These upper cliffs are generally sheer from top to bottom, but their actual height depends on variable thicknesses of talus deposits at the base, and the presence of several protruding ledge areas at the north and south ends of the cliffs that shorten the actual drop a bit. NOTE: Two NPS fences partially block access to the ledges above the southern cliffs and the small intermediate rib just to the north. Both fences have small gaps at their northern ends that allow passage.

The PT marks the base of open rock on these cliffs; below this level, the slope is generally forested with a few small cliff exposures scattered in the woods. This area (below the PT) is extremely steep, loose, and fairly dangerous to navigate, and thus was not mapped in full detail. One large exposure is present at this level, directly below a large, open overlook near the north end of the PT. Here, a cliff drops down to some vegetated ledges about 40' below, but behind a screen of trees the sheer rock continues for up to another 100', in an area that is dangerous and difficult to traverse. Although these exposures have a gentler slope than the near-vertical cliffs of the upper flow, they are still quite steep. This lower set of cliffs gradually pinches out to the north, as the slope of the mountain descends in that direction. Some access can be had by following a social trail north from the PT overlook to a large social camping area, then following the slope back south along the cliffs, but this is still difficult and tricky.

Vegetation: Dense

Above the Passamaquoddy Trail (PT), vegetation is generally not an issue. Established and social trails provide virtually all necessary access to open rock areas. Below the PT, however, the combination of very steep slopes, thicker vegetation, and copious deadfall make some areas very difficult to negotiate beyond the level of some near-trail ledges.

Human Effects

Impacts: Heavy

Most of the open ledge areas lie directly along established trails, or obvious social trails. Both Little Stony Man and the Stony Man Summit (which these trails lead to) are very popular hikes, and the results are clear. All of the accessible ledges show impacts to at least some degree, with the worst appearing to be the overlook along the Passamaquoddy Trail (PT), which has an open area at least 4mx10m that is completely stripped to gravel, with virtually no plant life. Other ledges are impacted similarly, though not always to the extreme degree of this location. For comparison, immediately north of the PT overlook, the same cliff/ledge complex continues north, and reverts to thick vegetation that reaches the cliff edge.

Climbing is another very popular activity here, and the PT below the sheerest portion of the upper cliffs (the preferred climbing area) takes the form of a large, impacted swath to the very base of the cliffs. In addition, several of the larger ledges partway up the upper cliffs (for example, between G166 and G169) show signs of human presence, though access to these requires at least some vertical climbing and/or bouldering. It is difficult to assess just what impacts this activity is having on the cliff faces themselves without actually climbing them.

C28 - Stony Man: Little Stony Man (continued...)

Evidence of past and recurring impact also exists in the form of several NPS fences limiting access to areas of the upper cliffs reached by social trail. Judging by old USGS topo maps, the Appalachian Trail (AT) originally ran through this area, before apparently being rerouted, and the social trails may follow the old AT route. The age of these fences is unknown. Finally, an old, battered 10" frying pan and tic-tac-toe graffitti, both found in relatively remote, inaccessible places within the site, are testament to pervasive human use of this area on- and off-trail.

Access Moderate

Reaching the most accessible point in the site, the PT overlook, still requires a climb of around 200' on a rocky trail. The trails are well-maintained and signed, but this popular site remains more challenging to reach than the average Skyline Drive overlook site.

Geologic Characteristics

Lithology: **Rock Type** Greenstone

Little Stony Man is underlain by Catoctin greenstone. The upper cliffs, between the Passamaquoddy Trail (PT) at the base and the Appalachian Trail (AT) at the top, appear to be a single, solid lava flow. This flow contains a good deal of epidote replacement, and in general contains few internal structures such as bedding. The dominant feature here is variably preserved columnar jointing. Veins of actinolite and quartz are common, however. The lower cliffs, below the PT overlook, appear to contain more internal flow layering and less columnar jointing than the exposures above. The thickness of this underlying flow is unclear, as no obvious basal boundary was observed in the limited exposures that can be accessed safely. In the upper few meters of both flows, cleavage becomes more prevalent, though it is mostly absent otherwise.

Separating these two flows is a distinct zone of volcanic breccia, at least 10m thick in places. This unit generally contains fragments of reddish, cherty siltstone or jasper, as well as angular fragments of greenstone, chaotically distributed in a rough, dark red/purple matrix that is heavily epidotized, and also contains numerous veins and pockets of quartz, actinolite, and other minerals. The best exposure of this rock can be found at the overlook on the PT, in the form of a large boulder/outcrop at the east side of the stripped, gravelly overlook area. While some such breccia is commonly found between lava flows, such deposits rarely exceed a few meters in thickness, so this location is fairly unique. At this overlook, the breccia reaches its most obvious thickness, beginning at trail level and extending up the rock exposures over 10m before giving way to the basalt flow above. To the south, the breccia gradually disappears from easy view, as the basalt cliffs extend right to trail level less than 100m south of the PT overlook. It is unclear whether the unit dips below the trail, and thus is hidden beneath trail fill and natural talus, or whether it pinches out and is only present in this one location. There is a small, isolated exposure of this breccia further south along the PT, but again it is unclear whether this outcrop connects to the northern exposures beneath the talus, or is an isolated occurrence.

Above the upper flow, a unit of breccia and/or conglomerate containing rounded quartz clasts occurs intermittently. The best exposure of this unit can be found southeast of G168, where an isolated knob of rock and talus rises within the forest. Similar rock can also be found sporadically at the top of the cliffs marked by G168. This unit is not found along the northern unit of the upper cliffs, though as these cliffs are slightly lower, it may have been eroded away already at that location.

Structure:

Columnar joints are prevalent within the upper flow, and can easily be seen within exposures along the Passamaquoddy Trail (PT). These become less prevalent toward the upper few meters of the flow, where cleavage becomes dominant. Strong cleavage is also present at the top of the lower flow, visible as angled, platy ledges at the PT overlook, and again fades from prominence a few meters down. Few columnar joints are evident in the lower flow, as internal flow layering appears to be more common. Overall, the flows appear to be dipping 15-20 degrees to the east or southeast, while the cleavage dips in a similar direction but steeper, around 45-60 degrees. The rocks contain numerous fractures that do not correspond to the columnar joint patterns, creating common small ledges.

Other:

There are two small, cave-like rock shelter structures within the site, both of which are somewhat remote and difficult to access, yet appear to have been visited by people. The first is located just north of G168, near the top of a small, talus-filled, heavily vegetated chute. It is several meters deep, with an opening about 2m square. Within the talus just below this opening, an old, battered 10" frying pan was found, demonstrating that people have visited this site. The second is located below the Passamaquoddy Trail (PT) overlook, and can be accessed by descending the slope just south of the overlook, where cliff ends abruptly and the PT is built on a tall rock wall. Down the steep, loose slope, perhaps 20m below this point, a narrow chute several meters deep is formed by a joint crack within the bedrock; at the head of this crack, a large slab of rock creates a cave-

C28 - Stony Man: Little Stony Man (continued...)

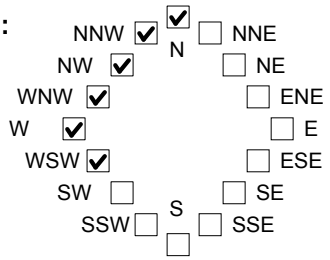
like opening that is 4-5m deep, and several meters wide and tall. This opening cannot be seen from above, but only from within or below the chute. “Tic-tac-toe” graffiti scratched onto the wall of this shelter indicates that this, too, has been visited by people. No plants were observed to be directly related to these caves/shelters, but they are unique features among sites studied in this project.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	70.0	0.0	0.0	30.0	0.0	100
Max relief(m):	30	0	0	2	0	

Maximum Slope: 45 **Texture:** Fractured

Aspects:



Setting:

The topography at Little Stony Man is controlled by two thick lava flows. The upper flow, which is around 30m thick, is capped by an intermittent conglomerate/breccia layer that represents stream deposits formed upon the cooled upper surface of the flow. This flow forms a clear line of near-sheer cliffs, at the top of which is an obvious topographic bench which dips gently to the east along the general trend of the flow itself. The upper portion of the Appalachian Trail (AT) runs along this bench, and the capping conglomerate occurs in protruding outcrops above this level. The base of this flow is defined by a thick layer of volcanic breccia, which seems to contain clasts of sedimentary material. This unit represents the effects of the molten lava flow advancing over a landscape of previously cooled lava over which streams and ponds had begun to deposit sediments, fragments of which are now mixed into the thick, chaotic breccia formed at the boundary between the lower and upper flows as the latter bulldozed across the landscape. Below this unit, the lower flow extends at least 30m down, though the lack of identifiable boundary layers prevents an exact description of its base.

These two flows are distinctly different; the upper flow is dominated by columnar jointing, which creates the tall, nearly sheer cliffs above the Passamaquoddy Trail (PT). These columns, along with the more random fracturing, create numerous ledges all over the cliff face which encourage both plant growth and climbing activity. The combination of high, sheer cliff exposure with well-developed columnar jointing and other fracture sets creates excellent climbing terrain, with numerous ledges, handholds, and cracks that are not present in many basaltic cliff areas within the park. The cliffs below the PT, with less fracturing and more flow layering, are both less steep and sheerer, and so are not as suitable for exciting and interesting climbing routes. The narrow topographic bench between the two flows provides the route upon which the PT was built, and the broad bench above on which the AT was built, provide natural access to these areas and also help to encourage human use.

The western orientation of all open cliff areas here corresponds to the regional southeastern dip of the lava flows, as in many other parts of the park. This pattern produces gentle, boulder-covered slopes to the east, where the tops of lava flows provide a resistant, table-like structure, while to the west cliff exposures are more common where the flows “jut out” into the air. In addition, it is worth noting that the contact between the Catoctin lava flows and the underlying basement granitic gneisses occurs not far below the exposures contained within the site. The Little Stony Man parking lot, and the large Stony Man Overlook just to the north, are built basically on the near-horizontal contact between these two units. One source (Badger, 1999) identified the upper flow at Little Stony Man as third in the sequence above the basement rock. In hiking from the parking lot, therefore, one is crossing through the first lava flow, then the second (which presumably forms the exposures below the PT), then the third (between the PT and the AT).

The intervening breccia layer has a very different character than the “pure” greenstone of either flow; it contains numerous fragments of various rock types, and is in general much more rough, rugged, and chaotic in texture. This unit forms a series of boulders and broad ledges that extend about 1/3 of the way up the upper cliffs at their north end, and seem to provide a bouldering route through this area. A similar breccia unit is found separating the two main cliffs at the Stony Man summit, and one source (Badger, 1999) has suggested that the two flows here correspond to the those at the summit, higher and to the south. The lithologies are similar in both locations, and the breccia layers are very unusual and distinct. If this is true, then the lava flows here are locally dipping to the north as well as off to the east in the regional pattern.

Stability: Stable

This rating applies to the areas above the Passamaquoddy Trail (PT), where most rare plant occurrences and visitor uses are located. The upper cliffs, despite common fracturing, appear quite solid, and persistent climbing, scrambling, and other human

C28 - Stony Man: Little Stony Man (continued...)

presence has reduced the amount of loose material. The talus chutes and surrounding slopes are quite steep, and can be unstable, but well-developed social trails along most possible routes mitigate this problem. Below the PT, conditions are much wilder, as there are no social trails and the slopes are mostly loose rock and soil. Great care should be taken in these areas; a loosened rock can easily roll out of earshot. The bedrock exposures here, on the other hand, are even more stable than those above, as there are fewer fractures and joints, and more flow layering that creates stable ledges.

GPS Points

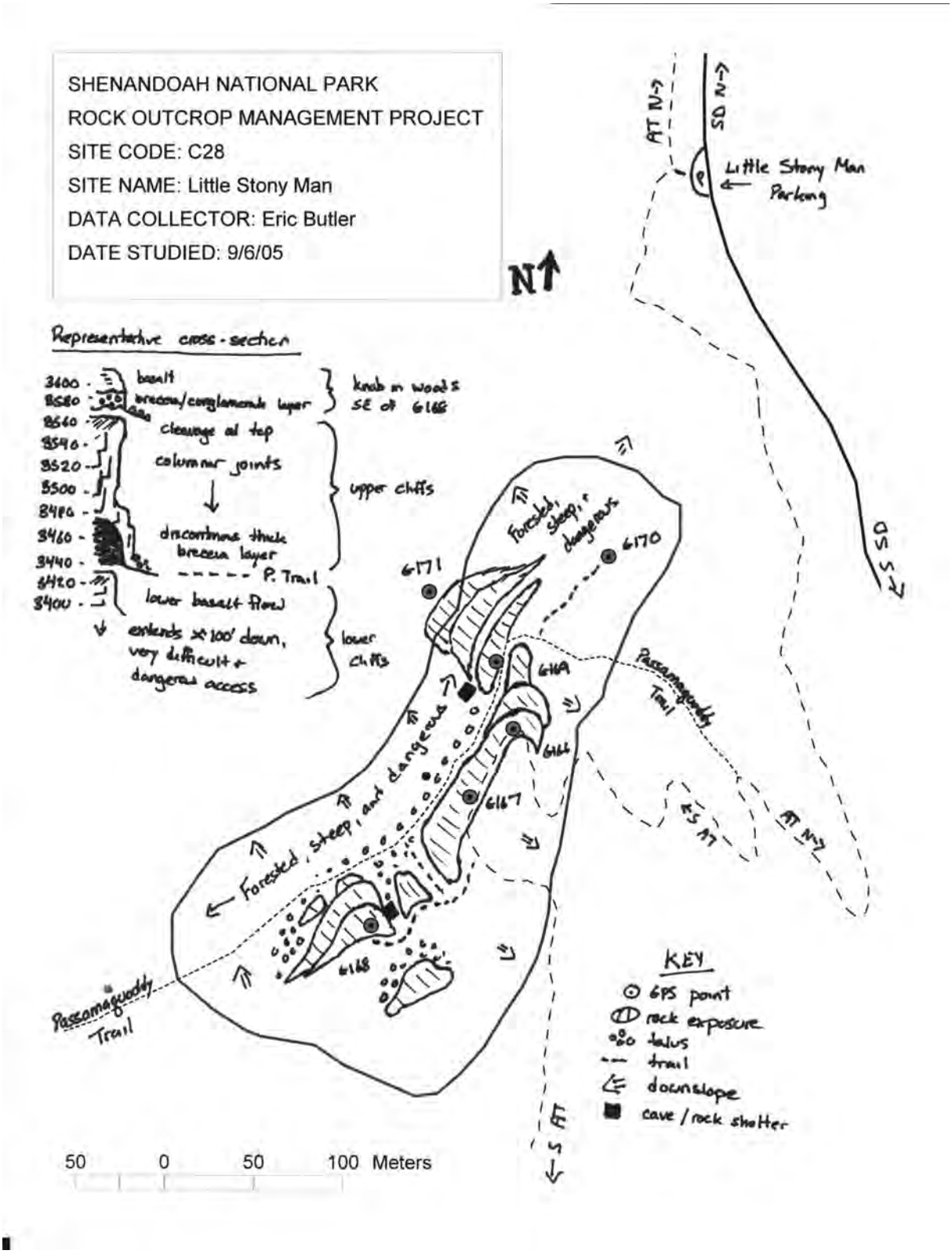
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
9/6/2005	G166-C28	729211	4276063	3560	North end of ledges along AT, upper cliff
9/6/2005	G167-C28	729186	4276025	3560	Near south end of ledges along AT, upper cliff
9/6/2005	G168-C28	729131	4275952	3500	High point on ledges above southern portion of upper cliff
9/6/2005	G169-C28	729201	4276101	3440	Large, stripped overlook ledges along Passamaquoddy Trail
9/6/2005	G170-C28	729264	4276160	3400	Apparent campsite in woods reached by social trail from PT overlook
9/6/2005	G171-C28	729163	4276140	3220	Base of series of cliffs below PT overlook

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
9/6/2005	G166-C28	SHEN_C28_G_20050906_001.jpg	50	Butler, Eric	Looking down onto stripped overlook along PT, with intermediate ledge in foreground
9/6/2005	G166-C28	SHEN_C28_G_20050906_002.jpg	205	Butler, Eric	Ledges atop northern portion of upper cliff, AT running along clifftop
9/6/2005	G167-C28	SHEN_C28_G_20050906_003.jpg	220	Butler, Eric	Columnar jointing in upper cliffs (southern portion in background)
9/6/2005	G167-C28	SHEN_C28_G_20050906_004.jpg	25	Butler, Eric	Impacted ledges along AT, atop northern portion of upper cliff
9/6/2005	G168-C28	SHEN_C28_G_20050906_005.jpg	25	Butler, Eric	View north along extent of site, including upper cliffs & PT overlook atop lower cliff
9/6/2005	G167-C28	SHEN_C28_G_20050906_006.jpg		Butler, Eric	PT along base of upper cliffs (below G167), a popular climbing area
9/6/2005	G167-C28	SHEN_C28_G_20050906_007.jpg		Butler, Eric	View up from PT (below G167) of popular climbing route – note columnar jointing
9/6/2005	G169-C28	SHEN_C28_G_20050906_008.jpg	35	Butler, Eric	Heavily impacted ledges at overlook along PT – note strong cleavage in bedrock
9/6/2005	G169-C28	SHEN_C28_G_20050906_009.jpg	90	Butler, Eric	Large exposure of volcanic breccia at PT overlook
9/6/2005	G169-C28	SHEN_C28_G_20050906_010.jpg		Butler, Eric	Closeup of vesicular greenstone fragments in breccia, above G169

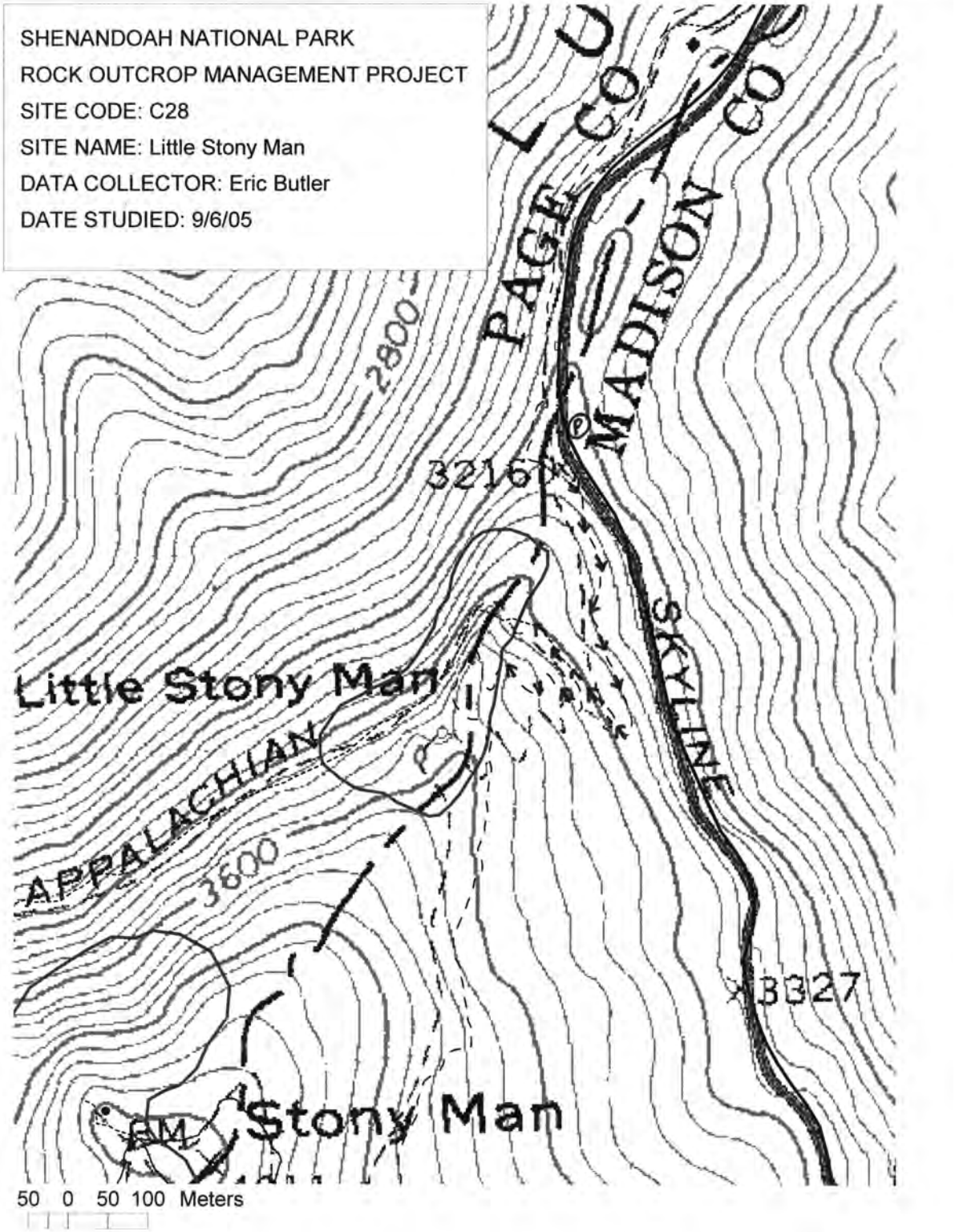
C28 - Stony Man: Little Stony Man (continued...)

Detail sketch map



C28 - Stony Man: Little Stony Man (continued...)

Area sketch map



C28 - Stony Man: Little Stony Man (continued...)



SHEN_C28_G_20050906_001.jpg Azmuth: 50

Looking down onto stripped overlook along PT, with intermediate ledge in foreground



SHEN_C28_G_20050906_002.jpg Azmuth: 205

Ledges atop northern portion of upper cliff, AT running along clifftop



SHEN_C28_G_20050906_003.jpg Azmuth: 220

Columnar jointing in upper cliffs (southern portion in background)



SHEN_C28_G_20050906_004.jpg Azmuth: 25

Impacted ledges along AT, atop northern portion of upper cliff

C28 - Stony Man: Little Stony Man (continued...)



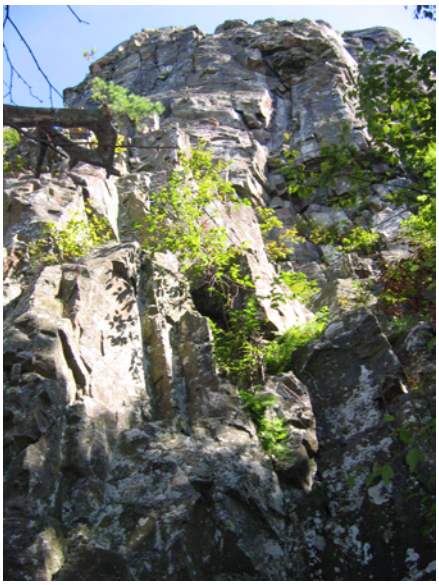
SHEN_C28_G_20050906_005.jpg Azmuth: 25

View north along extent of site, including upper cliffs & PT overlook atop lower cliff



SHEN_C28_G_20050906_006.jpg Azmuth:

PT along base of upper cliffs (below G167), a popular climbing area



SHEN_C28_G_20050906_007.jpg Azmuth:

View up from PT (below G167) of popular climbing route – note columnar jointing



SHEN_C28_G_20050906_008.jpg Azmuth: 35

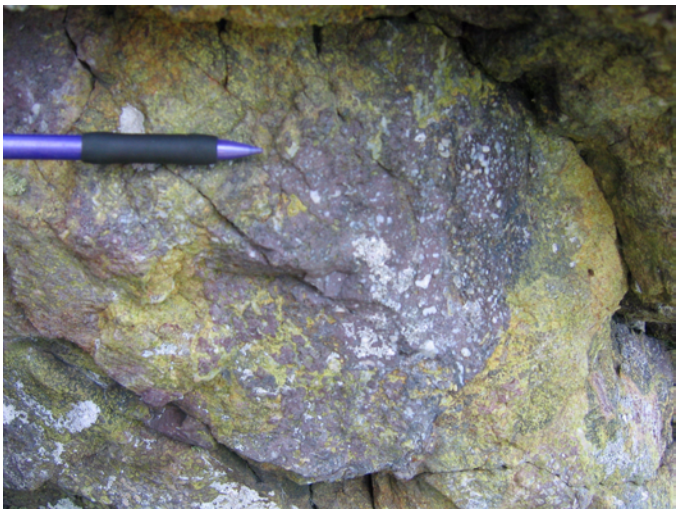
Heavily impacted ledges at overlook along PT – note strong cleavage in bedrock

C28 - Stony Man: Little Stony Man (continued...)



SHEN_C28_G_20050906_009.jpg Azmuth: 90

Large exposure of volcanic breccia at PT overlook



SHEN_C28_G_20050906_010.jpg Azmuth:

Closeup of vesicular greenstone fragments in breccia, above G169

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C29 - Loft Mountain summit

Site Code:	C29	**Polygon Centroid:**	**E:** 705100 **N:** 4237348
Site Name:	Loft Mountain summit		UTM (Zone 17 NAD83)
Data Collector	Butler, Eric	**Dimensions (m):**	240 x 430 (GIS est.)
Date Studied:	26-Jul-05	**Elevation Range (ft):**	3040 to 3320

Physical Characteristics

Location Acces

Park at Loft Mountain Wayside (Milepost 79.5) and find the Frazier Discovery Trail, which begins next to the entrance to Loft Mountain Campground, across Skyline Drive from the wayside. The Frazier Trail is a loop that meets the Appalachian Trail at its high point. From the trailhead along Skyline Drive to the highest point in the site is about 800m along either limb of the Frazier Trail, with an elevation gain of around 300'.

Physical Description:

There are two separate areas of exposure within this site. At the summit, a single cliff 5-10m high runs northeast for around 200m, with a bit of talus below. There are extensive open ledges atop this cliff, which in several places are accessed by social trails. Where these trails appear, the ledges are mostly stripped to bare rock with some grass, while in between these areas the vegetation is much thicker. Lower on the slope, away from trails, a very large set of cliffs occurs between 3040' and 3200', composed of two distinct units. The upper unit appears very jagged and rough, with angular ledges jutting out from the rock and creating numerous overhangs small and large. Below this unit, the lower cliffs are more smooth and sheer, appearing less dramatic though still quite high. To the north, these cliffs end very abruptly in a gently sloping landscape with little talus, while to the south the talus deposits grow thicker and produce a more gradual transition from cliff to forested slope. Along the slope dividing the upper and lower cliff units, scattered bedrock outcrops and boulders can be found, though these are generally under complete forest cover. Both cliff areas begin and end fairly suddenly to the north and south, from within otherwise average forested slopes.

Vegetation: Moderate

The vegetation here is highly variable. There are pockets of very dense growth at the base of the lower cliffs, and along the top of the upper cliffs. The slopes in between are mostly open forest floor and present no problem. The vegetation along clifftops varies from thick laurel to open trees to shrubs and grass.

Human Effects

Impacts: Moderate

This rating reflects the condition of the upper cliffs, which are directly accessed by trails and appear heavily used. In the two places where trails reach the clifftop, vegetation is mostly gone, with the exception of some grasses, and most of the rock ledges are stripped to gravel for up to 5m back from the cliff. In between these two places, the vegetation is much thicker and much less rock is exposed, giving an indication of the "natural" state of these exposures. The lower cliff areas, which are much more extensive than the upper, do not show any obvious human impact despite their proximity to a campground, wayside, and several trails; no side trails lead to these exposures from the maintained trails, no trash was found in the area, and the ledges do not look impacted.

Access Moderate

The site is close to numerous points of visitor use, including a campground and Skyline Drive wayside. In addition, the Frazier Discovery Trail makes a full loop around the site, and provides direct access to the upper cliffs. Published guides to this trail specifically direct visitors to the views from these exposures. The lower cliffs can be seen from Skyline Drive, but not from the Frazier Trail, though they are very close to the trail at either end. The trail is relatively steep, however, with an elevation gain of over 300' in a short distance; in addition, the lower cliffs require negotiation of some steep, off-trail terrain to reach.

Geologic Characteristics

Lithology: **Rock Type** Greenstone

This site is composed of Catoctin Formation greenstone, generally very fine-grained and grey-green on a fresh face. Gently dipping flow layering is present in places, especially in the bottom unit of the lower cliffs. The upper unit of the lower cliffs

C29 - Loft Mountain summit (continued...)

contains abundant pods (1-2m) of epidote-rich material, which appear as blocky-looking patches of bright green among the red-brown weathering greenstones; these are likely the result of hydrothermal alternation during metamorphism (hot fluids encouraging the growth of minerals such as epidote). Some of these appear to have formed before any physical deformation, as the cleavage commonly wraps around these pods. On the slopes between the upper and lower cliffs, abundant float and boulders of vesicular breccia can be found, but the lithologic contact these represent cannot be placed exactly. No such rocks are found in-place on or near any of the cliffs.

Structure:

Most of the exposures are dominated by a strong cleavage, dipping 45-60 degrees to the east and creating numerous ledges, overhangs, and protruding fingers of rock. The upper portions of both cliff units have an almost staircase-like texture that is formed by these cleavage planes. The rocks are variably fractured, but no consistent joint set is identifiable. There is one very obvious linear feature within the lower cliffs, a gap oriented about 310 degrees at which the upper unit abruptly ends, and the lower unit is split into a narrow "chute" that is navigable with care. This may be a well-developed joint, or a small fault, but there is no way to tell. Overall, the flows also appear to be tilted to the north, as the cliff units descend noticeably in that direction as they are traced.

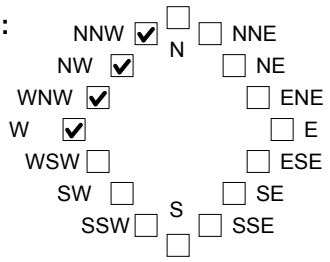
Other:

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	60.0	0.0	0.0	30.0	10.0	100
Max relief(m):	30	0	0	1	5	

Maximum Slope: 40 **Texture:** Fractured

Aspects:



Setting:

There are at least two lava flows within this site, and probably three or more. The presence of vesicular breccia on the slope dividing the upper and lower cliffs indicates that these exposures belong to different flows. The lower cliffs are likely composed of two separate flows, based on the presence of an obvious dividing bench between two units of cliff here, and on the change in lithology across that bench. Above this point, the rocks are dominated by cleavage, which creates numerous protruding and overhanging "fingers" and ledges, and contain numerous pods and veins of epidote-rich material. Below the bench, the cleavage is less prominent, the cliffs are much smoother and wall-like, and pods of epidote are much rarer. Without any clear contact, though, it remains possible that the entire exposure is composed of a single, very thick flow with a variable composition.
The western aspect of the cliffs fits the pattern for most greenstone exposures within the park, as the general eastern dip of the lava flows tends to create cliffs on the more exposed, upward tilted western sides of mountains. The unusually tall and sheer lower cliffs are likely the result of an especially resistant flow or flows, which remained in place while the surrounding slopes eroded. The dominant cleavage may also be a factor in cliff development, as it encourages the formation and erosion of large boulders and slabs that fall away at once to produce sheer faces.

Stability: Stable

There is very little loose rock or debris at this site. The cliffs and ledges are very stable, despite the fractured appearance produced by cleavage, and most of the surrounding slopes have some developed soil that seems to hold talus in place. A few narrow chutes between cliffs are very steep and slippery, but the overall site poses little danger in this regard.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
7/26/2005	G107-C29	705221	4237413	3240	NE end of upper cliff, along Frazier Trail
7/26/2005	G108-C29	705177	4237372	3280	Northern site of impacted ledges on upper cliff
7/26/2005	G109-C29	705072	4237293	3300	Southern site of impacted ledges on upper cliff
7/26/2005	G110-C29	704939	4237226	3160	Boulders and outcrops of vesicular greenstonet in forest
7/26/2005	G111-C29	704944	4237307	3160	Open ledges near top of lower cliff
8/3/2005	G125-C29	704970	4237338	3100	Small spring on bench between 2 units of lower cliff

C29 - Loft Mountain summit (continued...)

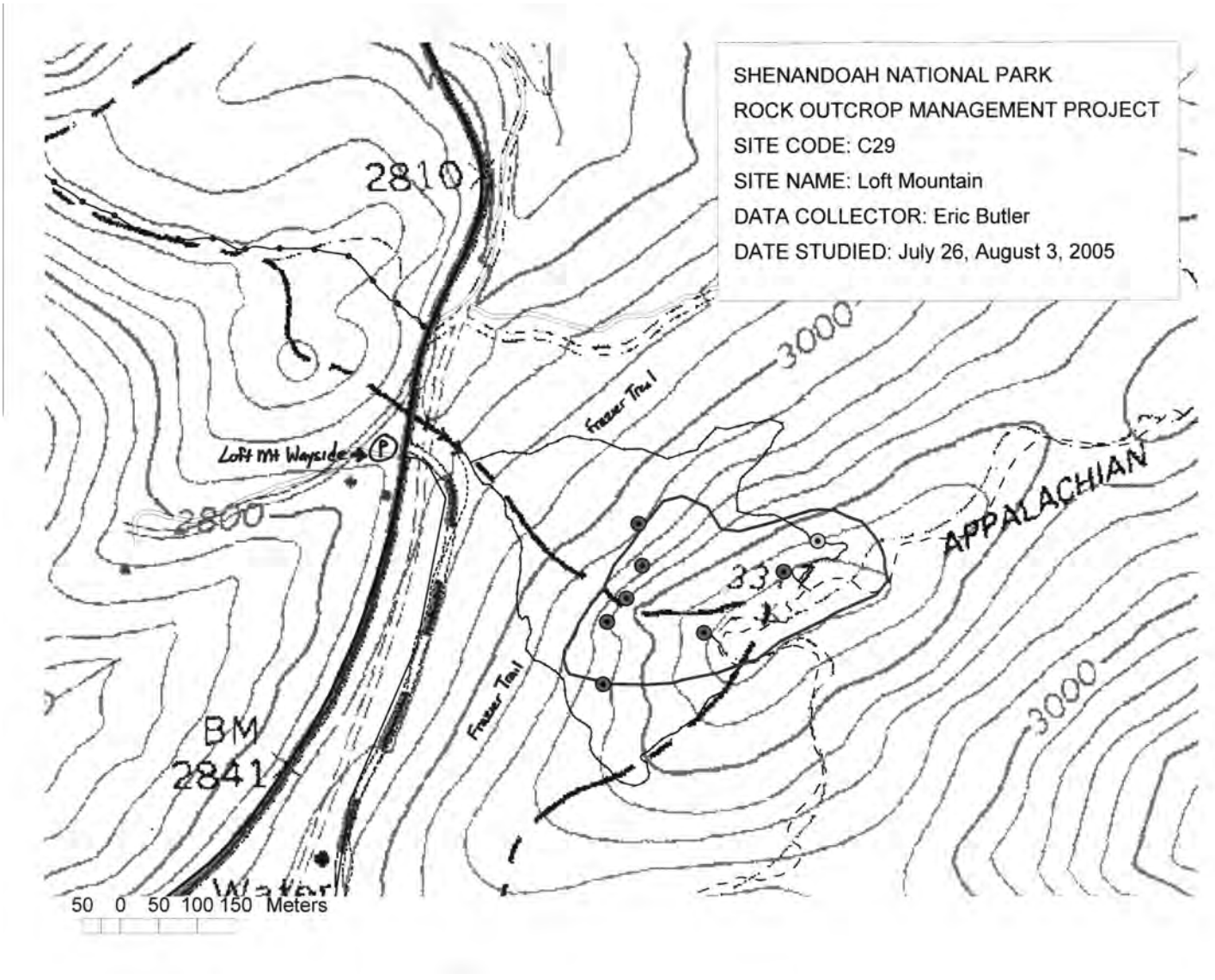
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
8/3/2005	G126-C29	704986	4237435	3040	Small springs at base of lowest cliffs within site
8/3/2005	G127-C29	704991	4237381	3100	Large, linear crack/chute at 310 degrees, providing access to all cliff le

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
7/26/2005	G108-C29	SHEN_C29_G_20050726_001.jpg	90	Butler, Eric	Open ledges on upper cliff showing human impact and cleavage ledges
7/26/2005	G108-C29	SHEN_C29_G_20050726_002.jpg	90	Butler, Eric	Open ledges on upper cliff showing human impact, trails, and cleavage ledges
7/26/2005	G110-C29	SHEN_C29_G_20050726_003.jpg		Butler, Eric	Vesicular greenstone found in forest at south end of site.
7/26/2005	G111-C29	SHEN_C29_G_20050726_004.jpg	200	Butler, Eric	Ledges above lower cliffs, showing strong cleavage
7/26/2005	G125-C29	SHEN_C29_G_20050803_001.JPG	30	Butler, Eric	Overhanging cliffs above bench at 3100', showing effect of cleavage
7/26/2005	G125-C29	SHEN_C29_G_20050803_002.JPG		Butler, Eric	Epidote-rich pocket within greenstone; note how cleavage deforms around lens of material

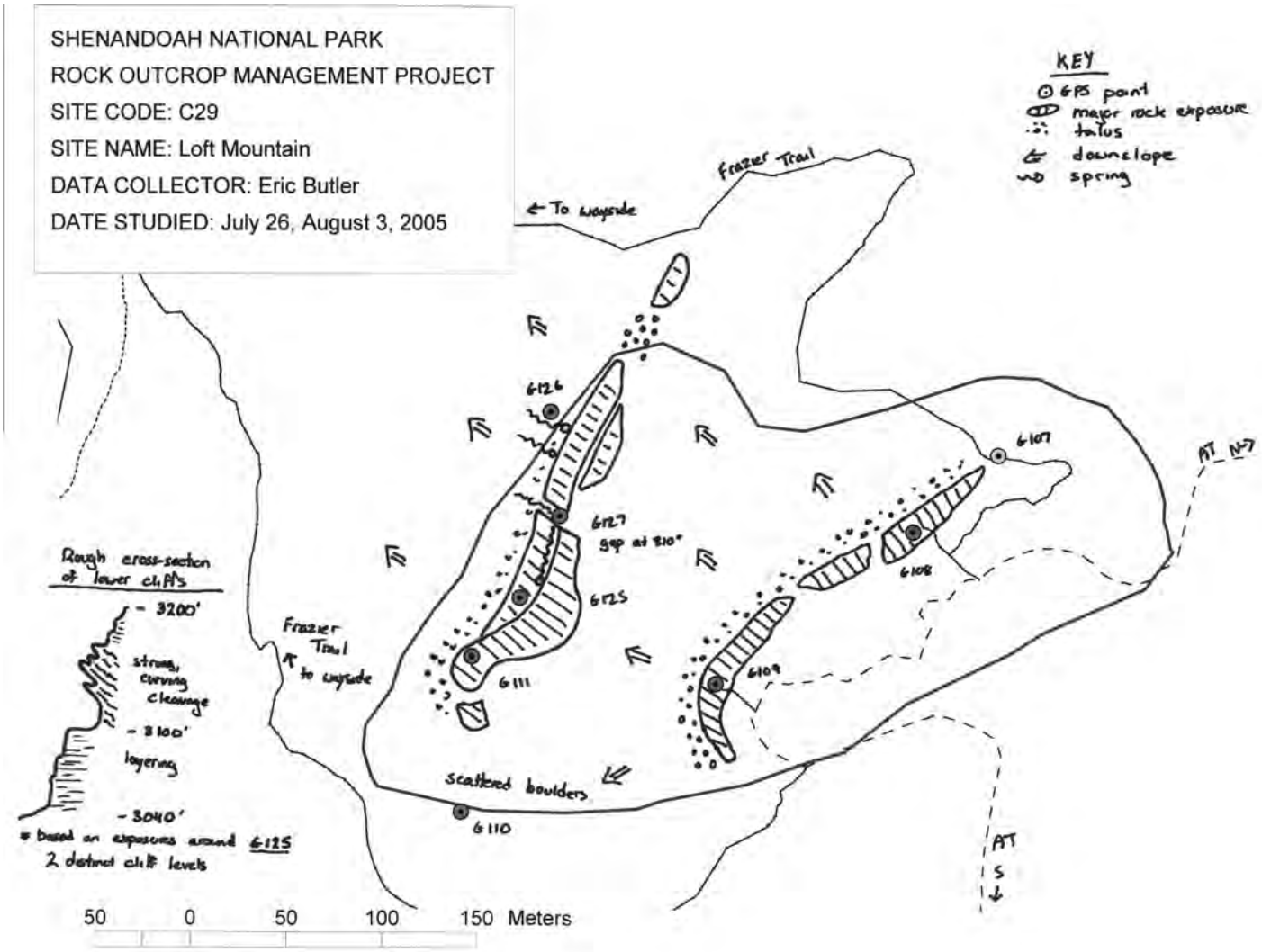
C29 - Loft Mountain summit (continued...)

Area sketch map



C29 - Loft Mountain summit (continued...)

Detail sketch map



C29 - Loft Mountain summit (continued...)



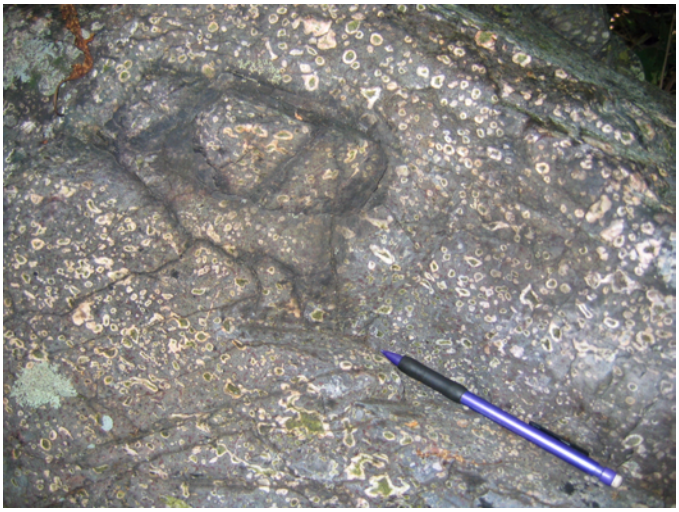
SHEN_C29_G_20050726_001.jpg Azmuth: 90

Open ledges on upper cliff showing human impact and cleavage ledges



SHEN_C29_G_20050726_002.jpg Azmuth: 90

Open ledges on upper cliff showing human impact, trails, and cleavage ledges



SHEN_C29_G_20050726_003.jpg Azmuth:

Vesicular greenstone found in forest at south end of site.



SHEN_C29_G_20050726_004.jpg Azmuth: 200

Ledges above lower cliffs, showing strong cleavage

C29 - Loft Mountain summit (continued...)



SHEN_C29_G_20050803_001.JPG Azmuth: 30

Overhanging cliffs above bench at 3100', showing effect of cleavage



SHEN_C29_G_20050803_002.JPG Azmuth:

Epidote-rich pocket within greenstone; note how cleavage deforms around lens of material

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C31 - Marys Rock

Site Code: C31
Site Name: Marys Rock
Data Collector Butler, Eric
Date Studied: 13-Jan-06

Polygon Centroid: **E:** 733435 **N:** 4281331
UTM (Zone 17 NAD83)
Dimensions (m): 170 x 350 (GIS est.)
Elevation Range (ft): 3280 to 3514

Physical Characteristics

Location Acces

Park at the Meadow Springs lot (Milepost 34.5) and follow the Meadow Springs Trail 900m upslope to intersect with the Appalachian Trail (AT); take the AT north another 1,000m to an intersection with the side trail that leads to Mary's Rock. Take this trail 150m up to the prominent overlook at the north end of Mary's Rock. Alternatively, Mary's Rock can be reached from Thornton Gap by parking at the upper or lower Panorama lots, and following the AT south to the side trail junction. This route is about 1km longer and 600' steeper, but remains accessible when the Skyline Drive is closed.

Physical Description:

This site consists of a long, narrow bedrock ridge capping a steep slope. Mary's Rock is the summit of a prominent peak overlooking Thornton Gap, dropping off steeply to the west, north, and east, while connecting to a long, narrow ridge to the south which eventually leads into Pinnacle Ridge (C41). The official park trail to Mary's Rock leads to the north end of the bedrock ridge, where a large gravelly overlook offers views in many directions.
From here the bedrock ridge leads south, dropping off into a sheer cliff to the west, and rising into a narrow rock rib to the south, with a gentler, easily traversable slope to the east. Social trails follow the eastern side of this rib, offering access up onto the rocks at various places. The physically highest point (marked by several benchmarks) occurs about halfway down the length of the open rock, and is accessible by a relatively easy climb up a rock face. South of this, a small saddle in the rock rib allows access to several ledges along the west side, while other social trails continue to lead south along the east side. The rock exposures end to the south in a large, jumbled dome that extends down to the Appalachian Trail.
Below the sheer dropoffs on the western side, the slope is steep, thickly vegetated in places, and slippery. A large boulder field extends along the northwest portion of the site, wrapping around the northern nose of the ridge before blending back into the forest. These areas are difficult to traverse, especially when wet. Outside the site boundary, along the ridge to the north, are several large exposures of smooth, open rock facing southeast-east. These may or may not be of interest to the study, but a faint social trail leads along a topographic bench much of the way to these exposures.

Vegetation: Moderate

Vegetation thickness depends entirely on location within the site. On the gentler slopes to the east, the forest floor is more open, with some tangled thickets. Below the rocks to the west and north, the vegetation is very thick, with downed limbs a significant barrier in places.

Human Effects

Impacts: Heavy

The overlook at the end of the park side trail (G178) is very heavily impacted, with a wide area of many square meters completely stripped down to bare dirt and gravel, and the surrounding rocks polished smooth and virtually lichen-free. Many social trails lace the woods and exposures on the east side of the ridge. Two fire rings were observed near G179, and trash was common throughout the site. There appears to be little human activity below the ridge and cliffs; most impact is concentrated on the eastern slope and ridge top.

Access Moderate

Mary's Rock is a prominent landmark, visible from far away, and a clear hiking destination. It offers one of the few 360-degree views in Shenandoah, and is mentioned in many guidebooks. The hike from Meadow Springs involves some significant climbing, but the trail route is clear. The access route from Thornton Gap is another important route, despite the extra distance and climb. Although the Skyline Drive is often closed during the fall, winter, and spring, limiting access to most summits and viewpoints, the lower Panorama parking lot at Thornton Gap is open to Rt 211, and so Mary's Rock is accessible from the north year-round. It seems to be a well-known off-season hike, and it is not uncommon to see many cars parked there on any winter weekend.

C31 - Marys Rock (continued...)

Geologic Characteristics

Lithology: **Rock Type** Granitic gneiss

This site is underlain by basement rock of generally granitic composition. There are two distinct lithologies present within the site. The first, and dominant lithology, is a light-colored (white-pink), medium-fine grained rock composed of quartz and feldspars (especially orthoclase), with a well-developed foliation and many larger crystals of feldspar up to 5cm in diameter. These larger crystals can be very obvious in smooth rock faces. There is no significant mica present, with the dominant darker mineral appearing to be pyroxene. Garnet is present in highly variable quantities. The dominance of pyroxene over mica suggests that this rock may be charnockite, a somewhat unusual lithology but common in parts of the park. This rock forms virtually all of the exposed bedrock within the site. The second lithology is visible mostly as loose rock along the side trail leading from the Appalachian Trail up to the overlook at G178; it is a much darker (grey-black), coarser grained rock, with little to no foliation, and a higher percentage of plagioclase feldspar than the dominant rock. It is difficult to find this lithology in-place within the site, but it is very common along the ground in the eastern part of the site, and so warrants mention.

Structure:

There is a very strong joint set here, oriented roughly along 035-215 degrees, and dipping to the northwest between 45-70 degrees. Most of the cliff faces and erosion planes present within this site are oriented along this joint set, and indeed the entire ridgeline in this area follows the orientation of this joint set. Foliation is generally well-developed, forming fine bands of aligned minerals. The orientation of this structure is variable throughout the site, but it seems to have a general trend similar to the joints (035-215), but dipping to the southeast instead around 50 degrees. These two structures interact to form many planar exposures and block-like structures within the rock. Many of the gently sloping faces present in exposures to the east of the ridge seem to be forming along the foliation planes, while the steeper cliff exposures to the west are predominately formed along the joint planes.

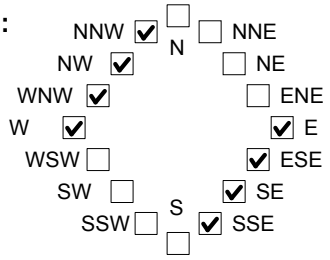
Other:

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	30.0	30.0	10.0	20.0	10.0	100
Max relief(m):	10	5	2	1	5	

Maximum Slope: 25 **Texture:** Smooth

Aspects:



Setting:

The dominant joint set is the single most important factor controlling the shape of rock exposures in this site, along with a secondary partner in the well-developed foliation. These two planes of weakness, when acted upon by physical weathering agents such as frost wedging, create large blocks of rock that loosen and move downslope. These joint surfaces are also a source of strength for the exposures, as they create a solid, unbroken wall that is exposed to the elements. It is no coincidence that the general trend of the ridgeline here is parallel to the joint set and foliation; most erosion takes place along these planes, which are generally quite stable except when a segment breaks loose and slides down. Compare this single, long ridge, where the general slope is parallel to the structural features, to the area just south along Pinnacle Ridge (C41), composed of the same rock type and similar structural features. There, the structural features are not parallel with the surrounding slope, resulting in a set of isolated outcrops jutting from the slope, which are much more unstable than is the case at Mary's Rock.

This relationship between the orientation of the structural features and the surrounding slope also creates very different habitats. There is very little in the way of sheltered areas at Mary's Rock, because the exposures are effectively one long cliff face parallel to the general slope. At C41, just a few miles south, the joint sets and foliation extending across the slope create many sheltered areas among and behind the rock exposures that jut from the slope, following their structural features.

Unlike Pinnacle Ridge to the south, Mary's Rock is an isolated promontory, more susceptible to weathering processes from all sides, thus allowing its general shape to conform more directly to its underlying structural features. Mary's Rock is effectively the northernmost extension of Pinnacle Ridge. The presence of this long, unusually high-elevation granitic ridge (most areas in the park at this elevation are capped in the overlying Catoctin Formation lava flows) is due to a larger structural feature, the Stanley thrust fault. During the formation of the Appalachian Mountains, the entire bedrock sequence of the Shenandoah area

C31 - Marys Rock (continued...)

was thrust up and over itself several times, in effect stacking the rocks upon themselves. The Stanley fault runs along the western edge of the Blue Ridge mountains from the town of Stanley north to Thornton Gap, where it crosses the mountains and then proceeds along the east side (this fault is likely the primary factor in the formation of Thornton Gap). Thus, the granitic bedrock underlying Mary's Rock and Pinnacle Ridge has been thrust up and over the Catoctin lava flows capping nearby Pass Mountain and the rest of the North District, creating the unusually high-elevation granitic exposures present here.

Stability: Smooth

Except for the single dominant joint set, the rock here is very solid and unfractured. While the exposures are certainly eroding away in a geologic time scale, there is little evidence of any significant physical changes here on a human time scale. This is likely due to the smooth cliffs and faces created by the joints and foliation present here, which align with the slope and create a relatively stable exposures.

GPS Points

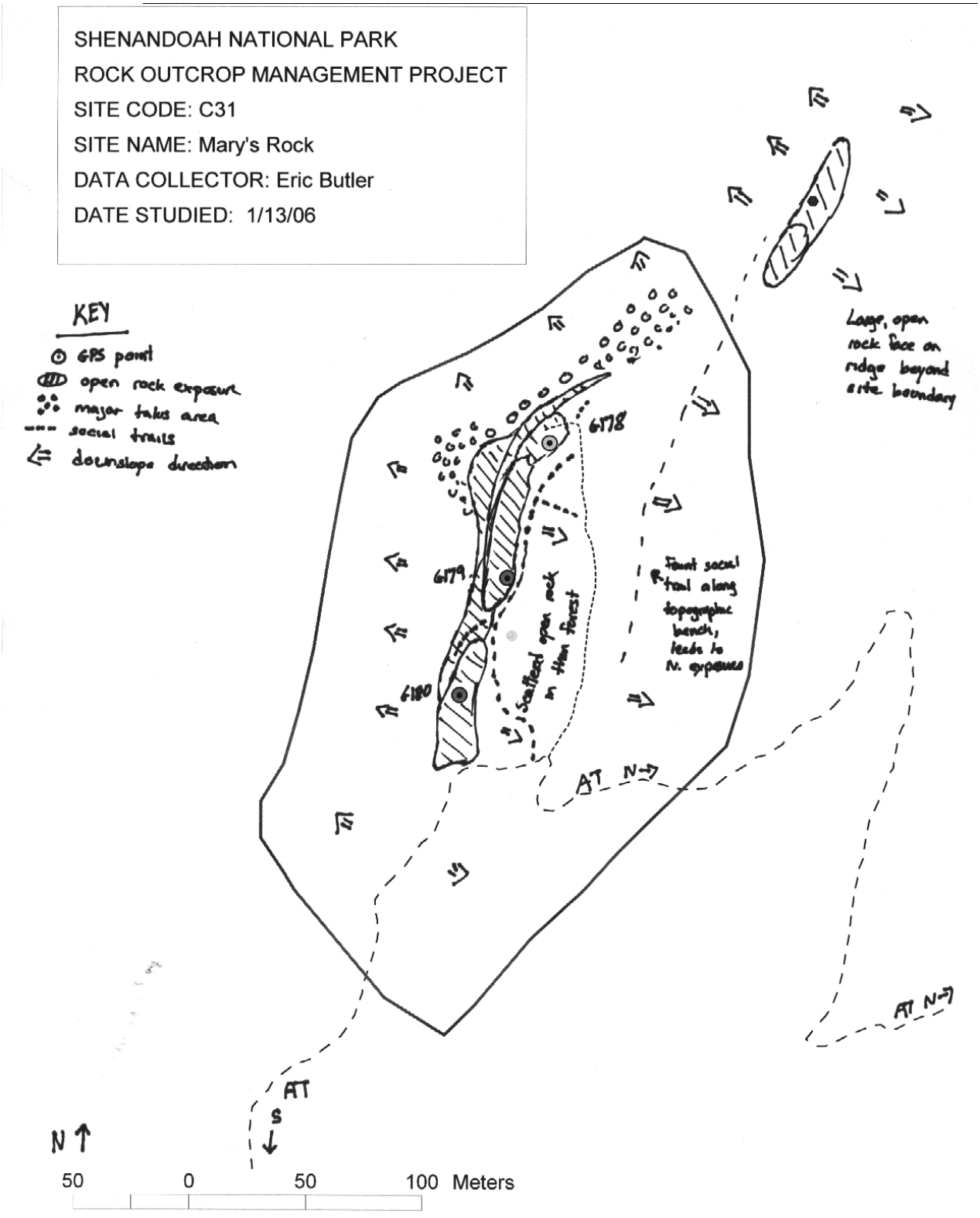
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
1/13/2006	G178-C31	733451	4281415	3480	End of side trail at overlook, very heavily impacted area.
1/13/2006	G179-C31	733433	4281356	3514	Top of summit knob, highest point in site. Several social trails lead to t
1/13/2006	G180-C31	733413	4281305	3440	Mildly impacted area on southern portion of ridge

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
1/13/2006	G178-C31	SHEN_C31_G_20060113_001.jpg	35	Butler, Eric	Parallel joints forming smooth cliffs; note heavily impact overlook in background
1/13/2006	G178-C31	SHEN_C31_G_20060113_002.jpg	215	Butler, Eric	View south toward summit, showing influence of joints on cliff formation and orientation.
1/13/2006	G179-C31	SHEN_C31_G_20060113_003.jpg	215	Butler, Eric	View of southern portion of ridge, taken from summit. Planes dipping to east (left) are following foliation.
1/13/2006	G180-C31	SHEN_C31_G_20060113_004.jpg	35	Butler, Eric	Minor impact along southern portion of ridge.
1/13/2006	G178-C31	SHEN_C31_G_20060113_005.jpg	215	Butler, Eric	Heavy impact at northern overlook; also interaction of joint faces (dipping west/right) and foliation (dipping east/left)
1/13/2006	G178-C31	SHEN_C31_G_20060113_006.jpg	270	Butler, Eric	Heavy impact at northern overlook; gravel & dirt with footprints, rocks stripped of lichens, plant growth destroyed
1/13/2006	G178-C31	SHEN_C31_G_20060113_007.jpg	215	Butler, Eric	Interaction of joint faces (dipping west/right) and foliation (dipping east(left) to create stable surfaces and occasional loose blocks
1/13/2006		SHEN_C31_G_20060113_008.jpg	215	Butler, Eric	Southeast-facing open rock faces outside site boundary along ridge to north; of interest?

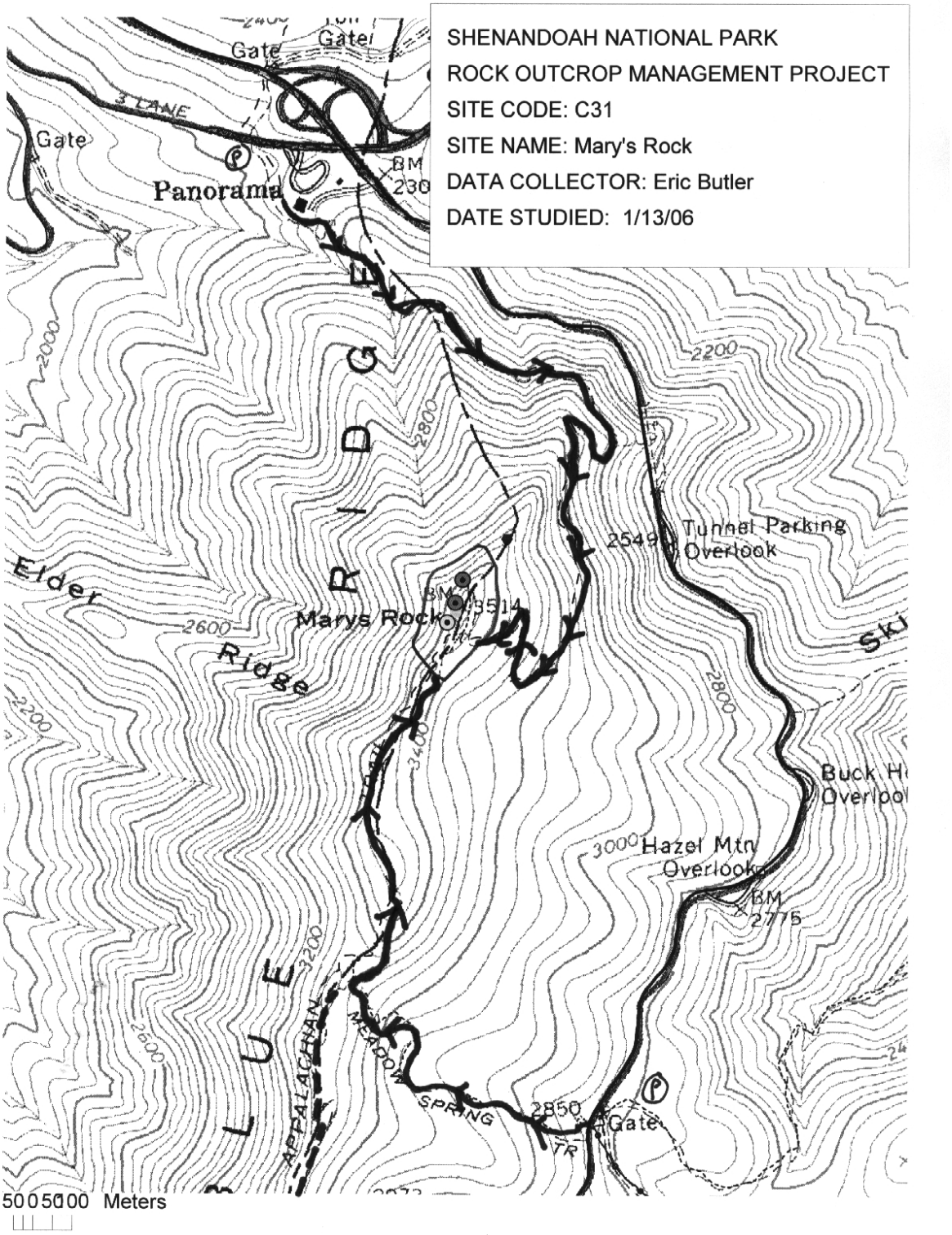
C31 - Marys Rock (continued...)

Detail sketch map



C31 - Marys Rock (continued...)

Area sketch map



C31 - Marys Rock (continued...)



SHEN_C31_G_20060113_001.jpg Azmuth: 35

Parallel joints forming smooth cliffs; note heavily impact overlook in background



SHEN_C31_G_20060113_002.jpg Azmuth: 215

View south toward summit, showing influence of joints on cliff formation and orientation.



SHEN_C31_G_20060113_003.jpg Azmuth: 215

View of southern portion of ridge, taken from summit. Planes dipping to east (left) are following foliation.



SHEN_C31_G_20060113_004.jpg Azmuth: 35

Minor impact along southern portion of ridge.

C31 - Marys Rock (continued...)



SHEN_C31_G_20060113_005.jpg Azmuth: 215

Heavy impact at northern overlook; also interaction of joint faces (dipping west/right) and foliation (dipping east(left)



SHEN_C31_G_20060113_006.jpg Azmuth: 270

Heavy impact at northern overlook; gravel & dirt with footprints, rocks stripped of lichens, plant growth destroyed.



SHEN_C31_G_20060113_007.jpg Azmuth: 215

Interaction of joint faces (dipping west/right) and foliation (dipping east(left) to create stable surfaces and occasional loose blocks



SHEN_C31_G_20060113_008.jpg Azmuth: 215

Southeast-facing open rock faces outside site boundary along ridge to north; of interest?

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C32 - Millers Head

Site Code: C32
Site Name: Millers Head
Data Collector Butler, Eric
Date Studied: 02-Feb-06

Polygon Centroid: **E:** 726931 **N:** 4274849
UTM (Zone 17 NAD83)
Dimensions (m): 150 x 220 (GIS est.)
Elevation Range (ft): 3240 to 3480

Physical Characteristics

Location Acces

Turn into the south entrance to Skyland (Milepost 42.5) and proceed past the stables and a small access road. Up a short hill, follow a paved road to the left. At the crest of the hill, a gravel road leads left through a small meadow. Park here or in one of the nearby cabin lots. To reach Miller's Head, follow either the gravel road or the actual trailhead, which is located a short distance up the paved road. Either will lead to a radio repeater station at the summit of Bushytop; from here a single trail continues along the ridge for about 800m until the trail ends at a stone observation tower.

Physical Description:

Miller's Head is a small rock knob at the western end of a long ridge protruding into the Page Valley. It is capped by a stone observation tower that offers an excellent view to the north, west, and south. The primary open rock areas extend down the southwest slope, and can be initially reached by a small social trail that wraps around the south end of the tower. From here the rocks form several successive sloping faces that ultimately end in a drop-off of about 15m. Smaller outcrops of rock occur to the west and northwest of the tower, but these are partially forested and may not be of interest.

Vegetation: Dense

The upper portion of the site, near the tower, consists of open grasses and is easily negotiable. However, lower down along the edges of the open rock, laurels, blueberries, and other shrubs are common. In addition, the forest is often thick and difficult to navigate.

Human Effects

Impacts: Mild

Despite the presence of a trail and observation tower, most of the open rock areas at this site seem surprisingly undisturbed. The social trail leading southwest from the tower dies out quickly, and little soil, lichens, or vegetation appear impacted. No trash was found within the site. It is possible, if not likely, that the observation tower concentrates visitor use and serves to protect the nearby open rock, as the views from the tower are superior to those from the rocks, and its presence forms a clear boundary for visitation. In addition, the main open rock area is not quite visible from the tower, being just down the slope, giving even less incentive to continue off-trail past this point.

Access Moderate

The total trail distance to Miller's Head is over 1km, and the trail is more rugged and topographic than it appears on a map. Although the trail leads directly from a major park lodge (Skyland), the trailhead is somewhat difficult to find, and there is no obvious, signed parking lot associated with it. (Note: while living at Skyland in 2005, the author encountered numerous hikers who had gotten lost while trying to find the Miller's Head trailhead; this was a near-weekly occurrence). In addition, the trailhead is not easy to locate from Skyline Drive, and it is likely that few visitors traveling the drive are aware of or utilize this trail; most users of it are likely lodgers at Skyland.

Geologic Characteristics

Lithology: **Rock Type** Granite

The rocks here are dominantly composed of a light-colored granite, mostly quartz and feldspar with traces of garnet. This rock is heavily weathered, with chemical weathering effects extending deep into the rocks along fractures. The surface often takes on a reddish tinge, and the lack of fresh surfaces (even when broken) makes mineral identification difficult. Overall the rock resembles a darker version of the Old Rag Granite, with orthoclase feldspar still common, though without the typical blue quartz. Few significant darker minerals can be located. A few dikes of very light-colored granite cross-cut the rock in no consistent orientation.

C32 - Millers Head (continued...)

Structure:

Several joint sets are present, most notably at 025-205 and 045-225. These are not common throughout the site, however. Foliation is very weak where present, and the rock is mostly massive (unstructured) in physical character.

Other:

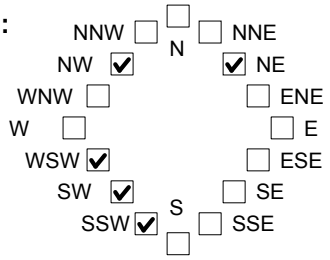
To the west, one outcrop in the woods contains a significant exposure of unakite, an unusual form of granite in which large amounts of epidote have replaced other minerals, resulting in a brightly colored pink, green, and white rock. This rock is usually found near the contact with the overlying Catoctin Formation, reflecting the effects of very hot, mineral-laden water percolating down into the bedrock from the advancing lava flows. The presence of unakite here suggests that this portion of Miller's Head may once have been near the surface of the old paleolandscape, 570 million years ago.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	30.0	20.0	30.0	20.0	0.0	100
Max relief(m):	15	5	10	2	0	

Maximum Slope: 20 **Texture:** Smooth

Aspects:



Setting:

Although this site contains the rounded, sloping exposures so common on granitic areas within the park, it is noticeably different from many of its contemporaries. First, there are very few structures of any sort (foliation, joints, fractures) which usually influence the outcrop pattern, so that this site has formed a more or less random erosional surface. Second, the rocks here are very deeply weathered, and form a rougher surface than many granitic areas. The presence of unakite nearby suggests an answer; it is possible that these rocks were very near the surface of the Catoctin-era landscape, and were already undergoing chemical and physical weathering at that time, before being covered and altered by the advancing lava flows. Recent erosion of the Catoctin has uncovered these rocks and continued the already advanced weathering. A similar texture and history has been described at Hogback Mountain in the North District, and so may be relevant here as well. Although the nearest exposure of the Catoctin greenstones is over 1km away, east of Skyland, the unusually straight and linear nature of the ridgeline leading to Miller's Head suggests that it may reflect an old landscape surface, from which the Catoctin has only recently (geologically speaking) eroded away. There is no clear reason why the major rock exposures should be on the south face of the knob, as opposed to the west or north.

The rounded surface exposures here are still typical of granitic rocks, despite the unusually deep weathering. This pattern is related to the process of exfoliation, in which rocks slowly expand as erosion removes overlying layers and releases the incredible pressures inherent with burial many miles below the surface. As these rocks expand, they fracture into gently curved slabs, like the layers on an onion, and so gradually form rounded surface exposures. Examples of the exfoliation slabs can be seen on many granitic exposures within the park, though none are particularly visible at Miller's Head. This type of weathering is typical of granites, because of their uniform mineral texture and lack of interfering structures such as layering or cleavage.

Stability: Stable

The lack of any significant or common geologic structures (fractures, foliation, joints) makes the rock here very solid, and there are few places where loose rock of any sort can be found.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
2/2/2006	G198-C32	726979	4274871	3480	Stone overlook tower at end of trail
2/2/2006	G199-C32	726885	4274854	3320	Western end of lower cliff area

Site Photos

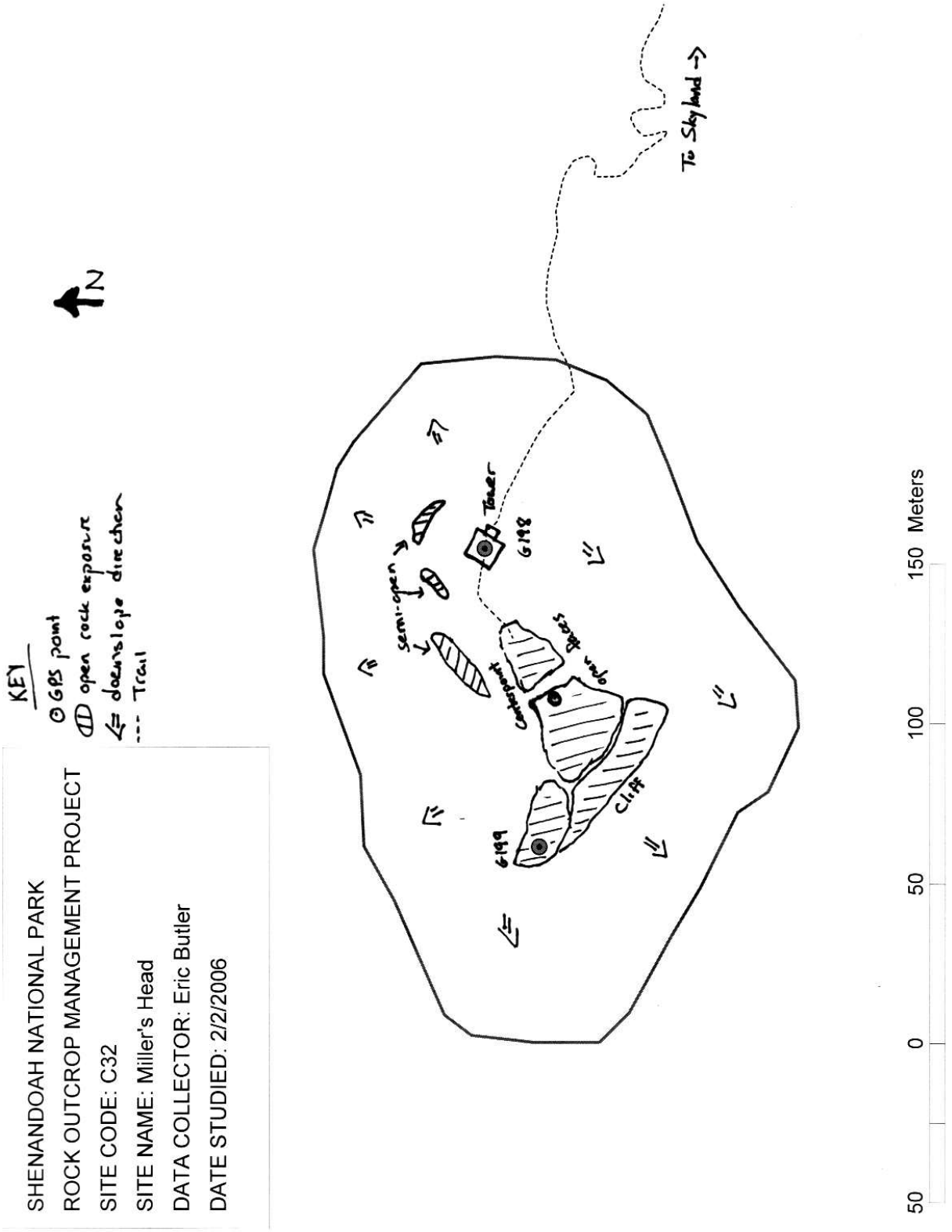
Image Date	GPS Point	File Name	Azmuth	Taken By	Description
2/2/2006	G198-C32	SHEN_C32_G_20050502_005.jpg		Butler, Eric	View up toward stone overlook tower from south-facing slope

C32 - Millers Head (continued...)

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
2/2/2006	G198-C32	SHEN_C32_G_20060202_001.jpg		Butler, Eric	Felsic dike in darker granitic rock
2/2/2006	G198-C32	SHEN_C32_G_20060202_002.jpg		Butler, Eric	View southwest of open rock faces just below tower
2/2/2006		SHEN_C32_G_20060202_003.jpg	60	Butler, Eric	Short cliff dividing upper and lower face exposure. Taken at site centerpoint.
2/2/2006		SHEN_C32_G_20060202_004.jpg	240	Butler, Eric	Lower faces, above cliff. Taken at site centerpoint.
2/2/2006	G199-C32	SHEN_C32_G_20060202_005.jpg	160	Butler, Eric	Ledges with lichens above cliff areas
2/2/2006	G199-C32	SHEN_C32_G_20060202_006.jpg	140	Butler, Eric	Cliff face viewed from west
2/2/2006		SHEN_C32_G_20060202_007.jpg		Butler, Eric	Unakite (epidotized granite) in large boulder to NW of stone tower
2/2/2006		SHEN_C32_G_20060202_008.jpg		Butler, Eric	Mossy, wet exposure to NE of stone tower.
2/2/2006	G198-C32	SHEN_C32_G_20060202_009.jpg		Butler, Eric	Stone overlook tower from trail
2/16/2006		SHEN_C32_G_20060216_001.JPG		Butler, Eric	View of site through zoom lens from Hawksbill summit

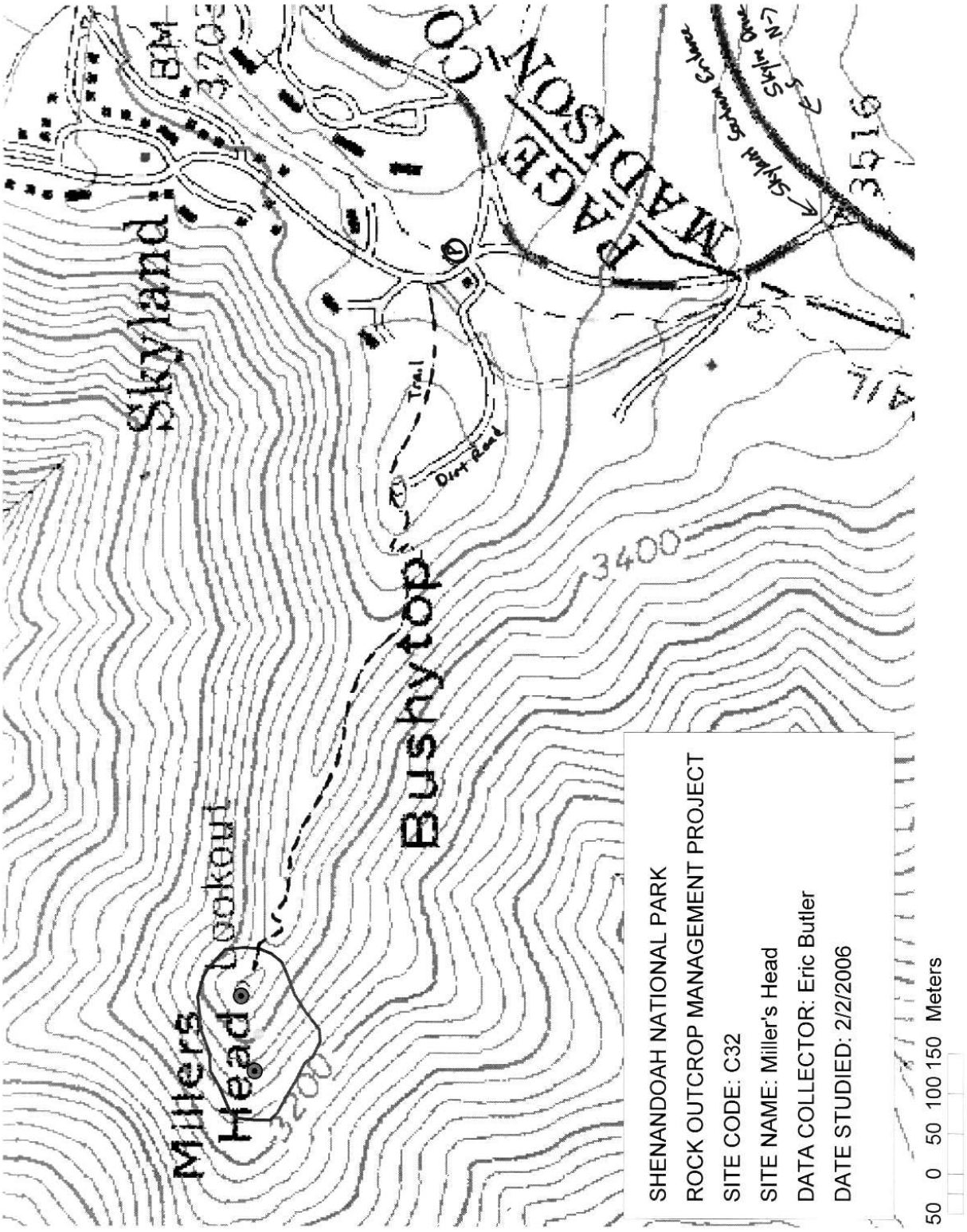
C32 - Millers Head (continued...)

Detail sketch map



C32 - Millers Head (continued...)

Area sketch map



C32 - Millers Head (continued...)



SHEN_C32_G_20050502_005.jpg Azmuth:

View up toward stone overlook tower from south-facing slope



SHEN_C32_G_20060202_001.jpg Azmuth:

Felsic dike in darker granitic rock



SHEN_C32_G_20060202_002.jpg Azmuth:

View southwest of open rock faces just below tower



SHEN_C32_G_20060202_003.jpg Azmuth: 60

Short cliff dividing upper and lower face exposure. Taken at site centerpoint.

C32 - Millers Head (continued...)



SHEN_C32_G_20060202_004.jpg Azmuth: 240

Lower faces, above cliff. Taken at site centerpoint.



SHEN_C32_G_20060202_005.jpg Azmuth: 160

Ledges with lichens above cliff areas



SHEN_C32_G_20060202_006.jpg Azmuth: 140

Cliff face viewed from west



SHEN_C32_G_20060202_007.jpg Azmuth:

Unakite (epidotized granite) in large boulder to NW of stone tower

C32 - Millers Head (continued...)



SHEN_C32_G_20060202_008.jpg Azmuth:

Mossy, wet exposure to NE of stone tower.



SHEN_C32_G_20060202_009.jpg Azmuth:

Stone overlook tower from trail



SHEN_C32_G_20060216_001.JPG Azmuth:

View of site through zoom lens from Hawksbill summit

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C34 - Nakedtop

Site Code:	C34	**Polygon Centroid:**	**E:** **N:**
Site Name:	Nakedtop		UTM (Zone 17 NAD83)
Data Collector	Butler, Eric	**Dimensions (m):**	100 x 200 (GIS est.)
Date Studied:	22-Aug-06	**Elevation Range (ft):**	3080 to 3360

Physical Characteristics

Location Acces

Park at Hawksbill Gap parking lot (Milepost 45.5), and follow the Appalachian Trail (AT) south for 1.6 km, wrapping around the north face of Hawskbill Mt (be careful not to take the Hawskbill summit trail by mistake, which leads from the same parking lot). On the west side of Hawksbill, at the junction with the Salamander Trail (which leads east to Hawksbill summit), instead turn west off the AT and follow a social trail/game trail across the broad saddle separating Hawksbill and Nakedtop. This trail is fairly easy to follow for the 500m to the summit of Nakedtop, then grows fainter as it descends the narrow north ridge. Follow the north ridge down, and the trail when it can be seen, for about 600m to reach a point directly above the open exposures. These cannot be clearly seen from the ridge, but it is a short distance from the ridge down to the site. Throughout the off-trail portion of this route, the navigation will be made much easier by remaining on the ridges rather than trying to cut across the slopes. In 2006 a piece of pink flagging was left on a tree on the ridge directly above the site in order to mark the turn.

Physical Description:

This site consists of a single broad area of open rock exposure on the steep eastern flank of Nakedtop's north ridge. The bedrock surface is fairly smooth and angled between 30-40 degrees, matching the surrounding slopes. Within the open area, grasses and other low vegetation are intermixed with thick lichens and mosses. There are no cliffs or dropoffs, just the single large, smooth expanse of angled rock surface.

Vegetation: Open

The access route in contains some thick laurels and other vegetation, but the site itself consists of open, grassy expanses with scattered trees.

Human Effects

Impacts: Pristine

There is no evidence of any significant human presence at this site. The faint trail leading down the ridge is likely a game trail, and no disturbance of any kind was identified.

Access Remote

Reaching this site requires hiking off-trail for over a kilometer, up and down fairly steep topography. Although the open area of the site is clearly visible from many popular viewpoints such as Crescent Rock and Hawksbill summit, it is far from trails, even farther from roads, and is highly unlikely to attract any visitor attention.

Geologic Characteristics

Lithology: **Rock Type** Granitic gneiss

This site is underlain by various granitic basement rocks. Several different compositions are present, interfingering at centimeter to meter scale with no consistent pattern. All of these subunits are fairly felsic, meaning they have a high proportion of light-colored minerals such as quartz and feldspar, and a low proportion of darker minerals such as biotite or pyroxene. The south end of the site is dominated by a medium-grained granite composed of quartz, orthoclase and plagioclase feldspar, and biotite. This subunit shows very little structure or evidence of metamorphism, and may have intruded the surrounding rocks. Toward the north end of the site, the rocks become more metamorphic, with varying degrees of foliation developed. These rocks tend to contain a higher percentage of quartz, and fewer mafic (dark) minerals, to the point that some pieces resemble quartzite (metamorphosed sandstone). Throughout the site there are many subtle changes in composition, sometimes appearing as gradations within the rock, sometimes as sharper contacts or veins between noticeably different compositions. These patterns are likely due to the extreme conditions under which the basement rocks here formed, as very high temperatures and pressures combined to melt some areas while severely deforming others and mixing all of these effects together. All of these rocks formed around the same time, over 1 billion years ago, but their variable appearance reflects the subtly different reactions of various

C34 - Nakedtop (continued...)

mineral assemblages to the temperature and pressure conditions they experienced.

Structure:

There are few structures within the rocks here, other than some faintly to moderately well-developed foliation and gneissic banding within some of the subunits toward the north of the site. Even the most well-developed foliation here is far fainter than is found in many other locations in Shenandoah. In a few locations, shear bands were identified (where the otherwise parallel foliation is bent or kinked by other deformation). The major structure here is a common, parallel set of fractures or joints that dips due east at around 35-37 degrees, nearly parallel with the surrounding topographic slope. Much of the exposed rock surface here is developed along the surface of one of these fractures, which seem to be best formed toward the south end of the site. The stronger foliation to the north may interfere slightly with the fracture system and thus produce a somewhat more random erosion pattern.

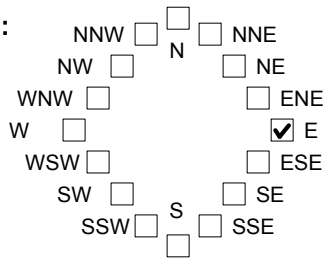
Other:

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	0.0	0.0	80.0	20.0	0.0	100
Max relief(m):	0	0	40	1	0	

Maximum Slope: 35 **Texture:** Smooth

Aspects:



Setting:

This site is in many ways typical of granitic exposures within Shenandoah. Granitic rocks tend to form large, smooth, rounded exposures due to their relatively homogenous grain sizes and the lack of other structural features that might control their erosion (such as the cleavage and bedding of lava flows). Exfoliation is a common process under such conditions, as the gradual expansion and contraction of the rock due to weather and climate condition slowly breaks off thin slabs of rock that then slide down the surface, leaving a clean exposure behind. Where foliation in granitic rocks is well-developed, it can help drive the shape of the exposures (as at Mary's Rock), but at this site the foliation is fairly weak and does not appear to be a dominant factor, except for the possibility that it might mitigate the effects of the otherwise common fracture set.

The east-dipping fracture set that creates planar, parallel rock faces appears to be dominant here. It is not clear whether these fractures are pervasive throughout the rock (i.e. a true structural joint set) or whether they are localized at the surface; the former would have developed through tectonic stresses, while the latter would more likely be related to surface processes such as exfoliation that fracture the rock from the surface inward . In either case, the orientation of these fractures coincides with the surrounding topography so that any loose rock or soil forming here would simply slide down the rock surface until encountering some barrier, thus leaving the exposures clean. It is likely that these exposures were once more extensive, and that vegetation and soil formation have slowly colonized the edges and shrunk the open area.

There are small, flatter ledges scattered through the otherwise sloping rock exposures, which trap enough soil to provide habitat for the grassy vegetation that has colonized much of the open rock. These ledges are likely just natural variations in the overall slope of the rock; no evidence was observed of a second fracture set or other structural feature controlling their formation.

Overall it is not entirely clear why this particular area should remain open while the rest of the surrounding slope is covered in loose rock, soil, and forest. It may be that the surrounding slope here has achieved just the right coordination with the underlying fracture orientation to keep this area open, or just that the fracturing is more developed here and thus is strong enough to keep the local area exposed. It is also possible that these slopes were once far more open and this is the last remaining stronghold of rock exposure that will one day be fully covered. No clear evidence could be observed on-site that would prove one way or another.

Stability: Stable

There are few fractures or loose rocks within the site, which is dominated by the large, smooth, solid bedrock faces. Although surfaces may be slippery due to lichen or moss, the rock itself is stable.

C34 - Nakedtop (continued...)

GPS Points

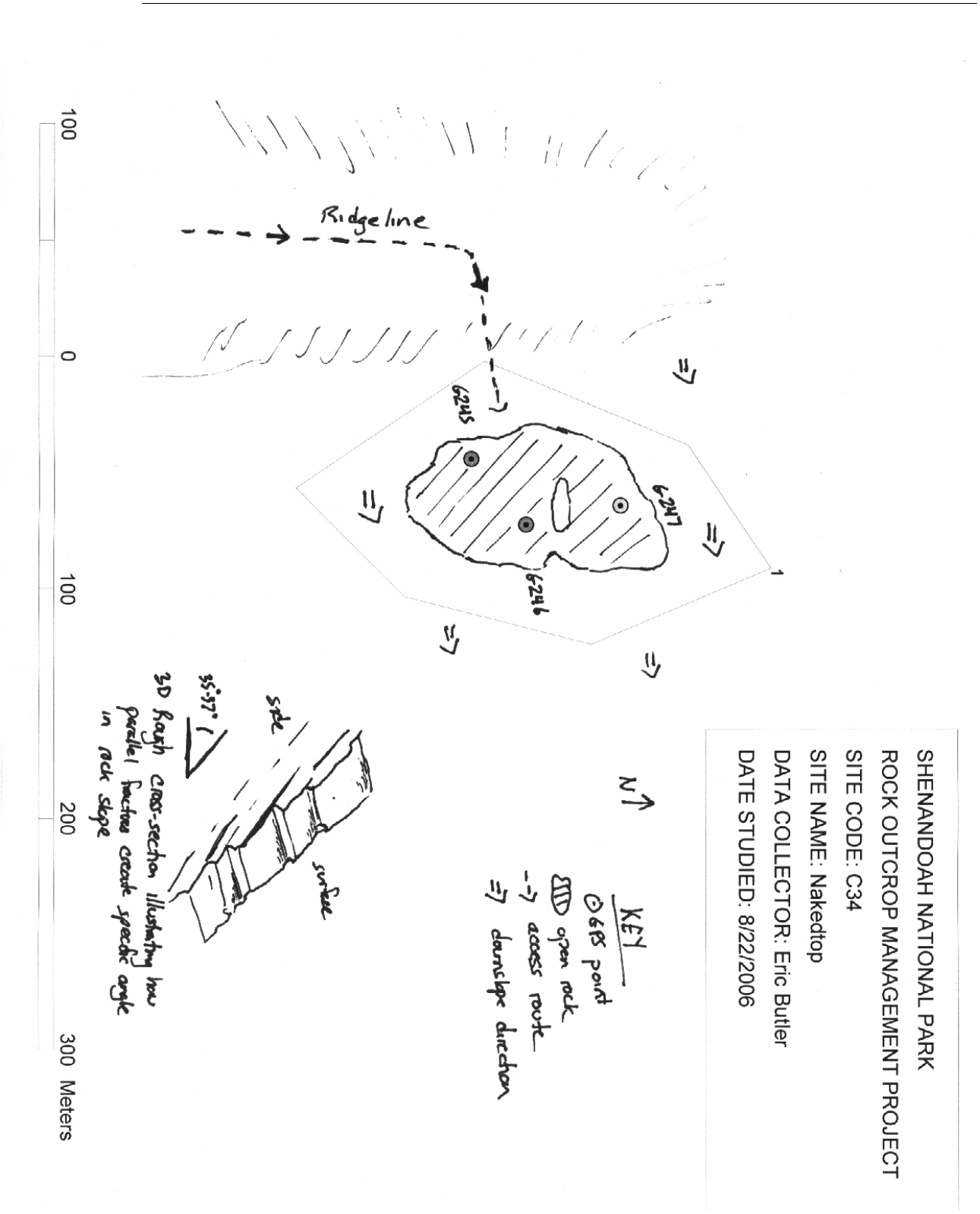
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
8/22/2006	G245-C34	726006	4271455	3280	Upper southwest corner of exposure
8/22/2006	G246-C34	726034	4271478	3200	Center-base of exposure, down slope to east
8/22/2006	G247-C34	726026	4271519	3240	Middle northern extent of exposure

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
8/22/2006	G245-C34	SHEN_C34_G_20060822_001.jpg	270	Butler, Eric	Up face toward G245
8/22/2006	G245-C34	SHEN_C34_G_20060822_002.jpg	35	Butler, Eric	Down slope to NE
8/22/2006	G245-C34	SHEN_C34_G_20060822_003.jpg	180	Butler, Eric	View across face; note smooth slope developed along planar fractures
8/22/2006	G245-C34	SHEN_C34_G_20060822_004.jpg	325	Butler, Eric	Planar fractures dipping with slope, producing smooth faces and subtle ledges
8/22/2006	G245-C34	SHEN_C34_G_20060822_005.jpg		Butler, Eric	Weathered surface typical of southern exposures; note quartz, feldspar, and biotite with no visible foliation
8/22/2006		SHEN_C34_G_20060822_006.jpg		Butler, Eric	Foliation in granitic gneiss typical of northern portion of exposure; note small sheared area bending the foliation on left
8/22/2006	G247-C34	SHEN_C34_G_20060822_007.jpg	180	Butler, Eric	View back across slope from farthest north end of exposure
8/22/2006	G245-C34	SHEN_C34_G_20060822_008.jpg		Butler, Eric	Another view of massive granite from south portion of site.

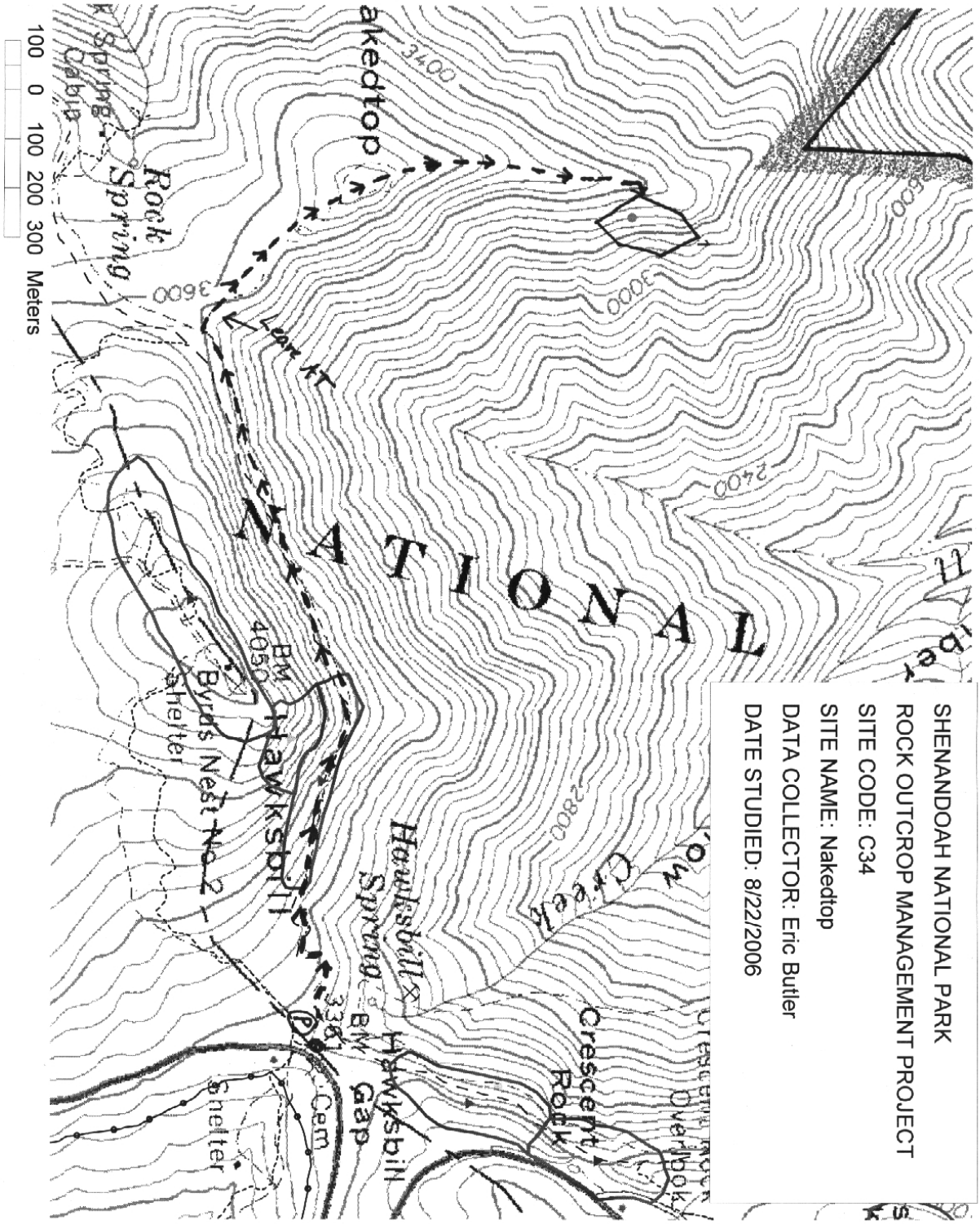
C34 - Nakedtop (continued...)

Detail map



C34 - Nakedtop (continued...)

Area map



C34 - Nakedtop (continued...)



SHEN_C34_G_20060822_001.jpg Azmuth: 270

Up face toward G245



SHEN_C34_G_20060822_002.jpg Azmuth: 35

Down slope to NE



SHEN_C34_G_20060822_003.jpg Azmuth: 180

View across face; note smooth slope developed along planar fractures



SHEN_C34_G_20060822_004.jpg Azmuth: 325

Planar fractures dipping with slope, producing smooth faces and subtle ledges

C34 - Nakedtop (continued...)



SHEN_C34_G_20060822_005.jpg Azmuth:

Weathered surface typical of southern exposures; note quartz, feldspar, and biotite with no visible foliation



SHEN_C34_G_20060822_006.jpg Azmuth:

Foliation in granitic gneiss typical of northern portion of exposure; note small sheared area bending the foliation on left



SHEN_C34_G_20060822_007.jpg Azmuth: 180

View back across slope from farthest north end of exposure



SHEN_C34_G_20060822_008.jpg Azmuth:

Another view of massive granite from south portion of site.

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C35 - North Marshall summit

Site Code: C35
Site Name: North Marshall summit
Data Collector Butler, Eric
Date Studied: 08-Jun-05

Polygon Centroid: **E:** 742695 **N:** 4295500
UTM (Zone 17 NAD83)
Dimensions (m): 250 x 700 (GIS est.)
Elevation Range (ft): 3140 to 3360

Physical Characteristics

Location Acces

This site begins about 400m east of Skyline Drive along Appalachian Trail (AT). Park in small lot on east side of the drive, just north of Milepost 16. An easy, mostly flat hike along AT leads to an abrupt rampart of boulder talus that marks the beginning of the site. The AT switchbacks up this slope and continues north along the mountain, providing reasonably good access to most of the open exposures with some bushwhacking.

Physical Description:

This site consists of two main sets of cliffs that trend along the western face of North Marshall, which form several topographic benches, and some additional exposures at the summit. The lowest level of cliffs is by far the largest, averaging 40' high, while the second, upper level averages less than 10'. Both sets of cliffs are intermittent, each individual exposure divided by talus and soil slopes that are generally forested. Between the two levels is a gentler, forested slope. Talus fields are nearly continuous across the slopes at the base of each topographic bench, but are mostly forested except for open areas directly beneath cliffs. Above the second level, most of Mount Marshall is a broad, gently sloping plateau, until the northeastern end, where an abrupt knob rises another 20'-40' to form the summit. Here the main rock exposure faces to the east and south, unlike all others at this site, and another open talus field extends down slope.

Vegetation: Dense

Thickets of laurel and other vegetation cover much of the talus slopes and the slope dividing cliff levels 1 and 2. Open forest can be found above level 2, and at the base of level 1, but much of the areas that must be crossed to reach exposures are densely vegetated and difficult to push through.

Human Effects

Impacts: Moderate

Most of site is easily accessed from Appalachian Trail, and numerous social trails lead to overlooks and campsites. Soil compaction and stripping is visible on at least three of the largest ledges. Climbing activity has been reported here, although no specific evidence was observed during this survey. Although many exposures remain fairly untouched, they are accessible and visible.

Access Easy

Site is bisected by AT, 400m from parking lot. Although the lot is unmarked, and there are no trail signs encouraging visitors to hike Marshall, the cliffs are very visible from SD and it is clear that many people visit the area.

Geologic Characteristics

Lithology: **Rock Type** Greenstone

There appear to be three distinct greenstone lava flows that compose the top of North Marshall. The lowest flow (1) is a thick (60'-80'), massive unit of fine-grained greenstone that contains abundant original flow layering centimeters thick. This unit weathers dark red to orange on large, sheer cliff faces. The next flow (2) is thinner (20'-40'), with fewer visible flow layering structures, and weathers green. It is less massive, and more blocky-looking, than (1). The upper flow (3) only occurs on a small knob that forms the summit of North Marshall. It is similar in appearance to (2) and is also around 40' thick.

Structure:

There is no obvious site-wide joint set present. The three flows described above are most clearly identified by topographic expression, as each creates a separate bench with associated steep slopes, cliffs, and talus fields at the edges of those benches.

Other:

In only one place is a clear boundary between two flows preserved in the bedrock, at point G037, 1m east of the Appalachian

C35 - North Marshall summit (continued...)

Trail. Here, the upper extent of flow (1) consists of smooth, massive basalt exposures that are fractured in near-rectangular blocks. Directly above these bench-like outcrops, a large rock (3m?) preserves a chaotic mix of breccia, shale, and vesicular basalt, all heavily altered with epidote. Such an assemblage is indicative of a flow boundary, and falls directly at the transition to the bench separating flows (1) and (2). Similar lithologies can be found in loose talus, but only here is it easily visible in the bedrock.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	30.0	30.0	0.0	20.0	20.0	100
Max relief(m):	15	5	0	1	20	

Aspects:

NNW ☐	N ☐	NNE ☐
NW ☑		NE ☐
WNW ☑		ENE ☐
W ☑		E ☐
WSW ☐		ESE ☐
SW ☐		SE ☐
SSW ☐	S ☑	SSE ☐

Maximum Slope:

Texture: Rough

Setting:

The dominant geomorphic agents here are the three lava flows that make up the site. In aerial photography, the topographic benches created by these flows are easily visible. On the ground, these produce a staircase-like pattern, with each level consisting of a steep talus slope capped in places by a cliff, followed by a gentle slope leading into the next talus field. The original thickness of these flows controls the height of the associated cliffs. Overall, the flows in this area are gently dipping to the southeast, an orientation which encourages the formation of cliffs on the western side of the mountain, as the "end" of the flow is more exposed here, while the smooth "top" of the flow bends down the east side and resists erosion. A similar pattern can be seen on South Marshall (C46), immediately to the west. It is worth noting that when hiking from the parking lot to the site boundary, along the Appalachian Trail (AT), the trail crosses several smaller topographic benches that likely represent thin flows located stratigraphically below the three discussed here.

Flows (1) and (2) create different types of exposures; (1) tends to produce sheer cliffs, while (2) tends to appear as smaller, discontinuous outcrops. This may be partly related to their relative thickness, as well as their relative position on the mountain. (2) caps most of Mount Marshall, and so is more exposed on all sides to weathering agents, while (1) is somewhat protected by (2) above. This may result in accelerated weathering of (2), which would not only wear down exposed faces, but also result in thicker talus slopes that build up along the exposed western aspect. Indeed, the bench between (1) and (2) is in many places closer to a low-angle talus slope that leads gradually up to a few small outcrops at the top, as opposed to the much flatter benches above (2), and below (1)

The small knob created by flow (3) represents the last remnant of a flow that would have originally covered the broad bench now underlain by (2). Originally, similar processes to those discussed above would have operated on flow (3), eroding it back on all sides until it remained as the final small core visible today. (3) is very unusual in that its remaining exposure faces south, in direct contrast to the general western aspect of basalt cliffs in the park. It is possible that as this bench grew smaller and smaller, erosion was able to "wrap around" all sides and finally cut into the more protected southern and eastern aspects. In addition, this small knob sits on the eastern edge of Mount Marshall, set back from the western cliffs by almost 100m. The western face, originally exposed, is now buried under a talus slope similar to that developing on (2) today, leaving the south and east less protected as erosion "wrapped around" from the sides. A similar process might one day produce cliffs and exposure on the south and east sides of (2).

Stability: Moderate

Most cliffs and outcrops are solid, while talus slopes will shift in places.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
6/8/2005	G033-C35	742566	4295378	3260	Large cliff accessable from switchback in AT
6/8/2005	G034-C35	742546	4295310	3240	Center of next cliff to south of G033, reached by social trail
6/8/2005	G035-C35	742601	4295341	3300	Outcrop near south end of site
6/8/2005	G036-C35	742532	4295268	3160	Base of semi-open talus southwest of G034
6/8/2005	G037-C35	742630	4295451	3280	Bedrock exposure of contact between flows (1) and (2)
6/8/2005	G038-C35	742754	4295546	3320	Outcrop accessed by social trail from AT

C35 - North Marshall summit (continued...)

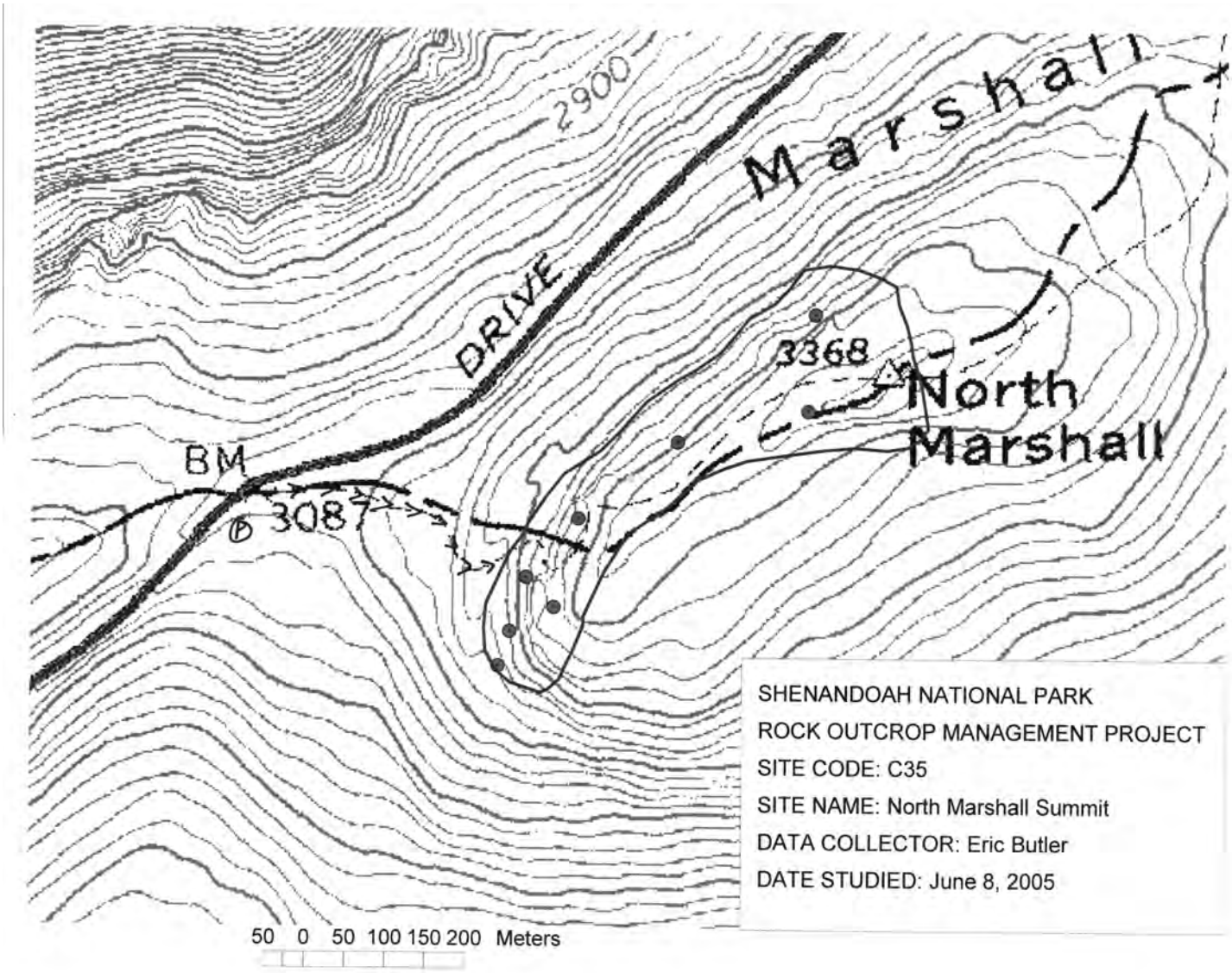
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
6/8/2005	G039-C35	742917	4295585	3360	Talus field and bedrock exposure at top of knob, Mount Marshall sum
6/8/2005	G040-C35	742925	4295705	3320	Northernmost bedrock exposure within site

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
6/8/2005	G036-C35	SHEN_C35_G_20050608_001.jpg	35	Butler, Eric	Looking up talus slope from G036 toward G034
6/8/2005	G037-C35	SHEN_C35_G_20050608_002.jpg	90	Butler, Eric	Contact between flows (1) and (2). Note differing natures of bench below and boulder above.
6/8/2005	G037-C35	SHEN_C35_G_20050608_003.jpg		Butler, Eric	Closer view of contact between (1) and (2)
6/8/2005	G040-C35	SHEN_C35_G_20050608_004.jpg	200	Butler, Eric	Cliff and talus at G040, flow (2)
6/8/2005	G033-C35	SHEN_C35_G_20050608_005.jpg		Butler, Eric	Closeup of flow bedding in (1), at base of cliff marked by G033

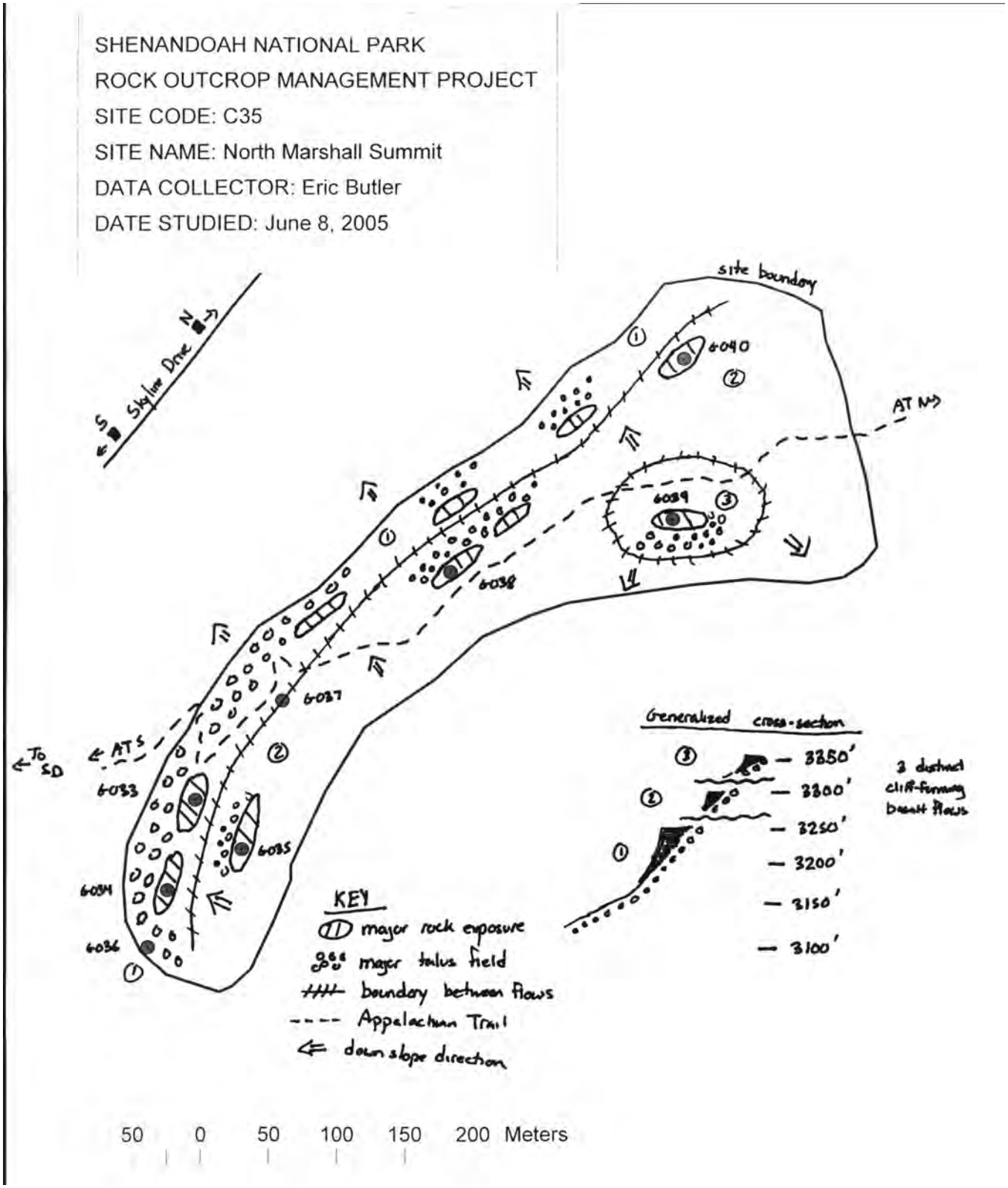
C35 - North Marshall summit (continued...)

Area sketch map



C35 - North Marshall summit (continued...)

Detail sketch map



C35 - North Marshall summit (continued...)



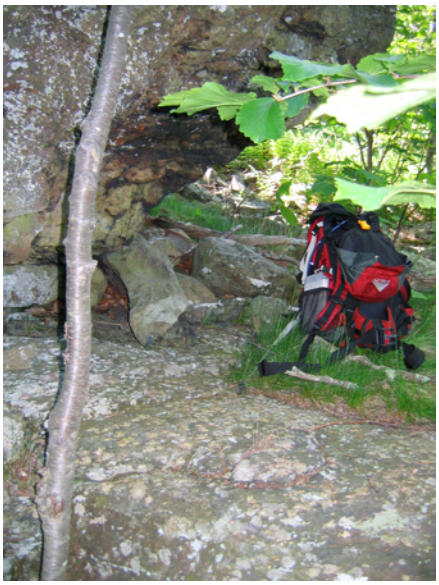
SHEN_C35_G_20050608_001.jpg Azmuth: 35

Looking up talus slope from G036 toward G034



SHEN_C35_G_20050608_002.jpg Azmuth: 90

Contact between flows (1) and (2). Note differing natures of bench below and boulder above.



SHEN_C35_G_20050608_003.jpg Azmuth:

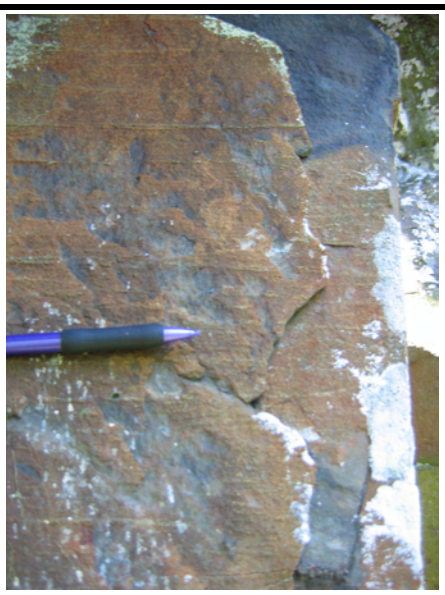
Closer view of contact between (1) and (2)



SHEN_C35_G_20050608_004.jpg Azmuth: 200

Cliff and talus at G040, flow (2)

C35 - North Marshall summit (continued...)



SHEN_C35_G_20050608_005.jpg Azmuth:

Closeup of flow bedding in (1), at base of cliff marked by G033

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C36 - Old Rag Southside

Site Code: C36
Site Name: Old Rag Southside
Data Collector Butler, Eric
Date Studied: 07-Sep-06

Polygon Centroid: **E:** 734613 **N:** 4270330
UTM (Zone 17 NAD83)
Dimensions (m): 210 x 500 (GIS est.)
Elevation Range (ft): 2480 to 3000

Physical Characteristics

Location Acces

Park at lots along VA 600 and hike up the Ridge Trail for about 3.5km, ascending through the Old Rag "boulder scramble" (also site C37). Exposures within this remote site are accessable from various points along the trail. To reach G273, find the faint social trail at the base of a large, gently sloping rock face at the upper end of C37 (Old Rag East) and follow it downslope appx. 50m to reach open rock. To reach G272, follow the ridge trail past the boulder scramble and into C62 (Old Rag Summit), leaving open rock behind and passing through forested areas near the top of the ridge. At a prominent switchback in the trail, where a large boulder sits alone, leave the trail and bushwhack SSE appx. 100m through low laurels to reach the top of the large, open face and cliff area at G272. Other parts of the site are very rugged, remote, and difficult to access, and may best be attempted during leaf-off seasons. Consult maps and text from Horst (2001) for additional suggestions on access routes to various rock exposure areas (selected maps included in this report).

Physical Description:

This site covers a portion of the remote southeastern side of Old Rag Mountain. This region includes a great deal of large, steep rock exposure, but has no official trail access. The landscape is extremely rugged, with cliffs and other exposures separated by steep, rocky, narrow chutes covered in very thick vegetation. A prominent climber's guide to Virginia (Horst, 2001) describes many known climbing routes in this area, and offers sketch maps of social trails leading to them, but most of these trails are either very faint, in disuse, or cannot be followed during the leaf-on season (the guide says as much, suggesting that climbers do not visit the mountain in the summer). The largest single exposure, "Reflector Oven", consists of an expanse of open rock face near the top of the ridge, which curves down into an impressive cliff with more sloping face below it. In "God's Area", accessed at G273, the steep slope is covered in intermittent cliff/face exposures that wrap around the ridge to the east. The northeastern portion of the site was not visited or observed.

Vegetation: Dense

The vegetation surrounding these rock exposures is generally extremely thick, and made all the more difficult due to the steep and unstable terrain. The only exception occurs on the bushwhack out to G272 from the Ridge Trail, where the gentle slope leading down to the exposures is "only" covered in waist-high laurel and is relatively straightforward to navigate. Do not angle too far to the east on this route, however, as the vegetation becomes much thicker in that direction.

Human Effects

Impacts: Mild

Few impacts were directly observed, although the prevalence of mapped social trails and identified climbing areas in Horst (2001) makes it likely that more would be identified if the site were revisited during leaf-off. The most noticeable impact was a fire ring and campsite on the edge of the woods above the "Reflector Oven", G272. Given the difficulty involved in finding the mapped social trails, it does not appear that any of these areas receive a great deal of traffic.

Access Remote

This site is very difficult to get to, involving either a full ascent of the boulder scramble, or climbing over the summit of Old Rag and descending the other side. Once at the edge, any visitor must then bushwhack or attempt to follow a faint social trail through rugged topography and thick vegetation to reach any open rock areas. None of these areas are visible from anywhere on established trails, though they are prominently exposed to the access roads leading in from the east. The detailed descriptions and maps in Horst (2001) certainly provide more impetus to visit than other remote sites in the ROMP, but it is unclear how many people actually do so.

Geologic Characteristics

C36 - Old Rag Southside (continued...)

Lithology: **Rock Type** Old Rag Granite

Old Rag Mountain is formed entirely from the Old Rag Granite, a distinct rock unit in SHEN. This granite is predominately quartz and orthoclase feldspar, with virtually no other minerals visible. The granite is very uniform in appearance; fairly coarse-grained, with individual crystals growing over 2cm, especially the feldspars. The quartz is generally a dark grey-blue, while the orthoclase is white-pink. There may be a faint foliation present, mostly visible as a slight linear texture formed by strung-out quartz crystals, but the rock is generally massive (no internal structures). Garnets are present in small and scattered quantities, appearing as small red/maroon crystals.

Structure:

Joints (large parallel fractures) are common in the area, though few specific examples were observed in the limited areas visited for this survey. The bedrock contains the usual faint foliation typical of the Old Rag Granite.

Other:

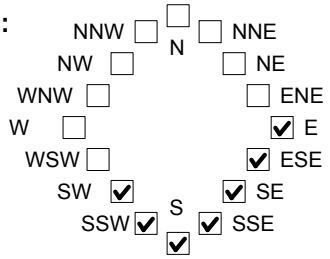
Greenstone dikes are very common within the area, including many just to the northeast in C37 (Old Rag East), though none were observed within the limited area visited in this survey. It is likely that some would be identified during a more thorough exploration of the area, especially during leaf-off.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	30.0	20.0	40.0	10.0	0.0	100
Max relief(m):	25	10	10	1	0	

Maximum Slope: 35 **Texture:** Smooth

Aspects:



Setting:

The Old Rag Granite is quite resistant to weathering for several reasons. First, quartz and orthoclase feldspar are stable minerals at the Earth's surface, and so are resistant to chemical weathering of individual crystals. Unlike most granites, there are few secondary mafic minerals on which these processes can preferentially operate, so the rock remains especially cohesive and stable. Second, the generally massive (structureless) nature of the granitic bedrock provides few obvious planes of weakness on which physical weathering can operate. These factors mean that large-scale physical weathering is the dominant process on Old Rag Mt.

The joints and other fractures within the bedrock are the main geomorphic agent, as they provide a conduit for physical weathering processes such as the freeze/thaw cycle to operate. The wide spacing of these fractures, coupled with the otherwise massive and resistant nature of the rock, produces large, angular blocks that evolve more rounded shapes as the exposed corners are worn down. At an extreme, this process can result in "balanced rocks" such as that shown in photo 007. The smooth, gently sloping faces are likely a product of exfoliation, in which an otherwise massive bedrock slowly fractures into parallel or concentric layers which then peel away, leaving behind a rounded face such as that seen above the "Reflector Oven", G272.

Stability: Stable

Though there are numerous fractures within the bedrock on Old Rag Mountain, these are generally spaced far enough apart that there is very little danger of any individual piece moving. Almost by definition in this area, the rock exposures are broad, massive, and stable. The steeper slopes between exposures generally have loose soil and debris, but in general the rock is very solid and trustworthy. Danger comes primarily from steep slopes and thick vegetation.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
9/7/2006	G272-C36	734492	4270285	3000	Top of very large face/cliff area, referred to in climbing guides as the "
9/7/2006	G273-C36	734626	4270358	2920	Exposures reached by social trail within larger area of isolated exposur

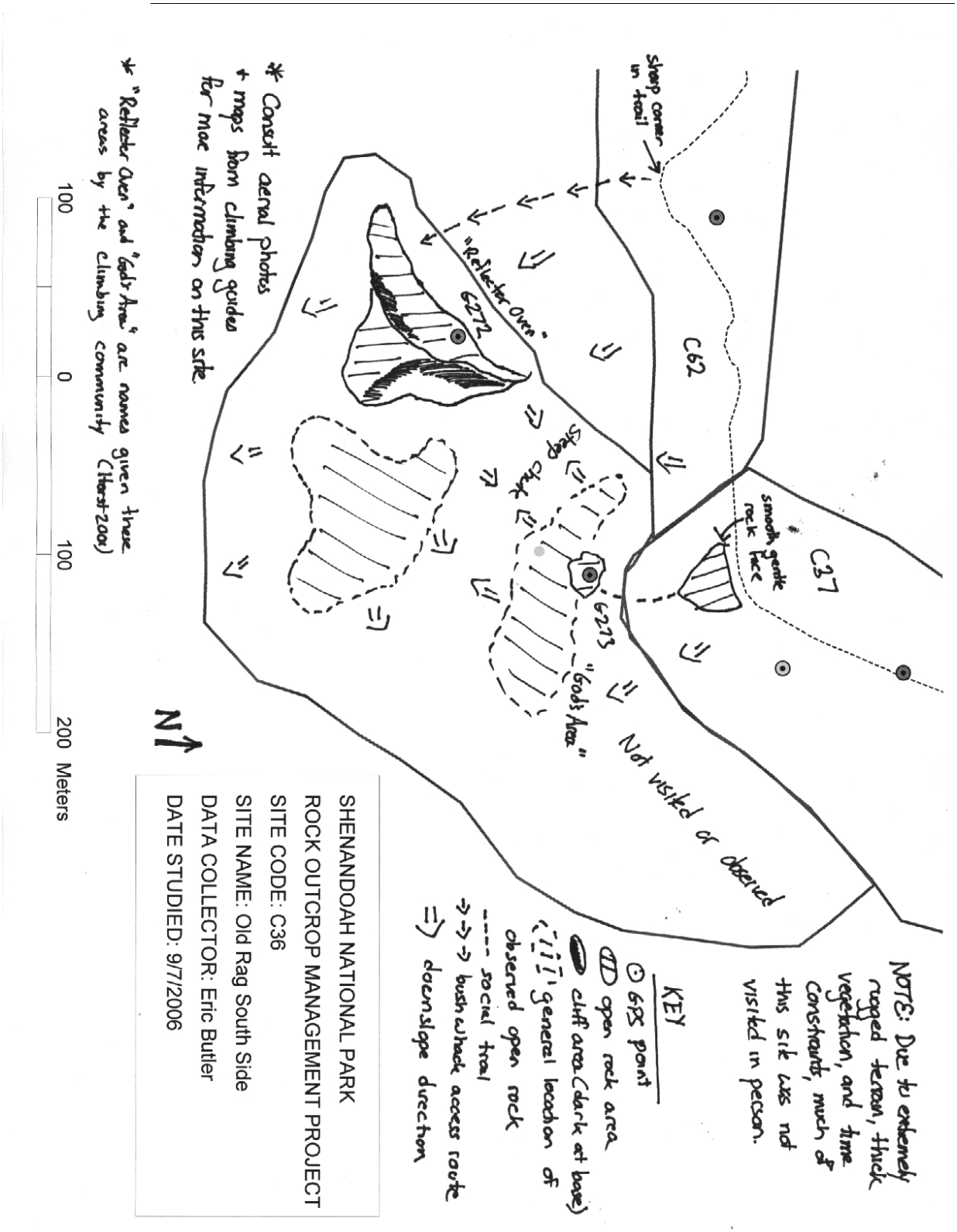
Site Photos

C36 - Old Rag Southside (continued...)

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
9/7/2006	G272-C36	SHEN_C36_G_20060907_001.jpg	70	Butler, Eric	View across top of face at "Reflector Oven" toward outcrops and faces in "God's Area", G273
9/7/2006	G272-C36	SHEN_C36_G_20060907_002.jpg	215	Butler, Eric	Closer view of smooth rock face at G272
9/7/2006	G272-C36	SHEN_C36_G_20060907_003.jpg		Butler, Eric	Trees growing within fractures at top of face just south of G272
9/7/2006	G272-C36	SHEN_C36_G_20060907_004.jpg		Butler, Eric	Fire ring at campsite found at edge of woods next to large face at "Reflector Oven"
9/7/2006	G272-C36	SHEN_C36_G_20060907_005.jpg		Butler, Eric	View from campsite out at open rock area
9/7/2006	G273-C36	SHEN_C36_G_20060907_006.jpg	250	Butler, Eric	View from "God's Area" over to very large open rock face and cliff ("Reflector Oven"); G272 was taken at upper right of this cliff
9/7/2006	G273-C36	SHEN_C36_G_20060907_007.jpg	210	Butler, Eric	Balanced rock on outcrop below G273; typical of formations found in the Old Rag Granite
9/7/2006	G273-C36	SHEN_C36_G_20060907_008.jpg	230	Butler, Eric	Large open rock faces down slope from "Reflector Oven" cliff

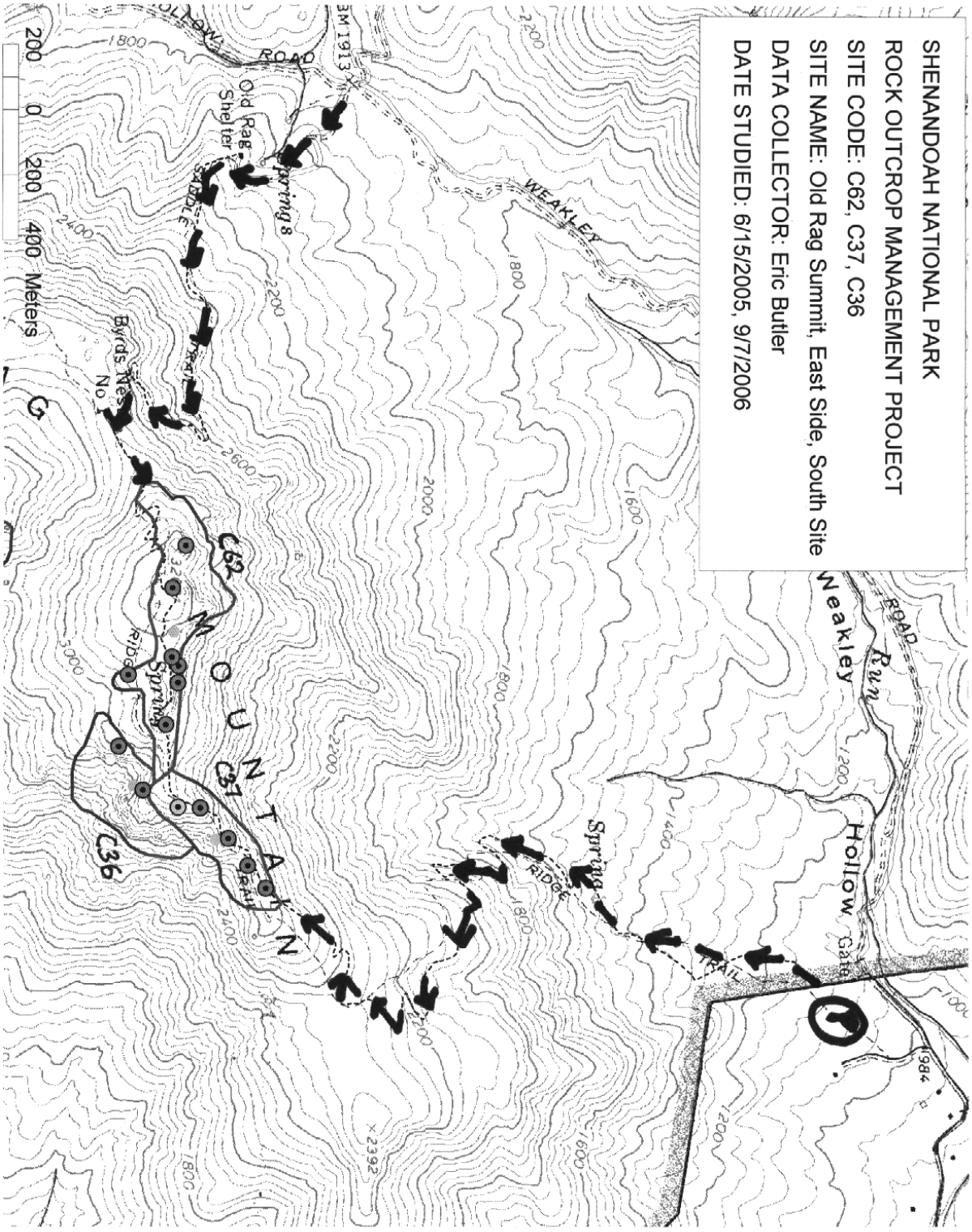
C36 - Old Rag Southside (continued...)

Detail map



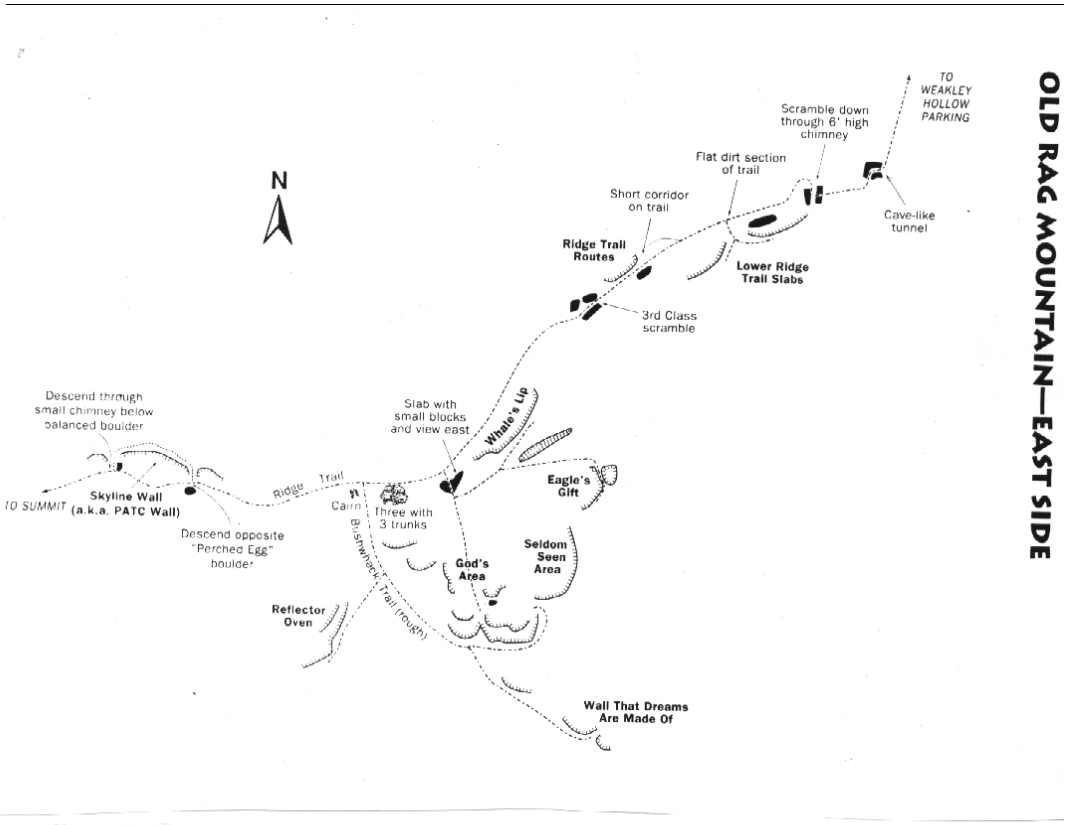
C36 - Old Rag Southside (continued...)

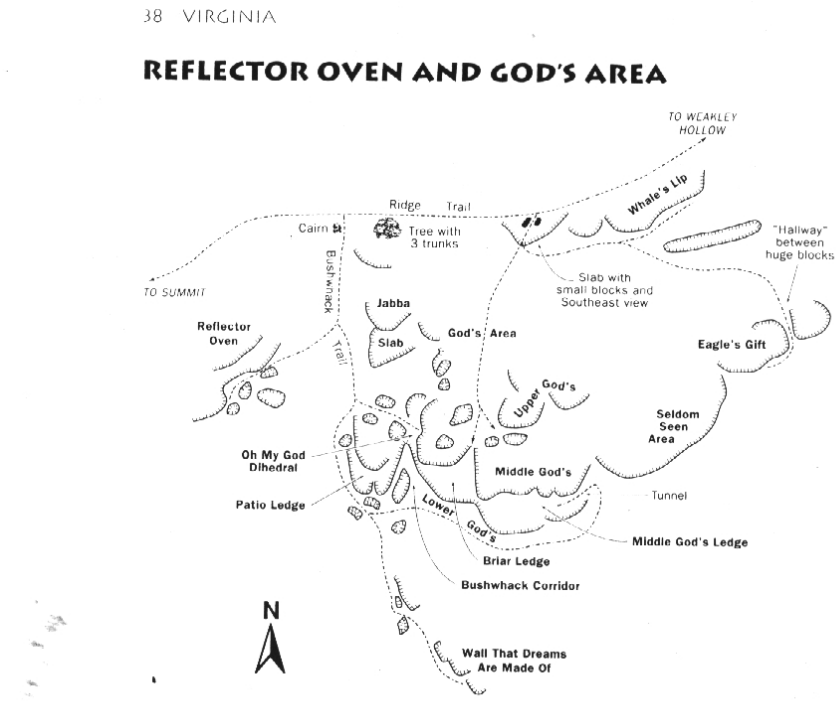
Area map



C36 - Old Rag Southside (continued...)

Maps showing climbing areas and access routes from Horst (2001)





C36 - Old Rag Southside (continued...)



SHEN_C36_G_20060907_001.jpg Azmuth: 70

View across top of face at "Reflector Oven" toward outcrops and faces in "God's Area", G273



SHEN_C36_G_20060907_002.jpg Azmuth: 215

Closer view of smooth rock face at G272



SHEN_C36_G_20060907_003.jpg Azmuth:

Trees growing within fractures at top of face just south of G272



SHEN_C36_G_20060907_004.jpg Azmuth:

Fire ring at campsite found at edge of woods next to large face at "Reflector Oven"

C36 - Old Rag Southside (continued...)



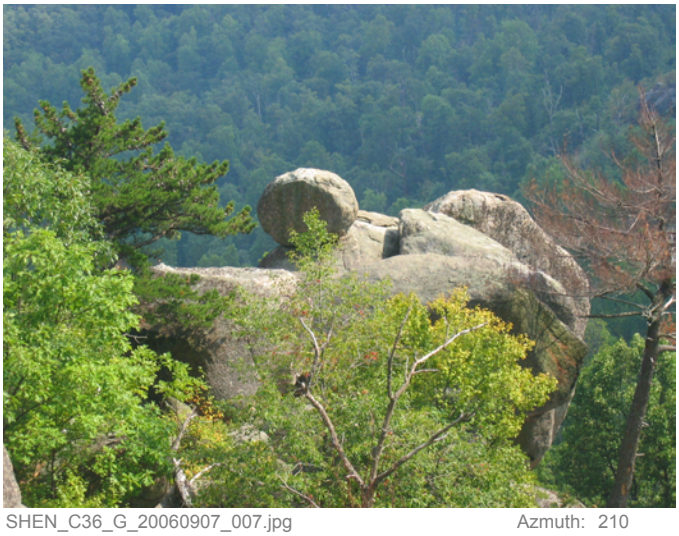
SHEN_C36_G_20060907_005.jpg Azmuth:

View from campsite out at open rock area



SHEN_C36_G_20060907_006.jpg Azmuth: 250

View from "God's Area" over to very large open rock face and cliff ("Reflector Oven"); G272 was taken at upper right of this cliff



SHEN_C36_G_20060907_007.jpg Azmuth: 210

Balanced rock on outcrop below G273; typical of formations found in the Old Rag Granite



SHEN_C36_G_20060907_008.jpg Azmuth: 230

Large open rock faces down slope from "Reflector Oven" cliff

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C37 - Old Rag Summit East

Site Code:	C37	**Polygon Centroid:**	**E:** 734780 **N:** 4270579
Site Name:	Old Rag Summit East		UTM (Zone 17 NAD83)
Data Collector	Butler, Eric	**Dimensions (m):**	160 x 540 (GIS est.)
Date Studied:	07-Sep-06	**Elevation Range (ft):**	2600 to 3000

Physical Characteristics

Location Acces

Park at lots along VA 600 and hike up the Ridge Trail for about 3km to reach the first large area of open rock at the base of the Old Rag "boulder scramble". The trail continues through the heart of the site on the way to Old Rag's summit. This is a long and strenuous hike, particularly within the site itself.

Physical Description:

This site covers the rugged, narrow eastern ridge of Old Rag Mountain. The trail along this ridge is known as the "boulder scramble" due to the numerous cracks, climbs, boulders, and other obstacles that must be negotiated when hiking this trail. On either side of the trail, the slope drops away steeply over mostly open rock exposures. Large, smooth rock faces are more common along the southeastern side, where these exposures drop away into large cliffs. To the north and west, the rock exposures tend to drop away more steeply into several levels of outcrops and cliffs, with less smooth, open rock. The lower ledges along the northwest side are difficult to access, due to vegetation and lack of good routes down the dropoffs. The ridge crest is dominated by large boulders, deep cracks, and narrow passages among these. One large gap cuts through the ridge between G268 and G269, which otherwise climbs consistently toward the summit. In several places the trail passes through deep, narrow cracks taller than a person, as well as a significant "tunnel" formed by a large tilted rock slab.

Vegetation: Dense

Vegetation is intermittent near the top of the ridge, mostly clustered in cracks and protected ledges. The large gap is densely forested, as are the lower slopes below the rock exposures, which are very difficult to negotiate during leaf-on. Most of the upper exposures can be accessed without much vegetative interference, but the lower areas are a far different story.

Human Effects

Impacts: Heavy

Along the trail, and in areas easily reached from the trail, impacts are obvious. This trail is heavily used, and the rock is often polished to a sheen by the action of countless boots. Soils & lichens are commonly stripped away, and trash is common, especially collected in crevices and at the base of exposures. In several places climbing equipment such as bolts and straps were observed left on the rock exposures. A trampled campsite and fire ring were found off a small social trail at G269, hidden among a boulder pile.

Access Difficult

This is a very strenuous trail to hike, and not simply because of the elevation gain involved. Reaching the summit through this method requires significant physical activity to negotiate the myriad cracks, climbs, slots, and boulders along the trail. Nevertheless, this is clearly one of the most visited routes in the park, due to the unique and spectacular experience and views it provides. The attraction of the trail and the region obviously more than outweigh the difficulties involved in hiking it.

Geologic Characteristics

Lithology: **Rock Type** Old Rag Granite

Old Rag Mountain is formed entirely from the Old Rag Granite, a distinct rock unit in SHEN. This granite is predominately quartz and orthoclase feldspar, with virtually no other minerals visible. The granite is very uniform in appearance; fairly coarse-grained, with individual crystals growing over 2cm, especially the feldspars. The quartz is generally a dark grey-blue, while the orthoclase is white-pink. There may be a faint foliation present, mostly visible as a slight linear texture formed by strung-out quartz crystals, but the rock is generally massive (no internal structures). Garnets are present in small and scattered quantities, appearing as small red/maroon crystals. In one location along the trail, a narrow (<50cm) band of very garnet-rich material appears, and extends for many meters.

C37 - Old Rag Summit East (continued...)

Structure:

Joints (large parallel fractures) are common, following a variety of orientations. Most are near-vertical, though horizontal orientations do occur. The granite contains a subtle foliation, but this is not well-developed enough to form a truly planar structure and so does not appear to affect the rock exposures. The common greenstone dikes (see OTHER below) generally fall into one of two orientations: 10-190, and 135-315, as do many of the more prominent joints.

Other:

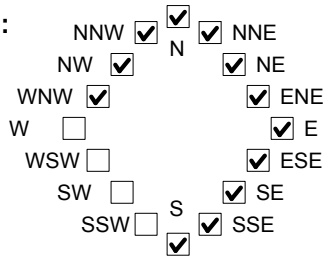
Greenstone dikes are very common within this site. These bodies of molten basalt intruded the granite through fractures such as joint sets, and form thin, planar masses of dark-colored, fine-grained rock. The original basalt was later metamorphosed into greenstone, much like the related Catoctin Formation lava flows. Where these dikes occur, they have generally weathered faster than the surrounding granite, and so tend to form linear cracks and slots deep into the rock. The trail passes through many of the larger examples. These dikes usually contain excellent columnar jointing, formed at right angles to the fracture in which the dike cooled. Thus, given the vertical orientation of the dikes, the columnar jointing is generally horizontal, thus forming a series of "steps" that the trail frequently utilizes.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	30.0	10.0	50.0	10.0	0.0	100
Max relief(m):	10	5	10	1	0	

Maximum Slope: 40 **Texture:** Smooth

Aspects:



Setting:

The Old Rag Granite is quite resistant to weathering for several reasons. First, quartz and orthoclase feldspar are stable minerals at the Earth's surface, and so are resistant to chemical weathering of individual crystals. Unlike most granites, there are few secondary mafic minerals on which these processes can preferentially operate, so the rock remains especially cohesive and stable. This is especially true when compared to the mostly mafic greenstone dikes, which chemically weather much more quickly and thus form the typical deep slots associated with dikes on Old Rag and particularly within the "boulder scramble" area. Second, the generally massive (structureless) nature of the granitic bedrock provides few obvious planes of weakness on which physical weathering can operate. These factors mean that large-scale physical weathering is the dominant process on Old Rag Mt.

The joints and other fractures within the bedrock are the main geomorphic agent, as they provide a conduit for physical weathering processes such as the freeze/thaw cycle to operate. The wide spacing of these fractures, coupled with the otherwise massive and resistant nature of the rock, produces large, angular blocks that evolve more rounded shapes as the exposed corners are worn down. The large boulders that appear "balanced" along the ridge are examples of this process. The smooth, gently sloping faces are likely a product of exfoliation, in which an otherwise massive bedrock slowly fractures into parallel or concentric layers which then peel away, leaving behind a rounded face such as those seen along the southeastern side of the site.

The prominent gap in the ridge between G268 and G269 may have been influenced by a large joint or dike crossing the ridge at this point. This cannot be proven, as the area is now buried in loose rock and thick vegetation, but the increased weathering associated with either structure could explain this unusual feature. It is worth noting that one of the two common dike orientations (135-315) cuts across the ridge at a near right-angle and could thus easily produce such a gap; on the summit of Old Rag one visible dike reaches nearly 3m across, so others of significant size may be present. Overall, the extremely resistant bedrock, planes of weakness along joints, and the exposed nature of the high-elevation ridge here have combined to produce the extensive open rock areas present within the site.

Stability: Stable

Though there are numerous fractures within the bedrock, these are generally spaced far enough apart that there is very little danger of any individual piece moving. The steeper slopes between cliffs may have loose soil and debris, but in general the rock is very solid and trustworthy. Danger comes primarily from steep slopes and thick vegetation.

GPS Points

C37 - Old Rag Summit East (continued...)

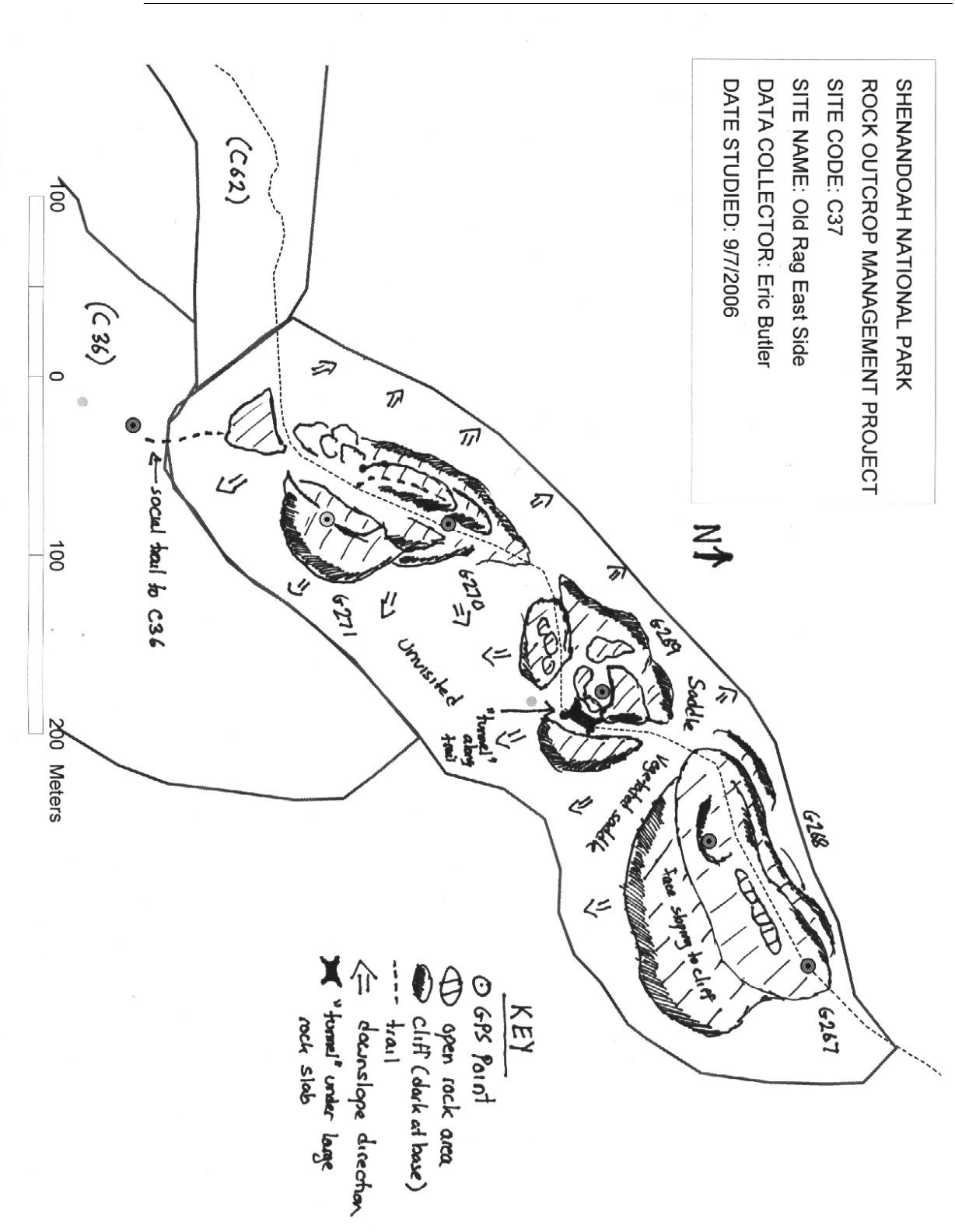
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
9/7/2006	G267-C37	734928	4270731	2640	First/lowest occurrence of open rock along trail within site
9/7/2006	G268-C37	734858	4270677	2700	High point above east-dipping face, north of large gap in ridge
9/7/2006	G269-C37	734774	4270618	2760	Hidden camping spot among boulders above "tunnel" along trail; acce
9/7/2006	G270-C37	734681	4270533	2860	Large, smooth cliff above trail with climbers bolts in rock; top accessab
9/7/2006	G271-C37	734678	4270465	2920	Large, smooth face dropping off to cliff on east side of trail; climbers b

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
9/7/2006	G267-C37	SHEN_C37_G_20060907_001.jpg		Butler, Eric	Closeup of typical Old Rag Granite, with coarse-grained quartz and feldspar; few mafic (dark) minerals visible
9/7/2006	G267-C37	SHEN_C37_G_20060907_002.jpg	230	Butler, Eric	Vertical joints cutting smoothly sloping rock face
9/7/2006	G268-C37	SHEN_C37_G_20060907_003.jpg	230	Butler, Eric	Weathering along vertical joints creating rounded corners typical of this site
9/7/2006	G268-C37	SHEN_C37_G_20060907_004.jpg		Butler, Eric	Closeup of preferential weathering along joints creating rounded surfaces & corners
9/7/2006	G268-C37	SHEN_C37_G_20060907_005.jpg	240	Butler, Eric	View across deep gap in ridge at upper portion of site; in background are cliffs of C62 (Old Rag Summit)
9/7/2006		SHEN_C37_G_20060907_006.jpg		Butler, Eric	Greenstone dike with horizontal columnar jointing, cutting through granite between G268 and G269
9/7/2006		SHEN_C37_G_20060907_007.jpg		Butler, Eric	Vein of very garnet-rich material within granite between G268 and G269
9/7/2006	G269-C37	SHEN_C37_G_20060907_008.jpg	35	Butler, Eric	View to NE of lower eastern face/cliff area below G268, taken from trail before tunnel below G269
9/7/2006	G269-C37	SHEN_C37_G_20060907_009.jpg		Butler, Eric	Impacted camping spot tucked into boulders above "tunnel"; fire ring outside view to left. Accessed by social trail just southwest of tunnel
9/7/2006	G269-C37	SHEN_C37_G_20060907_010.jpg		Butler, Eric	Social trail leading to campsite; view looks back toward official trail.
9/7/2006	G269-C37	SHEN_C37_G_20060907_011.jpg		Butler, Eric	Another closeup of typical Old Rag granite, with blue-grey quartz, white-pink feldspar, and virtually no mafic (dark) minerals
9/7/2006		SHEN_C37_G_20060907_012.jpg		Butler, Eric	Large greenstone dike with horizontal columnar jointing creating slot staircase for trail between G269 and G270
9/7/2006	G270-C37	SHEN_C37_G_20060907_013.jpg	315	Butler, Eric	Open crack where greenstone dike has eroded away, just north of G270
9/7/2006	G270-C37	SHEN_C37_G_20060907_014.jpg	300	Butler, Eric	Climber's bolt and strap left in cliff above and to west of trail
9/7/2006	G270-C37	SHEN_C37_G_20060907_015.jpg	210	Butler, Eric	View south to large boulder pile that marks the end of open rock exposure along this portion of the ridge; view from top of narrow ridge above G270
9/7/2006	G270-C37	SHEN_C37_G_20060907_016.jpg	30	Butler, Eric	Typical outcrop above G270, with near-vertical joints constraining the erosion of the granite into rounded blocks
9/7/2006	G271-C37	SHEN_C37_G_20060907_017.jpg	50	Butler, Eric	Viewacross large face at upper end of site, back across to lower faces below G268.
9/7/2006	G271-C37	SHEN_C37_G_20060907_018.jpg	50	Butler, Eric	Zoomed view of exposures below G268 (person is standing near G268). Note horizontal "stripe" partially defined by vegetation halfway down large face in the
9/7/2006		SHEN_C37_G_20060907_019.jpg	165	Butler, Eric	Gently sloping open face at far southern/upper end of site. From the base of this exposure, a faint social/climbers trail leads to exposures in C36 (Old

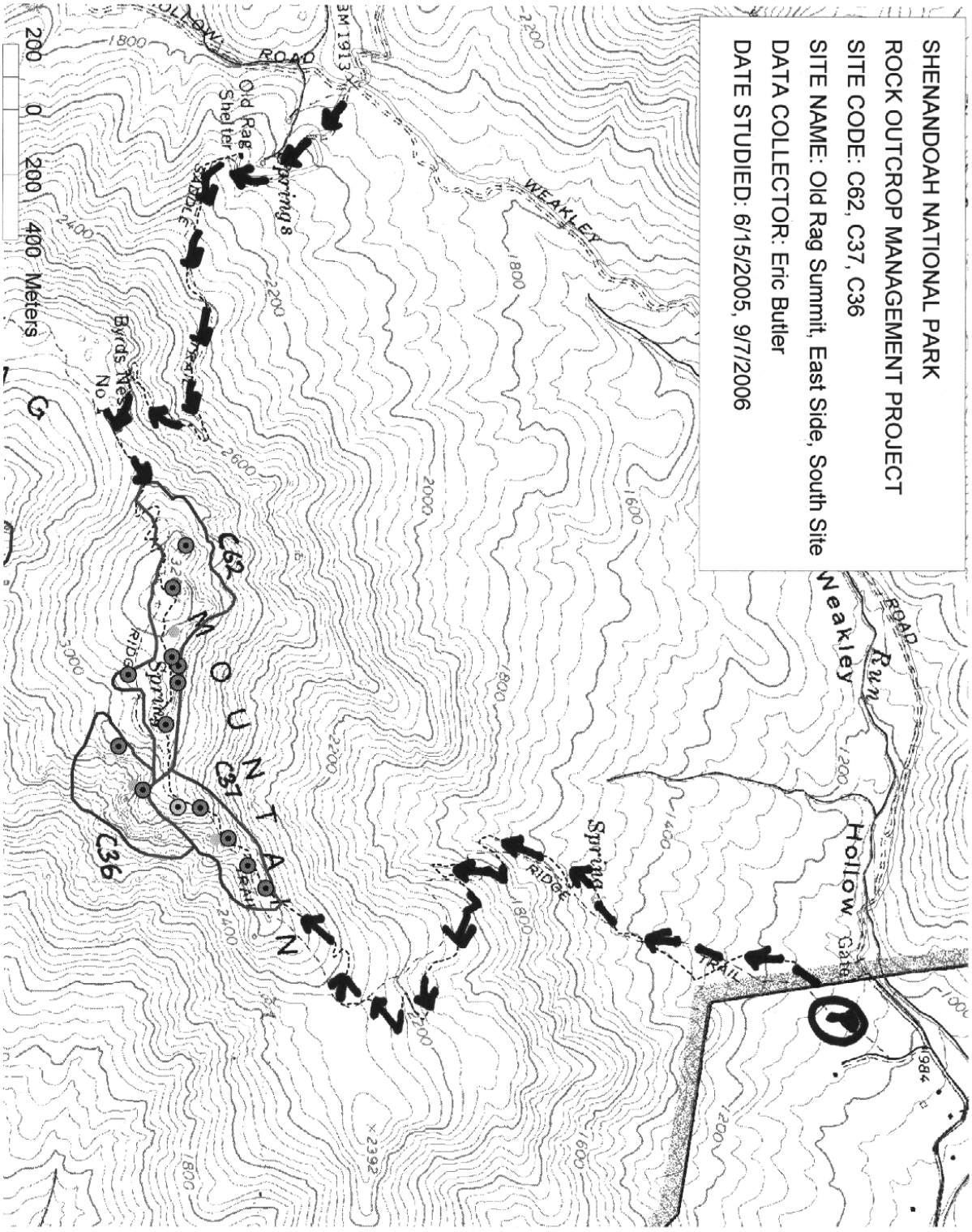
C37 - Old Rag Summit East (continued...)

Detail map



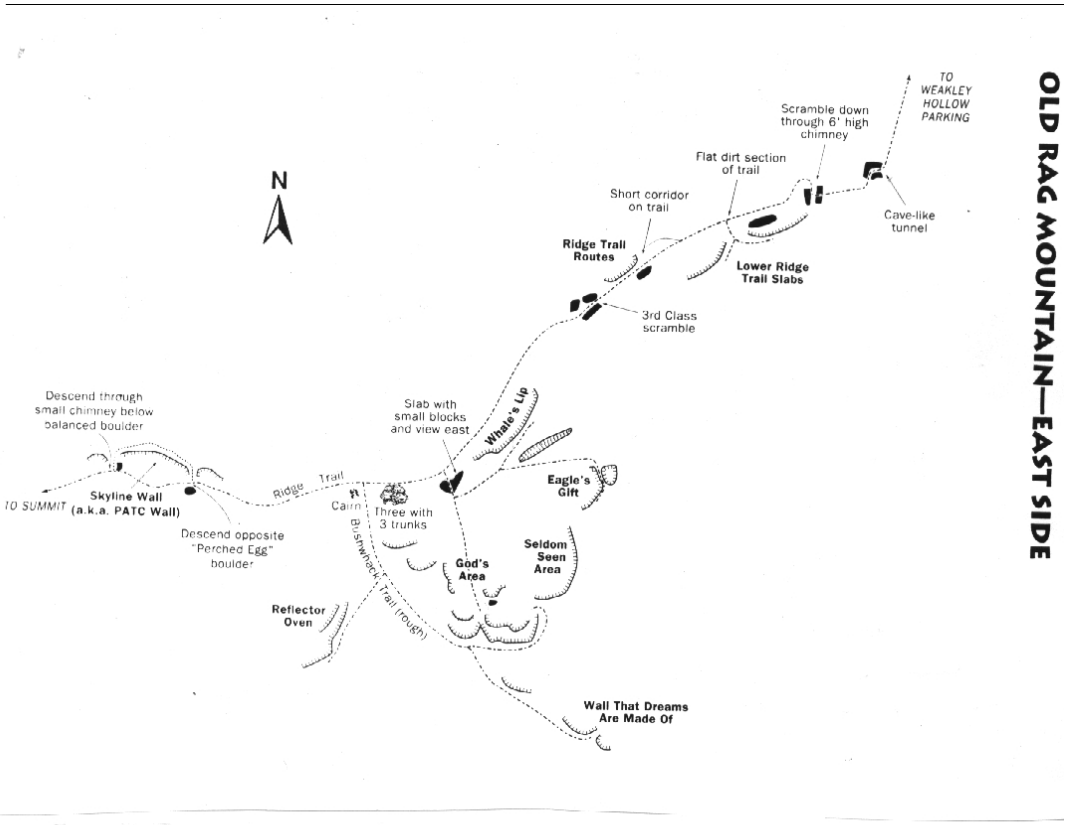
C37 - Old Rag Summit East (continued...)

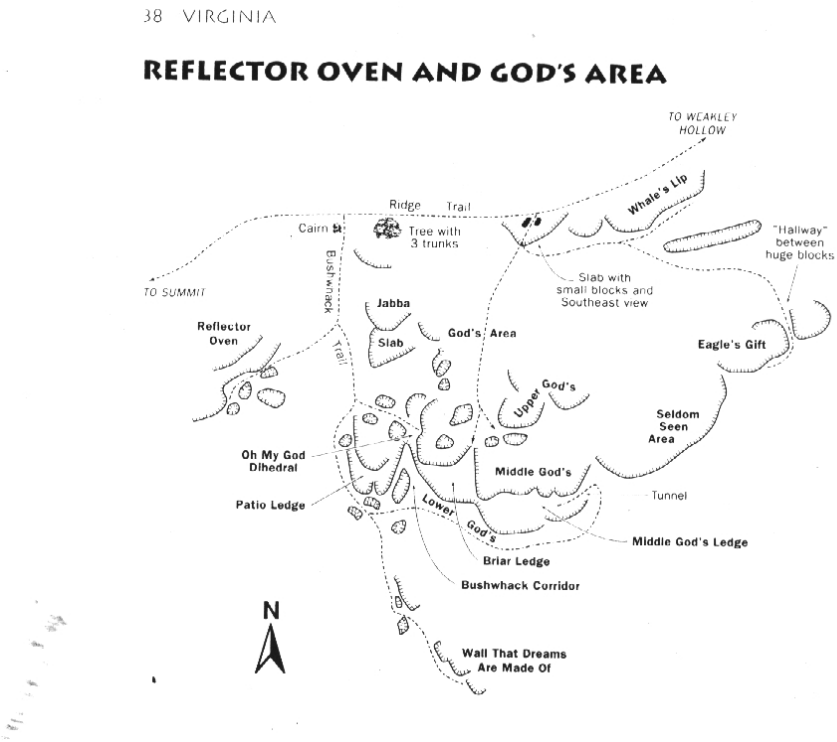
Area map



C37 - Old Rag Summit East (continued...)

Maps showing climbing areas and access routes from Horst (2001)





C37 - Old Rag Summit East (continued...)



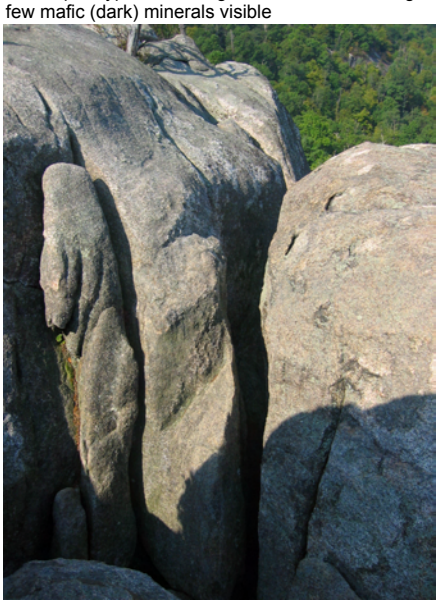
SHEN_C37_G_20060907_001.jpg Azmuth:

Closeup of typical Old Rag Granite, with coarse-grained quartz and feldspar; few mafic (dark) minerals visible



SHEN_C37_G_20060907_002.jpg Azmuth: 230

Vertical joints cutting smoothly sloping rock face



SHEN_C37_G_20060907_003.jpg Azmuth: 230

Weathering along vertical joints creating rounded corners typical of this site



SHEN_C37_G_20060907_004.jpg Azmuth:

Closeup of preferential weathering along joints creating rounded surfaces & corners

C37 - Old Rag Summit East (continued...)



SHEN_C37_G_20060907_005.jpg Azmuth: 240

View across deep gap in ridge at upper portion of site; in background are cliffs of C62 (Old Rag Summit)



SHEN_C37_G_20060907_006.jpg Azmuth:

Greenstone dike with horizontal columnar jointing, cutting through granite between G268 and G269



SHEN_C37_G_20060907_007.jpg Azmuth:

Vein of very garnet-rich material within granite between G268 and G269



SHEN_C37_G_20060907_008.jpg Azmuth: 35

View to NE of lower eastern face/cliff area below G268, taken from trail before tunnel below G269

C37 - Old Rag Summit East (continued...)



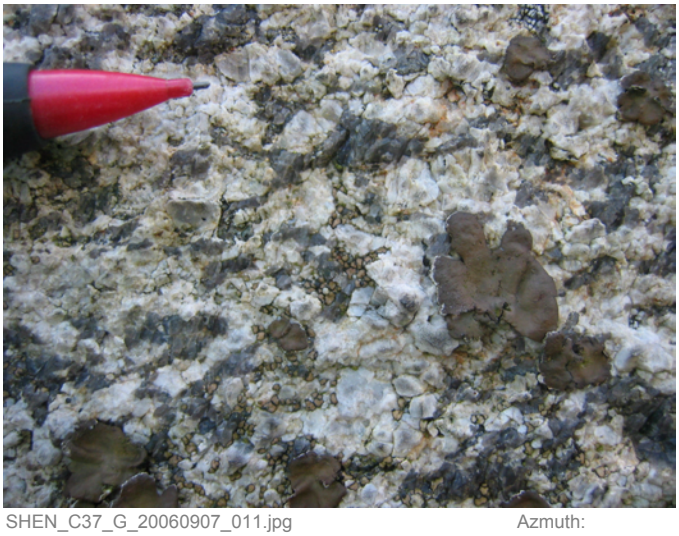
SHEN_C37_G_20060907_009.jpg Azmuth:

Impacted camping spot tucked into boulders above "tunnel"; fire ring outside view to left. Accessed by social trail just southwest of tunnel.



SHEN_C37_G_20060907_010.jpg Azmuth:

Social trail leading to campsite; view looks back toward official trail.



SHEN_C37_G_20060907_011.jpg Azmuth:

Another closeup of typical Old Rag granite, with blue-grey quartz, white-pink feldspar, and virtually no mafic (dark) minerals



SHEN_C37_G_20060907_012.jpg Azmuth:

Large greenstone dike with horizontal columnar jointing creating slot staircase for trail between G269 and G270

C37 - Old Rag Summit East (continued...)



SHEN_C37_G_20060907_013.jpg Azmuth: 315

Open crack where greenstone dike has eroded away, just north of G270



SHEN_C37_G_20060907_014.jpg Azmuth: 300

Climber's bolt and strap left in cliff above and to west of trail



SHEN_C37_G_20060907_015.jpg Azmuth: 210

View south to large boulder pile that marks the end of open rock exposure along this portion of the ridge; view from top of narrow ridge above G270



SHEN_C37_G_20060907_016.jpg Azmuth: 30

Typical outcrop above G270, with near-vertical joints constraining the erosion of the granite into rounded blocks.

C37 - Old Rag Summit East (continued...)



SHEN_C37_G_20060907_017.jpg Azmuth: 50

Viewacross large face at upper end of site, back across to lower faces below G268.



SHEN_C37_G_20060907_018.jpg Azmuth: 50

Zoomed view of exposures below G268 (person is standing near G268). Note horizontal "stripe" partially defined by vegetation halfway down large face in the distance; this may be the trace of a large dike.



SHEN_C37_G_20060907_019.jpg Azmuth: 165

Gently sloping open face at far southern/upper end of site. From the base of this exposure, a faint social/climbers trail leads to exposures in C36 (Old Rag South).

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C38 - Oventop

Site Code: C38
Site Name: Oventop
Data Collector Butler, Eric
Date Studied: 20-Jan-06

Polygon Centroid: **E:** 737210 **N:** 4283778
UTM (Zone 17 NAD83)
Dimensions (m): 150 x 460 (GIS est.)
Elevation Range (ft): 2000 to 2440

Physical Characteristics

Location Acces

Trailhead is along Rt 211 E., approximately 2.6 road miles east of Thornton Gap. Trail begins at north end of a large, tight, 180-degree switchback in the road. The nearest parking is .1 miles farther east, in a small gravel pull off on the south side of the road. Take the Pass Mountain trail approximately 1km north to an old trail junction in the saddle between Pass Mt and Oventop Mt. The Pass Mountain trail turns west here, while old (unmaintained) park trails continue north and east. Follow the old trail east, up the west ridge of Oventop. This trail varies in preservation and visibility throughout its length, and in places requires some searching to follow. Old trail blazes are still present on trees and rocks, though some have been painted over.
Old topographic maps show this trail following the main ridgeline all the way to the summit of Oventop, but this is apparently inaccurate. Around 2100' in elevation, the trail leaves the ridgeline to swing south across a hollow before climbing gently through a thick stand of laurels (the trail makes navigation much easier) to reach the broad, gently sloping surface of a southwest-trending ridge. Here the trail turns back to the northeast and ascends this gentle, openly forested ridge to the lower summit knob of Oventop. It is particularly difficult to follow the trail in this section, especially on the descent. Once on the summit ridgeline, the trail is easier to follow, and leads directly over the true summit to the first open rock exposures of the site. The trail distance after leaving the maintained park trail is roughly 2km.

Physical Description:

The Oventop site consists of two large open rock faces, with many smaller semi-open exposures nearby. The old trail leads directly to the top of the largest face, the upper portions of which are accessible and navigable (G182,G183). Most of this exposure, however, drops off into a very steep, sheer face about 30m high. Along the ridgeline above and to the west of this face, a jumble of partially forested bedrock and boulders (G181) stretches along the trail. To the southwest, another smaller but significant open rock face (G184) occurs, again with a gentler slope at the top that steepens toward the base. Other semi-forested exposures are found to the north and west of this face, including a large boulder pile that is visible in aerial photography. All the rock faces here are very smooth, with little to no fracturing or other disruptions to the surface.

Vegetation: Dense

The vegetation surrounding these exposures is often very thick, including undergrowth and evergreen/laurel thickets. The approach to the site can be equally thick, though following the trace of the old trail can help with this (particularly when it creates a tunnel through laurel stands). Access between exposures within the site is best achieved by cutting across slopes and avoiding steeper areas where the vegetation can hide or choke holes, drop-offs, or other barriers.

Human Effects

Impacts: Mild

Other than the abandoned trail leading to the edge of the site, little evidence of human use was found. Lichen coverage appeared to be thinner or not present on rock faces nearer trails, and thicker on steeper slopes just below these areas, possibly suggesting past use of the rock faces. No trash, graffiti, or other impacts were observed, although Steve Bair reports that occasional uses and impacts have occurred in the area. The "mild" rating reflects the presence of the old trail and the uneven lichen patterns, although in most respects this site qualifies as pristine.

Access Difficult

Although there is not a currently maintained trail to Oventop, the old trail is still visible at the trail junction, and remains followable for most of its distance. The rock faces of Oventop are very prominent, and it seems likely that memory of the route and interest in the site remains. It is a difficult hike, with thick vegetation and steep slopes in areas, but the continued presence of the trail keeps this site from earning a "remote" rating.

Geologic Characteristics

C38 - Oventop (continued...)

Lithology: **Rock Type** Old Rag Granite

Oventop is underlain primarily by the Old Rag Granite, a distinct rock unit in SHEN. This granite is predominately quartz and orthoclase feldspar, with virtually no other significant minerals visible. The granite is very uniform in appearance; fairly coarse-grained, with individual crystals growing over 2cm, especially the feldspars. The quartz is generally a dark grey-blue, while the orthoclase is white-pink. There may be a faint foliation present, mostly visible as a slight linear texture formed by strung-out quartz crystals, but the rock is generally massive (no internal structures). Photo 007 shows a close-up of a representative mineral texture on a weathered surface. Garnet is present in varying quantities as small red crystals within the rock.

Structure:

There are very few geologic structures present in the site. Foliation, when present, is faint and poorly developed, more a texture of vaguely aligned minerals than a well-developed planar structure. Joints are rare, and it is difficult to define any consistent orientation. Near G183, there appears to be joints oriented 070-250 and 145-325, but these are widely spaced and difficult to define.

Other:

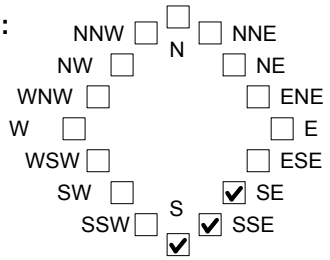
Trace amounts of basalt can be found scattered in the woods, remnants of old dikes intruded into the granite. None of these dikes appear in the bedrock itself, but only as loose float on the forest floor. The Pass Mt trail, however, passes through a very large pile of basaltic rocks which must represent a very large dike beneath the surface

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	30.0	60.0	10.0	0.0	0.0	100
Max relief(m):	30	5	40	0	0	

Maximum Slope: 30 **Texture:** Smooth

Aspects:



Setting:

The Old Rag Granite is quite resistant to weathering for several reasons. First, quartz and orthoclase feldspar are stable minerals at the Earth's surface, and so are resistant to chemical weathering of individual crystals. Unlike most granites, there are few secondary mafic minerals on which these processes can preferentially operate, so the rock remains especially cohesive and stable. Second, the generally massive nature of the rock provides few obvious planes of weakness on which physical weathering can operate. These factors mean that large-scale physical weathering is the dominant process on Oventop, as on Old Rag Mountain and other areas of similar lithology.

In particular, exfoliation plays a strong role here. This is the process by which massive (unstructured) granites gradually peel off layers of rock much like an onion, forming the smooth, rounded exposures typical of this lithology. In several places within the site, partially developed exfoliation layers can be seen as thin (5-30cm) slabs of rock clinging to a rounded surface. Jointing may also play a role here; although joints are rare, the orientation of those visible roughly correlates to the general trend of the exposures, and so a few large joints creating a natural plane of weakness may have helped create the large exposures in their current location and orientation.

The lack of significant jointing here creates an interesting contrast with Old Rag Mountain, where the same lithology creates many more rounded boulders, narrow slots, and uneven (though still smooth) exposures than are present at Oventop, which has far fewer joints, fractures, and other planes of weakness and thus has very smooth and uniform rock faces.

Stability: Stable

The bedrock exposures are very solid, with little fracturing or jointing. There is no talus to speak of, and most slopes are not overly steep. Thick beds of leaves are the greatest instability encountered.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
1/20/2006	G181-C38	737204	4283892	2400	Large open boulder; first view of site from trail
1/20/2006	G182-C38	737340	4283895	2400	East end of primary rock face

C38 - Oventop (continued...)

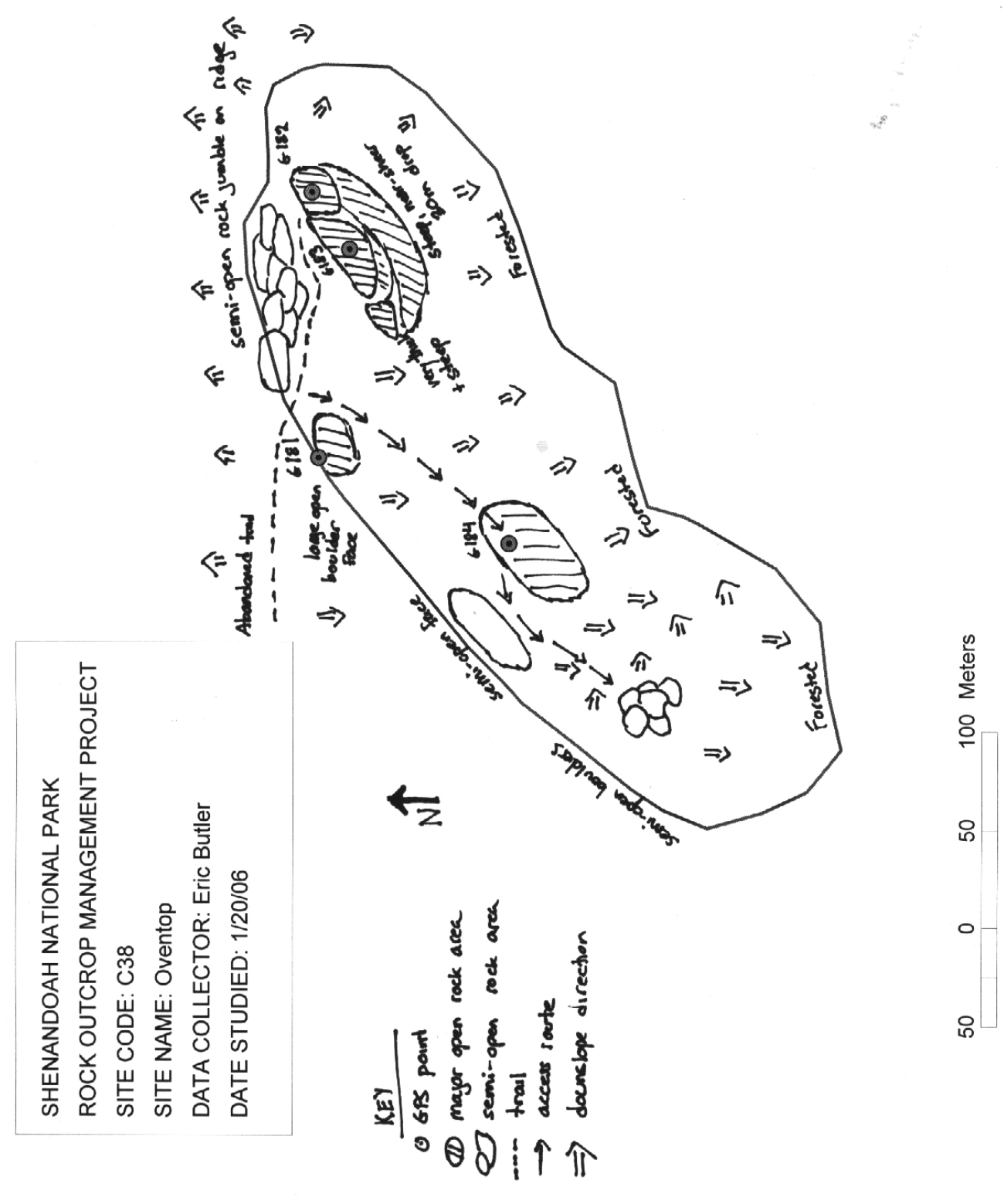
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
1/20/2006	G183-C38	737311	4283876	2380	Lower accessable level of primary rock face
1/20/2006	G184-C38	737160	4283795	2240	East end of secondary rock face

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
1/20/2006	G182-C38	SHEN_C38_G_20060120_001.jpg	235	Butler, Eric	View across upper face, Mary's Rock in background
1/20/2006	G182-C38	SHEN_C38_G_20060120_002.jpg	145	Butler, Eric	View down smooth eastern edge of exposure into woods
1/20/2006	G182-C38	SHEN_C38_G_20060120_003.jpg	235	Butler, Eric	View across upper face, Mary's Rock in background
1/20/2006	G183-C38	SHEN_C38_G_20060120_004.jpg	240	Butler, Eric	View across near face, also G184 exposure in background
1/20/2006	G183-C38	SHEN_C38_G_20060120_005.jpg	50	Butler, Eric	View across joint crack at upper face (G182)
1/20/2006	G183-C38	SHEN_C38_G_20060120_006.jpg	180	Butler, Eric	View down face toward forest at base
1/20/2006	G183-C38	SHEN_C38_G_20060120_007.jpg		Butler, Eric	Closeup of rock surface, showing "blue quartz" and white feldspar
1/20/2006	G184-C38	SHEN_C38_G_20060120_008.jpg	180	Butler, Eric	View down smooth rock face at secondary exposure
1/20/2006	G184-C38	SHEN_C38_G_20060120_009.jpg	260	Butler, Eric	View into woods of partially open rock faces
1/20/2006	G184-C38	SHEN_C38_G_20060120_010.jpg	230	Butler, Eric	View across secondary rock face; rocks in background are outside site, below G183
1/20/2006		SHEN_C38_G_20060120_011.JPG	45	Butler, Eric	View of Oventop site taken from Buck Hollow Overlook, Skyline Drive milepost 32.8

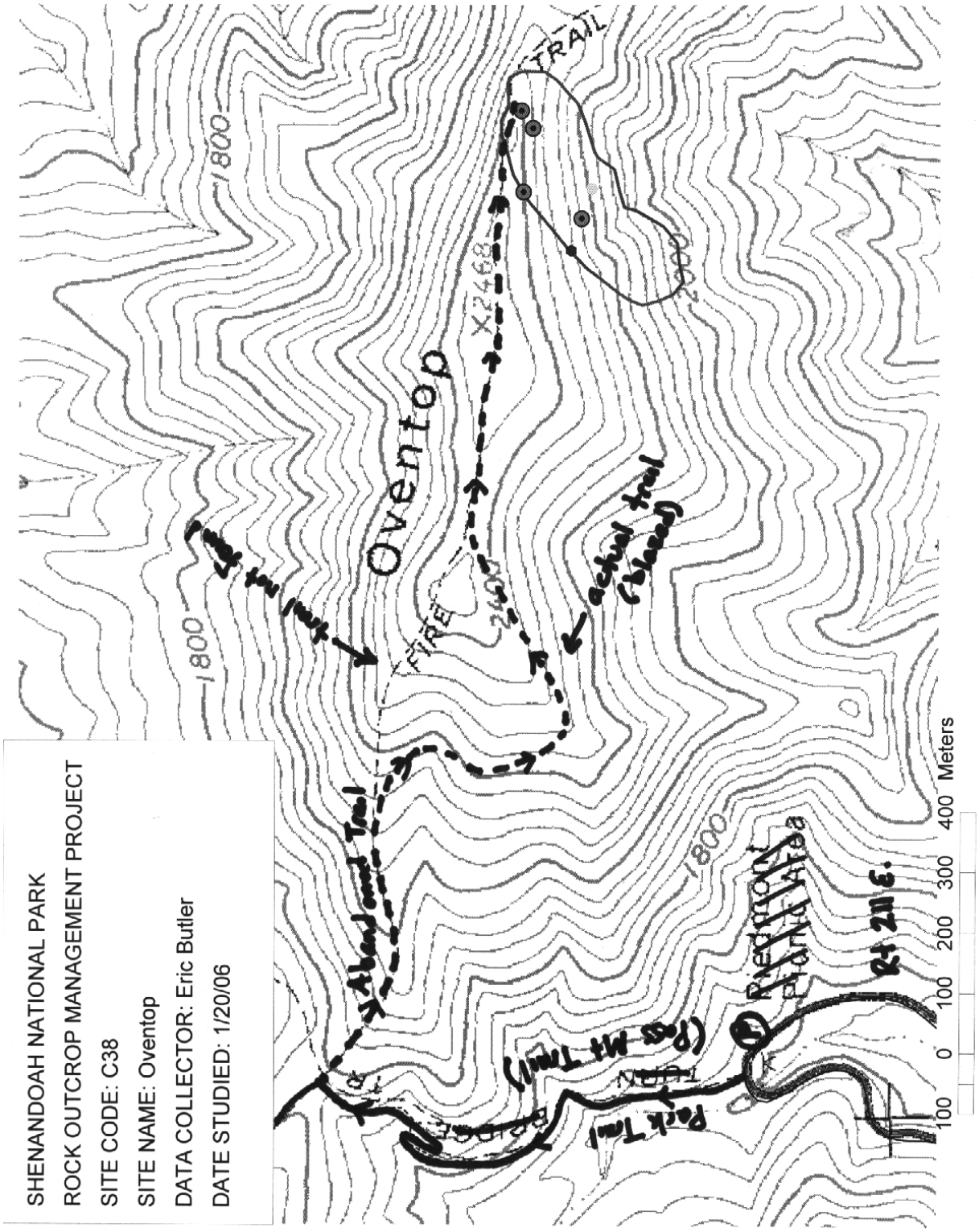
C38 - Oventop (continued...)

Detail sketch map



C38 - Oventop (continued...)

Area sketch map



C38 - Oventop (continued...)



SHEN_C38_G_20060120_001.jpg Azmuth: 235

View across upper face, Mary's Rock in background



SHEN_C38_G_20060120_002.jpg Azmuth: 145

View down smooth eastern edge of exposure into woods



SHEN_C38_G_20060120_003.jpg Azmuth: 235

View across upper face, Mary's Rock in background



SHEN_C38_G_20060120_004.jpg Azmuth: 240

View across near face, also G184 exposure in background

C38 - Oventop (continued...)



SHEN_C38_G_20060120_005.jpg Azmuth: 50

View across joint crack at upper face (G182)



SHEN_C38_G_20060120_006.jpg Azmuth: 180

View down face toward forest at base



SHEN_C38_G_20060120_007.jpg Azmuth:

Closeup of rock surface, showing "blue quartz" and white feldspar



SHEN_C38_G_20060120_008.jpg Azmuth: 180

View down smooth rock face at secondary exposure

C38 - Oventop (continued...)



SHEN_C38_G_20060120_009.jpg Azmuth: 260

View into woods of partially open rock faces



SHEN_C38_G_20060120_010.jpg Azmuth: 230

View across secondary rock face; rocks in background are outside site, below G183



SHEN_C38_G_20060120_011.JPG Azmuth: 45

View of Oventop site taken from Buck Hollow Overlook, Skyline Drive milepost 32.8

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C39 - Overall Run Falls South

Site Code: C39
Site Name: Overall Run Falls South
Data Collector Butler, Eric
Date Studied: 12-Sep-06

Polygon Centroid: **E:** 734926 **N:** 4296217
UTM (Zone 17 NAD83)
Dimensions (m): 120 x 140 (GIS est.)
Elevation Range (ft): 1600 to 1940

Physical Characteristics

Location Acces

Enter Matthews Arm Campground at about milepost 22.2 along Skyline Drive. Past the entrance station, bear right at a T junction. Follow Loop B to the far end of the campground, where a short road leads to the tenting-only sites. Park here, or if a gate key is available, continue through the gate along the fire road. The road will eventually end in a small turn-around; park and continue down the trail, past several trailheads for other routes, until reaching the trail head for the Tuscarora-Overall Run trail. This trail leads past a smaller waterfall to the much larger waterfall at the center of both sites. C39 is across the stream to the west, and can be accessed by crossing just above the waterfall and climbing the ridge. C63 stretches from the large open areas beyond the falls to several glades reached by social trails from the main trail above the falls. Total distance from Matthews Arm Campground is about 3km, with a drop in elevation of about 900'.

Physical Description:

This site encompasses a ridge along the western side of Overall Run, just past the large, signature waterfall in this area. The NE side of the site consists of sheer cliffs dropping down into the waterfall-produced canyon. Similar cliffs form the NW side of the site, with linear zone of open ledges and outcrops stretching across the slope above the cliff line. This open area wraps around the nose of the ridge before blending into the northeastern cliffs. The top of this ridge is fairly gently sloping and partially open, though little rock is exposed here. The companion site C63 encompasses the cliffs, ledges, and exposures along the north side of Overall Run in this area.

Vegetation: Moderate

Most of the vegetation within the site is either low blueberry scrub or small trees; in certain places thickets partially impede navigation.

Human Effects

Impacts: Pristine

No signs of human visitation were observed here, and the outcrops & ledges all appeared in natural condition.

Access Remote

Though many people visit the falls area, in particular the overlooks atop the cliffs across Overall Run, it appears few to none cross the stream to reach this site. Most of the open areas are not visible from any trail, and there is little indication from the trail overlooks of any reason to bushwhack over here.

Geologic Characteristics

Lithology:

Rock Type Greenstone

This site is underlain by several greenstone lava flows of the Catoctin Formation. There is relatively little open rock exposed within the site, but what can be observed is very typical fine-grained greenstone with no unusual characteristics. The linear zone of ledgy outcrops that form the open portion of the site are likely contained within a single flow, with a lower flow forming the sheer cliffs and an upper flow forming the gently rounded top of the ridge. No evidence of flow boundaries was observed in these areas, with the exception of some amygdaloidal greenstone breccia outside the site between G278 and G281, which appears to correlate to much thicker exposures at G282 in C63.

Structure:

The bedrock here is very fractured, though not in any organized fashion such as columnar jointing or cleavage. Other than the randomly oriented fracturing, few structures were evident. It appears that the lava flows themselves are nearly horizontal in this area, judging from the clear boundaries visible in the large cliffs near the falls (photo 001).

Other:

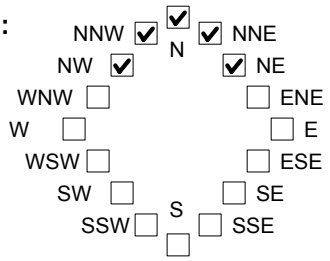
C39 - Overall Run Falls South (continued...)

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	20.0	35.0	0.0	35.0	10.0	100
Max relief(m):	15	5	0	1	5	

Maximum Slope: 30 **Texture:** Rough

Aspects:



Setting:

This site is probably underlain by three lava flows. The lowest, most resistant flow forms sheer cliffs that wrap around the site and form the main drop into the canyon past Overall Run Falls. Above this, a thinner, less resistant flow forms the linear zone of small outcrops and ledges that wraps around the ridge before blending into higher cliffs near the falls. At the top of the sequence, a third flow underlies the smooth, gentle upper slope of the ridge. Few contact rocks were identified to prove this, but the distinct changes in topography and outcrop pattern here support the above conclusions. The fractured nature of the central flow seems to be the dominant factor in producing the abundant small outcrops and ledges within its range, as opposed to another cliff line like the flow below.

This area, like several others studied in ROMP (e.g. C03 Big Devils Stairs) appears to host an unusually dry and acidic ecology for greenstone; the site looks like it belongs on granitic bedrock. No clear reason for this is evident from the bedrock; the site may be very well drained given its fractured nature and location atop a ridge, or there may be a chemical difference in the bedrock that cannot be identified visually. By outward appearances the greenstone here is quite typical of the park.

Stability: Stable

The common fracturing, while apparently contributing to the erosion of the bedrock, has not made the exposures unstable. All outcrops and ledges were solid underfoot, and the talus areas are mostly low-angle and stable.

GPS Points

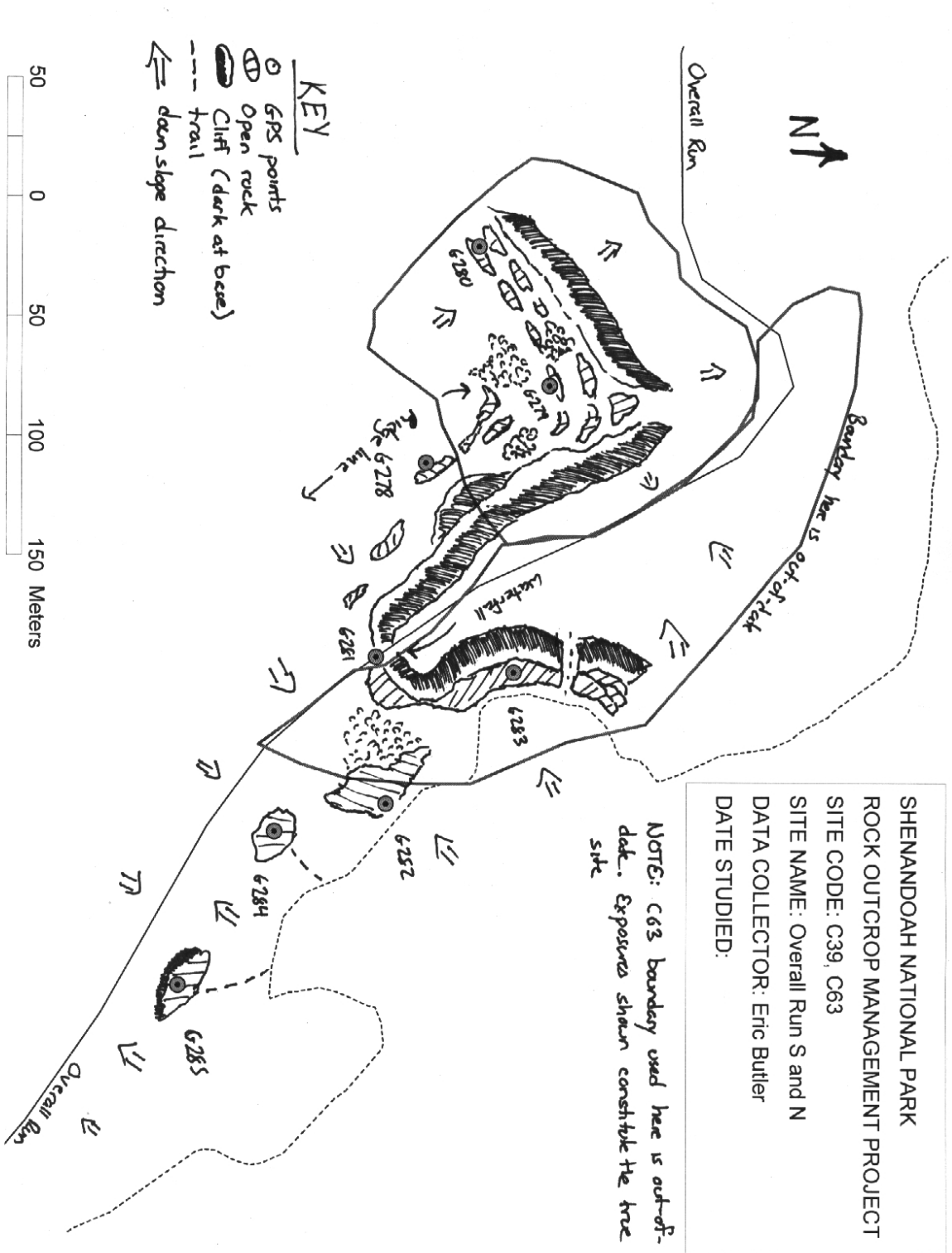
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
9/12/2006	G278-C39	734973	4296161	1940	Semi-open glade area at top of ridge; small rock exposures to east
9/12/2006	G279-C39	734940	4296212	1820	Top of open ledges & outcrops stretching across the slope to southwe
9/12/2006	G280-C39	734882	4296183	1800	Farthest SW extent of open ledg/outcrop area

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
9/12/2006		SHEN_C39_G_20060912_001.jpg	270	Butler, Eric	View across canyon to cliffs on eastern side of site, taken from G283 in C63
9/12/2006	G278-C39	SHEN_C39_G_20060912_002.jpg	270	Butler, Eric	Semi-open area at top of ridge; little bedrock exposed here.
9/12/2006	G278-C39	SHEN_C39_G_20060912_003.jpg	110	Butler, Eric	Small outcrops above eastern cliffs
9/12/2006	G279-C39	SHEN_C39_G_20060912_004.jpg	290	Butler, Eric	Small ledges at top of open slope along NW side of ridge
9/12/2006	G279-C39	SHEN_C39_G_20060912_005.jpg	245	Butler, Eric	Partially exposed outcrops within slope along NW side of ridge
9/12/2006	G279-C39	SHEN_C39_G_20060912_006.jpg	280	Butler, Eric	View down slope across semi-open outcrops & ledges; cliff at base of view
9/12/2006	G280-C39	SHEN_C39_G_20060912_007.jpg	55	Butler, Eric	View to NE of ledges and outcrops from furthest SW extent of open area
9/12/2006		SHEN_C39_G_20060912_008.jpg	45	Butler, Eric	Small semi-open talus area among outcrops near site centerpoint

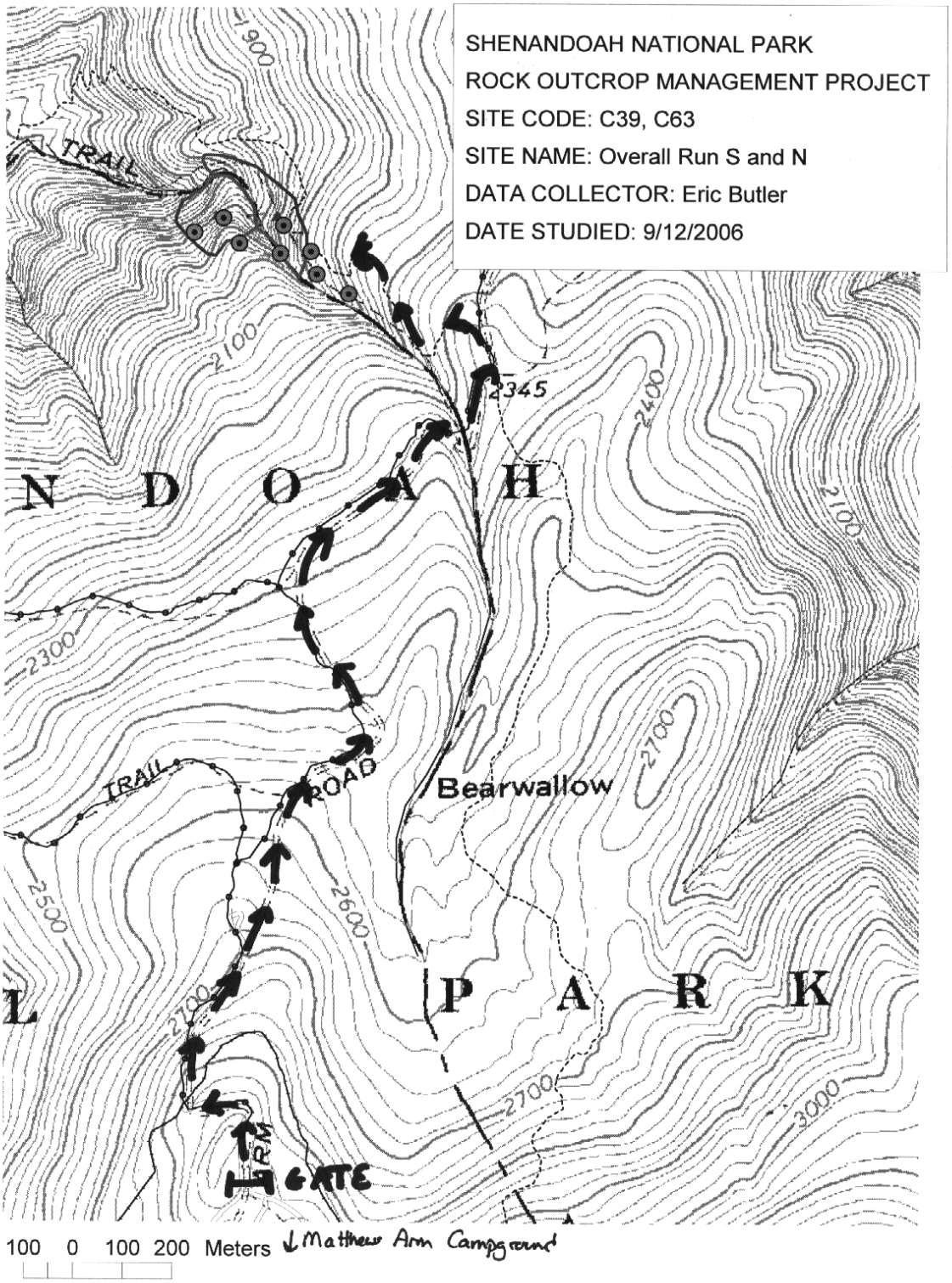
C39 - Overall Run Falls South (continued...)

Detail map



C39 - Overall Run Falls South (continued...)

Area map



C39 - Overall Run Falls South (continued...)



SHEN_C39_G_20060912_001.jpg Azmuth: 270

View across canyon to cliffs on eastern side of site, taken from G283 in C63



SHEN_C39_G_20060912_002.jpg Azmuth: 270

Semi-open area at top of ridge; little bedrock exposed here.



SHEN_C39_G_20060912_003.jpg Azmuth: 110

Small outcrops above eastern cliffs



SHEN_C39_G_20060912_004.jpg Azmuth: 290

Small ledges at top of open slope along NW side of ridge

C39 - Overall Run Falls South (continued...)



SHEN_C39_G_20060912_005.jpg Azmuth: 245

Partially exposed outcrops within slope along NW side of ridge



SHEN_C39_G_20060912_006.jpg Azmuth: 280

View down slope across semi-open outcrops & ledges; cliff at base of view



SHEN_C39_G_20060912_007.jpg Azmuth: 55

View to NE of ledges and outcrops from furthest SW extent of open area



SHEN_C39_G_20060912_008.jpg Azmuth: 45

Small semi-open talus area among outcrops near site centerpoint

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C40 - Pass Mountain

Site Code: C40
Site Name: Pass Mountain
Data Collector Butler, Eric
Date Studied: 12-Jul-05

Polygon Centroid: **E:** 733353 **N:** 4285357
UTM (Zone 17 NAD83)
Dimensions (m): 130 x 450 (GIS est.)
Elevation Range (ft): 2760 to 2940

Physical Characteristics

Location Acces

Park at Beahms Gap Overlook (Milepost 28.5) and follow the Appalachian Trail (AT) south for about 900m to reach north end of site (note: trailhead marker is difficult to see from parking lot; it is slightly south of the lot and partially hidden in vegetation). When trail levels off onto a broad plateau, look to west for several open patches within the forest. Alternatively, continue along AT a little longer, and where trail curves noticeably to the southeast, follow a social trail to the west to reach an open exposure.

Physical Description:

The western slope of Pass Mountain consists of a mostly gentle slope, with one steeper section between 2800' and 2900'. Above 2900', the slope levels out onto a flat plateau that caps the northern end of the mountain, with another rise to the south that creates the summit. The site is contained within the steeper slope between 2800'-2900'. This area changes character noticeably between the northern and southern end of the site boundary. In the north, the plateau transitions into gently sloping, west-facing rock exposures that create three distinct meadow-like openings. These drop off into several small cliffs with associated talus, which is generally forested. Overall, this northern section is quite wet and heavily vegetated with mosses and other small plants. Roughly near the centerpoint of the site, the physical character changes noticeably to the south. After this point, the rock exposures are more rugged and cliffy, with much larger talus deposits below and locally steeper slopes than in the north. The area is noticeably drier, as most mosses and small plants are replaced by laurels and dry leaves. At the southern end of the site, where the cliffs and talus fields are tallest, the rock exposures end abruptly, and beyond this to the south is gently sloping forest with few visible exposures or boulders. All along the north-south axis of the site, the top of the first rock exposure, whether ledge or cliff, is consistently between 2880' and 2900'.

Vegetation: Open

Most of the site is either developed forest with little understory, or open meadow-like exposures with mosses and small plants like blueberries that do not hamper navigation. There are patches of laurel in the southern, drier portion of the site, and some locally thick vegetation on the larger talus slopes in this area, but nothing large enough to cause any real difficulties.

Human Effects

Impacts: Moderate

The impacted areas here are actually quite small, but the moderate rating reflects the very distinct differences between impacted and non-impacted areas. Of the three meadow-like areas in the north, the middle one is connected by social trail to the Appalachian Trail (AT), while the other two are not, despite being equally visible from the trail. This middle meadow is heavily stripped, with much more bedrock visible, and obvious sand and gravel where soil and plants ought to be. In contrast, the meadow directly to the north, only tens of meters away, is lushly vegetated and apparently unimpacted, although trash was found in this area as well. There are no signs of impact in the southern portion of the site, which is farther from the AT and has no clear views to the west.

Access Moderate

The site is only 900m on the Appalachian Trail from a parking lot on Skyline Drive, but there are no signs or any other indication that visitors should climb Pass Mountain. The open exposures are not visible from the road or elsewhere. The trail is in good condition but climbs 400' through woods with no obvious destination at the end or farther along the trail.

Geologic Characteristics

Lithology:

Rock Type Greenstone

The Pass Mountain exposures are entirely greenstone of the Catoctin Formation, in this location a dark grey, fine-grained rock that changes character throughout the site. In the north, the rock appears to contain significant flow bedding, though this is not consistently found, and becomes less obvious to the south. In general, structural characteristics dominate the physical

C40 - Pass Mountain (continued...)

appearance of the rock here (see below). In the south, a distinct unit of red, vesicular breccia with quartz veins can be found apparently in-place at the base of a talus slope, marking the lower boundary of the cliff-forming flow. Oddly, in a low saddle separating two outcrops directly north of this location (just north of G095), large quantities of an identical-looking material can be found strewn along the slope from top to bottom, indicating a source above the flow. This location is the only place within the site that these rocks were observed.

Structure:

The structural characteristics of the greenstone here change noticeably from north to south within the site. In the north, the low-angle, ledgy outcrops cap the exposures, grading into an area with strong cleavage that drops away into small cliffs of massive, possibly layered basalt. In the south, the layering and cleavage become less apparent, and columnar jointing and other fracturing become the dominant structural feature. Likely for this reason, talus slopes become larger to the south, as do the individual blocks within them.

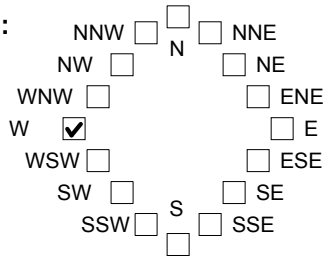
Other:

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	20.0	40.0	0.0	20.0	20.0	100
Max relief(m):	5	5	0	5	15	

Maximum Slope: **Texture:** Rough

Aspects:



Setting:

This highly variable site is difficult to interpret. View from a large scale, it seems clear that all the rock exposures are contained within a single greenstone flow. The upper elevation at which bedrock appears is remarkably consistent from north to south, as is the base of these exposures where the slope moderates and returns to forest. However, the very obvious physical differences between the northern and southern portions of the site require explanation. To recap, the northern portion of the site consists of more layered, massive rocks with less dominant physical structures and fractures, and is much wetter and vegetated. The southern portion of the site is dominated by fractures, columnar joints, and talus slopes, and is much drier (laurels instead of moss).

One possibility is the presence of a small fault near G095, which would mark the rough dividing line between the northern and southern parts of the site. This idea is supported by the occurrence of the distinct vesicular breccia discussed above, which south of this location is found at the base of the site, but north of this location is found along a slope, apparently eroding from above the site. A fault between these two locations could have vertically juxtaposed two different greenstone flows, explaining the horizontal change in lithology, structure, and ecology from north to south. This idea is problematic, however, as it does not explain the excellent correlation of the top and bottom elevations of rock exposure across entire length of the site. It seems unlikely that a fault would happen to perfectly juxtapose two different lava flows of exactly equal thickness at just the right elevation to otherwise seem like one. In addition, there is no direct evidence for a fault, and it seems a rather convenient excuse.

It seems more likely that the entire site is composed of a single lava flow, and some other factor(s) contributed to the variability. Portions of the flow may have cooled at different rates, creating changes in the fracture patterns within those rocks. There may have been several “lobes” of the same flow advancing separately across the landscape, flowing around paleotopography and meeting at times. Elsewhere in the park, vertical zones of breccia can be observed that mark places where such lobes collided, and the red vesicular breccia discussed above may represent one of these boundaries, rather than a horizontal boundary between separate flows (which would explain its occurrence from top to bottom of one specific slope). There is no in-place bedrock evidence of this, however.

The hydrologic difference from north to south (wetter north, drier south) is also a challenge. The northern portion of the site is located at the top of the large plateau that defines northern Pass Mountain, while the southern part reaches the end of the plateau, where the slope begins to rise again toward the summit. In theory, one might expect the north to be drier, as there is no slope above it to capture water, and the south to be wetter, with the higher slopes of Pass Mountain feeding groundwater and surface flow down slope. However, the fracture patterns in the rock may invert this pattern. The northern rocks are quite massive and gently sloping, with few obvious fractures, and so any water collecting on the surface will remain there, feeding

C40 - Pass Mountain (continued...)

the wet, mossy areas seen at the top of the site in this area. To the south, as columnar joints and fracturing become more dominant, any surficial water may drain quickly below the surface and become unavailable to plants, creating a drier surface environment. No springs or channels were observed anywhere in the site that could support or disprove this theory, but it fits the observed patterns.

Stability: Stable

The bedrock here is quite solid. The larger talus fields require care, but the boulders are large enough that sudden movement was not a concern. Most slopes within the site are fairly gentle, and the few steeper erosion slopes between outcrops are manageable.

GPS Points

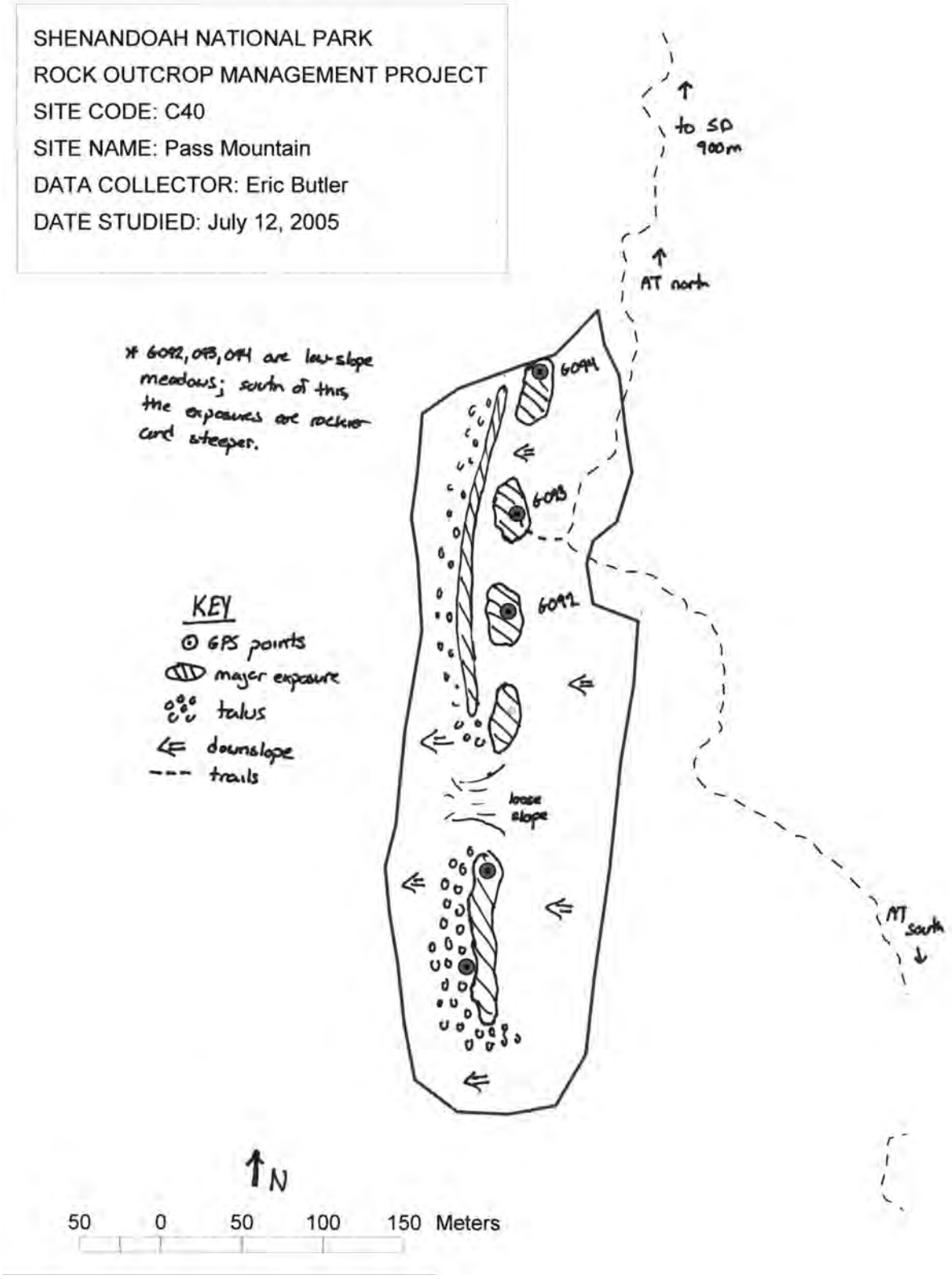
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
7/12/2005	G092-C40	733351	4285419	2880	Typical open ledgy outcrops
7/12/2005	G093-C40	733356	4285480	2900	More impacted ledges with social trail access
7/12/2005	G094-C40	733371	4285569	2880	Typical open ledgy outcrops
7/12/2005	G095-C40	733339	4285257	2900	Cliff with columnar jointing & talus
7/12/2005	G096-C40	733326	4285197	2900	Large talus field

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
7/12/2005		SHEN_C40_G_20050712_001.jpg	0	Butler, Eric	General view of typical low-angle, ledgy outcrops at N end of site
7/12/2005		SHEN_C40_G_20050712_002.jpg	60	Butler, Eric	Single outcrop
7/12/2005		SHEN_C40_G_20050712_003.jpg		Butler, Eric	Unique fracture patterns on surface – note some lichens following pattern
7/12/2005		SHEN_C40_G_20050712_004.jpg	0	Butler, Eric	Fully vegetated, pristine outcrops
7/12/2005		SHEN_C40_G_20050712_005.jpg	0	Butler, Eric	Stripped, impacted outcrops
7/12/2005		SHEN_C40_G_20050712_006.jpg	180	Butler, Eric	Large, open talus with loose blocks of columnar joints

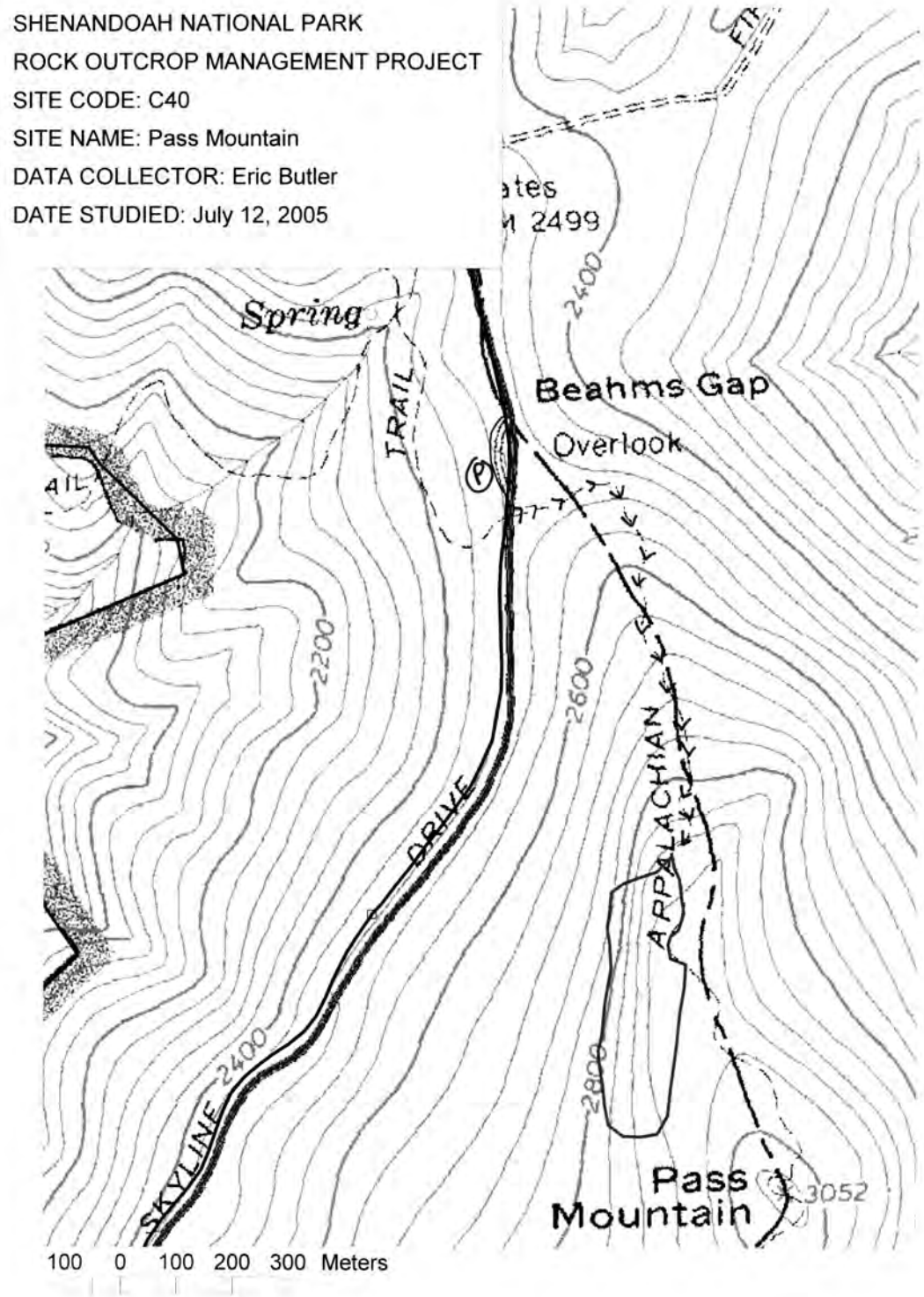
C40 - Pass Mountain (continued...)

Detail sketch map



C40 - Pass Mountain (continued...)

Area sketch map



C40 - Pass Mountain (continued...)



SHEN_C40_G_20050712_001.jpg Azmuth: 0

General view of typical low-angle, ledgy outcrops at N end of site



SHEN_C40_G_20050712_002.jpg Azmuth: 60

Single outcrop



SHEN_C40_G_20050712_003.jpg Azmuth:

Unique fracture patterns on surface – note some lichens following pattern



SHEN_C40_G_20050712_004.jpg Azmuth: 0

Fully vegetated, pristine outcrops

C40 - Pass Mountain (continued...)



SHEN_C40_G_20050712_005.jpg Azmuth: 0

Stripped, impacted outcrops



SHEN_C40_G_20050712_006.jpg Azmuth: 180

Large, open talus with loose blocks of columnar joints

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C41 - Pinnacles

Site Code: C41
Site Name: Pinnacles
Data Collector Butler, Eric
Date Studied: 09-Jan-06

Polygon Centroid: **E:** 732561 **N:** 4279056
UTM (Zone 17 NAD83)
Dimensions (m): 520 x 220 (GIS est.)
Elevation Range (ft): 3320 to 3730

Physical Characteristics

Location Acces

There are several access routes to this site. For the easiest route, park at Jewell Hollow Overlook (Milepost 36.5). Walk north along Skyline Drive for several hundred meters, then turn onto the Leading Ridge trailhead from the west side of the drive. Take this trail a short distance into the woods, where it crosses the Appalachian Trail (AT). Turn north (right) on the AT, and follow for about 1km. The AT leads directly to the southernmost exposure within the site, where the ridge becomes extremely narrow and drops away on both sides. The AT can also be accessed from the far western end of the overlook parking lot, where the trail climbs steeply up from below.

Alternatively, park at the Meadow Springs lot (Milepost 34.5) and follow the Meadow Springs Trail upslope to intersect with the AT; take the AT south to the top of the ridge, where the site begins. This route is longer and steeper, but provides convenient access to C31 (Mary's Rock) as well, if both are being visited in the same day.

Physical Description:

This site is located along a high, narrow ridge that drops away very steeply to the west, and somewhat more gently to the east. This ridge is slightly curved, forming a subtle bowl that opens to the west. The steep slope to the west is broken by a series of protruding rock exposures, with drops of up to 20m (G173), mostly arranged along the crest of the ridge. Toward the north end of the site, a prominent ridge descends to the west, with a series of rock exposures extending over 70m down from the ridgetop. This is the only place where significant open rock occurs below the ridgeline. The bedrock in general forms rounded, sloping outcrops that become sheer in places, protruding from the slope as steep domes up to 10m high on the west side, and merging with the slope on the east. There are few wide ledges or areas of gently sloping rock; the western-descending ridge contains the only significant face of truly open rock (G175), as well as the largest boulders (G176). The slopes around and below the bedrock range between thick talus deposits and a loose, unstable mixture of rock and soil.

Vegetation: Dense

Most of this site is overgrown with thick stands of laurel, stubby oaks, and other vegetation. Downed limbs and trees are very common, and undergrowth is thick as well. The forest becomes more open lower in the bowl, but there is no open rock here. There are few brambles or briars, however, and most areas can be navigated with patience.

Many areas containing significant populations of the rare plant Hupersia were observed during field work, and the most significant of these are marked on the field map. These were often in difficult-to-access areas, and so are noted to ensure that they are not missed by future work.

Human Effects

Impacts: Mild

The Appalachian Trail (AT) runs parallel to and just below the ridgeline, and some minor impacts can be found where short social trails lead off to small overlooks on rock exposures. These impacts consists of some trampling and soil erosion, but are very limited in scope, likely by the thick vegetation, steep dropoffs to the west, and lack of significant ledges. With the exception of these few places, the rest of the site appears quite pristine and unvisited (not surprisingly).

Access Moderate

The hike from Jewell Hollow Overlook up to the viewpoints on Pinnacle Ridge is not particularly long or steep by Shenandoah standards, but is enough to deter casual hikers. No trailhead leads directly from the overlook or parking area; the Appalachian Trail passes below the overlook, and the Leading Ridge trail begins several hundred meters up the road, with no obvious connecting path. No signs indicate the existence of the site, and it is invisible from any nearby point on the Skyline Drive.

Geologic Characteristics

C41 - Pinnacles (continued...)

Lithology: **Rock Type** Granitic gneiss

This site is underlain by basement rock of generally granitic composition. In general, the rock is coarsed-grained and dominated by quartz and feldspar crystals (mostly plagioclase, sporadic orthoclase) 1-5mm in diameter. Some isolated larger crystals of orthoclase feldspar and plagioclase feldspar reach 3cm in diameter. There is little to no mica present; the dominant mafic mineral appear to be pyroxene, which is present in quantities from 10%-50%. Garnet is present in minor quantities. This mineral assemblage is typical of the rock charnockite, which is a somewhat unusual lithology, though common in Shenandoah. The lack of mica and presence of pyroxene instead is the identifying factor.

Structure:

There is a very strong joint set here, oriented roughly along 075-255 degrees, and dipping steeply to the north around 70-80 degrees. Most of the cliff faces and erosion planes present within this site are oriented along this joint set, or along several less prominent sets in other orientations. The best examples of this are the sheer cliffs at the base of G173 and G175. Foliation ranges from nonexistant to very strong, formed by subtle alignments of mineral bands, generally oriented around 010-190 degrees, and dipping to the northwest around 50-60 degrees. The foliation also has a local control on the exposure morphology where strong enough, creating a few platy exposures and planes of weakness.

Other:

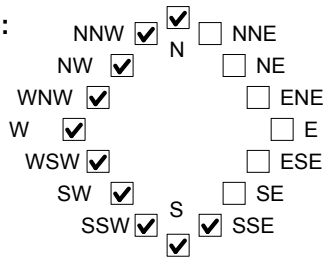
Many of the exposures in this site are domal, and thus have a wide range of aspect. The dominant NNE-SSW joint set in particular creates some unusual local aspects that might otherwise not exist based on the overall aspect of the site.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	20.0	40.0	15.0	10.0	15.0	100
Max relief(m):	20	10	5	1	5	

Maximum Slope: 45 **Texture:** Smooth

Aspects:



Setting:

The dominant joint set is the single most important factor controlling the shape of rock exposures in this site. Along with the lesser joints, these structures create planes of weakness along which large boulders crack away, forming angular blocks and sheer cliffs (see Photo 13). In addition, smaller-scale weathering acts first along these joints, rounding off the angular edges of the rock (see Photo 11 for this texture) before it actually breaks away. The presence of these joints also creates unusual aspects and habitats that might otherwise not exist; the cliffs at G173 and G175 are excellent examples of this. These cliffs extend back into the slope, creating sheltered pockets that are not representative of the slope in general. Even where a specific joint-formed cliff is not evident, the general outcrop pattern of the rock seems to follow their orientations.

At a larger scale, the presence of a steeper, rockier slope to the west may be related to the dominant weather patterns in the region; this side of the ridge is more exposed to storms, wind, and other elements, while the east side is relatively sheltered and so remains more stable. These conditions would have been exacerbated during glacial periods, when most of the current landscape was likely created under much more unstable, intense weather conditions than are found today.

In addition, this area lies within the upper block of a massive thrust fault, which has emplaced the entire geologic sequence of Shenandoah up and over the pre-existing bedrock. This fault runs along the western base of the mountains north from the town of Stanley, then rises through Thornton Gap and follows the east side from there. The mountains to the north of Thornton Gap (such as Pass Mt) are on the lower block of this fault, while Mary's Rock, Pinnacles, and the rest of the Central District are on the upper block. Thus, this westward faulting has thrust the Pinnacles area up into a more protruding, west-facing position, leaving it especially vulnerable to the prevailing weather patterns discussed above.

Stability: Loose

Though the large bedrock exposures are generally solid, there are numerous smaller exposures which are less so. In addition, the common joint sets create large blocks that are slowly peeling away from the main exposures. Frequently what appears to be solid bedrock is a large boulder, and these misleading rocks can shift underfoot. The best example of this is the rock pile at G176, which appears to be stable bedrock from a distance, but in fact is a stack of large boulders crumbling from the dome at

C41 - Pinnacles (continued...)

G175. The slope is very loose and unstable, and a rock that is loosened will travel a long distance before stopping. There are numerous holes and pits between boulders and smaller loose rocks, which are often hidden beneath thin veneers of leaves or soil.

GPS Points

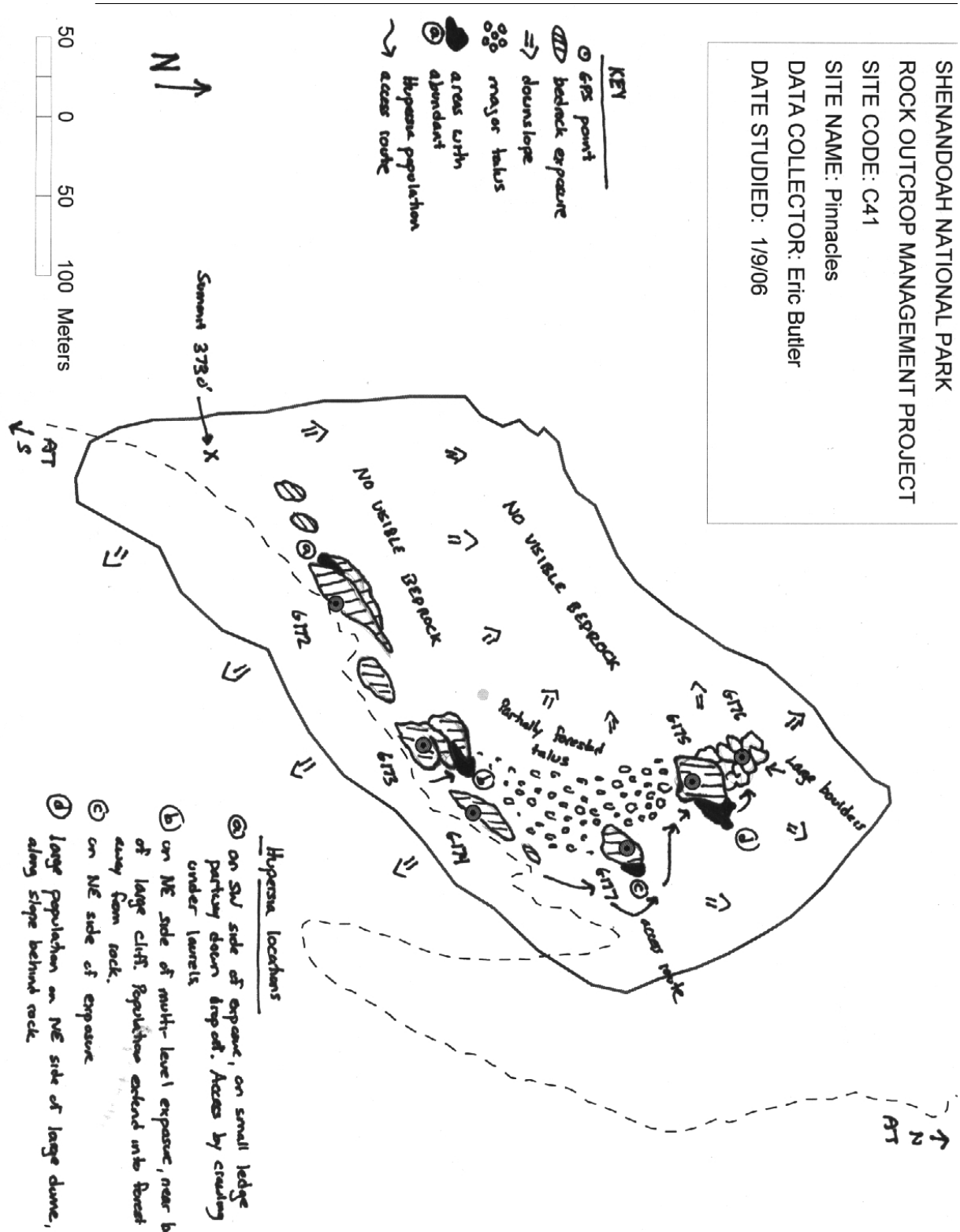
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
1/9/2006	G172-C41	732504	4278964	3680	Farthest south exposure along ridgeline
1/9/2006	G173-C41	732593	4279019	3680	Top of large outcrop extending downslope over two different cliff levels
1/9/2006	G174-C41	732635	4279050	3720	Highest exposure in site, accessed by social trail from AT
1/9/2006	G175-C41	732616	4279186	3520	Prominent open face and cliff downslope from ridge, visible from G172
1/9/2006	G176-C41	732600	4279217	3480	Very large-clast boulder pile below G175, appears to be bedrock from
1/9/2006	G177-C41	732657	4279146	3640	Bedrock knob above G175-176, beginning of route down to these.

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
1/9/2006	G172-C41	SHEN_C41_G_20060109_001.jpg	30	Butler, Eric	View north showing rest of site; G175 and 176 exposures are at center (background)
1/9/2006	G172-C41	SHEN_C41_G_20060109_002.jpg	180	Butler, Eric	Mildly impacted ground between G172 and AT (in background)
1/9/2006	G173-C41	SHEN_C41_G_20060109_003.jpg	305	Butler, Eric	View from upper level of this exposure toward top of lower cliff
1/9/2006	G173-C41	SHEN_C41_G_20060109_004.jpg		Butler, Eric	Occurrence of Hupersia on north side of G173 exposure, halfway down
1/9/2006	G173-C41	SHEN_C41_G_20060109_005.jpg		Butler, Eric	Occurrence of Hupersia growing on lower cliff face below G173
1/9/2006	G173-C41	SHEN_C41_G_20060109_006.jpg		Butler, Eric	Prominent foliation and joint on south side of G173 exposure (notebook for scale)
1/9/2006	G174-C41	SHEN_C41_G_20060109_007.jpg	250	Butler, Eric	View south of G173; lower cliff is to right, upper outcrop is to left. Foreground rocks are part of G174 exposure.
1/9/2006	G175-C41	SHEN_C41_G_20060109_008.jpg	50	Butler, Eric	View upslope toward G172-174. G174 is at upper left, G173 is at upper center (note sheer lower cliff), and G172 is at upper right
1/9/2006	G175-C41	SHEN_C41_G_20060109_009.jpg	0	Butler, Eric	Open rock face at G175, taken from top of protruding exposure.
1/9/2006	G175-C41	SHEN_C41_G_20060109_010.jpg	200	Butler, Eric	View down from top of G175 exposure toward large boulder pile at G176; these appear to be bedrock but are all loose boulders except foreground rock face
1/9/2006	G175-C41	SHEN_C41_G_20060109_011.jpg	20	Butler, Eric	Joints and foliation controlling weathering of bedrock, south edge of G175 exposure (excuse finger over lens)
1/9/2006	G176-C41	SHEN_C41_G_20060109_012.jpg		Butler, Eric	Protruding boulder capping thick boulder pile at G176; this is the prominent white piece seen in Photo 10
1/9/2006	G172-C41	SHEN_C41_G_20060109_013.jpg	30	Butler, Eric	Closeup of G175-176 exposures, seen from the south
1/9/2006	G172-C41	SHEN_C41_G_20060109_014.jpg	30	Butler, Eric	Wide view of site, with G175 and 176 in center background

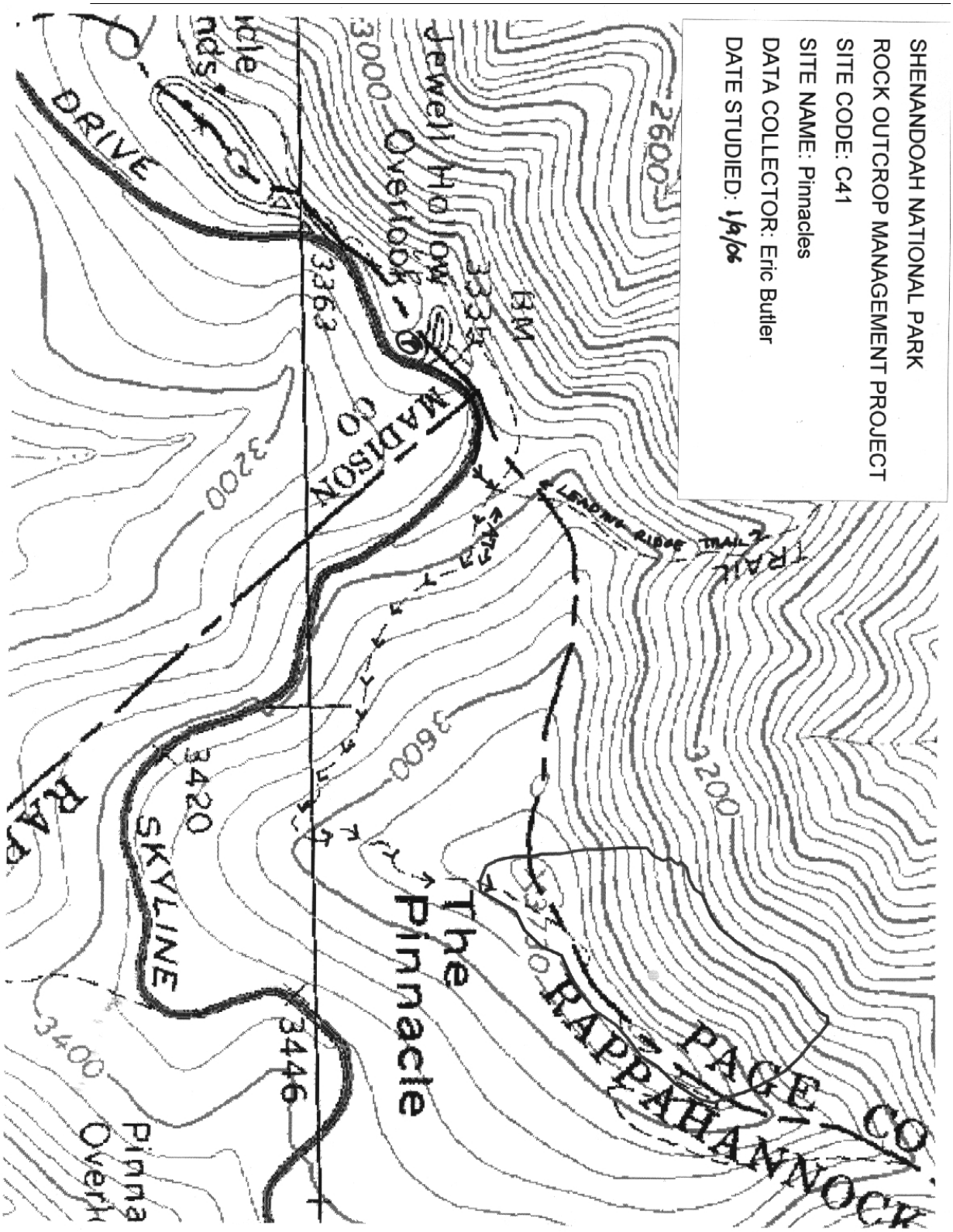
C41 - Pinnacles (continued...)

Detail sketch map

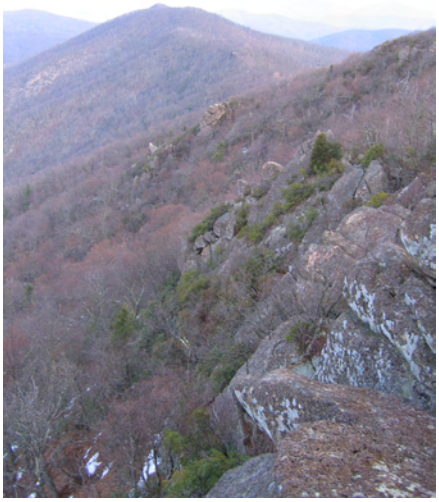


C41 - Pinnacles (continued...)

Area sketch map



C41 - Pinnacles (continued...)



SHEN_C41_G_20060109_001.jpg Azmuth: 30

View north showing rest of site; G175 and 176 exposures are at center (background)



SHEN_C41_G_20060109_002.jpg Azmuth: 180

Mildly impacted ground between G172 and AT (in background)



SHEN_C41_G_20060109_003.jpg Azmuth: 305

View from upper level of this exposure toward top of lower cliff



SHEN_C41_G_20060109_004.jpg Azmuth:

Occurrence of Hupersia on north side of G173 exposure, halfway down

C41 - Pinnacles (continued...)



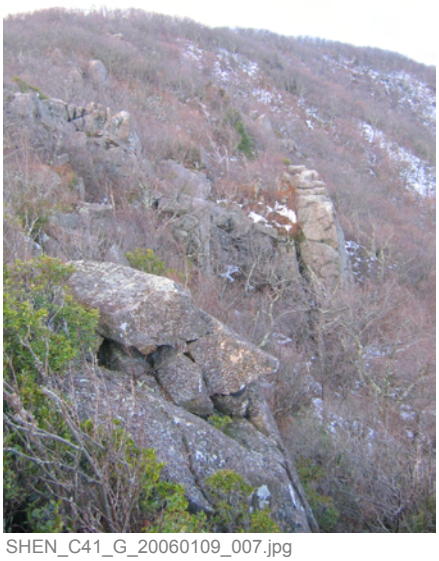
SHEN_C41_G_20060109_005.jpg Azmuth:

Occurrence of Hupersia growing on lower cliff face below G173



SHEN_C41_G_20060109_006.jpg Azmuth:

Prominent foliation and joint on south side of G173 exposure (notebook for scale)



SHEN_C41_G_20060109_007.jpg Azmuth: 250

View south of G173; lower cliff is to right, upper outcrop is to left. Foreground rocks are part of G174 exposure.



SHEN_C41_G_20060109_008.jpg Azmuth: 50

View upslope toward G172-174. G174 is at upper left, G173 is at upper center (note sheer lower cliff), and G172 is at upper right.

C41 - Pinnacles (continued...)



SHEN_C41_G_20060109_009.jpg Azmuth: 0

Open rock face at G175, taken from top of protruding exposure.



SHEN_C41_G_20060109_010.jpg Azmuth: 200

View down from top of G175 exposure toward large boulder pile at G176; these appear to be bedrock but are all loose boulders except foreground rock face.



SHEN_C41_G_20060109_011.jpg Azmuth: 20

Joints and foliation controlling weathering of bedrock, south edge of G175 exposure (excuse finger over lens)



SHEN_C41_G_20060109_012.jpg Azmuth:

Protruding boulder capping thick boulder pile at G176; this is the prominent white piece seen in Photo 10

C41 - Pinnacles (continued...)



SHEN_C41_G_20060109_013.jpg Azmuth: 30

Closeup of G175-176 exposures, seen from the south



SHEN_C41_G_20060109_014.jpg Azmuth: 30

Wide view of site, with G175 and 176 in center background

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C42 - Powell Gap cliff

Site Code: C42
Site Name: Powell Gap cliff
Data Collector Butler, Eric
Date Studied: 03-Aug-05

Polygon Centroid: **E:** 710263 **N:** 4243858
UTM (Zone 17 NAD83)
Dimensions (m): 140 x 290 (GIS est.)
Elevation Range (ft): 2400 to 2600

Physical Characteristics

Location Acces

Park at Powell Gap, just north of Milepost 70. There is no lot here, but ample room is available on both shoulders of Skyline Drive. Follow the Appalachian Trail (AT) south from the gap for about 800m, climbing about 300', until trail levels off at the top of a level line of small cliffs. Just beyond a small open overlook, where the AT bends southwest and leaves the cliffs behind, a wide break in the cliffs creates a chute-like slope that provides good access to the lower rock exposures. An excellent overall view of the site can be found by looking south from Bacon Hollow Overlook, just north of Powell Gap.

Physical Description:

This site is contained within a single steep slope, which levels out noticeably above the site. The dominant features are a line of cliffs running horizontally just below the Appalachian Trail, 5-10m high, and two large rock knobs that protrude from the slope just below these cliffs. There are numerous other small rock exposures scattered along the surrounding slopes, but these are mostly to fully forested. Access becomes more difficult at lower elevations, as the slope steepens, becomes looser and rockier, and the vegetation gets much thicker. Most open rock exposures are found near the top of the site, however.

Vegetation: Moderate

The site is almost completely forested, and only the uppermost portions of the largest rock exposures are open. The undergrowth is much thicker toward the base of the site, and navigation can be difficult below the level of the two large rock knobs. Above this level, around most of the open rocks, undergrowth is less dense and not problematic.

Human Effects

Impacts: Mild

Although the Appalchian Trail (AT) runs along the top of the upper cliffs, there is only one small cleared overlook, and the rest of the cliffs are forested and vegetated. There is no evidence that people leave the trail and explore downslope, nor any compelling reason why they should want to. The overlook is certainly impacted, the bare rock a noticeable contrast to the thickly vegetated surroundings, but it is a very small portion of the site.

Access Moderate

The site is a relatively easy hike from Skyline Drive, only 800m and 300' climb on a trail that is well-maintained and not overly steep. There is no parking lot or any indication along the Drive that visitors should hike here; the AT crossing is barely noticeable either. However, a visitor at the overlook mentioned that a guide to short hikes along the Drive specifically mentions Powell Gap as a good short hike to a nice view, and so this may encourage visitation. While the site is clearly visible from nearby Bacon Hollow Overlook, the rock exposures are not particularly noticeable or dramatic among the thick, surrounding forest.

Geologic Characteristics

Lithology: **Rock Type** Swift Run metasediments

This site is underlain entirely by metasediments of the Swift Run Formation. This unit is found intermittently between the basement gneisses of the old Pedlar Formation, and the basaltic lavas of the Catoctin Formation. The rocks are primarily composed of interbedded phyllite and sandstone, representing stream, river, and lake sediments deposited on the paleotopography prior to eruption of the Catoctin basalt flows. The phyllite is generally silver-grey and shiny, resembling fish-scales, while the sandstones are variable shades of brown and appear rough and/or grainy. These sediments have clearly been metamorphosed, as the phyllitic texture has developed from original clay minerals, and most of the sand grains appear fused together. The rocks are finely layered, which results in extremely ledgy exposures.

C42 - Powell Gap cliff (continued...)

Structure:

In many places the rocks appear almost "wrinkled", which is the effect of pervasive small-scale folding which can be seen in cross section. These folds look like waves or rumpled blankets, and are much more evident in the phyllitic layers as compared to the relatively massive and resistant sandstone layers.

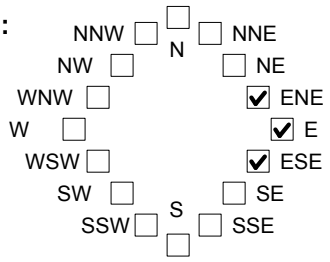
Other:

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	50.0	30.0	0.0	20.0	0.0	100
Max relief(m):	10	15	0	1	0	

Maximum Slope: 40 **Texture:** Rough

Aspects:



Setting:

This is a fairly unusual exposure; the Swift Run Formation is at least 200' thick here, one of the thicker exposures in the park, implying a deep basin in which these sediments were originally deposited. The top of the formation occurs right at the break in slope above the cliffs, where the landscape gently slopes upward to the south; this much smoother, gentler landscape is underlain by the lowest basalt flow in the Catoctin Formation. Below the site boundary, the gneisses of the old Pedlar Formation eventually appear. The finely layered sediments of this formation create very ledgy exposures, and even the cliffs are made up mostly of consecutive ledges. There is no clear explanation for the occurrence of the two very obvious rock knobs protruding from the slope; these must represent some especially resistant pocket within the sediments which have withstood the erosion of material around them, though no unique lithologies were observed here.

Stability: Moderate

The finely layered nature of the rock means that it is eroding into many small, platy pieces which can create a fairly unstable surface. The steeper slopes below the major exposures, while not quite talus, contain a great deal of small rock debris that slide very easily underfoot. This is balanced by the stability of the bedrock itself, although this also can crack and move in places.

GPS Points

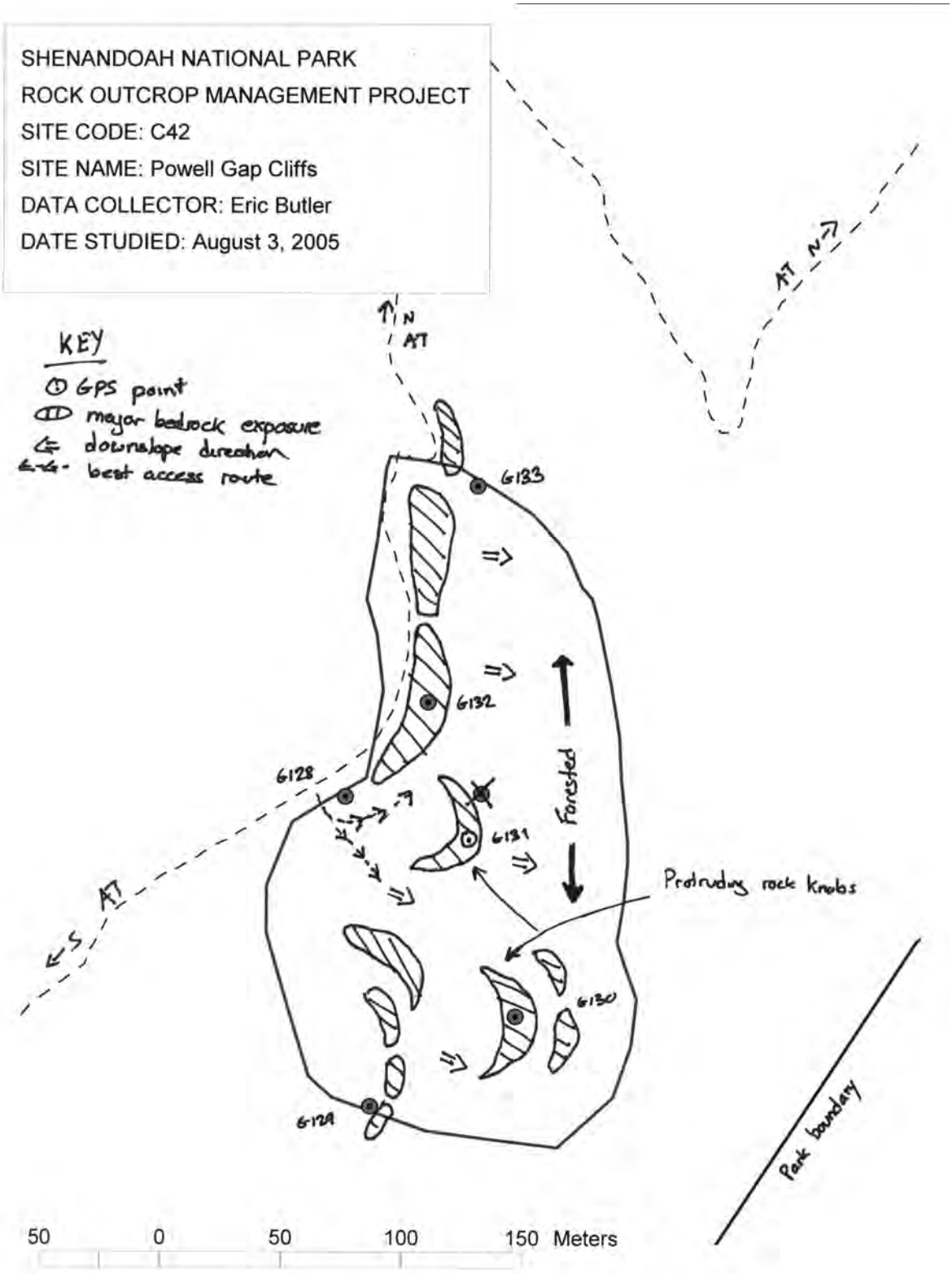
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
8/3/2005	G128-C42	710219	4243860	2600	Curve in AT, at top of accessable chute leading to lower slopes
8/3/2005	G129-C42	710229	4243731	2600	Top of cliffs at south end of site
8/3/2005	G130-C42	710289	4243769	2540	Top of southern rock knob
8/3/2005	G131-C42	710275	4243861	2560	Top of northern rock knob – not a very accurate point
8/3/2005	G132-C42	710253	4243899	2600	Overlook along AT
8/3/2005	G133-C42	710273	4243990	2560	Small chute at north end of site leading to lower slopes

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
8/3/2005	G132-C42	SHEN_C42_G_20050426_008.JPG		Butler, Eric	Folded phyllite exposure creating many small ledges
8/3/2005		SHEN_C42_G_20050426_010.JPG		Butler, Eric	Looking southwest at site from Bacon Hollow Overlook – note two prominent knobs
8/3/2005	G130-C42	SHEN_C42_G_20050803_001.jpg	345	Butler, Eric	Top of southern knob, showing ledgy rocks & vegetation
8/3/2005	G132-C42	SHEN_C42_G_20050803_002.jpg	20	Butler, Eric	Base of cliff at G132, mostly overgrown but more open above
8/3/2005	G133-C42	SHEN_C42_G_20050803_003.jpg	180	Butler, Eric	Contact between sandstone and phyllite, showing difference in structure & weathering

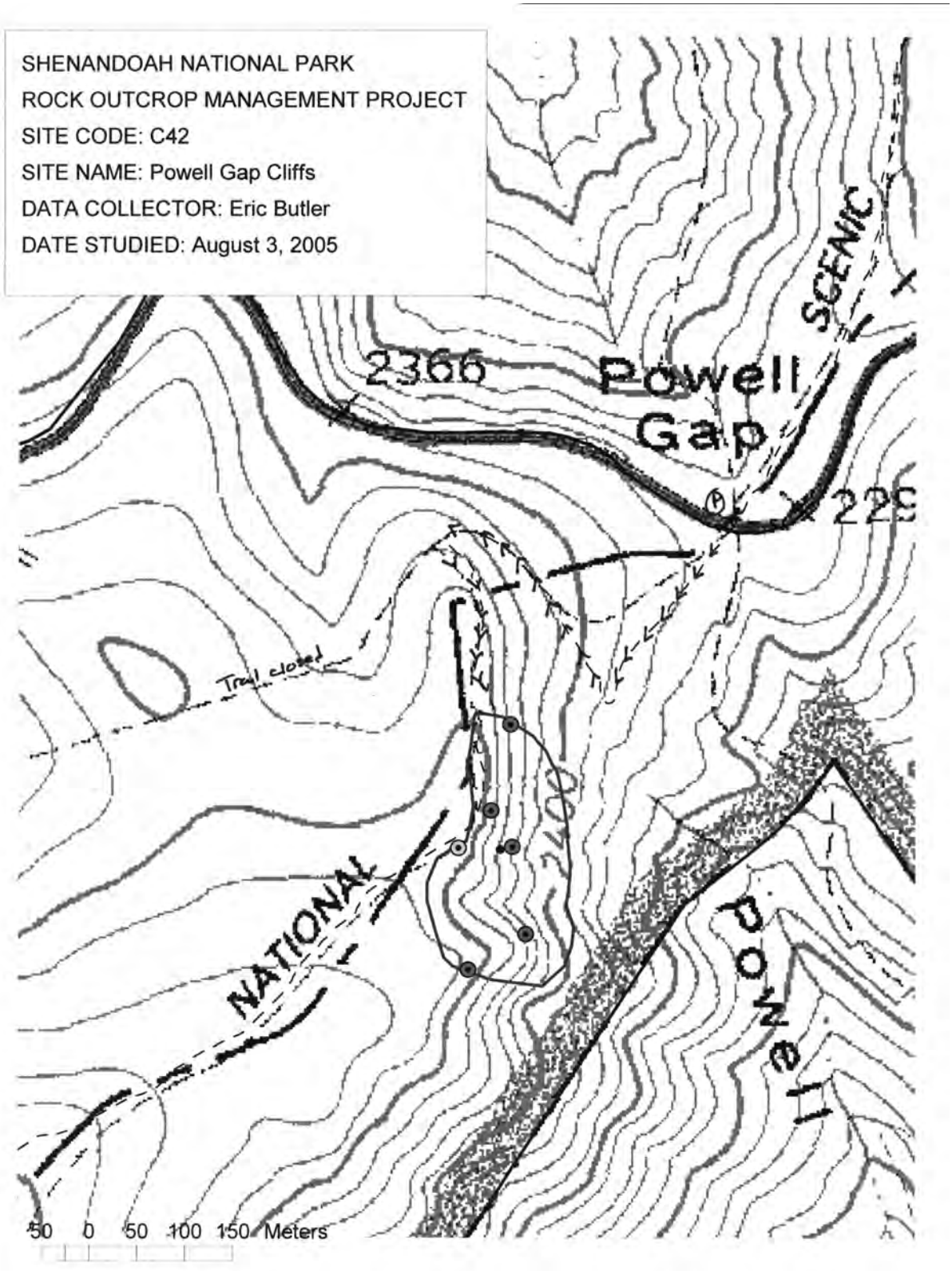
C42 - Powell Gap cliff (continued...)

Detail sketch map



C42 - Powell Gap cliff (continued...)

Area sketch map



C42 - Powell Gap cliff (continued...)



SHEN_C42_G_20050426_008.JPG Azmuth:

Folded phyllite exposure creating many small ledges



SHEN_C42_G_20050426_010.JPG Azmuth:

Looking southwest at site from Bacon Hollow Overlook – note two prominent knobs



SHEN_C42_G_20050803_001.jpg Azmuth: 345

Top of southern knob, showing ledgy rocks & vegetation



SHEN_C42_G_20050803_002.jpg Azmuth: 20

Base of cliff at G132, mostly overgrown but more open above

C42 - Powell Gap cliff (continued...)



SHEN_C42_G_20050803_003.jpg Azmuth: 180

Contact between sandstone and phyllite, showing difference in structure & weathering

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C44 - Rocky Mountain

Site Code: C44
Site Name: Rocky Mountain
Data Collector Butler, Eric
Date Studied: 28-Feb-06

Polygon Centroid: **E:** 703671 **N:** 4241699
UTM (Zone 17 NAD83)
Dimensions (m): 140 x 500 (GIS est.)
Elevation Range (ft): 2720 to 2820

Physical Characteristics

Location Acces

About 1.9km (trail distance) from Skyline Drive. Park at Brown Mountain Overlook (just north of Milepost 77) and take Brown Mt trail to west. Trail descends about 500' into saddle before climbing back up to reach a large swath of open rock. The site boundary begins at the first small exposure of open quartzite reached on the trail; continue on the trail another 300m to reach the larger exposures central to the site.

Physical Description:

This site consists of open rock exposures composing and surrounding a central knob on the larger ridge that makes up Rocky Mountain. When viewed from Skyline Drive, these exposures appear to form a large swatch of sheer cliffs and exposures that extend far down the slope, but the site encompasses only the uppermost portions of this open rock. Within the site, there are two parallel ridges with a shallow saddle between, all oriented NNE-SSW, capped by highly fractured rock and abundant talus. The central ridge is especially dramatic, with rock faces dropping away on both sides, creating a long, narrow rib of rock that extends well down the slope outside the site boundary. West of this, another similar rib of rock drops away to the west, creating a cliff line through the woods that is partially forested and mostly hidden from view (from the east), except for one very prominent spire which extends up to 15m of sheer rock above the forest floor. The central rock ridge extends far along the site boundary to the north, before eventually crumbling into a steep, linear talus slope that extends for the rest of the site, partially forested.

Vegetation: Dense

Typical of quartzite areas in the South District, the vegetation here is a thick tangle of undergrowth, which is almost impassable in places. Fortunately, most of the exposure areas are relatively accessible from the trail, with the exception of the G215 cliff and spire.

Human Effects

Impacts: Moderate

Although much of the site appears pristine, the trail runs straight through the largest area of open rock (G214), and significant impact is present here. Although social trails are difficult to preserve on open rock, this area contains a great deal of gravel and displaced sediment that is not seen elsewhere, and plant growth seems much diminished compared to areas farther from the trail. It appears clear that visitors have been exploring this rock rib off-trail, which is unsurprising given the dramatic views and accessibility of this exposure. However, rock areas not directly reached by the trail show no sign of impact. Although this trail likely doesn't receive a great deal of use, the views available from this point and the relatively fragile nature of the exposure means that any impact will be focused here.

Access Difficult

The hike in covers about 2km of trail distance and a significant amount of elevation gain and loss, much of which is accomplished in short, steep sections of trail. Reaching this site is not a casual hike from Skyline Drive, although the prominent visibility of the G214 exposure from the overlook may be a draw.

Geologic Characteristics

Lithology: **Rock Type** Quartzite

The open rock within this site is entirely white quartzite from the Erwin Formation, consisting of clear-white quartz sand grains that have been fused together by metamorphism into a very solid, resistant mass. The rock contains abundant skolithos fossils, preserved worm burrows that form a linear, tube-like structure within the rock. These are not present everywhere, but are locally abundant. Where they are not present, the rock has very little internal structure, preserving few original sedimentary features like bedding.

C44 - Rocky Mountain (continued...)

Structure:

The bedrock here is very heavily fractured, generally in a random pattern. Where skolithos are present, the fractures tend to follow the orientation of the burrows, much like perforations in paper (this is common in the Erwin). Skolithos form perpendicular to the orientation of the surrounding sediments (in flat-lying beds of sand, the worms burrow vertically), making the fossils a very good indicator of bedrock orientation. Within this site, all skolithos burrows are oriented near-horizontally, suggesting that the bedrock layers here are tilted about 90 degrees to near-vertical. This is difficult to confirm through other means, as there are few clear bedding layers or other sedimentary features to compare with, but the skolithos orientations are telling.

Other:

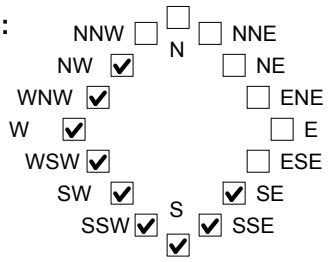
At the base of the large rock spire present at G215, there is a very interesting feature within the rock. The lower two meters of the vertical (western) face contain a series of linear, rounded structures that look like folds in a blanket. In cross-section, these appear to be preserved ripple marks, or more accurately a cast of preserved ripple marks, formed by sediments that covered the original ripples and solidified to hold their shape. This find supports the idea that the bedrock here is vertical, as does the presence of horizontal skolithos burrows immediately "above" (stratigraphically) the ripples. In theory, these ripples ought to extend the length of the spire, since the entire west face of the rock would thus be the same stratigraphic level, but perhaps subtle erosion has removed the ripples from the rest of the rock and left only those most protected at the base.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	20.0	30.0	0.0	30.0	20.0	100
Max relief(m):	15	15	0	2	5	

Maximum Slope: 30 **Texture:** Fractured

Aspects:



Setting:

The bedrock here is clearly Erwin quartzite (as opposed to Hampton quartzite), demonstrated by the white color and abundant well-preserved skolithos burrows. In addition, while hiking in to the site from Skyline Drive, the trail crosses a zone of blue-grey quartzite that is clearly Hampton Formation, and clearly distinct from the rocks within the site.

The greatest question here regards the orientation of the bedrock, and how that affects the unusual nature of the open rock exposures within this site. The rocks of the Chilhowee Group are commonly quite deformed in the South District, containing numerous large-scale folds (one of the best of which is just SW of here, within the C64 Brown Mountain site) and other deformations. At first glance the bedrock here appears to be horizontal, thus creating the sheer cliffs and exposures within the cross-section of the original sedimentary layering, and the ledges parallel to the original layering (this is the common pattern in this area). However, the abundance of horizontally oriented skolithos burrows argues persuasively that the rocks here have been tilted 90 degrees to a near-vertical orientation.

This orientation helps explain the somewhat unusual exposure pattern here, that of several parallel sheer, narrow, protruding ribs/ridges of rock, with dropoffs on both sides. Each protruding rib likely correlates to an individual layer of resistant quartzite, which when overturned produces the narrow rib seen here. Thus, the usual geomorphic pattern is inverted here; the cliffs/dropoffs are actually formed along bedding planes (or at least parallel to them), while the ledges are formed on the cross-sections of individual layers, thus exposing the horizontal skolithos. In between these ribs may be less resistant quartzite, or possibly a less resistant rock type such as phyllite or siltstone (these lithologies are common within the Erwin, but are rarely found exposed as they are far less resistant to erosion than the quartzites). At a larger scale, these rock exposures almost certainly connect to the thick, uniform quartzite cliffs a short distance away on Brown Mountain, and so the former theory seems more likely (that these are one or two very thick quartzite beds, variably susceptile to erosion, rather than 3 or more thin, separate beds). The thick deposits of talus filling the saddles between ribs precludes any further investigation of this question.

The presence of apparent ripple marks on a vertical face at G215 supports the vertical interpretation, although these structures are unusually large for ripple marks, and this is a tentative identification. It is not clear what else they could be, however. It is not clear why the ripples do not extend up the rest of the cliff (originally horizontal and all the same bedding plane), but perhaps erosion has removed them higher up, or perhaps they did not exist there (i.e. a transition from water to shore is preserved here).

C44 - Rocky Mountain (continued...)

Stability: Loose

The bedrock here is heavily fractured, and often creates partially free-standing blocks or spires that may be unstable. In places, fractures are partially filled or hidden by talus and soil, and may be difficult to spot (making unstable bedrock blocks harder to identify). The surrounding slopes are mostly loose talus.

GPS Points

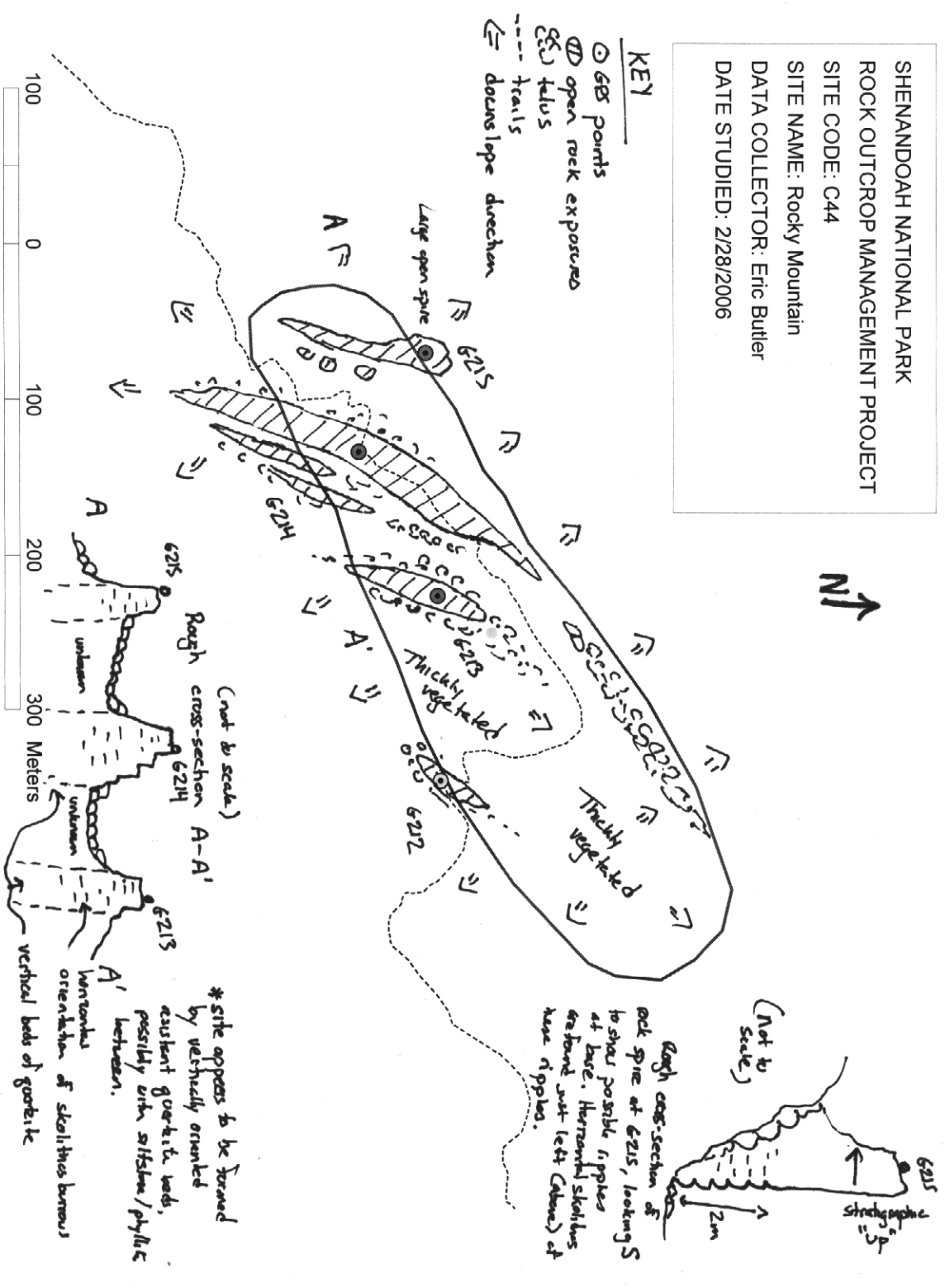
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
2/28/2006	G212-C44	703767	4241667	2760	First occurrence of open rock along trail from SD
2/28/2006	G213-C44	703647	4241665	2820	Top of semi-forested ridge capped by talus and fractured bedrock
2/28/2006	G214-C44	703554	4241615	2820	Open area along trail, atop large exposed bedrock ridge
2/28/2006	G215-C44	703491	4241658	2780	Top of large, protruding rock spire along cliffline hidden in woods

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
2/28/2006		SHEN_C44_G_20060228_001.jpg		Butler, Eric	View of site from overlook along SD
2/28/2006	G212-C44	SHEN_C44_G_20060228_002.jpg	235	Butler, Eric	Semi-open rock area along trail
2/28/2006	G212-C44	SHEN_C44_G_20060228_003.jpg	210	Butler, Eric	Semi-open rock area along trail
2/28/2006	G213-C44	SHEN_C44_G_20060228_004.jpg	280	Butler, Eric	Heavily fractured bedrock capping wooded ridge at G213
2/28/2006	G213-C44	SHEN_C44_G_20060228_005.jpg	200	Butler, Eric	Narrow, linear talus field in saddle between two ridges, just west of G213
2/28/2006	G214-C44	SHEN_C44_G_20060228_006.jpg	220	Butler, Eric	Trail leading through open rock on top of large, exposed ridge
2/28/2006	G214-C44	SHEN_C44_G_20060228_007.jpg		Butler, Eric	Skolithos burrows, oriented horizontally, suggesting that the bedrock here is oriented vertically
2/28/2006	G214-C44	SHEN_C44_G_20060228_008.jpg		Butler, Eric	Close-up of skolithos burrows at G214
2/28/2006	G214-C44	SHEN_C44_G_20060228_009.jpg	200	Butler, Eric	View southwest along top of protruding bedrock ridge, 50m south of G214. Rocks are likely vertical here.
2/28/2006	G214-C44	SHEN_C44_G_20060228_010.jpg	20	Butler, Eric	View NE back up protruding rock ridge, toward G214
2/28/2006	G214-C44	SHEN_C44_G_20060228_011.jpg	160	Butler, Eric	Large column of rock protruding from cliff line hidden in woods; rocks are likely vertical here
2/28/2006	G215-C44	SHEN_C44_G_20060228_012.jpg		Butler, Eric	Closeup of unusual structure at base of rock column; may be casts of large ripple marks in sandstone, now oriented vertically

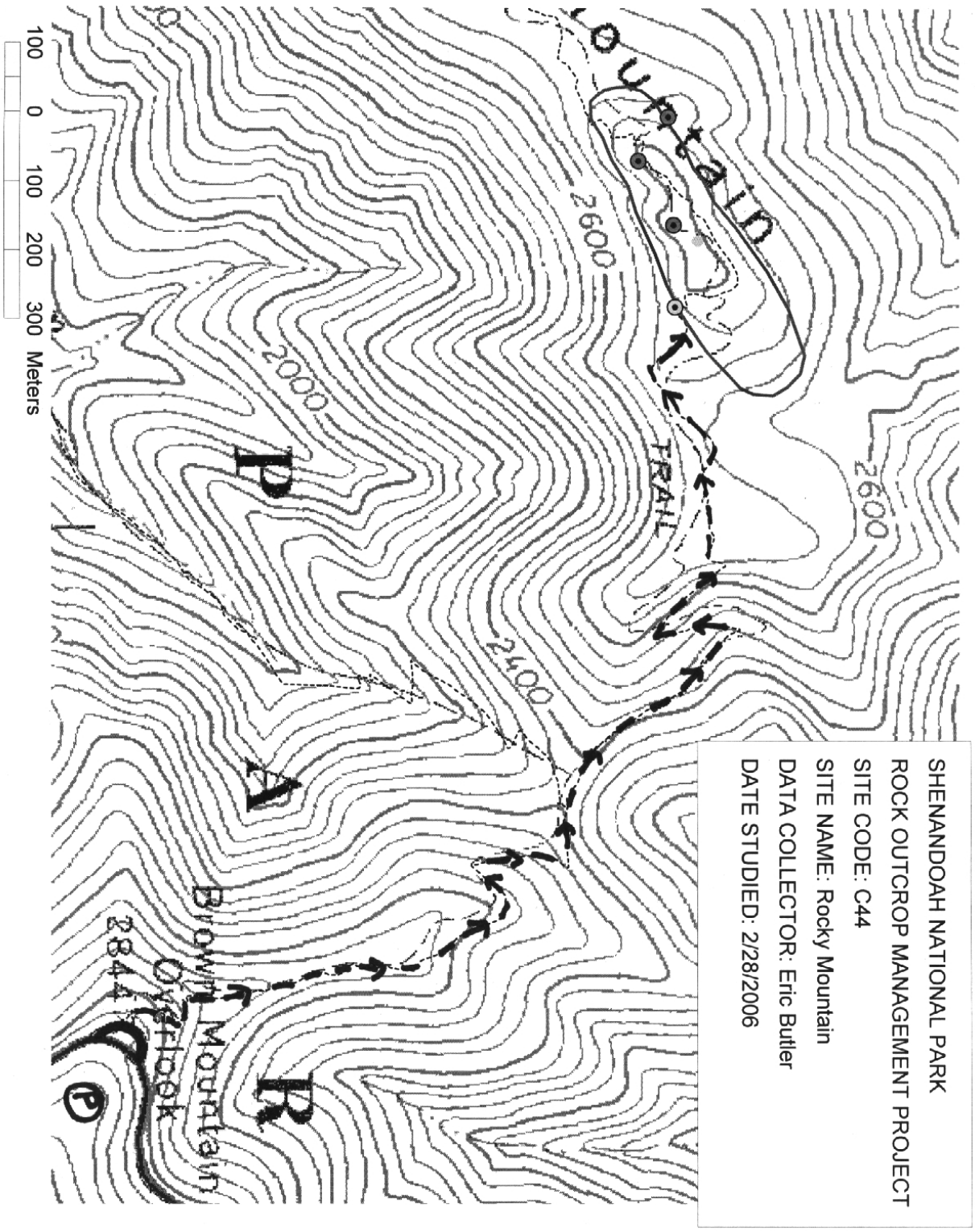
C44 - Rocky Mountain (continued...)

Detail sketch map



C44 - Rocky Mountain (continued...)

Area sketch map



C44 - Rocky Mountain (continued...)



SHEN_C44_G_20060228_001.jpg Azmuth:

View of site from overlook along SD



SHEN_C44_G_20060228_002.jpg Azmuth: 235

Semi-open rock area along trail



SHEN_C44_G_20060228_003.jpg Azmuth: 210

Semi-open rock area along trail



SHEN_C44_G_20060228_004.jpg Azmuth: 280

Heavily fractured bedrock capping wooded ridge at G213

C44 - Rocky Mountain (continued...)



SHEN_C44_G_20060228_005.jpg Azmuth: 200

Narrow, linear talus field in saddle between two ridges, just west of G213



SHEN_C44_G_20060228_006.jpg Azmuth: 220

Trail leading through open rock on top of large, exposed ridge



SHEN_C44_G_20060228_007.jpg Azmuth:

Skolithos burrows, oriented horizontally, suggesting that the bedrock here is oriented vertically



SHEN_C44_G_20060228_008.jpg Azmuth:

Close-up of skolithos burrows at G214

C44 - Rocky Mountain (continued...)



SHEN_C44_G_20060228_009.jpg Azmuth: 200

View southwest along top of protruding bedrock ridge, 50m south of G214. Rocks are likely vertical here.



SHEN_C44_G_20060228_010.jpg Azmuth: 20

View NE back up protruding rock ridge, toward G214



SHEN_C44_G_20060228_011.jpg Azmuth: 160

Large column of rock protruding from cliff line hidden in woods; rocks are likely vertical here



SHEN_C44_G_20060228_012.jpg Azmuth:

Closeup of unusual structure at base of rock column; may be casts of large ripple marks in sandstone, now oriented vertically.

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C45 - Sawlog Ridge

Site Code: C45
Site Name: Sawlog Ridge
Data Collector Butler, Eric
Date Studied: 23-Aug-05

Polygon Centroid: **E:** 696571 **N:** 4223520
UTM (Zone 17 NAD83)
Dimensions (m): 230 x 330 (GIS est.)
Elevation Range (ft): 1400 to 1880

Physical Characteristics

Location Acces

This site is best accessed from outside the park. On the east side of the South District, take Virginia 810 to White Hall, then turn west onto 614. This road leads to Charlottesville Reservoir, at the junction of the North and South Forks of the Moormans River. Park in the open gravel area just west of the reservoir. Cross the North Moormans River just south of the parking area, then follow South Moormans Fire Road 600m southwest to a large, rock-filled channel descending the slope; this channel leads directly to the lower clearing at G148. Follow the channel upslope for 300' vertical to reach the park boundary, then another 100' vertical to reach the first open clearing. Although the road and lower slopes here are not within the park, crossing these lands is not an issue.

Physical Description:

This site consists of two open clearings within an otherwise forested area on a uniformly steep slope. The lower clearing is a narrow, vertically oriented opening dominated by smooth, sloping rock faces and some loose rock, covered by thick, grassy vegetation. The upper clearing is a long, horizontally oriented opening that stretches at least 100m across the slope, also underlain by smooth rock faces and occasional loose rock. The vegetation is also thick and grassy here, though it appears to be different species dominating the two areas. Aerial photos suggest that there may be another, similar open area above this upper clearing, but this was not visited in person. There are no bare talus slopes like those found in other areas of the park, but areas of loose rock do form a noticeable portion of the clearings, generally composed of small clasts and held in place by soil and vegetation.

Vegetation: Open

The surrounding forest here consists of tall trees and very little undergrowth, very easy to traverse. Within the open clearings, the grasses and other vegetation are thick, but do not impede movement. Occasional patches of poison ivy provided the only barrier to access anywhere within the site.

Human Effects

Impacts: Pristine

There is no evidence that people have visited this site. The vegetation is lush and undisturbed, and no trails lead near or within sight of the open areas

Access Remote

This site is 400' vertical above the nearest trail, and is not visible from anywhere accessible to visitors. Reaching it requires a long hike up steep terrain, with no visible reward.

Geologic Characteristics

Lithology: **Rock Type** Greenstone

The site is underlain by Catoctin metabasalt. In the lower clearing the basalt is fairly coarse-grained, with most individual crystals visible to the naked eye, containing a great deal of chlorite. This mineral helps define the very prominent cleavage (see STRUCTURE) present here. In the upper clearing, the basalt is similar, though a bit finer-grained, also with very prominent cleavage. Except for the cleavage, the basalt here is quite homogenous and solid.

Structure:

There is a pervasive cleavage in the basalts at both clearings, which dips southeast between 30-60 degrees. This structure is defined by the ubiquitous chlorite within the rock, which is a secondary mineral grown from alteration of the original basalt during metamorphism. While this is common, the chlorite is unusually coarse-grained and dominant here. There are virtually no other visible structures within the rock, such as fractures or jointing.

C45 - Sawlog Ridge (continued...)

Other:

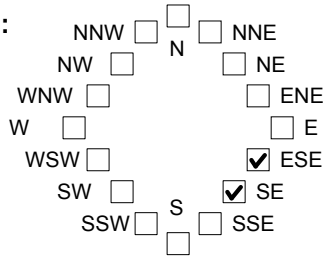
The forested slope between the two clearings is mostly underlain by a thick sequence of "boundary rock"; an assortment of vesicular basalt, breccia, purple-silver slate/phyllite, quartz-pebble conglomerate, and other mixed metabasaltic/metasedimentary rocks that define the boundary between two lava flows. These rocks, which are visually quite distinguishable from the regular flow basalt that underlies the open clearings, represent an unusually thick (up to 80'?) sequence; such a zone between two flows rarely exceeds a few meters in thickness. Clasts and talus deposits of this rock are extremely common along the surrounding forest slopes. Another unit of similar rock must be located above the upper flow, as similar talus is found within that slope, but no bedrock exposures were found.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	0.0	10.0	50.0	10.0	30.0	100
Max relief(m):	0	2	5	1	5	

Maximum Slope: 40 **Texture:** Smooth

Aspects:



Setting:

This site, and the very similar Goat Ridge site (C18) nearby, are unusual greenstone sites in their aspect and physical character. Most open greenstone sites in the park are rough, fractured rock exposures, varying from sheer cliffs to protruding outcrops to large-clast talus slopes. Here, the greenstone creates smooth, rounded rock faces whose physical appearance is much more typical of granitic areas such as Old Rag Mountain or Mary's Rock. Several factors combine to produce this unique effect.

Through much of the Central and North Districts of the park, the Catoctin Formation caps the mountains, dipping gently eastward to produce a geomorphic pattern in which western slopes are steep and/or cliffy, while eastern slopes follow the surfaces of flows and are generally smooth and gently sloping, with little to no bedrock exposure. In the South District, however, this pattern begins to change, as the Catoctin gradually occurs lower in the topography, the overlying metasedimentary units begin to cap the mountains, and the entire sequence begins to dip west instead of east. In the Moormans River area, this results in the Catoctin being almost entirely covered to the west, instead being exposed along the eastern base of the mountains where its western dip protrudes from the slope.

This change is exacerbated by the unusual erosional pattern of the Moormans River, which has incised deep, narrow valleys along the trend of the mountains rather than across (as most rivers do), creating even steeper, southeast-facing slopes along the valleys of the North and South Forks of the Moormans River. One explanation for this trend may be the presence of a small fault creating a zone of fractured or otherwise weakened rock along which the rivers have eroded.

The dominant internal structure here is the pervasive cleavage, which gives the greenstone a smooth, platy texture. The cleavage planes dip southeast, which is consistent with cleavage orientation through most of the park. However, the steep slopes underlain by greenstone generally face west, and so in these areas the southeastern dip of the cleavage produces sharp, jagged, upthrust-looking outcrops and cliffs. In the Moormans River area, this same cleavage orientation is instead nearly parallel with the general orientation and angle of the slope, and so produces exposures that are smooth, rounded, platy surfaces following the cleavage planes. In the absence of common fractures or joints, the resulting morphology is likely very difficult for soil to stick to, or trees to root into, thus creating areas that remain partially to fully open. This correlation is demonstrated best at Goat Ridge, where one clearing begins on an aligned slope, which then wraps west into a steep side drainage. The rock exposures continue, but begin to take on a much more cliff-like, protruding character as soon as the slope orientation has changed significantly.

A final factor may be soil movement or slumping. In a terrain underlain by such smooth rock slopes, any soil that forms may not be entirely stable. During large storms, the soil could liquefy and slump downslope, creating areas of clear, open bedrock that may remain open rather than reforming new soil. This is a possible explanation for why small clearings occur in certain places only, rather than across an entire slope. While no direct evidence of such a process could be observed in the field, it is a distinct possibility. Overall, open clearings appear to occur where the cleavage orientation and the slope orientation are most aligned, creating smooth rock faces that do not hold enough soil or talus to become and/or remain fully forested.

At both the Goat Ridge and Sawlog Ridge sites, open clearings appear to occur at two distinct topographic levels. These seem to correspond to two similar, highly cleaved greenstone lava flows, separated by a zone of volcanic breccia and metasediments

C45 - Sawlog Ridge (continued...)

up to 80' thick. This intermediate "boundary zone" does not contain cleavage (due to its very different composition), and in most places is much more rough, fractured, and rugged than the smooth, platy cleaved greenstones above and below it (thus not producing open rock faces).

Stability: Stable

The rock is quite solid, and where talus is present, it is generally small and held in place by vegetation or soil. The surrounding forest slopes seem more likely to be mobile than anything in the open clearings.

GPS Points

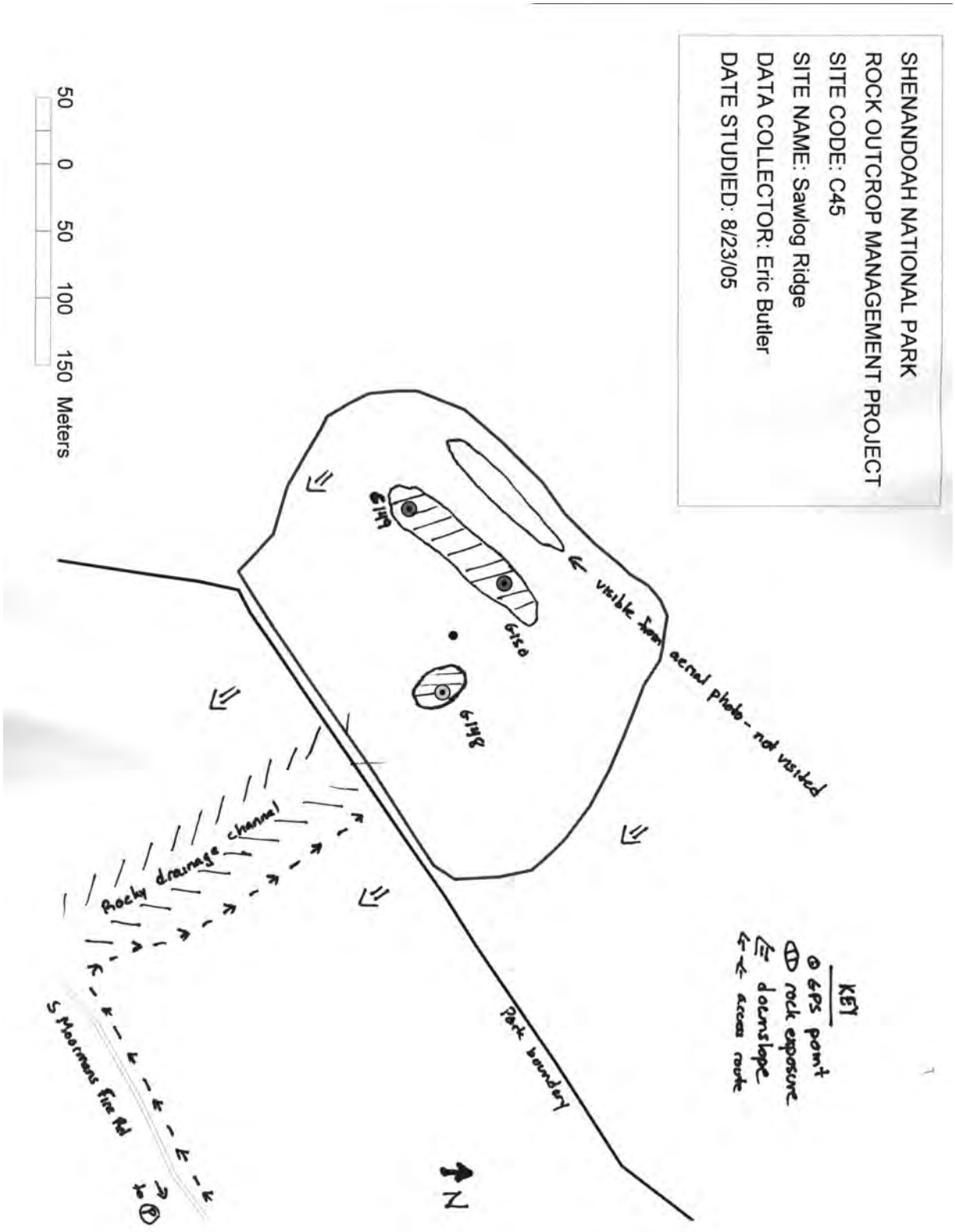
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
8/22/2005	G148-C45	696614	4223513	1560	Northern edge of lower clearing, halfway up slope
8/22/2005	G149-C45	696476	4223487	1760	SW end of upper clearing
8/22/2005	G150-C45	696532	4223559	1760	NW end of upper clearing

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
8/23/2005	G148-C45	SHEN_C45_G_20050822_001.jpg	220	Butler, Eric	View across lower clearing, showing steep slope and vegetated rock faces
8/23/2005	G148-C45	SHEN_C45_G_20050822_002.jpg	0	Butler, Eric	Closeup of pervasive cleavage in rock, dipping southeast with slope
8/23/2005		SHEN_C45_G_20050822_003.jpg		Butler, Eric	Closeup of conglomerate above lower clearing, showing large quartz pebbles
8/23/2005	G148-C45	SHEN_C45_G_20050822_004.jpg	340	Butler, Eric	View upslope from center of lower clearing, showing thick grasses on rock faces
8/23/2005	G149-C45	SHEN_C45_G_20050822_005.jpg	40	Butler, Eric	View across slope at upper clearing
8/23/2005	G150-C45	SHEN_C45_G_20050822_006.jpg	205	Butler, Eric	View across slope at upper clearing, site of dried-up spring

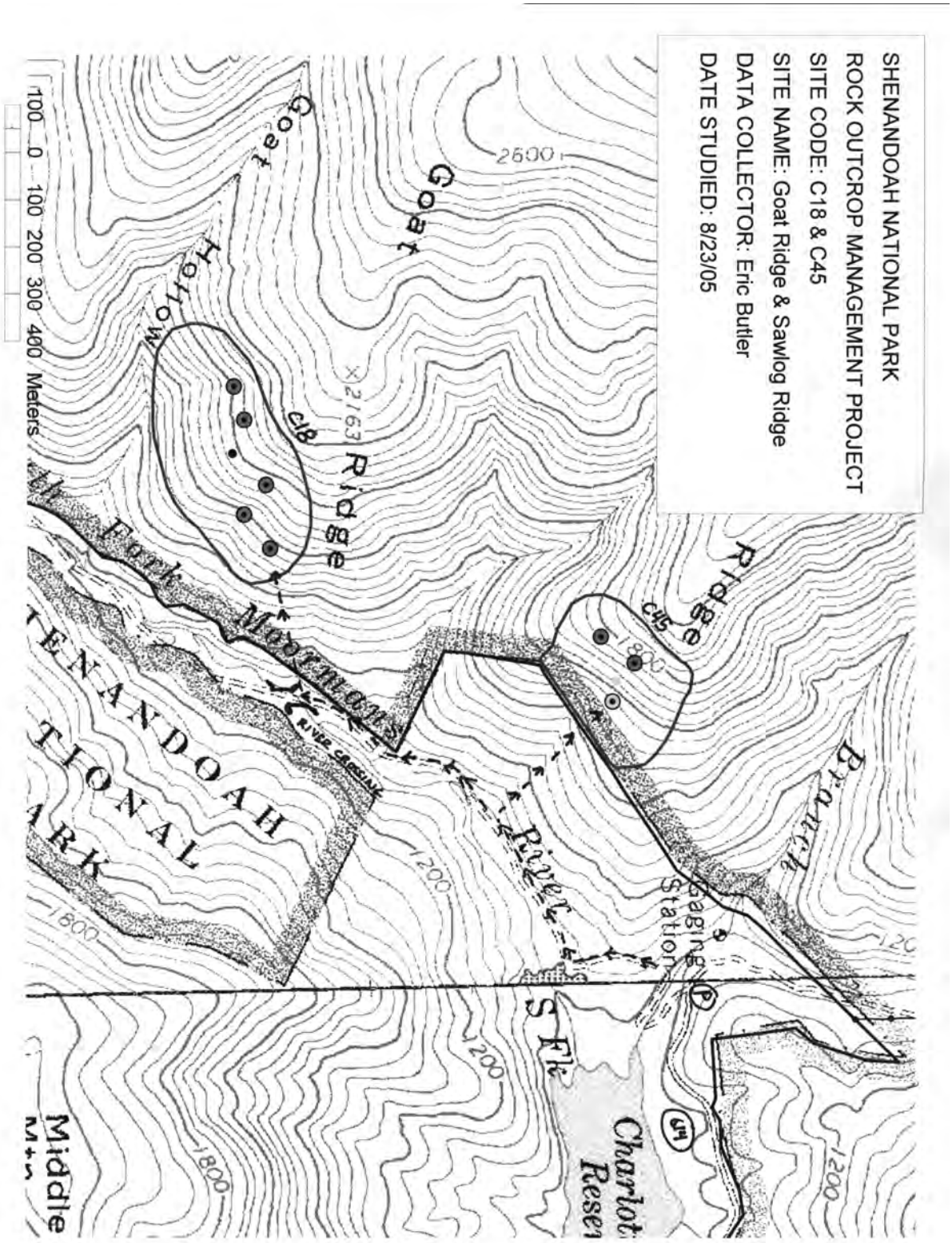
C45 - Sawlog Ridge (continued...)

Detail sketch map



C45 - Sawlog Ridge (continued...)

Area sketch map



C45 - Sawlog Ridge (continued...)



SHEN_C45_G_20050822_001.jpg Azmuth: 220

View across lower clearing, showing steep slope and vegetated rock faces



SHEN_C45_G_20050822_002.jpg Azmuth: 0

Closeup of pervasive cleavage in rock, dipping southeast with slope



SHEN_C45_G_20050822_003.jpg Azmuth:

Closeup of conglomerate above lower clearing, showing large quartz pebbles



SHEN_C45_G_20050822_004.jpg Azmuth: 340

View upslope from center of lower clearing, showing thick grasses on rock faces

C45 - Sawlog Ridge (continued...)



SHEN_C45_G_20050822_005.jpg Azmuth: 40

View across slope at upper clearing



SHEN_C45_G_20050822_006.jpg Azmuth: 205

View across slope at upper clearing, site of dried-up spring

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C46 - South Marshall cliff

Site Code:	C46	**Polygon Centroid:**	**E:** 741176 **N:** 4294994
Site Name:	South Marshall cliff		UTM (Zone 17 NAD83)
Data Collector	Butler, Eric	**Dimensions (m):**	200 x 540 (GIS est.)
Date Studied:	09-Jun-05	**Elevation Range (ft):**	2880 to 3180

Physical Characteristics

Location Acces

About 1000m west of Skyline Drive along Appalachian Trail (AT). Park in small lot on east side of Skyline Drive, just north of Mile 16 (not signed and easy to miss). Trail climbs up gentle slopes to high point on South Marshall, then descends. Easiest access is from two social trails about 200m apart that lead to cliff overlooks (G041 and G044), and from top of talus slopes south of G044 along AT.

Physical Description:

South Marshall consists of a series of cliff exposures stretching across the western face of the mountain, with associated talus fields. The Appalachian Trai (AT)l, which runs along the eastern edge of the site, generally follows a gentler slope, with a break in slope to the west marking the beginning of these cliffs, outcrops, and talus fields. Above the AT, the landscape is fully forested, with occasional small rock exposures and boulders, while below the AT the landscape is steep, covered in bedrock exposures and large-clast talus with thick vegetation. Most of the bedrock forms steep but ledgy exposures that supports many plants.

In the northern part of the site, a discontinuous line of cliffs between begins at around 3120', with near-continuous talus below and between the rock exposures. The talus at this level extends beyond the site boundary to the north, at least as far as G042. To the south, this level of cliffs and talus fades away into a gentler slope, while another line of cliffs begins around 3040', also surrounded by near-continuous talus. The main exposure at this level is one very large cliff (about 30m) at G044, which offers excellent views to the west, with smaller outcrops to the north and south. The talus and bedrock end around 2900', where the slope lessens and the landscape returns to forest.

Vegetation: Dense

Laurel and other thick vegetation is common, especially on and around the talus slopes that define much of the site. Convoluted routes along cliff tops and talus slopes are often necessary. Some ledges, especially on the main cliff, may not be passable due to thick vegetation and precipitous topography.

Human Effects

Impacts: Moderate

There are two exposures within this site that are easily reached by social trail from the Appalachian Trail (AT), and both are heavily impacted. Most areas appear pristine, but the wide ledge above the large cliff at G044 is mostly barren for several meters from the edge and shows extensive evidence of use. The upper cliff at G041 is also impacted, and offers an easy access route to talus fields below.

Access Moderate

Trail to site is smooth and gently sloping, very easy to traverse. There is no indication at the trailhead of anything of interest along the trail, and the parking lot itself is not marked. The distance (1km) may deter casual hikers with no prior knowledge of the excellent views to be gained. The main cliff is visible from overlooks further south, such as Hogback Overlook, but not from any trailhead or nearby access point.

Geologic Characteristics

Lithology: **Rock Type** Greenstone

The bedrock is very similar throughout the site, consisting of Catoctin basalt with very common flow bedding 10-50cm thick that creates numerous small ledges along the otherwise sheer cliff faces. The tops of many exposures also have wide ledges, which can be partially attributed to this bedding. The rock is fairly magnetic here, and weathers to a dark rusty brown, suggesting high iron content. The rock is very fine-grained, with few other minerals or internal features evident.

C46 - South Marshall cliff (continued...)

Structure:

Cleavage is present intermittently, dipping steeply to the east and creating more angular ledges than the more common flow bedding. There may be a joint set oriented 145-325, defining the sides of the major cliff at G044, but joints of this orientation could not be identified consistently throughout the site. The rocks contain numerous chaotic fractures, which contribute to the abundant talus surrounding the bedrock.

Other:

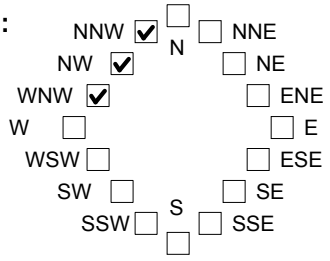
There appear to be two separate flows here, although the bedrock does not change appreciably across the contact. In several places just upslope from the main cliff at G044, outcrops of vesicular breccia indicated a flow boundary can be found, including at G099. These deposits are not found farther north, but may be covered by talus in that area. Near the base of the G044 cliff, a thick sequence of breccia, metasediments, and vesicular basalt marks the base of the lower flow.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	20.0	10.0	0.0	20.0	50.0	100
Max relief(m):	30	3	0	1	40	

Maximum Slope: 35 **Texture:** Rough

Aspects:



Setting:

The South Marshall site is defined by two separate lava flows that form lines of cliffs at different elevations. The upper flow is most prominent in the north, where it forms a line of cliffs and talus between 3120’ and 3040’. Below this talus, the slope becomes gentle and forested at an elevation that corresponds to the top of the next flow farther south. This flow forms the large cliff between 3040’-2940’, as well as several smaller outcrops within the flow. The distinction between these flows is based on the occurrence of a vesicular breccia layer roughly 3040’-3060’, and the occurrence of a small but visible topographic bench below the cliffs and talus of the upper level and the first ledges and cliffs of the lower level.

The base of the lower flow is harder to define; around 2940’ a distinct unit of vesicular basalt, metasediments, and breccia appears at the very base of the major cliff. This unit cannot be traced laterally or vertically, as the rest of the slope is covered in thick talus to the sides and below. At the base of the talus, another 5-10m down, the slope gentles noticeably and returns to open forest. It is likely that this marks the transition to the next flow down, although by implication the breccia unit would then be unusually thick here. Without more exposures it is difficult to tell, but this distinction does not affect the occurrence of plant habitat.

The very common bedding within both flows seems to be the dominant geomorphic agent here; the tops of most cliffs and outcrops create numerous near-horizontal ledges that support a great deal of plant growth. Where cleavage is present, it interacts with the bedding to create additional ledges and pockets for soil to develop. In several places, most notably on the main cliff at G044, series of bedding-related ledges along the cliff faces create additional habitat. There are several wide, obvious ledges on the main cliff, which may represent subunits within the one large flow, but access to these ledges was extremely difficult due to vegetation and topography, and so this could not be tested.

Stability: Moderate

Most cliffs and outcrops are solid, while talus slopes will shift in places.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
6/9/2005	G041-C46	741315	4295091	3120	Exposure reached by social trail from AT – highest exposure at site
6/9/2005	G042-C46	741460	4295221	3100	Open boulderfield outside site boundary to NE – maybe of interest?
6/9/2005	G043-C46	741336	4295147	3060	Outcropping below upper cliff level – possibly top of second flow? Also
6/9/2005	G044-C46	741160	4295015	3040	Top of major cliff on AT
6/9/2005	G045-C46	741120	4295054	2900	Base of talus below cliff at G044
6/13/2005	G046-C46	741089	4294902	2960	Top of portion of talus SW of cliff at G044
6/13/2005	G047-C46	741025	4294851	2920	Outcrop near SW extent of talus field

C46 - South Marshall cliff (continued...)

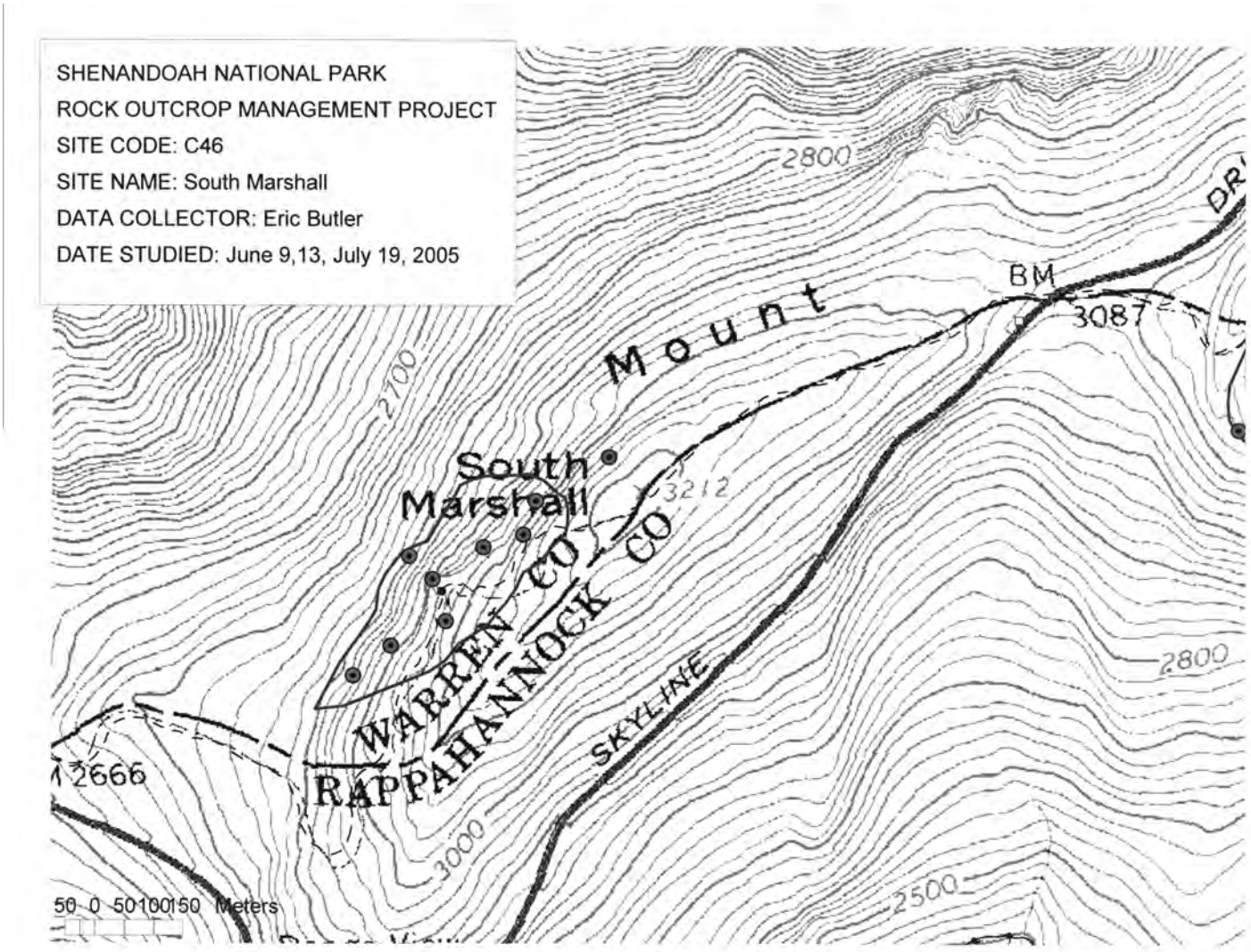
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
6/13/2005	G048-C46	741247	4295069	2980	Outcrop above open talus with spring seep below
7/19/2005	G099-C46	741183	4294944	3060	Outcrop of contact breccia – boundary between 2 flows

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
6/9/2005		SHEN_C46_G_20050609_001.jpg	25	Butler, Eric	Vegetated cliff of upper level, 20m NE of G041
6/9/2005		SHEN_C46_G_20050609_002.jpg	310	Butler, Eric	View down talus outside boundary; talus continues into vegetated areas
6/9/2005		SHEN_C46_G_20050609_003.jpg	270	Butler, Eric	View across talus outside boundary; talus continues through vegetation into another field
6/9/2005		SHEN_C46_G_20050609_004.jpg	65	Butler, Eric	Cliffs and talus of upper level
6/9/2005		SHEN_C46_G_20050609_005.jpg	125	Butler, Eric	View up talus toward large cliff at G044; note several levels within cliff, marked by veg.
6/9/2005		SHEN_C46_G_20050613_001.jpg	235	Butler, Eric	View across main cliff to south; note vegetated ledge
6/9/2005		SHEN_C46_G_20050613_002.jpg	55	Butler, Eric	Northern extent of main cliff; exposure fades to talus and vegetation north of here.
6/9/2005		SHEN_C46_G_20050613_003.jpg	30	Butler, Eric	View across extensive talus S of main cliff, toward this cliff at G044

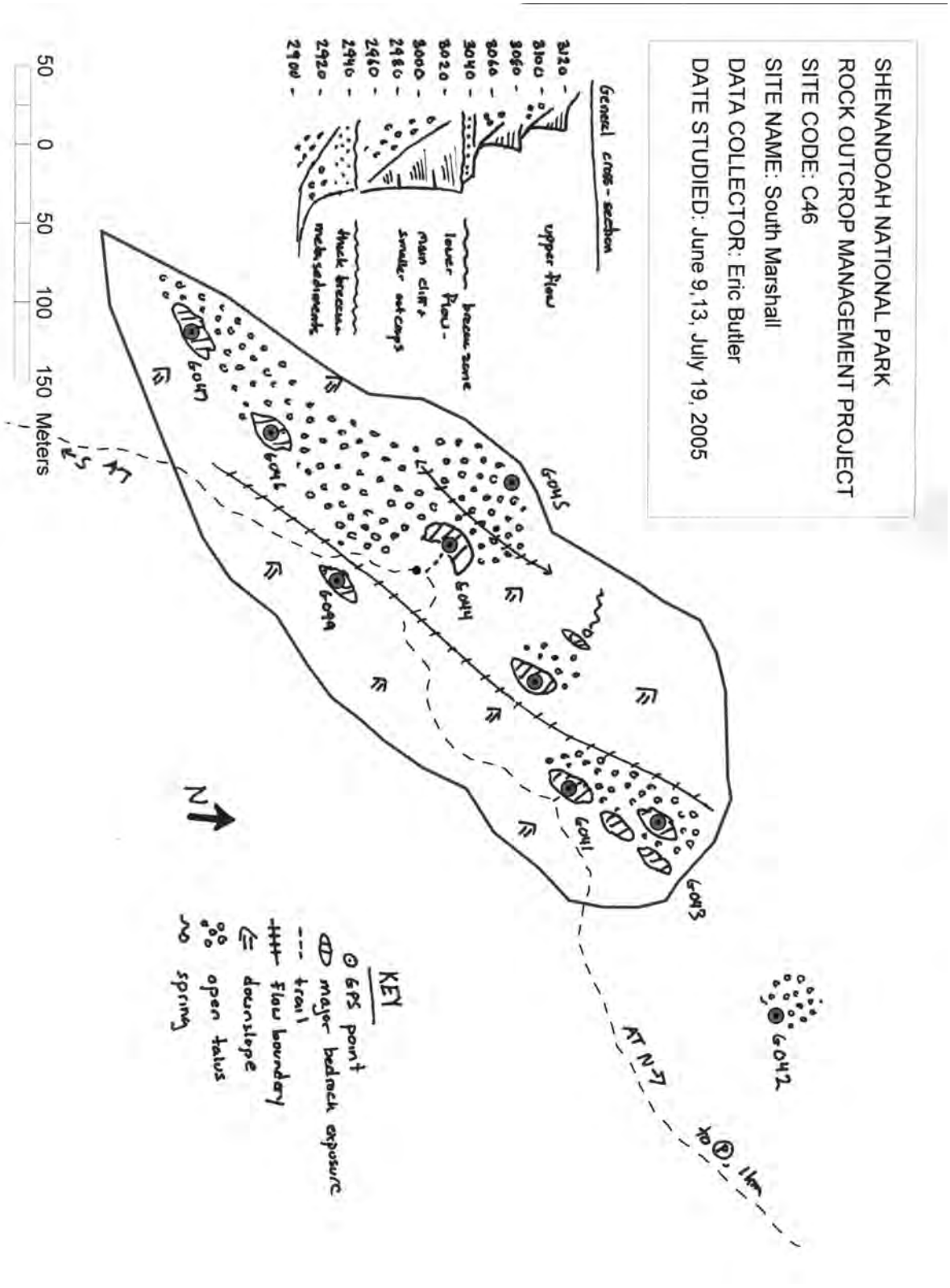
C46 - South Marshall cliff (continued...)

Area sketch map

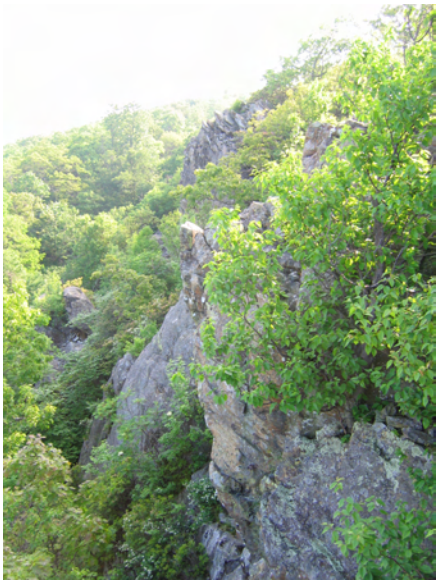


C46 - South Marshall cliff (continued...)

Detail sketch map



C46 - South Marshall cliff (continued...)



SHEN_C46_G_20050609_001.jpg Azmuth: 25

Vegetated cliff of upper level, 20m NE of G041



SHEN_C46_G_20050609_002.jpg Azmuth: 310

View down talus outside boundary; talus continues into vegetated areas



SHEN_C46_G_20050609_003.jpg Azmuth: 270

View across talus outside boundary; talus continues through vegetation into another field



SHEN_C46_G_20050609_004.jpg Azmuth: 65

Cliffs and talus of upper level

C46 - South Marshall cliff (continued...)



SHEN_C46_G_20050609_005.jpg Azmuth: 125

View up talus toward large cliff at G044; note several levels within cliff, marked by veg.



SHEN_C46_G_20050613_001.jpg Azmuth: 235

View across main cliff to south; note vegetated ledge



SHEN_C46_G_20050613_002.jpg Azmuth: 55

Northern extent of main cliff; exposure fades to talus and vegetation north of here.

SHEN_C46_G_20050613_003.jpg Azmuth: 30

View across extensive talus S of main cliff, toward this cliff at G044

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C47 - Stony Man: summit/N slope

Site Code:	C47	**Polygon Centroid:**	**E:** 728753 **N:** 4275484
Site Name:	Stony Man: summit/N slope		UTM (Zone 17 NAD83)
Data Collector	Butler, Eric	**Dimensions (m):**	200 x 440 (GIS est.)
Date Studied:	10-Aug-05	**Elevation Range (ft):**	3520 to 4011

Physical Characteristics

Location Acces

Park at the Stony Man parking lot, just inside the main Skyland entrance at Milepost 41.7. From this lot there are several routes to the site. First, follow the Appalachian Trail (AT) north from the eastern end of the parking lot for 600m to a trail junction, where the AT continues northeast while the Stony Man summit trail turns northwest. Follow this trail 150m to another trail junction, where the summit trail splits to make a loop around the mountain. Follow the left-hand fork, as this will provide a more direct route. From here, another 250m leads to the actual summit, a trail junction in the woods, where a small side trail leads to the main summit exposure. Alternatively, follow the horse trail from the western end of the parking lot, which leads all the way to the summit. This trail and the regular trail are parallel to each other in several places, but the horse trail leads to one rock exposure area that is not reached by other trails.

Physical Description:

The Stony Man summit consists of two levels of cliffs, each with intermittent exposures broken by steep, rocky slopes and vegetation. The upper cliff level contains three main exposures, 50-100m apart, each consisting of a large cliff with open talus around the base and open ledges at the top. These upper exposures wrap around the summit from west to north. The southernmost upper exposure is reached only by the horse trail, the middle exposure is reached by various social trails, and the northernmost exposure is the main open area at the summit that is used by most visitors to the mountain, and is accessed by a park trail. From here, a long, narrow rib of rock extends down to the north-northwest from the main cliff, bisecting a large expanse of open talus. A social trail of sorts leads down the west side of this rib from the summit, providing access to the lower clifftop.

This long rock rib terminates at the top of the lower line of cliffs, which are taller and more sheer than the upper cliffs. These cliffs are tallest and most dominant in the north; to the west they fade away into a more subtle talus slope broken by occasional bedrock outcrops that are partially forested. Between the two cliff lines, and below the lower cliffs, are flatter topographic benches that clearly delineate the two areas. These benches are most prominent to the west, where the slope of the mountain is generally lower, but become smaller and less obvious as the cliffs steepen to the northwest and north.

Vegetation: Dense

Laurels, briars, and other thick growth are very common around the summit, and bordering most of the open rock areas (bedrock and talus).

Human Effects

Impacts: Heavy

The three rock exposures of the upper cliffs are heavily impacted. All three contain significant soil stripping, lichen and vegetation trampling, and social trails. Much of the upper ledges in these areas are nearly bare, and appear polished from repeated human treading. Rock graffiti is present in some places. The impacts are most severe at G136, where the main hiking trail to the summit leads. From this main summit exposure, several social trails extend through cracks in the rock and down over the open talus to reach the top of the lower cliff at G137. The area around G137 is also significantly impacted, again containing trampling, soil stripping, graffiti, and more. These impacts are more restricted in area, however, as the cliff top and ledges extending in both directions rapidly return to a more vegetated and natural state (probably partly due to the thickness of the vegetation in these areas). The base of the lower cliff appears relatively pristine, and there is no evidence of climbing activity along either line of cliffs. Trash is common, often as water bottles or other debris that may have been thrown or swept by wind from the upper exposures. One boulder at the base of the lower cliff contains evidence of rock graffiti that appears fairly old, given the nature of the script chiseled into the rock, and may represent a slab that was carved years ago into the ledges atop the cliff, and has since broken away.

Access Moderate

The hike to Stony Man Summit is a very common and popular one, well-publicized in park guides. In addition, the location of

C47 - Stony Man: summit/N slope (continued...)

Skyland Lodge and associated cabins nearby makes the hike an even more common one for park visitors. The trail distance by either route is just over 1km, and neither trail is very steep or difficult, as they wind gently up the sloping east side of the mountain. The routes are well-established and blazed, and booklets for a self-guided interpretive tour of the Loop Trail are available at the trailhead. Despite these advantages, the elevation gain (almost 400') and trail distance is enough to warrant the Moderate rating. The established trails lead to the most impacted cliff areas, which give the best views of the surrounding terrain, whereas the lower cliff areas require negotiation of some steep, loose talus areas or some bushwhacking through unmarked terrain. Access to the areas below the lower cliffs is more difficult, due to terrain and large, loose talus.

Geologic Characteristics

Lithology: **Rock Type** Greenstone

This site is underlain by several lava flows of Catoctin Formation greenstone. These flows are very similar in texture, consisting of fine-grained greenstone with scattered amygdules of quartz. The rocks weather to a reddish/tan hue, but remain black to dark green in fresher faces. Each flow creates a discrete line of cliffs, separated by topographic benches as is common within the Catoctin. At this site, however, the two flows are also separated by a thick, unusual layer of volcanic breccia. This unit may be up to 10m thick, and generally consists of abundant fragments of fine-grained, reddish material, surrounded by a very fine-grained, highly cleaved greenstone matrix, lighter in color than the regular lava (possibly due to an abundance of epidote). Badger (1999) interpreted a similar unit found between flows at Little Stony Man to be composed of ripped-up clasts of fine-grained sediment, originally deposited on an old erosional surface atop the lower lava flow, and this interpretation seems to fit here as well. As at Little Stony Man, this unit is highly variable in thickness, color, and appearance, but throughout the site is distinct from the regular greenstones above and below, forming a surface that is much more rugged and chaotic in appearance than the generally smooth greenstones. Also unusual is the fact that within the site, the full extent of this breccia unit caps the lower cliff, extending its height far above the top of the lower lava flow. Such breccia units are generally not cliff-forming, usually disintegrating into loose float found mostly along the topographic benches that mark flow boundaries.

Structure:

Both flows contain abundant columnar jointing of variable quality, ranging from well-preserved columns several meters in length to vaguely polygonal fracture sets. These joints help form rugged, uneven ledges at the tops of cliffs, where individual columns protrude at various heights. Cleavage is also a dominant structure where present, particularly near the tops of both flows, where it creates angular ledges and shelves dipping around 45 degrees into the rock. Where cleavage and columns interact along the cliff tops, the ledges are especially varied and pronounced.

Other:

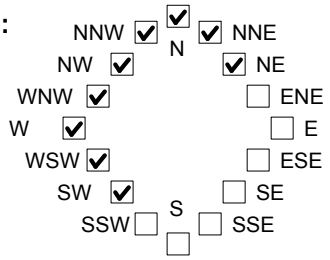
The upper flow contains occasional deposits of well-formed but unidentified iron oxide minerals, usually taking the form of dark brown-red, rounded, bubble-like structures in mineral veins within the greenstones. These are most often found in the talus slopes directly below the cliff exposures of the upper flow, as thin skins on exposed surfaces of loose greenstone fragments.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	40.0	10.0	0.0	20.0	30.0	100
Max relief(m):	40	5	0	2	20	

Maximum Slope: 30 **Texture:** Fractured

Aspects:



Setting:

The open rock exposures within this site are clearly formed from two greenstone lava flows, separated by a thick unit of volcanic breccia. Although such breccias are not normally cliff-forming, the unusual composition and thickness of this unit may render it more resistant and dominant, thus preserving its presence atop the lower cliff. Badger (1999) suggests that this breccia unit correlates to a similar unit found separating the two cliff levels at Little Stony Man, 800m north and 400' down, and the geologic evidence at this site supports such a conclusion. In both cases a very unique breccia unit separates two resistant, cliff-forming lava flows that both contain abundant columnar jointing. This correlation implies that the lava flows here must be locally dipping down to the north, as well as down to the east as is the wider regional pattern. Bushwhacking from Little Stony

C47 - Stony Man: summit/N slope (continued...)

Man to the Stony Man summit supports the conclusion that the flows are locally dipping north, as this route follows a generally smooth slope broken by occasional sudden rises in topography (a hallmark of transitions between Catoctin lava flows).

In general, the Catoctin lava flows in this region of the park dip off to the east at around 10-20 degrees. This is one of the basic geologic and geomorphic patterns within Shenandoah, and is responsible for the broad occurrence of steep, cliff-forming areas to the north and west of the ridges, and widespread gentle slopes descending to the east. This can be seen in photo SHEN_C47_G_20060208_001, which gives a cross-section of Stony Man Mountain's profile; the subtle topographic benches of successive lava flows can be seen descending to the east (left), while the steep cliff areas to the west (right) are developed within individual flows (which are generally more resistant to erosion than the contact zones between them). This is why the trail up to Stony Man summit is so deceptively gentle and easy to traverse; it is built along the surface of the flows dipping gently toward Skyline Drive, where the trail begins. The same is true of Hawksbill Mountain, to the south.

At a smaller scale, the widespread columnar jointing appears to be a dominant factor in the formation and nature of the cliffs on Stony Man summit. These joints create tall, vertical, smooth fracture surfaces along which the rock erodes, resulting in relatively active erosion that still preserves sheer dropoffs (due to the length and continuity of the joints where present). The resulting rock columns also help create numerous ledges atop the cliffs (and occasionally along them), where individual columns protrude from the surface at various heights and angles. Cleavage is common, especially toward the cliff tops and within the breccia unit, and the sharp dip of this structure creates a different form of ledge, defined by the sharp, angular, protruding nature of the rock slabs the cleavage creates. Where these two structures interact, especially interested ledge formations are created.

The widespread columnar jointing is also likely a factor in the development of extensive talus fields around the summit. Much of this talus shows evidence of such jointing, the fragments being smoother and more angular than might otherwise be the case. As the jointing encourages active erosion to form large cliffs, the material cracking away along these joints readily collects as large, otherwise solid boulders in the talus fields, and so quickly armor the slope against soil or vegetation development. Without this jointing, these talus fields might be smaller in clast size and less dominant on the slope.

The thick breccia unit creates its own unique exposure characteristics. The general surface of this unit appears very rough and chaotic, due to the jumbled and deformed fragments of sediment found throughout the rock. These fragments are more resistant to erosion than the surrounding greenstone matrix, and so stand out in relief to create this texture. Cleavage is still common within the greenstone matrix, in places creating an off mix of angular, platy rock that still preserves the typical chaotic breccia appearance. The ledge areas atop the lower cliff are noticeably different from those atop the upper cliff, in ledge shape, abundance, and texture, all due to this lithologic difference. The transition between this breccia and the underlying greenstone lava flow can be clearly seen partway down the lower cliff (when viewed from the side), as the rocks are very rugged and chaotic higher up, then become smooth, jointed, and sheer lower down. This likely influences the presence of ledges and other habitat areas along this cliff face.

Stability: Moderate

Although columnar jointing is common, and the cliffs have clearly been actively eroding at a geologic time scale, the exposures are fairly stable to navigate at a human time scale. It appears that most of the very loose rock has already cracked away, leaving yet-to-be-weakened structures remaining. The large-clast talus fields are quite loose, however, and easily shift underfoot. This may be related to the shapes created by columnar jointing; the large, angular rocks slide easily on one another.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
8/10/2005	G134-C47	728760	4275387	3980	Open ledges atop cliff along horse trail; 1st of three summit exposures
8/10/2005	G135-C47	728714	4275452	4000	Open ledges atop cliff near summit, reached by several social trails; 2
8/10/2005	G136-C47	728721	4275494	4000	Broad open area at summit, reached by main hiking trail; 3rd summit e
8/10/2005	G137-C47	728688	4275545	3900	Top of large, lower cliff below upper summit cliff; reached by descendi
8/10/2005	G138-C47	728709	4275583	3860	Continuation to north of large lower cliff at summit
8/10/2005	G139-C47	728772	4275607	3800	Farthest extent of open rock along lower cliff line
8/10/2005	G140-C47	728681	4275503	3880	Re-emergence of lower cliff after talus chute providing access to base
2/7/2006	G200-C47	728644	4275421	3840	Open bedrock exposure correlated to rocks of lower cliff
2/7/2006	G201-C47	728698	4275384	3900	Open bedrock exposure correlated to rocks of lower cliff

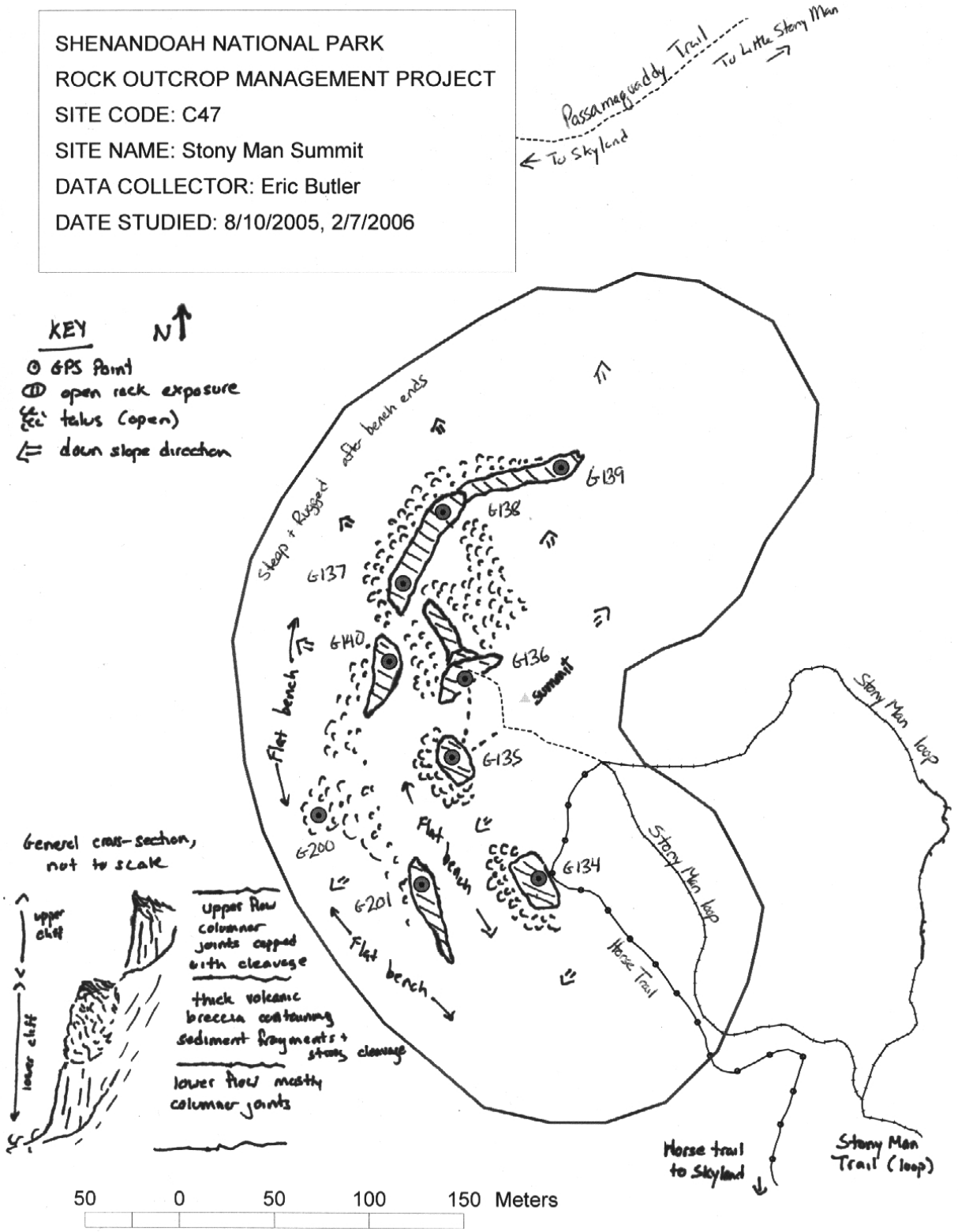
Site Photos

C47 - Stony Man: summit/N slope (continued...)

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
8/10/2005	G134-C47	SHEN_C47_G_20050810_001.jpg	70	Butler, Eric	Impacted ledges along horse trail
8/10/2005	G134-C47	SHEN_C47_G_20050810_002.jpg		Butler, Eric	Rare plant Sibbaldiopsis in crack at G134
8/10/2005	G135-C47	SHEN_C47_G_20050810_003.jpg	90	Butler, Eric	Protruding columnar joints at ledgy outcrop reached by social trails from summit
8/10/2005	G135-C47	SHEN_C47_G_20050810_004.jpg	270	Butler, Eric	Poorly preserved columnar joints creating protruding exposures
8/10/2005	G136-C47	SHEN_C47_G_20050810_005.jpg	30	Butler, Eric	Bare rocks at summit exposure, soils & vegetation gone
8/10/2005	G136-C47	SHEN_C47_G_20050810_006.jpg	160	Butler, Eric	Interaction of columnar joints (vertical) and cleavage (angled) to create uneven surface at summit
8/10/2005	G136-C47	SHEN_C47_G_20050810_007.jpg	340	Butler, Eric	Rib of columnar joints extending from summit exposures down to lower cliff at G137
8/10/2005	G137-C47	SHEN_C47_G_20050810_008.jpg	205	Butler, Eric	Impact on ledges above lower cliff (stripped soil, rock grafitti). Note strong cleavage in boulder to right
8/10/2005	G138-C47	SHEN_C47_G_20050810_009.jpg		Butler, Eric	Large lower cliff, below G138. Note rugged, uneven texture caused by breccia
8/10/2005	G139-C47	SHEN_C47_G_20050810_010.jpg		Butler, Eric	Volcanic breccia with fragmented sediments, capping exposures at G139
8/10/2005	G137-C47	SHEN_C47_G_20050810_011.jpg		Butler, Eric	Volcanic breccia with fragmented sediments capping large cliff at G137
2/7/2006	G200-C47	SHEN_C47_G_20060207_001.jpg		Butler, Eric	Volcanic breccia with fragmented sediments at southwest edge of site, correlating to G137 and G139
2/8/2006		SHEN_C47_G_20060208_001.JPG		Butler, Eric	Wide view of Stony Man Mountain, looking south from Skyline Drive
2/13/2006		SHEN_C47_G_20060213_001.jpg		Butler, Eric	Unidentified iron oxide minerals on surface of greenstone fragment, from talus below G136
8/10/2005		SHEN_C47_G_20060216_001.JPG		Butler, Eric	View through zoom lens from Hawksbill summit, showing exposures at G134 & G135

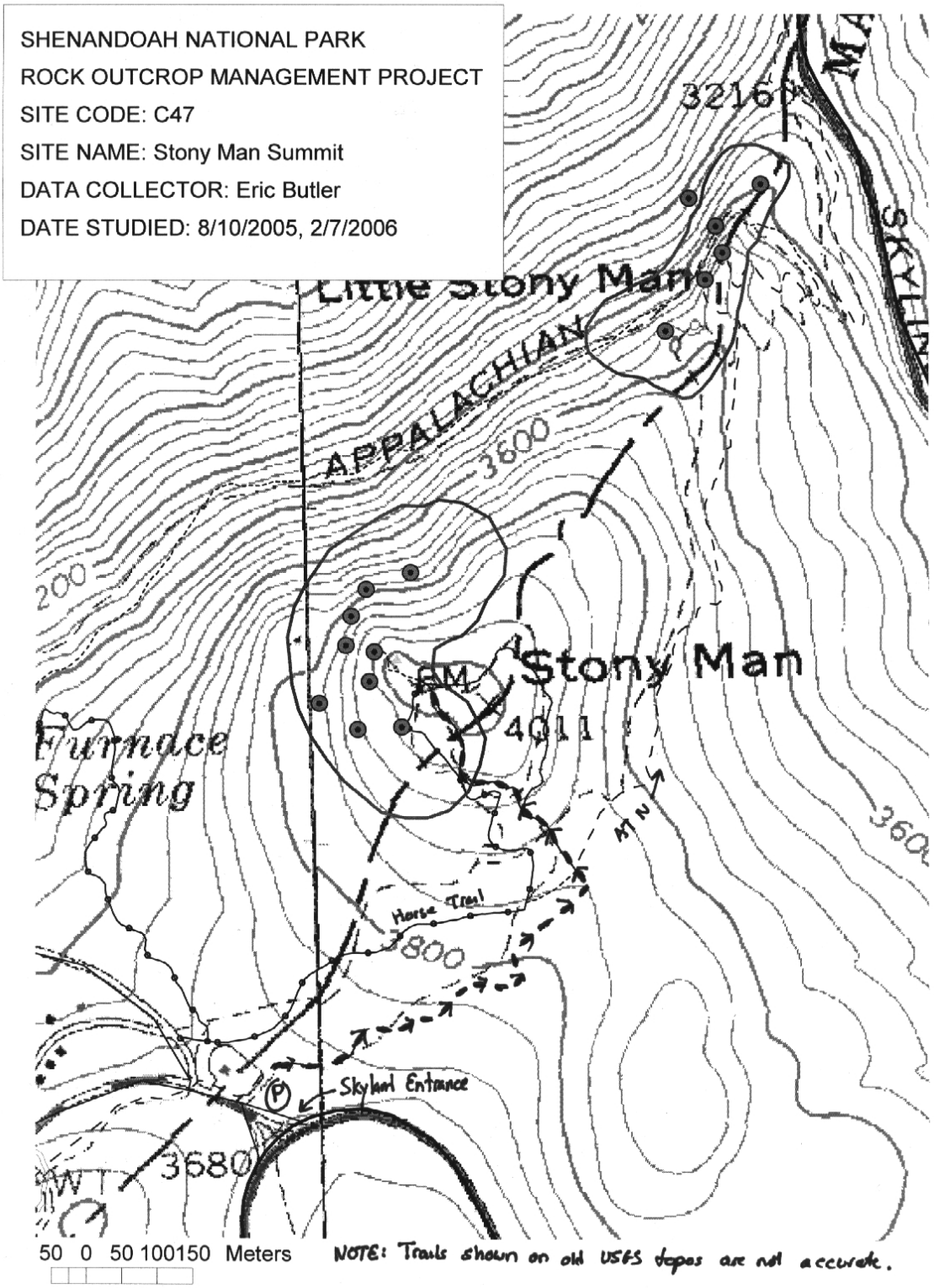
C47 - Stony Man: summit/N slope (continued...)

Detail sketch map



C47 - Stony Man: summit/N slope (continued...)

Area sketch map



C47 - Stony Man: summit/N slope (continued...)



SHEN_C47_G_20050810_001.jpg Azmuth: 70

Impacted ledges along horse trail



SHEN_C47_G_20050810_002.jpg Azmuth:

Rare plant Sibbaldiopsis in crack at G134



SHEN_C47_G_20050810_003.jpg Azmuth: 90

Protruding columnar joints at ledgy outcrop reached by social trails from summit



SHEN_C47_G_20050810_004.jpg Azmuth: 270

Poorly preserved columnar joints creating protruding exposures

C47 - Stony Man: summit/N slope (continued...)



SHEN_C47_G_20050810_005.jpg Azmuth: 30

Bare rocks at summit exposure, soils & vegetation gone



SHEN_C47_G_20050810_006.jpg Azmuth: 160

Interaction of columnar joints (vertical) and cleavage (angled) to create uneven surface at summit



SHEN_C47_G_20050810_007.jpg Azmuth: 340

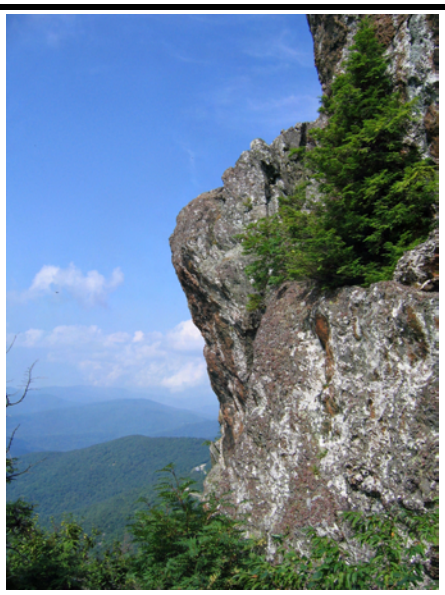
Rib of columnar joints extending from summit exposures down to lower cliff at G137



SHEN_C47_G_20050810_008.jpg Azmuth: 205

Impact on ledges above lower cliff (stripped soil, rock grafitti). Note strong cleavage in boulder to right

C47 - Stony Man: summit/N slope (continued...)



SHEN_C47_G_20050810_009.jpg Azmuth:

Large lower cliff, below G138. Note rugged, uneven texture caused by breccia



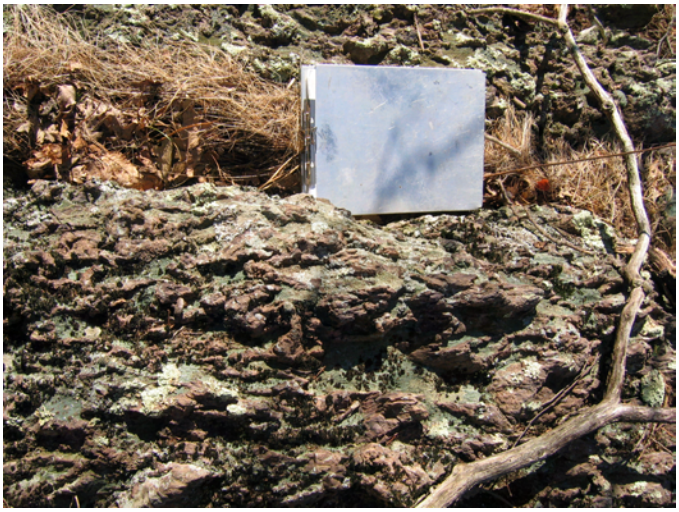
SHEN_C47_G_20050810_010.jpg Azmuth:

Volcanic breccia with fragmented sediments, capping exposures at G139



SHEN_C47_G_20050810_011.jpg Azmuth:

Volcanic breccia with fragmented sediments capping large cliff at G137



SHEN_C47_G_20060207_001.jpg Azmuth:

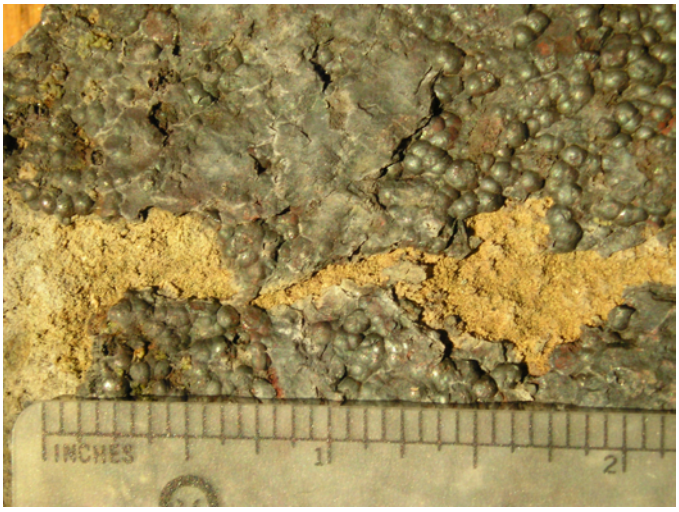
Volcanic breccia with fragmented sediments at southwest edge of site, correlating to G137 and G139

C47 - Stony Man: summit/N slope (continued...)



SHEN_C47_G_20060208_001.JPG Azmuth:

Wide view of Stony Man Mountain, looking south from Skyline Drive



SHEN_C47_G_20060213_001.jpg Azmuth:

Unidentified iron oxide minerals on surface of greenstone fragment, from talus below G136



SHEN_C47_G_20060216_001.JPG Azmuth:

View through zoom lens from Hawksbill summit, showing exposures at G134 & G135

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C49 - Trayfoot Saddle boulderfields - west

Site Code: C49
Site Name: Trayfoot Saddle boulderfields - west
Data Collector Butler, Eric
Date Studied: 28-Feb-06

Polygon Centroid: **E:** 696731 **N:** 4233415
UTM (Zone 17 NAD83)
Dimensions (m): 180 x 270 (GIS est.)
Elevation Range (ft): 2880 to 3120

Physical Characteristics

Location Acces

Park at Blackrock Summit Parking Area, just north of Milepost 85. Follow the Appalachian Trail to the Blackrock boulderfield (C05), then turn right onto the Trayfoot Mountain trail. This will lead about 1.1 km down into a saddle and back up the flank of Trayfoot Mountain, before reaching a junction with the Furnace Mountain trail, where the Trayfoot trail turns sharply left and the Furnace trail continues straight. Take the latter trail a few hundred more meters to a small, open talus field next to the trail. This is point G216; C65 lies to the east, and C49 to the west.

Physical Description:

C49 consists of two large open talus fields that flank the west side of a ridge extending north from Trayfoot Mountain. A similar set of talus fields on the east side of the ridge makes up C65. These two talus fields are separated by narrow bands of vegetation, which are really just growing within the talus, so that in effect the entire site is one large talus field. No in-place bedrock is present anywhere within the site. Reaching this site from the trail requires a short, easy bushwhack through forest, down the slope from the trail. Several smaller patches of open talus exist immediately to the west and south of the main talus fields, although these are really still part of the main field and are simply screened by narrow bands of vegetation grown up among the rocks.

Vegetation: Moderate

There are patches of dense undergrowth, but most of the forest immediately surrounding the open talus is fairly open. The thickest growths are often right on the edge of the open rock areas, and can screen these from view within the forest.

Human Effects

Impacts: Pristine

No evidence of human visitation to these sites could be observed, save for a single broken glass bottle that appeared fairly old. Although it is often difficult to assess impact on talus slopes, there were no visible social trails, impact to lichens, or other evidence of regular or debilitating visitation. None of this site is visible from the trail, or really from anywhere else in the park, so it is unlikely that most visitors ever find this area. There is an excellent view from here, however.

Access Difficult

The total trail distance to these sites is just over 2km with a total elevation gain/loss of around 700'. Although the trails have a relatively gentle grade for most of the distance, the route takes more commitment than a quick jaunt from Skyline Drive, and it is doubtful that most visitors continue past Blackrock.

Geologic Characteristics

Lithology: **Rock Type** Quartzite

This site (and its neighbor, C65) contains no in-place bedrock, consisting entirely of quartzite boulders arranged loosely on the slopes. The rocks are fine-medium-grained quartzite, ranging in color from darker blue-grey to white-tan. Most of the blocks contain no visible structures, but a few have sets of thin, black layers that create a banded appearance in the rock. These are likely formed from thin deposits of darker minerals laid down between thicker units of quartz sand. In general, these rocks are originally thick units of quartz sand likely deposited near an ocean shore, and since fused and hardened by later metamorphism into a solid and resistant mass.

In appearance and composition, these rocks seem to be a compromise between the commonly dark grey/blue, finely layered quartzites of the Hampton Formation (i.e. C05 Blackrock) and the white-clear, unstructured quartzites with abundant skolithos fossils of the Erwin Formation (i.e. C44 Rocky Mountain & C64 Brown Mountain). Gathright (1976) mapped this area as Hampton, and the rocks do appear closer in character to that formation than to the brilliantly white Erwin rocks that show up clearly on the flanks of Furnace Mountain further to the west. The surrounding lithologies, mostly fine-grained siltstones and

C49 - Trayfoot Saddle boulderfields - west (continued...)

phyllites (as uncovered in loose float on surrounding slopes) also fits the Hampton Formation best.

Structure:

In addition to the occasional fine layers of dark minerals within quartzite blocks, a few blocks preserve evidence of cross-bedding, an internal structure formed by cross-cutting sediment layers, usually formed in currents or dunes. The rocks are, of course, very heavily fractured to form the angular boulders present here, but with no exposed bedrock.

Other:

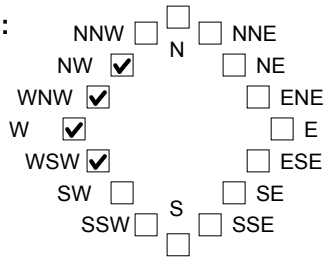
Deposits of metallic iron oxide minerals are relatively common, usually occurring as dark red/brown minerals in veins within the boulders, or as thin skins on the surfaces of boulders where these veins have cracked open. Generally these minerals have a rounded, almost bubbly formation, suggesting that they may be the mineral hematite.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	0.0	0.0	0.0	0.0	100.0	100
Max relief(m):	0	0	0	0	60	

Maximum Slope: 30 **Texture:** Fractured

Aspects:



Setting:

This site and its neighbor, C65, share the same history and interpretation. While large areas of talus unrelated to any visible bedrock are generally unusual, this is a common pattern within Shenandoah NP, particularly within the quartzite areas of the South District. The Hampton Formation in particular seems to create this pattern. Such large fields of boulders are likely the result of bedrock rapidly eroding and crumbling more or less in place, rather than the more common pattern of talus collecting below a cliff.

Evidence for this interpretation can be found at C05 Blackrock, where some bedrock is present at various places within the boulders, where it appears heavily fractured and weathered. Most of the quartzite areas within the park are very heavily fractured, likely a relict of the intense deformation these rocks suffered during the building of the Appalachians (the numerous large-scale folds in the bedrock, visible through the South District, attest to these pressure). These fractures provide a perfect conduit for physical weathering processes such as frost wedging to split the otherwise resistant bedrock and produce many large, angular boulders. These processes were likely extremely active and effective during the extreme climate variations during the last glacial period. Other reports and researchers have suggested that many of the large talus fields of the South District (like Blackrock) were at least partially shaped by such periglacial forces, and such an interpretation fits at this site.

In other words, it is likely that this ridge was once a resistant area of quartzite bedrock, which has since crumbled into talus during intense periods of weathering. Standing at Blackrock, one can look west toward Trayfoot Mountain and see a series of quartzite talus fields extending across the slope of the mountain from south to north, most likely reflecting the location of this particular quartzite bed within the greater stratigraphy. This site and its nearby companion are simply the northernmost exposure of this unit, before the deeply eroded valley of Madison Run to the north eliminates it.

Stability: Loose

The entire site consists of loose talus collected on steep slopes, and these boulders often shift underfoot; once disturbed, some will move quite a distance.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
2/28/2006	G220-C49	696743	4233436	3040	Lower edge of upper field
2/28/2006	G221-C49	696737	4233377	3040	Upper center of lower, larger field

Site Photos

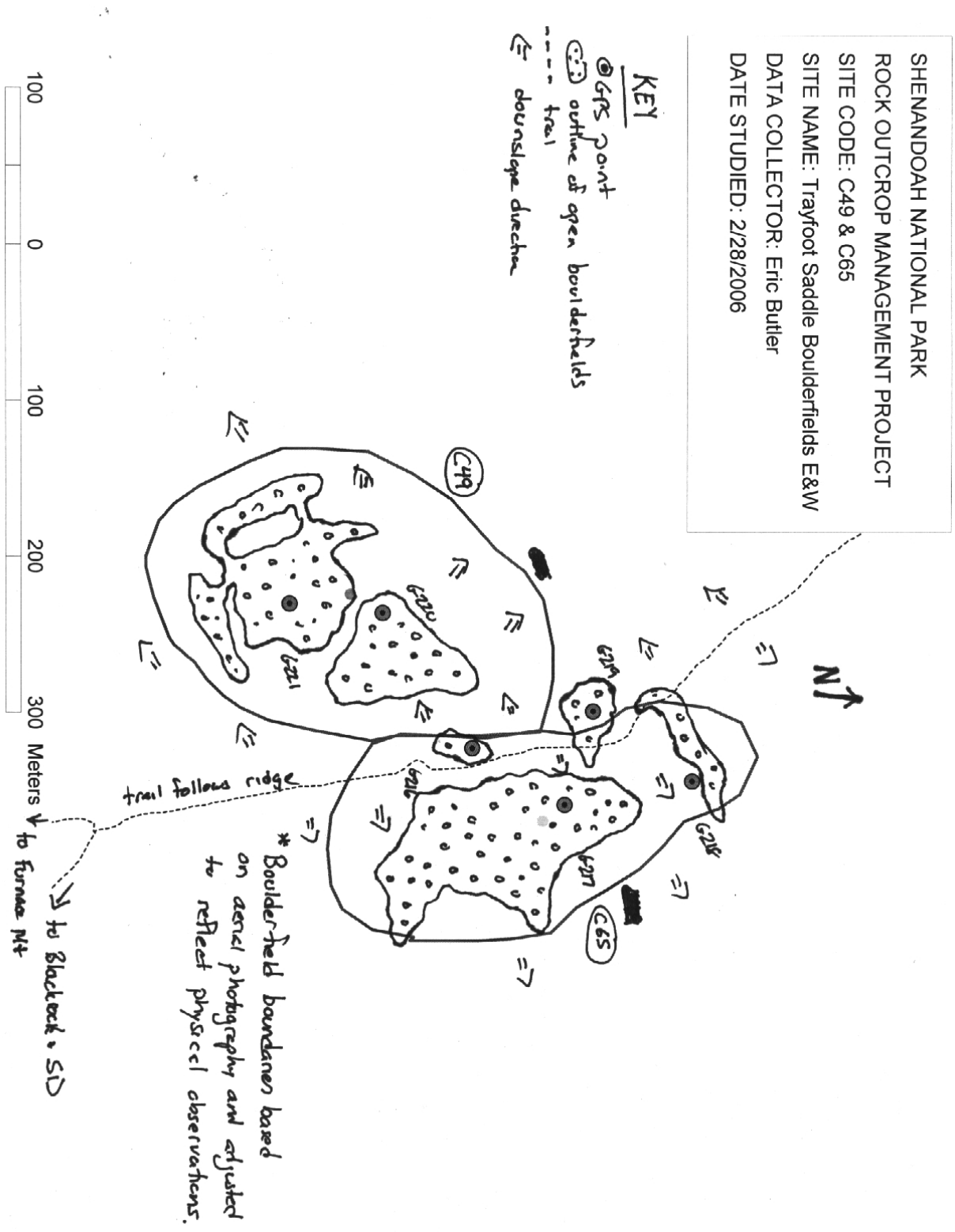
Image Date	GPS Point	File Name	Azmuth	Taken By	Description
2/28/2006	G220-C49	SHEN_C49_G_20060228_001.jpg	115	Butler, Eric	Looking up boulder field

C49 - Trayfoot Saddle boulderfields - west (continued...)

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
2/28/2006	G221-C49	SHEN_C49_G_20060228_002.jpg	10	Butler, Eric	Looking across domed boulder field
2/28/2006	G221-C49	SHEN_C49_G_20060228_003.jpg		Butler, Eric	Typical sharply angled quartzite talus
2/28/2006	G221-C49	SHEN_C49_G_20060228_004.jpg		Butler, Eric	Preserved layering in quartzite

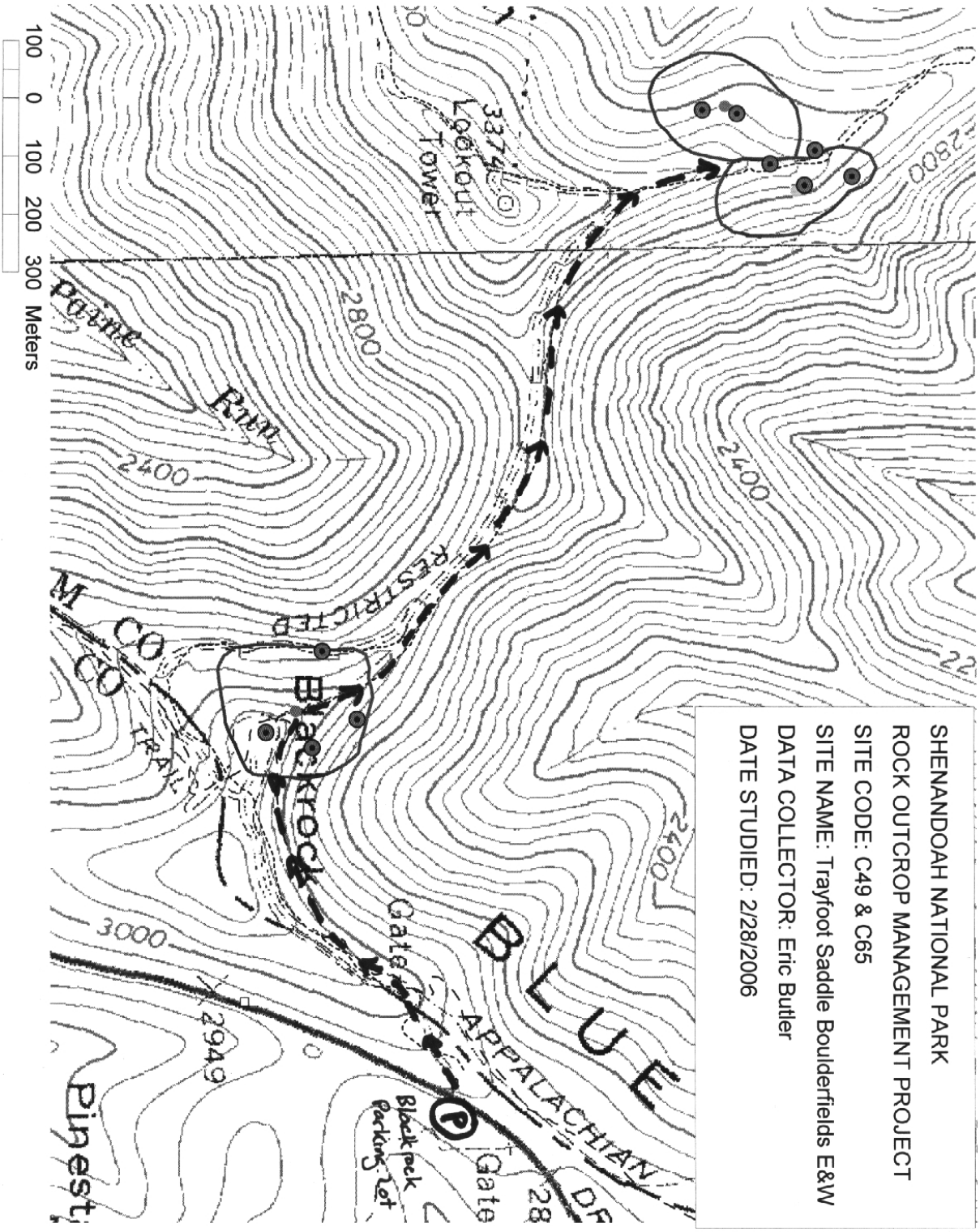
C49 - Trayfoot Saddle boulderfields - west (continued...)

Detail map



C49 - Trayfoot Saddle boulderfields - west (continued...)

Area map



C49 - Trayfoot Saddle boulderfields - west (continued...)



SHEN_C49_G_20060228_001.jpg Azmuth: 115

Looking up boulder field



SHEN_C49_G_20060228_002.jpg Azmuth: 10

Looking across domed boulder field



SHEN_C49_G_20060228_003.jpg Azmuth:

Typical sharply angled quartzite talus



SHEN_C49_G_20060228_004.jpg Azmuth:

Preserved layering in quartzite

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C50 - Upper Devils Ditch

Site Code: C50
Site Name: Upper Devils Ditch
Data Collector Butler, Eric
Date Studied: 08-Feb-06

Polygon Centroid: **E:** 721132 **N:** 4257682
UTM (Zone 17 NAD83)
Dimensions (m): 200 x 550 (GIS est.)
Elevation Range (ft): 3000 to 3320

Physical Characteristics

Location Acces

Park at access road to Bearfence Mountain Hut; there are two options here. Just north of Milepost 57, there is a small parking lot on the northwest side of the road, while a gravel road leads a short distance southeast to a small gravel lot before a gate. Either way, follow the gravel road south down into the valley. About 200m from Skyline Drive, a side track leads to the Bearfence Mountain Hut. Continue south on the main gravel road for about another 400m, then leave the road and bushwhack 100m southeast up the slope to reach the northernmost rock exposure within the site. Looking at a map, it may be tempting to leave the road earlier in order to maintain elevation by following contours, but the extremely thick laurels make using the road as long as possible a better bet.

Physical Description:

This site consists of two major rock exposures along a west-facing ridge, with several smaller exposure areas scattered around. It is a very rocky area; most of the slopes are armored by loose rocks, which in places become thick enough to be considered talus or scree. Both major exposures are similar; smooth, rounded, west-facing rock faces, gently sloping at the top and gradually steepening into near-cliffs at the base. Although the slopes are rocky, they are not overly unstable and are generally traversable without too much trouble (laurels notwithstanding). Several smaller smooth rock faces occur near the site centerpoint, which may be of interest though they are only partially open. There is a noticeable break in slope within the site; the landscape begins in a smooth, gently sloping terrain with isolated rocks, then suddenly steepens along a nearly straight N-S line to form a rampart along which open rock faces and thick talus occur. All open areas within the site occur along this steeper rampart.

Vegetation: Dense

This site is dominated by dense thickets of laurel, in places virtually impermeable to humans. The laurels are omnipresent in all but the southwest corner of the site and present a significant barrier to navigation. They are especially thick near the tops of the major rock exposures, and in several places care must be taken when pushing through to access the rock beyond.

Human Effects

Impacts: Pristine

No signs of human presence or impact to this site was identified. No social trails were present; lichens, soil, and vegetation appeared natural; and no trash or human debris was found.

Access Remote

Although the site boundary briefly intersects with a park trail (the old gravel road), this site is best classified with other remote sites. There are no trails, official or social, that lead to the rock exposures themselves, and these exposures are not visible from the established trails during most parts of the year (even in the winter, the rocks are barely visible through the trees). In addition, the especially thick laurels surrounding the site provide a significant discouragement to most potential visitors to the site.

Geologic Characteristics

Lithology: **Rock Type** Granitic gneiss

In general, the rock exposures are mostly composed of a medium-fine grained granite (most crystals <1cm), dominated by quartz and orthoclase feldspar, though the composition can be quite variable in a few places. The rock appears similar to Old Rag Granite in that it contains very few darker minerals, but it does not contain the blue quartz typical of Old Rag Granite. It weathers to a common reddish staining on the surface and within broken samples. At one small exposure near the site centerpoint, the rock appears closer to charnockite, in this place being a darker grey-green coarse-grained rock, but this is not typical of the site.

C50 - Upper Devils Ditch (continued...)

Structure:

Most of the rock contains a strong foliation, defined by bands of aligned, similar minerals. This foliation generally dips to the east at around 15 degrees, and manifests itself on the surface by subtly breaking up the rounded rock faces into a series of lobes. There are no obvious joint sets present. Exfoliation is common, creating thin slabs that cling to the sloping faces of the major exposures as well generating some platy talus fragments.

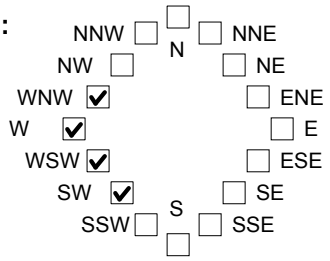
Other:

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	20.0	10.0	50.0	10.0	10.0	100
Max relief(m):	15	5	10	1	5	

Maximum Slope: 20 **Texture:** Smooth

Aspects:



Setting:

The rock exposures in this site are typical of granitic exposures within Shenandoah, forming rounded, sloping faces that steepen toward the base. These rounded faces are a result of exfoliation, a process in which rocks slowly fracture into thin, curved slabs over a long period of time, due to many cycles of thermal expansion and contraction in the rock. This process is especially common in granitic rocks, due to their relatively coarse grain size and lack of other dominant structures that would override this process, such as layering or cleavage. At this site, the strong foliation does influence the shape of the exposures as well, creating some narrow ledges where this planar feature interacts with the surface. The lack of joints or other fractures within the rock, however, makes the exposures very solid, and also contributes to the large, smooth, open exposures. Areas within the site where bedrock is not present, but thick boulder deposits are, may represent areas with more joints or fractures that have eroded more quickly.

The western aspect reflects the surrounding topography, as the site is located along a north-south oriented ridge that defines one side of the drainage basin here. The abrupt change in slope at the base of the cliff, where the landscape goes from steep and rocky to gentle and forested, may represent fill from a once-larger cliff. At some point in the past, when climatic conditions resulted in increased erosional processes (and the streams could move more material), the valley floor may have been deeper and the steep rocky slopes and exposures higher. Recently, loose rock eroding from the cliffs and faces may have begun to fill in this valley (once the streams lost their power to move this material). This process could build up a smooth terrace butted against the cliffs, creating the sharp break in slope seen today. This is a common process, and seems a likely explanation for the topographic pattern seen here.

Stability: Stable

There are little to no fractures within the bedrock, which forms a very solid mass. While there is a great deal of loose rock on the surrounding slopes, very little of it forms open talus. Exfoliating slabs clinging to the rock faces should be avoided, but these are not common enough to be of significant concern.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
2/8/2006	G208-C50	721113	4257793	3160	Center top of northern major rock exposure
2/8/2006	G209-C50	721204	4257751	3280	Knob of semi-open talus upslope to southeast of northern exposure
2/8/2006	G210-C50	721174	4257575	3200	Upper face of southern major rock exposure
2/8/2006	G211-C50	721164	4257445	3080	Several small cliff/outcrop areas, partially forested

Site Photos

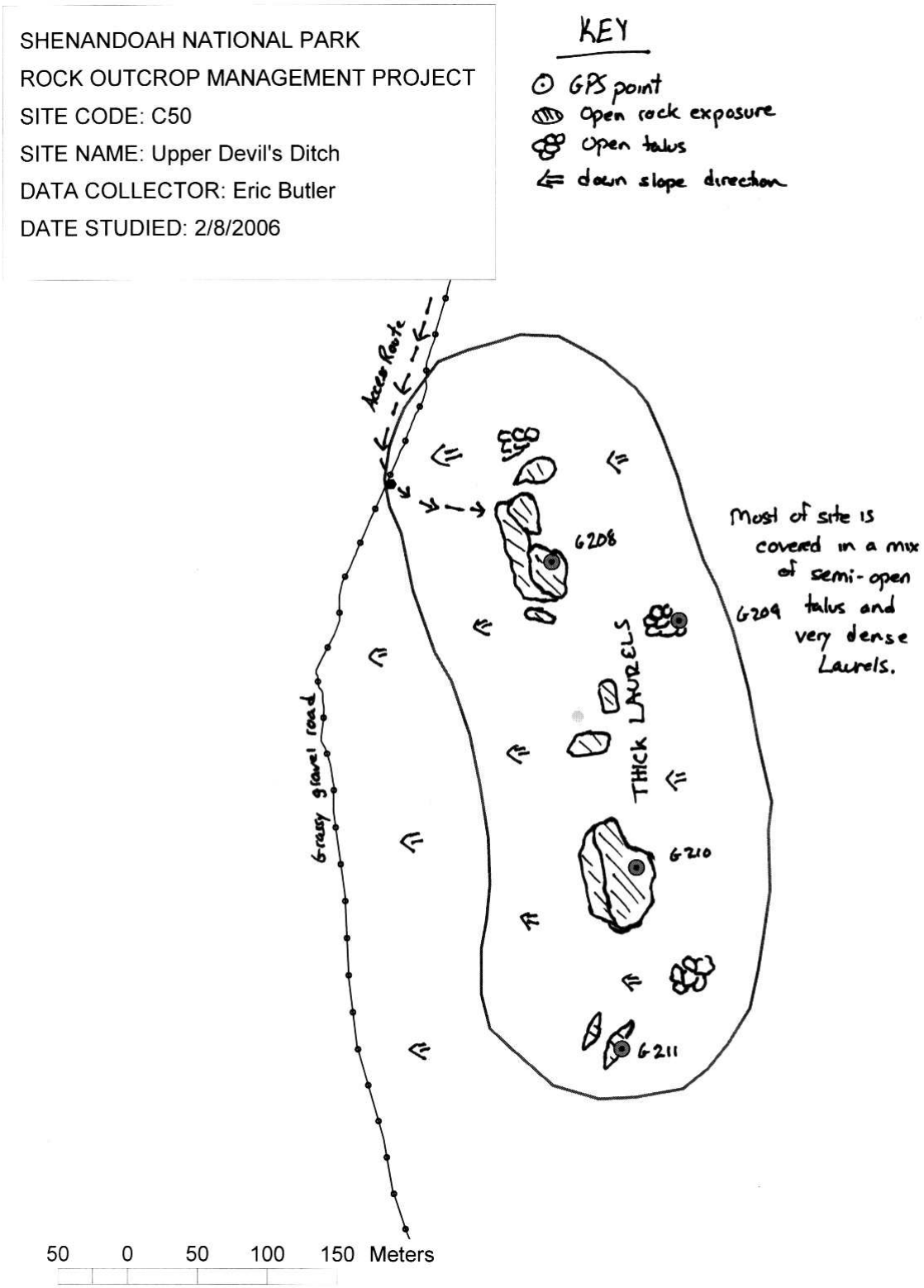
Image Date	GPS Point	File Name	Azmuth	Taken By	Description
2/8/2006		SHEN_C50_G_20060208_001.JPG	130	Butler, Eric	View of G208 exposure through zoom lens from Skyline Drive

C50 - Upper Devils Ditch (continued...)

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
2/8/2006		SHEN_C50_G_20060208_002.JPG	120	Butler, Eric	View of G210 exposure through zoom lens from Skyline Drive
2/8/2006	G208-C50	SHEN_C50_G_20060208_003.jpg	155	Butler, Eric	Base of open rock face below G208
2/8/2006	G208-C50	SHEN_C50_G_20060208_004.jpg	345	Butler, Eric	Open face and trees south of G208
2/8/2006		SHEN_C50_G_20060208_005.jpg	270	Butler, Eric	Small open face near site centerpoint
2/8/2006	G210-C50	SHEN_C50_G_20060208_006.jpg	150	Butler, Eric	Open face at G210
2/8/2006	G210-C50	SHEN_C50_G_20060208_007.jpg	350	Butler, Eric	Open face with exfoliation slabs
2/8/2006	G210-C50	SHEN_C50_G_20060208_008.jpg	280	Butler, Eric	View down open face at exfoliating slabs
2/8/2006		SHEN_C50_G_20060208_009.jpg		Butler, Eric	Banded foliation in bedrock
2/8/2006		SHEN_C50_G_20060208_010.jpg		Butler, Eric	Less foliated, coarser grained bedrock

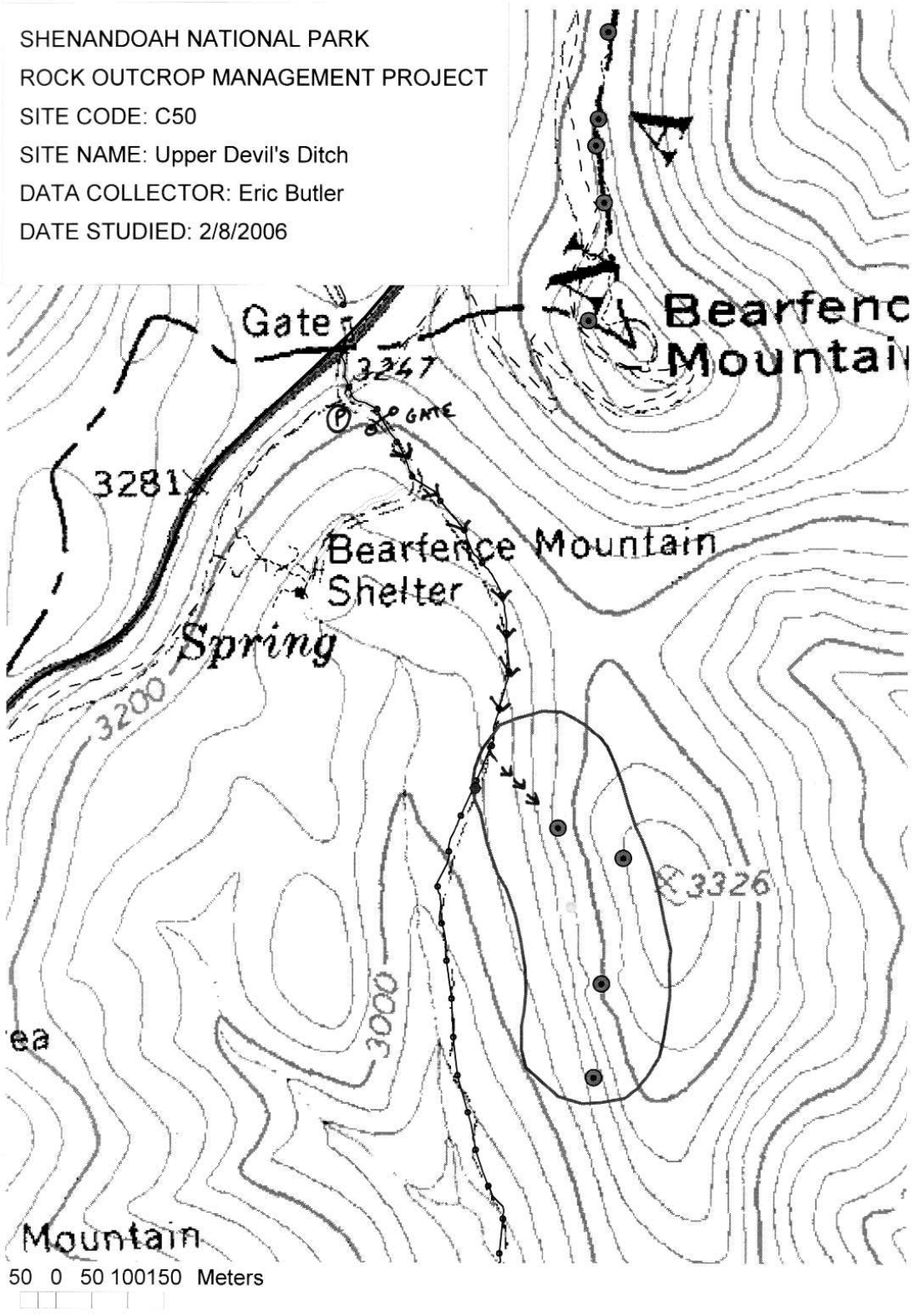
C50 - Upper Devils Ditch (continued...)

Detail sketch map



C50 - Upper Devils Ditch (continued...)

Area sketch map



C50 - Upper Devils Ditch (continued...)



SHEN_C50_G_20060208_001.JPG Azmuth: 130

View of G208 exposure through zoom lens from Skyline Drive



SHEN_C50_G_20060208_002.JPG Azmuth: 120

View of G210 exposure through zoom lens from Skyline Drive



SHEN_C50_G_20060208_003.jpg Azmuth: 155

Base of open rock face below G208



SHEN_C50_G_20060208_004.jpg Azmuth: 345

Open face and trees south of G208

C50 - Upper Devils Ditch (continued...)



SHEN_C50_G_20060208_005.jpg Azmuth: 270

Small open face near site centerpoint



SHEN_C50_G_20060208_006.jpg Azmuth: 150

Open face at G210



SHEN_C50_G_20060208_007.jpg Azmuth: 350

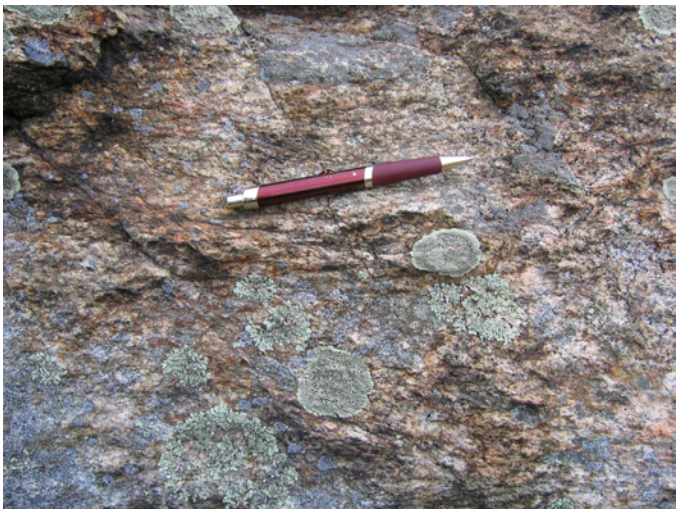
Open face with exfoliation slabs



SHEN_C50_G_20060208_008.jpg Azmuth: 280

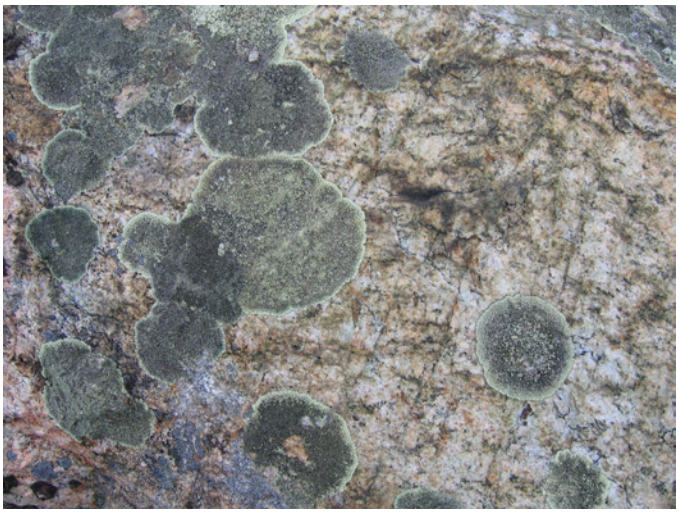
View down open face at exfoliating slabs

C50 - Upper Devils Ditch (continued...)



SHEN_C50_G_20060208_009.jpg Azmuth:

Banded foliation in bedrock



SHEN_C50_G_20060208_010.jpg Azmuth:

Less foliated, coarser grained bedrock

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C60 - Hawksbill N slope talus

Site Code: C60
Site Name: Hawksbill N slope talus
Data Collector Butler, Eric
Date Studied: 27-Mar-06

Polygon Centroid: **E:** 727165 **N:** 4270828
UTM (Zone 17 NAD83)
Dimensions (m): 70 x 620 (GIS est.)
Elevation Range (ft): 3600 to 3720

Physical Characteristics

Location Acces

Park at the Hawksbill Gap parking area (Milepost 45.5) and follow a short connector trail to the Appalachian Trail (AT). Make sure not to follow the Hawksbill Trail, which begins from the same lot but leads to Hawksbill summit rather than the north slope via the AT. Once on the AT, hike south for about 400m, climbing steadily, until the trail begins to cross a series of linear talus slopes with views to the north and east.

Physical Description:

This site consists of open to semi-open talus fields forming below the large cliffs on the north side of Hawksbill Mountain (C21). The largest of these talus fields are found below the cliffs, though several smaller open areas are present scattered along the slope to the east, along with some small bedrock outcrops. This site overlaps somewhat with C21 (Hawksbill North Slope), as the talus fields extend to the base of that site's cliffs and thus the boundaries overlap. The Appalachian Trail crosses directly through or next to most of the open areas. Just outside the northwest site boundary, a large semi-open cliff area is present, below and just to the east of which several occurrences of the rare plant Huperzia were found.

Vegetation: Moderate

Most of these open areas are directly adjacent to, if not crossed by, a trail. Thus vegetative barriers are generally minimal, although the growth surrounding the talus fields can be quite thick.

Human Effects

Impacts: Mild

Human impacts are difficult to measure on talus fields, as little physical evidence remains on the bare rock. Lichen cover does seem diminished near the trail, but this is difficult to quantify. No obvious signs of social trails or other impacts were seen. No graffiti or trash was observed.

Access Moderate

The hike in from Hawksbill Gap involves a steady gain in elevation and offers no views or broad attractions, making it unlikely that casual hikers will make it to this site. The portion of the Appalachain Trail that crosses the site does, however, form part of a natural loop by which hikers might explore Hawksbill, and so likely does draw more people than it otherwise might. Average AT traffic also contributes to the human presence at this site, which does offer some good views to the north and thus is a natural stopping point.

Geologic Characteristics

Lithology: **Rock Type** Greenstone

The boulders within these talus fields are composed of Catoctin Formation greenstone, sourced in the cliffs of C21 (Hawksbill North Slope) directly above. The loose material is a broad mix of possible greenstone compositions, due to the large cliff area from which they are sourced (underlain by at least three different lava flows). Most boulders are standard greenstone, fine grained with variable cleavage present. A few consist of material from the contact zones between flows, containing breccia, amygdules, higher quantities of epidote, and so on.

Structure:

Several of the source flows contain well-developed columnar jointing, and these structures are preserved in some of the boulders within C60. These fragments exhibit smooth sides joined at obtuse angles, and their columnar look is easily contrasted with the more jagged appearance of blocks primarily affected by cleavage. Otherwise there are no structures to discuss, as by definition the vast majority of the site consists of loose talus material.

Other:

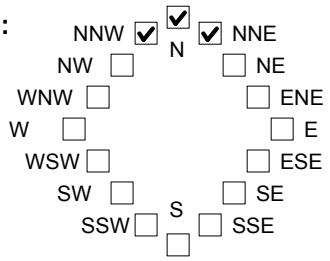
C60 - Hawksbill N slope talus (continued...)

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	10.0	10.0	0.0	10.0	70.0	100
Max relief(m):	10	5	0	1	15	

Maximum Slope: 35 **Texture:** Fractured

Aspects:



Setting:

The larger talus fields here are clearly formed by erosion of the large cliff areas directly above. Physical weathering of the cliffs, including frost wedging, loosens boulders and fragments that tumble down the slope some distance. These talus fields form a very linear chain across the face of the mountain, seeming to stop at a consistent elevation across the slope. This pattern may be due to the presence of another resistant flow below the main cliffs, which formed a topographic bench onto which these boulders came to rest. The moderate cliff found at G234 may be the most visible evidence for this hypothesis. The smaller talus fields toward the eastern end of the site, which do not have cliffs or other rock exposures directly above them, may be the result of bedrock eroding mostly in-place. This process has been described in the quartzite areas of the park's South District, and is attributed to the extreme weather conditions present during the last glacial period. Periglacial weathering of this type may be a main factor in large talus field formation through this site, and not just at the isolated areas to the east.

The abundant cleavage planes and columnar jointing found throughout the lava flows in this area. as well as other fractures developed during later mountain-building, all combine to make the otherwise erosion-resistant greenstone more likely to erode into medium to large blocks that then collect on and armor a slope. These boulder fields seem to be more prevalent in areas where the bedrock contains high amounts of such structures, as compared to areas with few fractures or joints. When the resulting boulders create a thick enough layer, most soil and vegetation is unable to establish itself among the large and deep spaces between individual boulders, and the result is an open and unvegetated boulder field. Observation of the edges of these areas suggests that they may once have been larger, and that soil and thicker vegetation are slowly colonizing their edges and thus gradually shrinking the area of truly open rock exposure.

Stability: Loose

By definition, most of the open areas within the site are underlain by large, loose rocks. These can shift easily, and often have deep crevices between them. The steep angle of the talus also raises the risk of unexpected shifting and unstable footing.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
3/27/2006	G230-C60	727237	4270786	3580	Center of small open talus field, first visible from AT when approaching
3/27/2006	G231-C60	727328	4270717	3600	Small open talus area outside site boundary to southeast; possibly of i
3/27/2006	G232-C60	727189	4270808	3580	Eastern of two larger talus areas extending above and below AT
3/27/2006	G233-C60	727132	4270826	3620	Western of two larger talus areas extending above and below AT
3/27/2006	G234-C60	727000	4270911	3580	Top of cliff/ledge area just below AT; rare plant huperzia was found alo
3/27/2006	G235-C60	726979	4270844	3680	Center of large talus area on western side of bedrock ridge extending

Site Photos

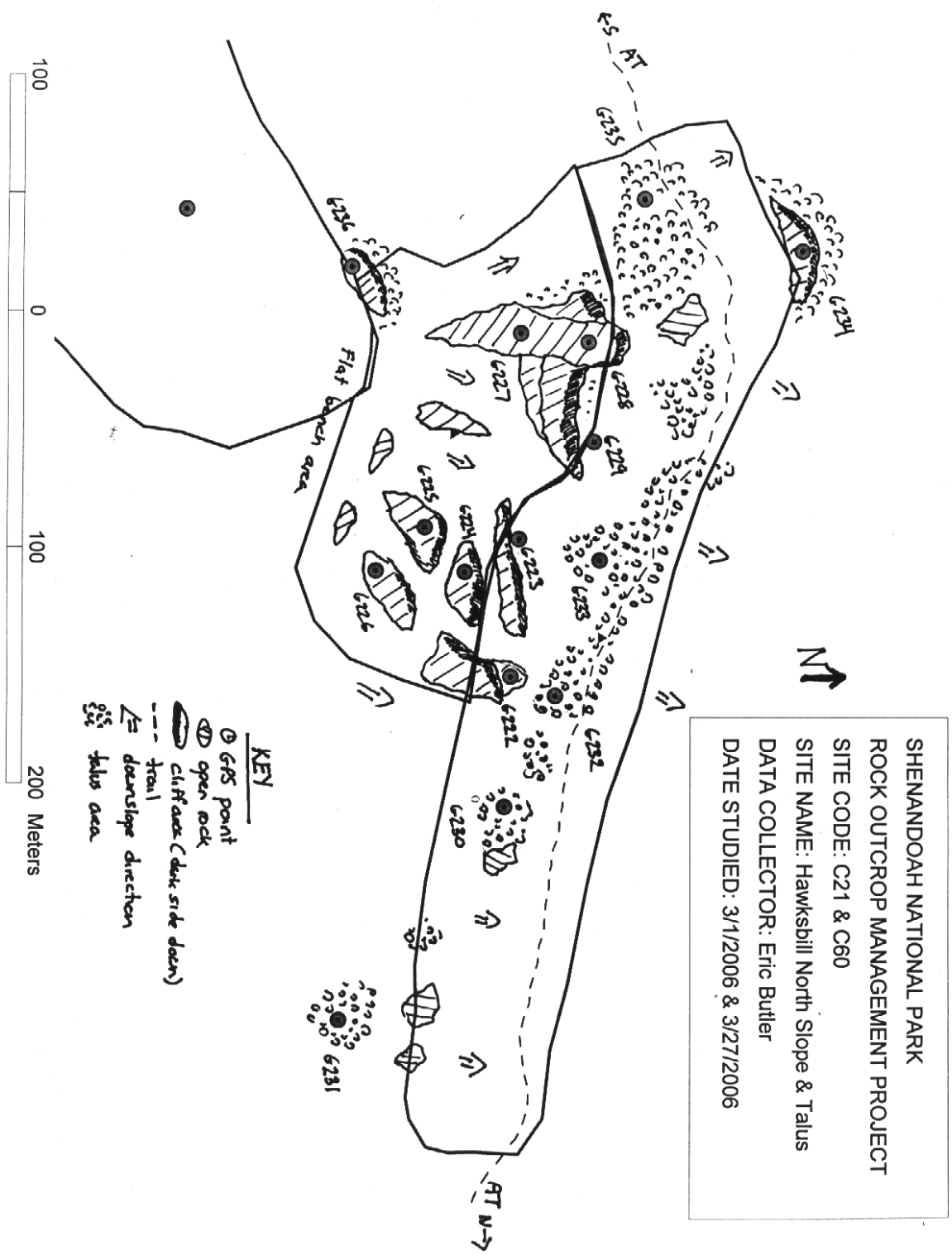
Image Date	GPS Point	File Name	Azmuth	Taken By	Description
3/27/2006		SHEN_C60_G_20050428_001.JPG		Butler, Eric	Wide view of talus fields and cliffs above, taken from Crescent Rock
3/27/2006	G230-C60	SHEN_C60_G_20060327_001.jpg	280	Butler, Eric	Boulders on steep slope; notice forest vegetation slowly encroaching
3/27/2006	G231-C60	SHEN_C60_G_20060327_002.jpg	335	Butler, Eric	Small open talus area at east end of site
3/27/2006	G232-C60	SHEN_C60_G_20060327_003.jpg	290	Butler, Eric	View across large open areas just above Appalachian Trail

C60 - Hawksbill N slope talus (continued...)

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
3/27/2006	G232-C60	SHEN_C60_G_20060327_004.jpg	350	Butler, Eric	View down talus toward AT near base of open area
3/27/2006	G232-C60	SHEN_C60_G_20060327_005.jpg		Butler, Eric	Typical angular greenstone boulders, with variable lichen coverage
3/27/2006	G234-C60	SHEN_C60_G_20060327_006.jpg		Butler, Eric	Cliff below AT along which huperzia was found
3/27/2006	G234-C60	SHEN_C60_G_20060327_007.jpg		Butler, Eric	Angled columnar jointing along cliff area
3/27/2006	G234-C60	SHEN_C60_G_20060327_008.jpg		Butler, Eric	Huperzia near G234
3/27/2006	G234-C60	SHEN_C60_G_20060327_009.jpg		Butler, Eric	Huperzia near G234

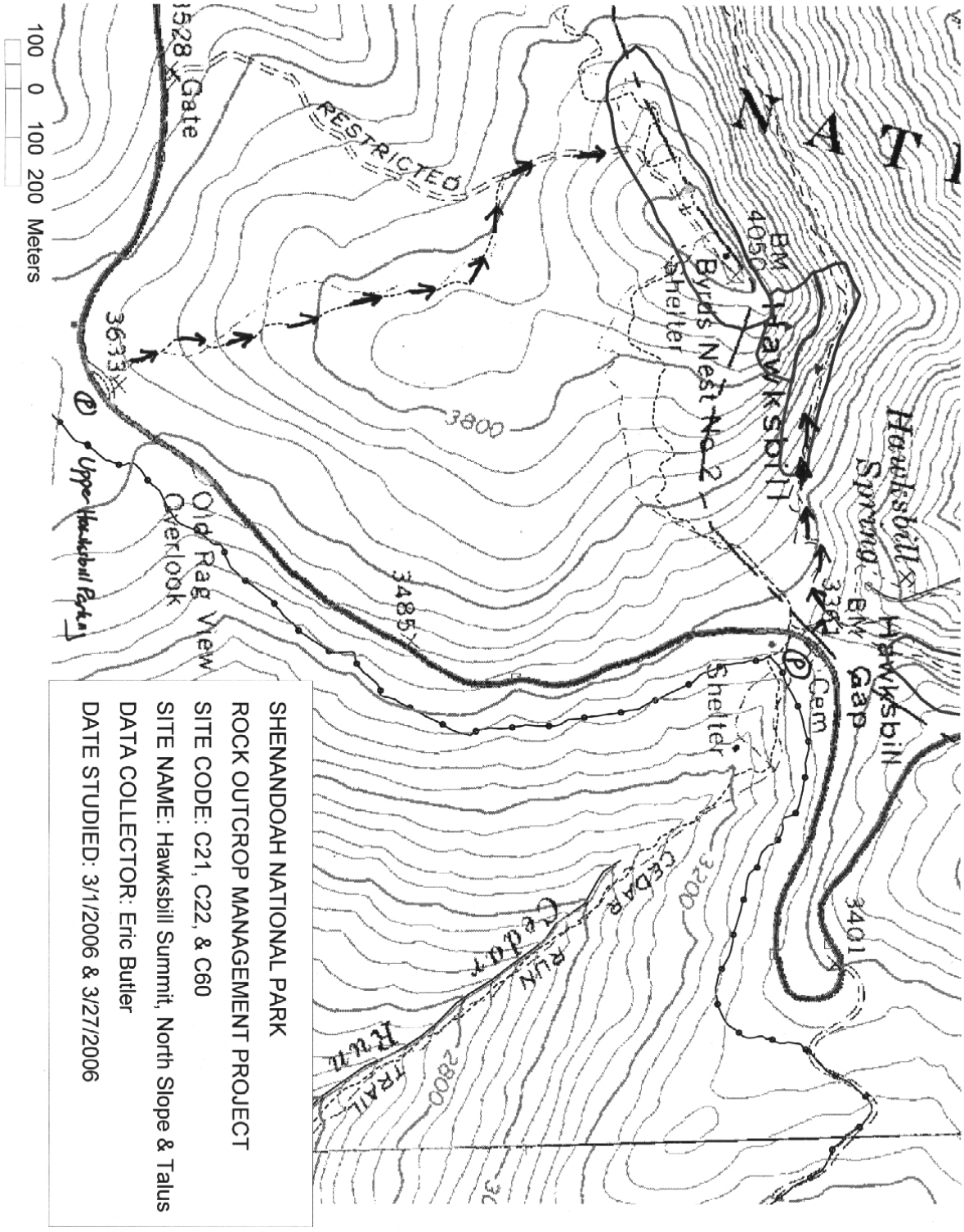
C60 - Hawksbill N slope talus (continued...)

Detail map



C60 - Hawksbill N slope talus (continued...)

Area map



C60 - Hawksbill N slope talus (continued...)



SHEN_C60_G_20050428_001.JPG Azmuth:

Wide view of talus fields and cliffs above, taken from Crescent Rock



SHEN_C60_G_20060327_001.jpg Azmuth: 280

Boulders on steep slope; notice forest vegetation slowly encroaching



SHEN_C60_G_20060327_002.jpg Azmuth: 335

Small open talus area at east end of site



SHEN_C60_G_20060327_003.jpg Azmuth: 290

View across large open areas just above Appalachian Trail

C60 - Hawksbill N slope talus (continued...)



SHEN_C60_G_20060327_004.jpg Azmuth: 350

View down talus toward AT near base of open area



SHEN_C60_G_20060327_005.jpg Azmuth:

Typical angular greenstone boulders, with variable lichen coverage



SHEN_C60_G_20060327_006.jpg Azmuth:

Cliff below AT along which huperzia was found



SHEN_C60_G_20060327_007.jpg Azmuth:

Angled columnar jointing along cliff area

C60 - Hawksbill N slope talus (continued...)



SHEN_C60_G_20060327_008.jpg Azmuth:

Huperzia near G234



SHEN_C60_G_20060327_009.jpg Azmuth:

Huperzia near G234

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C62 - Old Rag Summit West

Site Code:	C62	**Polygon Centroid:**	**E:** 734142 **N:** 4270453
Site Name:	Old Rag Summit West		UTM (Zone 17 NAD83)
Data Collector	Butler, Eric	**Dimensions (m):**	250 x 920 (GIS est.)
Date Studied:	15-Jun-05	**Elevation Range (ft):**	2920 to 3280

Physical Characteristics

Location Acces

Site is located about 7km southeast of Skyline Drive, on an isolated peak east of the main body of mountains. Access from Skyline Drive along Old Rag Fire Road (requires gate key and 4WD vehicle), which begins from Limberlost parking area (Mile 43) and leads east to fire road junction at base of Old Rag Mountain. Park here at side of fire road and follow Saddle Trail 2.7km to summit of Old Rag. For access from outside SHEN, park at lots along VA 600 and hike Weakley Hollow Fire Road (from north) or Berry Hollow Fire Road (from south) to fire road junction, and follow Saddle Trail to summit. Summit can also be accessed along Ridge Trail (4.3km) from Weakley Hollow parking lot, although this route is more rugged.

Physical Description:

The summit ridge of Old Rag Mountain consists of large expanses of smooth, open rock exposures that transition from gently sloping faces to sheer cliffs up to 50m high. The summit ridge is littered with large, sub-spherical boulders that form jumbled piles and isolated knobs. Within the bedrock, numerous joints and fractures create a maze of eroded cracks, passages, and smaller cliffs that make bushwhacking difficult and dangerous. The north side of the mountain drops away to sheer cliffs divided by rugged, overgrown boulder piles, while the south side has a more gentle slope (within the site) with variable vegetation. In at least one location on the south slope (G055), there is a large, gently sloping face that is quite different from the rugged, boulder-dominated cliffs and faces on the north side.

Vegetation: Dense

Thickets of laurel and other vegetation cover much of the summit that is not bare rock, and can be nearly impassable in places. On the south side of the summit ridge, vegetation varies within a few meters from dense laurel to semi-open forest and back.

Human Effects

Impacts: Heavy

The summit of Old Rag is extensively impacted, as are numerous areas along the main trail and several side trails. Impacts consist of near-total stripping of soil and vegetation, leaving barren gravel deposits in cracks and ledges among bare rock exposures. Numerous social trails lead into woods, down slopes, and around boulders and cliffs. At the base of one major cliff, a continous social trail (G058) leads directly through numerous occurences of the rare plant hupersia. At one location along this trail (G056) several climbing bolts and leftover ropes are visible on the cliff above, while the area around the base is bare gravel.

Access Difficult

Of the two trails to the Old Rag summit, the Saddle Trail is easier (though still steep and rocky), but is much farther from public points of access. The Ridge Trail, from the Weakley Hollow parking lot, requires a great deal of scrambling up, around, and through numerous boulders and cracks. Despite the difficulties of ascending either trail, Old Rag Mountain is an extremely popular hike, well advertised and signed, and is heavily visited.

Geologic Characteristics

Lithology: **Rock Type** Old Rag Granite

Old Rag Mountain is formed entirely from the Old Rag Granite, a distinct rock unit in SHEN. This granite is predominately quartz and orthoclase feldspar, with virtually no other minerals visible. The granite is very uniform in appearance; fairly coarse-grained, with individual crystals growing over 2cm, especially the feldspars. The quartz is generally a dark grey-blue, while the orthoclase is white-pink. There may be a faint foliation present, mostly visible as a slight linear texture formed by strung-out quartz crystals, but the rock is generally massive (no internal structures). Garnets may be present in minor amounts, with isolated concentrations.There are also many basaltic dikes along the summit, which result in linear deposits of dark, fine-grained rocks along the surface.

C62 - Old Rag Summit West (continued...)

Structure:

The granite is heavily fractured, with no readily apparent fracture orientation dominant, as the fractures appear to be oriented in all directions through 3 axes. These fractures tend to be widely spaced (meters apart), and do not follow any structure within the rock, which is otherwise massive. There is, in fact, a regional joint set that trends NNE, along which most the basaltic dikes are oriented, but the locally chaotic nature of the fractures makes this difficult to notice from within the site. This joint set is better seen from far away (from Skyline Drive overlooks, for example), where its influence on the morphology of Old Rag summit is more noticeable.

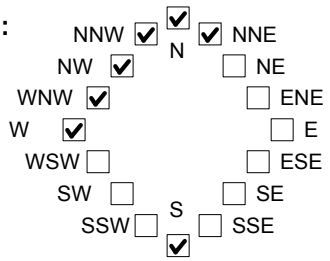
Other:

The basaltic dikes found on Old Rag are composed of mafic minerals that are generally much more susceptible to weathering than the quartz and orthoclase of the granite, and so the dikes tend to form linear depressions across the summit that are generally filled in with rubble and vegetation so that the underlying rock cannot be seen; the widest of these is around 3m across. These dikes are mostly recognized by the presence of basaltic float on the surface rather than bedrock exposure.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	45.0	10.0	45.0	0.0	0.0	100
Max relief(m):	50	5	5	0	0	

Aspects:



Maximum Slope:

Texture: Smooth to fractured

Setting:

The Old Rag Granite is quite resistant to weathering for several reasons. First, quartz and orthoclase feldspar are stable minerals at the Earth's surface, and so are resistant to chemical weathering of individual crystals. Unlike most granites, there are few secondary mafic minerals on which these processes can preferentially operate, so the rock remains especially cohesive and stable. Second, the generally massive nature of the rock provides few obvious planes of weakness on which physical weathering can operate. These factors mean that large-scale physical weathering is the dominant process on Old Rag Mt.

The widespread fractures so obvious in the area are the main geomorphic agent, as they provide a conduit for physical weathering processes such as the freeze/thaw cycle to operate. The wide spacing of these fractures, coupled with the otherwise massive and resistant nature of the rock, produces large, angular blocks that evolve more rounded shapes as the exposed corners are worn down. The large boulders that appear "balanced" on top of the bedrock faces along the summit ridge were produced in-place by this process. The smooth, gently sloping faces are likely a product of exfoliation, in which an otherwise massive bedrock slowly fractures into parallel or concentric layers which then peel away, leaving behind a rounded face. The best example of this process can be seen at G055, where several fragments of an exfoliated layer remain on the surface, above the current bedrock face.

The regional NNE joint set, while not obvious on-site, is more apparent when viewed from a distance, especially in low-angle sunlight. These joints cut across the E-W trend of the summit ridge and appear to define the sides of several "lobes" of granite that stick out from the ridge, including the summit, divided by more eroded troughs that also follow this general NNE orientation. In a few places, these NNE troughs are underlain by preferentially weathering basaltic dikes.

Stability: Stable

Though there are numerous fractures within the bedrock, these are generally spaced far enough apart that there is very little danger of any individual piece moving. The steeper slopes between cliffs may have loose soil and debris, but in general the rock is very solid and trustworthy. Danger comes primarily from steep slopes and thick vegetation.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
6/15/2005	G052-C62	734004	4270449	3260	Large basaltic dike at summit
6/15/2005	G053-C62	734425	4270429	3180	East end of exposures within site
6/15/2005	G054-C62	733873	4270489	3250	West end of exposures; top of smaller knob to west of summit
6/15/2005	G055-C62	734272	4270315	3100	Open face in southern extent of site

C62 - Old Rag Summit West (continued...)

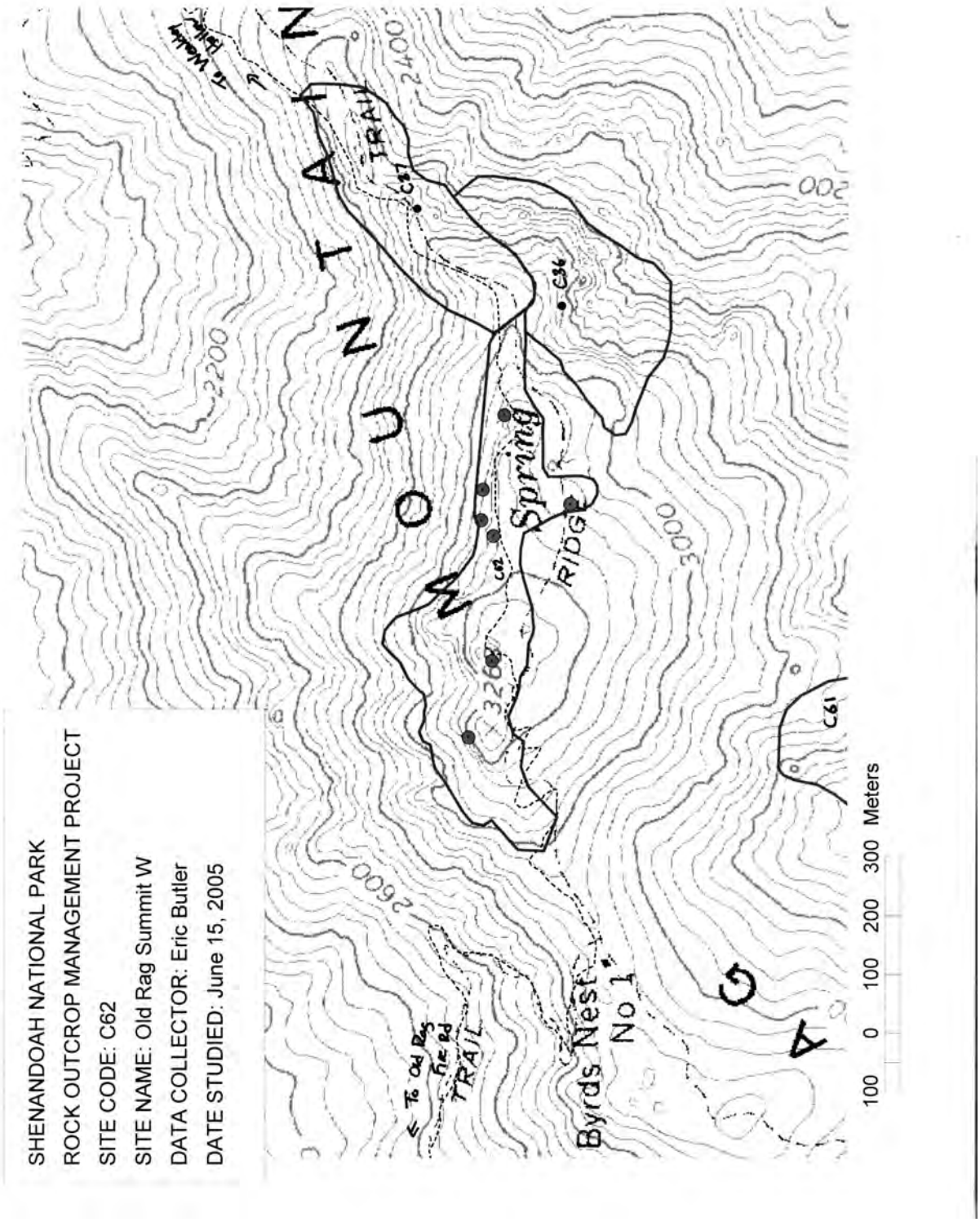
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
6/15/2005	G056-C62	734296	4270465	3100	Site of climbing impact; also location of rare plant hupersia
6/15/2005	G057-C62	734244	4270467	3100	Location of rare plant hupersia
6/15/2005	G058-C62	734217	4270447	3120	Location of rare plant hupersia; head of social trail leading below cliffs

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
6/15/2005	G052-C62	SHEN_C62_G_20050615_001.jpg	25	Butler, Eric	NE-oriented slot in summit, marks location of basaltic dike
6/15/2005	G052-C62	SHEN_C62_G_20050615_002.jpg	25	Butler, Eric	View along joint toward fractured blocks further downslope
6/15/2005	G054-C62	SHEN_C62_G_20050615_003.jpg	90	Butler, Eric	View east toward main summit; note random fracturing throughout rock
6/15/2005	G055-C62	SHEN_C62_G_20050615_004.jpg	135	Butler, Eric	Large open exfoliated face to south
6/15/2005	G056-C62	SHEN_C62_G_20050615_005.jpg		Butler, Eric	Human impact along social trail at base of eastern cliff.
6/15/2005		SHEN_C62_G_20050615_006.JPG		Butler, Eric	Exfoliation in basaltic boulder along ridge trail
6/15/2005	G057-C62	SHEN_C62_G_20050615_007.JPG		Butler, Eric	Example of hupersia along base of eastern cliff

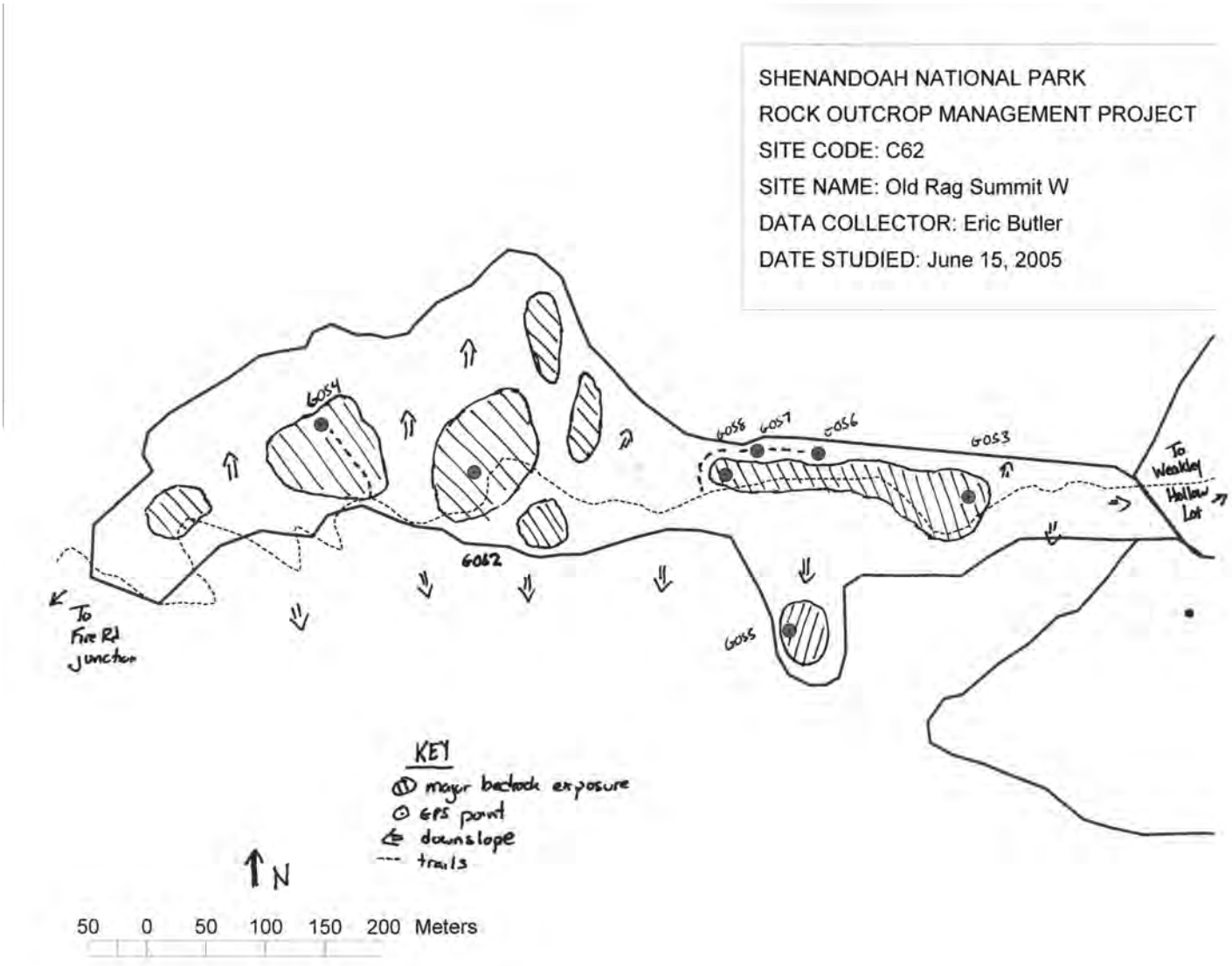
C62 - Old Rag Summit West (continued...)

Area sketch map



C62 - Old Rag Summit West (continued...)

Detail sketch map



C62 - Old Rag Summit West (continued...)



SHEN_C62_G_20050615_001.jpg Azmuth: 25

NE-oriented slot in summit, marks location of basaltic dike



SHEN_C62_G_20050615_002.jpg Azmuth: 25

View along joint toward fractured blocks further downslope



SHEN_C62_G_20050615_003.jpg Azmuth: 90

View east toward main summit; note random fracturing throughout rock



SHEN_C62_G_20050615_004.jpg Azmuth: 135

Large open exfoliated face to south

C62 - Old Rag Summit West (continued...)



SHEN_C62_G_20050615_005.jpg Azmuth:

Human impact along social trail at base of eastern cliff.



SHEN_C62_G_20050615_006.JPG Azmuth:

Exfoliation in basaltic boulder along ridge trail



SHEN_C62_G_20050615_007.JPG Azmuth:

Example of hupersia along base of eastern cliff

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C63 - Overall Run Falls North

Site Code: C63
Site Name: Overall Run Falls North
Data Collector Butler, Eric
Date Studied: 12-Sep-06

Polygon Centroid: **E:** 735048 **N:** 4296216
UTM (Zone 17 NAD83)
Dimensions (m): 80 x 250 (GIS est.)
Elevation Range (ft): 1700 to 2100

Physical Characteristics

Location Acces

Enter Matthews Arm Campground at about milepost 22.2 along Skyline Drive. Past the entrance station, bear right at a T junction. Follow Loop B to the far end of the campground, where a short road leads to the tenting-only sites. Park here, or if a gate key is available, continue through the gate along the fire road. The road will eventually end in a small turn-around; park and continue down the trail, past several trailheads for other routes, until reaching the trail head for the Tuscarora-Overall Run trail. This trail leads past a smaller waterfall to the much larger waterfall at the center of both sites. C39 is across the stream to the west, and can be accessed by crossing just above the waterfall and climbing the ridge. C63 stretches from the large open areas beyond the falls to several glades reached by social trails from the main trail above the falls. Total distance from Matthews Arm Campground is about 3km, with a drop in elevation of about 900'.

Physical Description:

This site covers a series of cliffs and other rock exposures northeast of Overall Run, roughly centered on Overall Run Falls. Companion site C39 consists of open ledge areas on the remote southwestern side of Overall Run. North of the falls, a large cliff line extends from the falls with the main trail running near or on top of the associated ledges. Upstream of the falls, a series of smaller bedrock exposures appear along the slope above the stream, some accessed by social trails from the main trail in the woods. Three of these are at least partially open, and are marked by points G282, G284, and G285.

Vegetation: Open

Most of the site is open forest or open rock, and thickets or difficult vegetation are rare.

Human Effects

Impacts: Heavy

Overall Run Falls is a popular destination, and impact along the trail is heavy. Numerous social trails lead from the main trail to various exposures, particularly at and downstream of the falls. Right at the top of the falls, two fire rings of various ages were observed, while most of the clifftop ledges to the north appeared heavily traveled with soil stripped away, rock surfaces polished, and gravel common. This impacts can be seen from the remote areas across the stream (see photo 001).

Access Difficult

It is a long hike down to the falls, with a great deal of elevation change, but it appears that many visitors complete the trip. The large and visually striking nature of the falls, combined with their location near a major park campground (Matthews Arm) likely account for this traffic. The area may be difficult to reach, but it is well known and advertised, and so like Old Rag Mountain the attraction outweighs the difficulty.

Geologic Characteristics

Lithology: **Rock Type** Greenstone

This site is formed from several greenstone lava flows of the Catoctin Formation. A single thick, resistant flow forms the sheer cliffs surrounding Overall Run Falls, with several thinner flows capping it, as can be seen in the higher cliffs on the southwest side of the stream. There is a thick but inconsistent unit of amygdaloidal volcanic breccia capping this basal flow, which has a highly variable composition (see OTHER). This unit appears at its greatest thickness below G282, where it descends at least 5m between the trail and the falls, though in other places it seems thinner, and is hardly visible in exposures across the stream to the southwest. Above this unit, the remaining scattered rock exposures are typical fine-grained greenstone forming ledgy outcrops in the woods.

Structure:

The lava flow sequence here appears to be near-horizontal, judging from clear exposures visible near the waterfall. The basal

C63 - Overall Run Falls North (continued...)

flow forming the large cliffs is obviously more resistant to erosion than the rocks above it, though due to a lack of good access this flow could not be observed in detail. There are few specific structures such as columnar jointing or cleavage visible here; the rocks are relatively massive other than some random fracturing that leads to ledges and outcrops, particularly in those flows above the main cliff line.

Other:

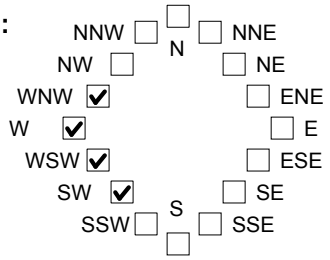
The zone of "contact rock" found roughly above the major cliff line is highly variable. It varies from abundant amygdules of quartz in greenstone, to zones which appear to contain quartz pebbles and sedimentary fragments, to actual brecciated rock fragments. The cleanest exposures of this unit appear along the cliff top near G283, though it is not consistently present. It becomes very thick below G282, but is hardly present across the stream. This variability is common in contact rocks between flows, however.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	30.0	30.0	0.0	40.0	0.0	100
Max relief(m):	15	5	0	2	0	

Maximum Slope: 30 **Texture:** Rough

Aspects:



Setting:

The overall stratigraphy here correlates well to the sequence found across the stream in C39, in which the lowest flow forms a sheer cliff line while the next flow up forms a series of outcrops and ledges rather than sheer exposures. The formation of the large waterfall and associated deep canyon are likely related to the resistance of the thick flow at that level, while those above it have eroded away more quickly. The thick unit of contact rocks is not present across the stream, though here it is quite common. Contact rock units between lava flows are often quite variably in thickness and extent, so this is not unusual. In particular, this unit forms a distinctive set of exposures on the slope between G281 and G282. This area is a rugged, randomly fractured, shapeless zone of bedrock outcrops ascending the slope, quite distinct from the better-defined outcrops and ledges that appear above it and upstream. If ecological or botanical differences are noted between the G282 exposure and those at G284 and G285, the presence of this very different contact rock at G282 may be the reason. Otherwise, this rock is variably present along the cliff tops downstream of the falls, alternating with regular greenstone.

Stability: Stable

All exposures visited in this site were quite stable.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
9/12/2006	G281-C63	735054	4296140	1900	Top of large waterfall, impacted ledges with two fire rings.
9/12/2006	G282-C63	735116	4296144	2020	Top of outcrop area formed from thick, amygdaloidal volcanic breccia
9/12/2006	G283-C63	735061	4296197	1920	Middle of long ledge area along trail, heavily impacted
9/12/2006	G284-C63	735128	4296098	2020	Small open glade on rock outcrops
9/12/2006	G285-C63	735193	4296058	2080	Small open glade on rock outcrops

Site Photos

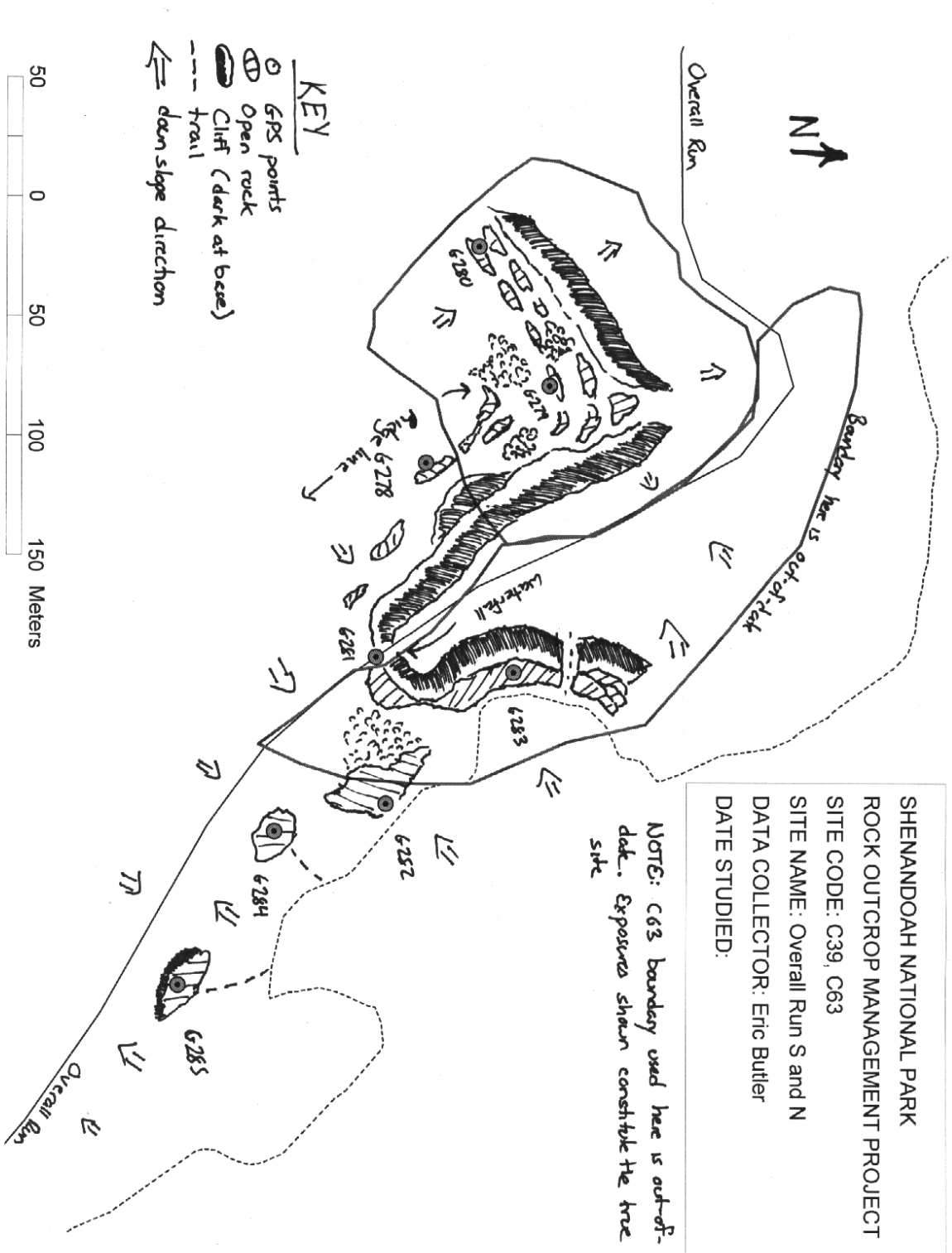
Image Date	GPS Point	File Name	Azmuth	Taken By	Description
9/12/2006		SHEN_C63_G_20060912_001.jpg	60	Butler, Eric	View of cliffs and ledges below falls. Note visible trail impact along ledges at cliff top. Taken from G278 in C39
9/12/2006	G281-C63	SHEN_C63_G_20060912_002.jpg	30	Butler, Eric	Fire ring on impacted ledges next to falls, reached by social trail from main trail to northeast.
9/12/2006	G283-C63	SHEN_C63_G_20060912_003.jpg		Butler, Eric	Amygdaloidal greenstone along top of cliffs below falls; part of a thick and diverse unit of contact rock in the area

C63 - Overall Run Falls North (continued...)

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
9/12/2006	G283-C63	SHEN_C63_G_20060912_004.jpg	280	Butler, Eric	View down trail toward impacted area along clifftop, just below falls.
9/12/2006	G283-C63	SHEN_C63_G_20060912_005.jpg		Butler, Eric	More contact rock; amygdaloidal greenstone or possibly quartz pebbles included in greenstone
9/12/2006	G283-C63	SHEN_C63_G_20060912_006.jpg		Butler, Eric	Amygdaloidal greenstone within contact rock along cliff tops
9/12/2006		SHEN_C63_G_20060912_007.jpg	290	Butler, Eric	Impacted ledges along trail near G283
9/12/2006		SHEN_C63_G_20060912_008.jpg	210	Butler, Eric	Cliff with minor ledges, falls in background. Main cliff line here is likely formed in a single lava flow
9/12/2006		SHEN_C63_G_20060912_009.jpg		Butler, Eric	Overall Run Falls; note notch in cliff near base of falls; possible contact with a lower flow?
9/12/2006		SHEN_C63_G_20060912_010.jpg	305	Butler, Eric	Small grassy glade below main trail; reached by social trail
9/12/2006		SHEN_C63_G_20060912_011.jpg		Butler, Eric	Ledges above outcrop in small open area below main trail; reached by social trail

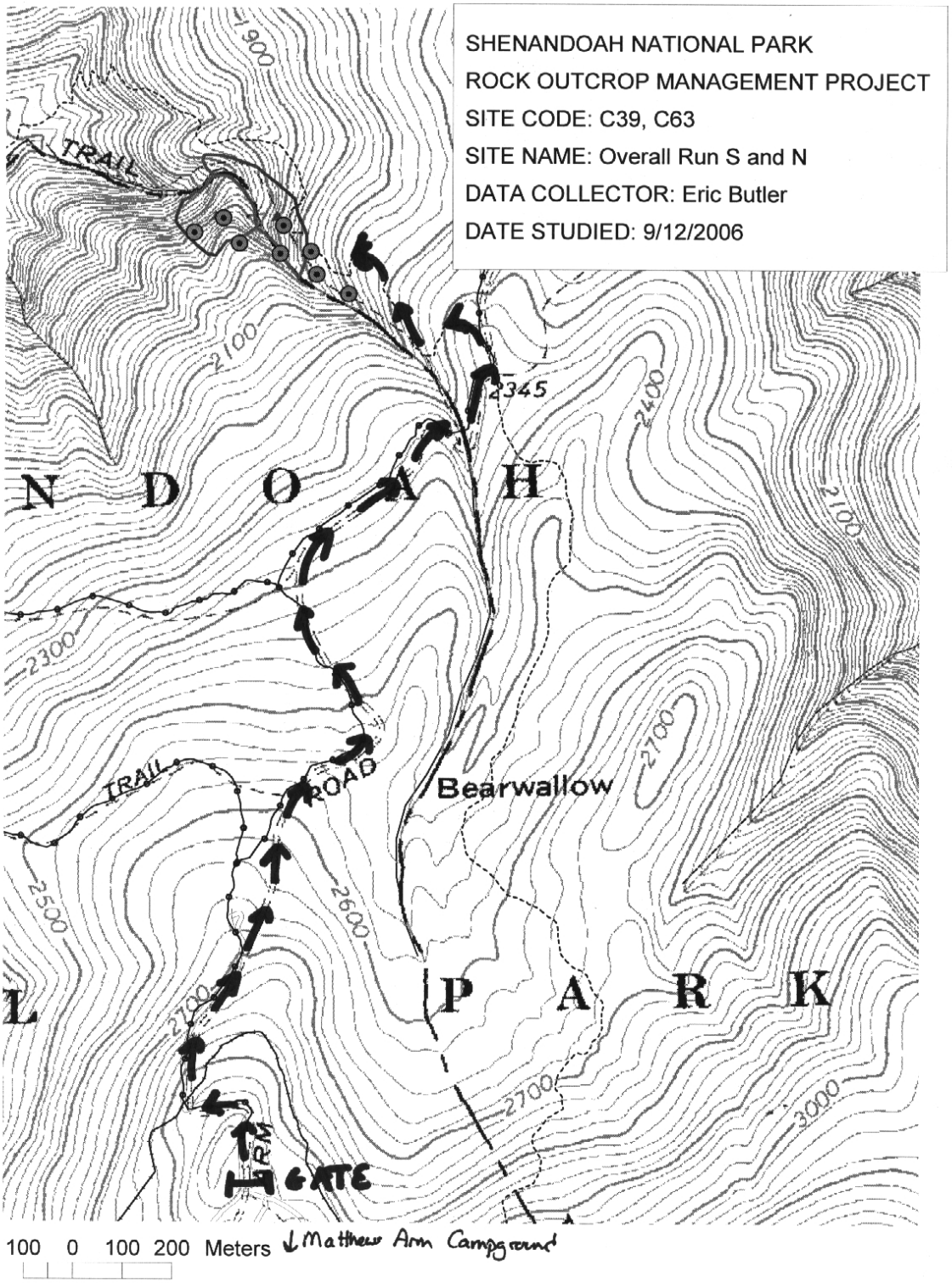
C63 - Overall Run Falls North (continued...)

Detail map



C63 - Overall Run Falls North (continued...)

Area map



C63 - Overall Run Falls North (continued...)



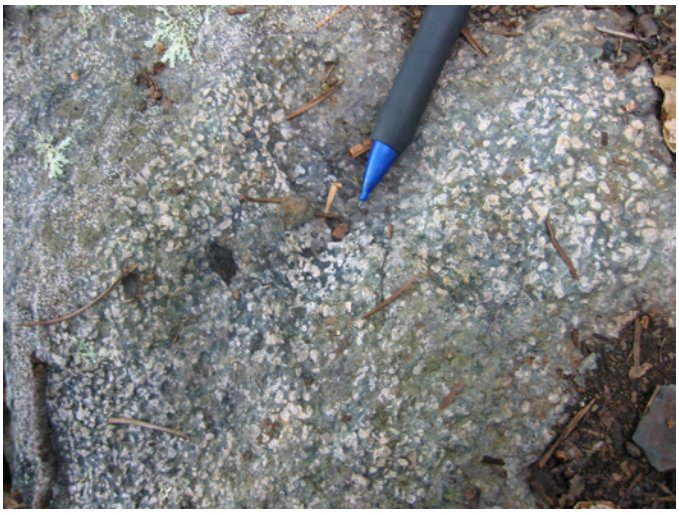
SHEN_C63_G_20060912_001.jpg Azmuth: 60

View of cliffs and ledges below falls. Note visible trail impact along ledges at cliff top. Taken from G278 in C39.



SHEN_C63_G_20060912_002.jpg Azmuth: 30

Fire ring on impacted ledges next to falls, reached by social trail from main trail to northeast.



SHEN_C63_G_20060912_003.jpg Azmuth:

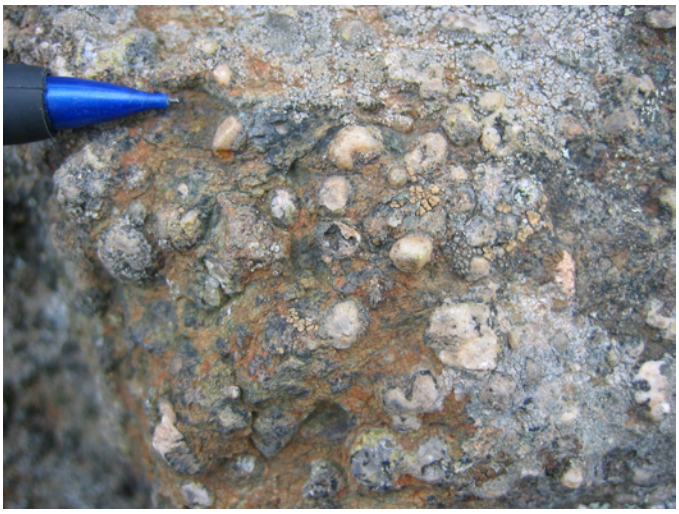
Amygdaloidal greenstone along top of cliffs below falls; part of a thick and diverse unit of contact rock in the area



SHEN_C63_G_20060912_004.jpg Azmuth: 280

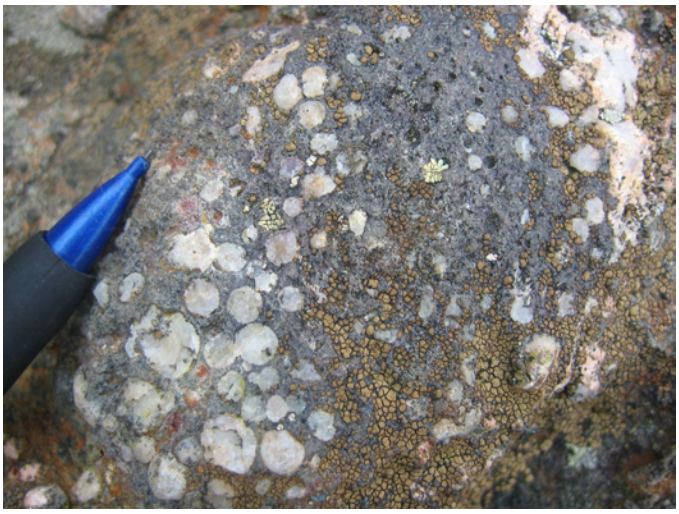
View down trail toward impacted area along clifftop, just below falls.

C63 - Overall Run Falls North (continued...)



SHEN_C63_G_20060912_005.jpg Azmuth:

More contact rock; amygdaloidal greenstone or possibly quartz pebbles included in greenstone



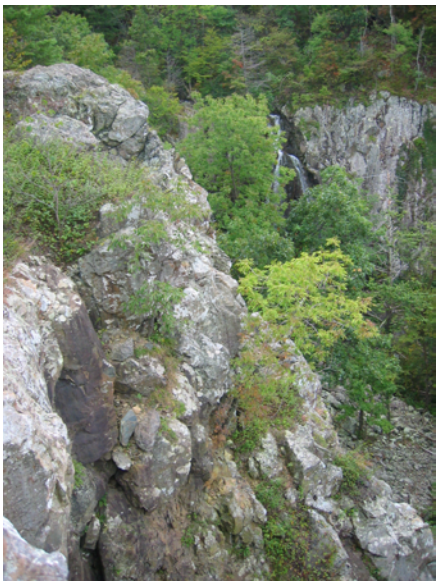
SHEN_C63_G_20060912_006.jpg Azmuth:

Amygdaloidal greenstone within contact rock along cliff tops



SHEN_C63_G_20060912_007.jpg Azmuth: 290

Impacted ledges along trail near G283



SHEN_C63_G_20060912_008.jpg Azmuth: 210

Cliff with minor ledges, falls in background. Main cliff line here is likely formed in a single lava flow

C63 - Overall Run Falls North (continued...)



SHEN_C63_G_20060912_009.jpg Azmuth:

Overall Run Falls; note notch in cliff near base of falls; possible contact with a lower flow?



SHEN_C63_G_20060912_010.jpg Azmuth: 305

Small grassy glade below main trail; reached by social trail



SHEN_C63_G_20060912_011.jpg Azmuth:

Ledges above outcrop in small open area below main trail; reached by social trail

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C64 - Brown Mountain

Site Code:	C64	**Polygon Centroid:**	**E:** 702372 **N:** 4241392
Site Name:	Brown Mountain		UTM (Zone 17 NAD83)
Data Collector	Butler, Eric	**Dimensions (m):**	300 x 1000 (GIS est.)
Date Studied:	20-Jun-05	**Elevation Range (ft):**	2440 to 2720

Physical Characteristics

Location Acces

This site is located about 3.5km (trail distance) from Skyline Drive. Park at the Brown Mountain Overlook (just north of Mile 77) and take the Brown Mt trail to west, which descends about 500' into saddle before climbing 500' back up to skirt summit of Rocky Mt; the site begins just west of this summit. From here the trail leads north along the eastern side of a ridge between Rocky Mt and Brown Mt. Access to exposures from the trail is much easier in the northern half of site, where vegetation is open, as compared to the southern half, where vegetation is extremely dense. The best long-range view of this site can be had from Big Run Overlook (south of Milepost 81), where the full western side of the ridge can be seen. From Rockytop Overlook (Milepost 78), only the southernmost cliff and talus can be seen.

Physical Description:

This is a large and complex site. It is highest in the south, on the western summit of Rocky Mountain, with a long, narrow ridge extending along a saddle to the north, with another, smaller peak (Brown Mt) capping the north end. This ridge is capped by intermittent bedrock outcrops, while most of the western slope and a good portion of the ridgeline is covered in thick, blocky talus fields. Clast size in this talus ranges from <10cm to over a meter. From afar, the talus appears to form linear fields that generally stretch down slope, divided by tree and vegetation cover. On site, however, most of the slope is covered in talus, and the linear appearance is in fact due to the development of trees and vegetation in patches among the near-continuous talus. To the east, a few smaller talus fields occur, but most of the eastern slope is forested. This vegetation thickens to the south, and most of the higher portions of western Rocky Mountain are densely vegetated and forested. At the south end of the site, a large cliff is exposed, forming an arch whose limbs stretch well down the slope to the SW and SE. There is another large talus field below this cliff, both of which are easily seen from Skyline Drive. To the N and NW of this cliff, on and near the western summit of Rocky Mountain, several open flatrocks occur within the forest, one of which forms a continuous surface that extends to the SW as it gradually becomes steeper and ends up angled 45 degrees to the NW.

Vegetation: Dense

There is little significant vegetation on the western side of the northern ridge and saddle, until the knob of Brown Mountain. On the east side of the ridge & saddle, the vegetation is reasonably open. To the south, where the ridge widens into the western summit of Rocky Mountain, the forest becomes extremely thick and is dominated by a dense heath of laurel, blueberry, thorny vines, and scrubby oaks, becoming virtually impassible in places.

Human Effects

Impacts: Mild

Although the trail extends along the ridge, a large percentage of the site appears untouched. There are several social trails that lead to small overlooks, but these affect only a few meters of exposure. Most of the site is quite difficult to access, due to vegetation, slope, and general stability. It is possible that a few people have explored the talus that is somewhat accessible from the trail, but no evidence of this can be seen.

Access Difficult

Although this site located along a trail, it is not easily accessed. The trail is steep, long, and appears little-used, and only offers direct access along the saddle in a few places where the talus reaches to the top of the ridge. Otherwise, visitors must push through dense vegetation and/or negotiate steep and unstable slopes, with no improvement in views than those seen from the trail. The southern cliff is especially remote, as it can only be reached by bushwhacking through at least 100m of extremely dense vegetation, and there is no indication from anywhere on the trail of its existence or direction.

Geologic Characteristics

C64 - Brown Mountain (continued...)

Lithology: **Rock Type** Quartzite

The site is entirely quartzite of the Erwin Formation. This is a fine-medium grained, white-pink, almost pure quartz sandstone that has been metamorphosed so that the individual grains are fused together into a very solid, resistant rock. The quartzites range from thick, undifferentiated beds meters thick, to finely layered beds less than 1cm thick, distinguished by fine layers of darker minerals. In many places excellent cross-bedding can be observed. Coarser, conglomeratic layers are uncommon but present.

Structure:

There appears to be one main cliff-forming bed within the quartzites, which is responsible for almost all of the cliffs, outcrops, and talus present within the site. There is at least a second quartzite bed present, stratigraphically above the primary bed, which appears in one location on western Rocky Mountain and may be otherwise mostly eroded away or covered in heath. The main quartzite unit is folded in several places along the ridge, most noticeably on the south face of western Rocky Mountain, where it forms a very obvious anticline, with the fold axis oriented NNE and the limbs forming exposed cliffs and outcrops in a prominent line down the SW and SW slopes of the peak. North of this, the 1976 Gathright map marks several additional anticline/syncline structures along the ridge between Rocky Mountain and Brown Mountain, but every bedrock outcrop on this ridge consistently dips gently to the east and shows no sign of folding. The Gathright folds may have been extrapolated from fold structures visible in ridges further north, or may have been mapped based on long-range views of talus patterns on the slope, which create fold-like patterns when viewed from miles away. On the western slope of the Brown Mountain summit, another line of bedrock outcrops sweeps far down the slope; this may represent the limb of a new syncline.

The rocks are quite fractured, though no one joint orientation seems dominant, generally forming large polygonal blocks that range from tens of centimeters to well over a meter. These fractures often seem to follow the orientation of the fossil skolithos (see below), which effectively perforates the rock vertically and creates vertical planes of weakness that are exploited by fractures.

Other:

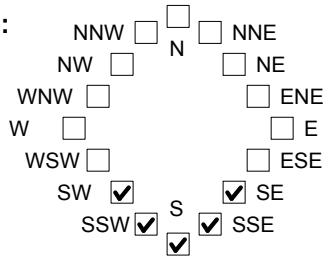
The quartzites at this site commonly contain the fossil skolithos, which is a preserved worm burrow that creates vertical tubes that can be over a meter long. These burrows generally appear as linear traces on fractured faces, as well as round dots on horizontal bedding planes. In some cases, a cast of the original burrow is present, appearing like a straw in the rock, while in others only the mold is present, appearing like a partial or whole groove in the rock. These burrows can be incredibly densely packed, and often act almost like a perforation, providing easy planes of weakness along which the rock fractures.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	10.0	20.0	5.0	10.0	55.0	100
Max relief(m):	10	5	5	1	30	

Maximum Slope: **Texture:** Fractured

Aspects:



Setting:

The dominant geomorphic agent here is the ubiquitous fracturing of the otherwise very resistant quartzite beds, which creates extensive talus fields of large boulders and rugged, unstable outcrops and cliffs. The orientation of these fractures appears to be at least partially controlled by the skolithos burrows, although areas of rock without this fossil are still extensively fractured. The fractures themselves are partially a result of the widespread folding and deformation of the rocks, as well as periglacial weathering during more extreme climatic conditions.

The fact that open talus fields are much more dominant on the central part of the ridge, as opposed to the heavily vegetated southern part and the very northern part, may be related to the physical orientation of the bedrock. In areas where the rocks are generally flat-lying, capping the saddle on the ridge, extensive and thick talus fields form below. At the north and south of the site, where the bedrock is heavily folded and the cliff-forming unit plunges lower on the slope, the areas above it are heavily vegetated. It is not clear exactly what rock is directly above the quartzite ledges, but if it is not as resistant, it may encourage the development of soil and vegetation, resulting in thick forest wherever the main quartzite unit is not capping the slope. There is no direct evidence of a correlation, but the pattern is there.

C64 - Brown Mountain (continued...)

Stability: Loose

The talus fields are steep and contain a wide range of clast sizes, many of which are very unstable and will tilt or slide with little provocation. In addition, the outcrops and cliff faces are heavily fractured. These fractures can extend many meters back into the bedrock, with the result that large blocks of rock may appear stable when in fact they are almost free-standing, connected to the main slope only by talus or thin remnants of bedrock. The gaps between the main bedrock and these free-standing slabs are often filled with rock, woody debris, soil, and covered by thick vegetation, and it is easy to step through vegetation into a gap or onto an unstable slab that appears to be a solid ledge or cliff.

GPS Points

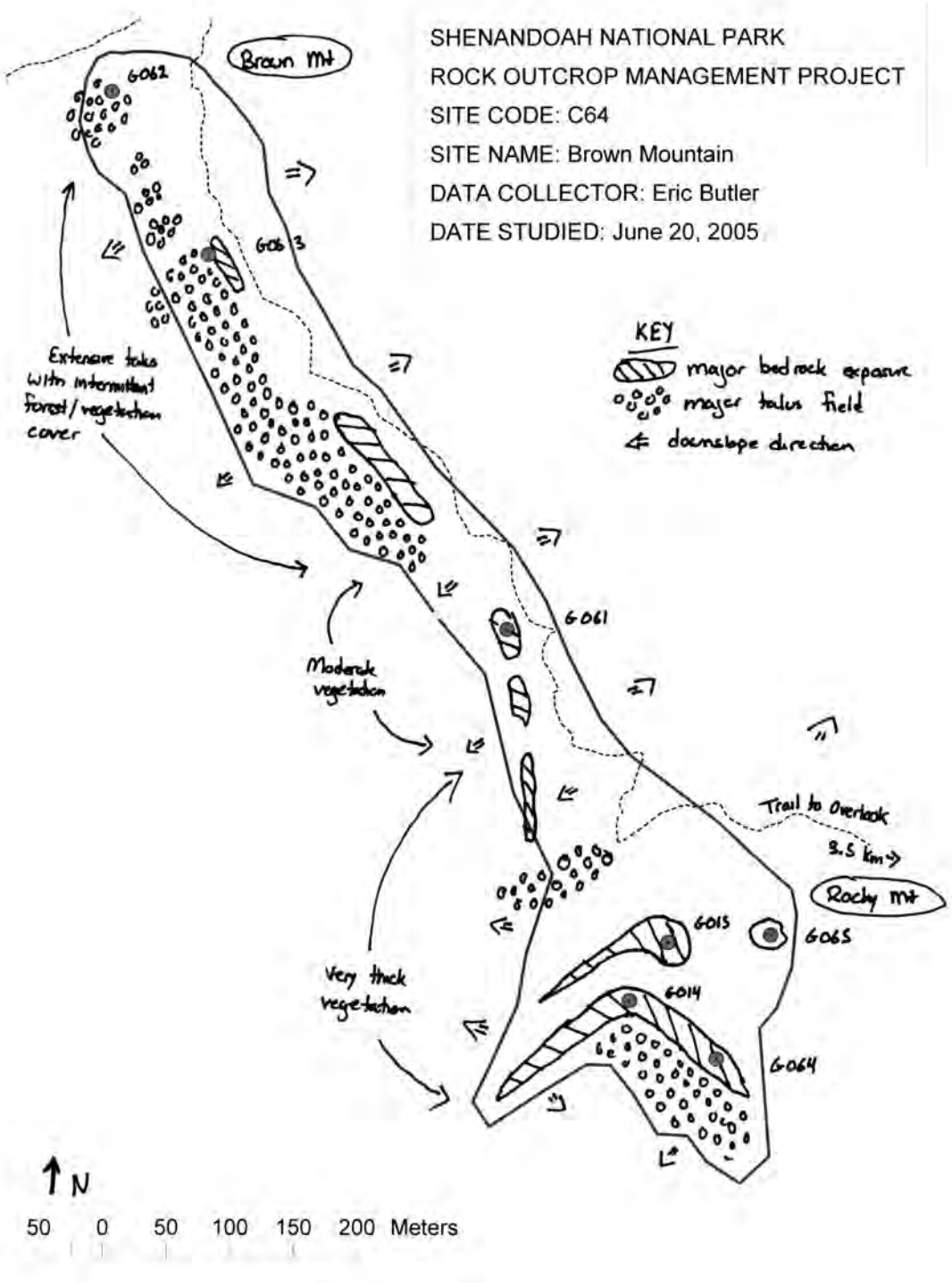
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
5/23/2005	G014-C64	702522	4241090	2680	Top of major cliff at south end of site; also top of anticline arch
5/23/2005	G015-C64	702552	4241136	2700	Flatrock in woods to NE of cliff
6/20/2005	G061-C64	702426	4241380	2560	Small open exposure & talus to west of trail
6/20/2005	G062-C64	702115	4241804	2500	Northernmost open talus, Brown Mt summit
6/20/2005	G063-C64	702191	4241675	2520	Northernmost bedrock exposure, N end of saddle ridge
6/20/2005	G064-C64	702590	4241045	2680	Southern extent of open cliff within site boundary, also access to/from t
6/20/2005	G065-C64	702633	4241141	2720	High open outcrop near western summit of Rocky Mt, within thick vege

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
6/20/2005		SHEN_C64_G_20050523_001.jpg	130	Butler, Eric	View SE toward Rockytop Overlook from quartzite rib near G014
6/20/2005		SHEN_C64_G_20050523_002.jpg	130	Butler, Eric	View SE toward Rockytop Overlook from quartzite rib near G014
6/20/2005		SHEN_C64_G_20050523_003.jpg		Butler, Eric	Flatrock in forest on western summit of Rocky Mountain
6/20/2005		SHEN_C64_G_20050620_001.jpg		Butler, Eric	EB studying talus field near G063
6/20/2005		SHEN_C64_G_20050620_002.jpg	215	Butler, Eric	Talus slope divided by trees
6/20/2005		SHEN_C64_G_20050620_003.jpg		Butler, Eric	Fracture patterns in talus, controlled by skolithos. Pencil indicates original vertical orientation of skolithos burrows
6/20/2005		SHEN_C64_G_20050620_004.jpg	165	Butler, Eric	View along talus slope, 20m SE of G063. Note how tree growth divides slope into smaller segments, even though the entire slope is covered in the same talus
6/20/2005		SHEN_C64_G_20050620_005.jpg	130	Butler, Eric	View SE toward Rockytop Overlook from talus below G014
6/20/2005		SHEN_C64_G_20050620_006.jpg	35	Butler, Eric	View NE toward cliffs below G064, talus in foreground

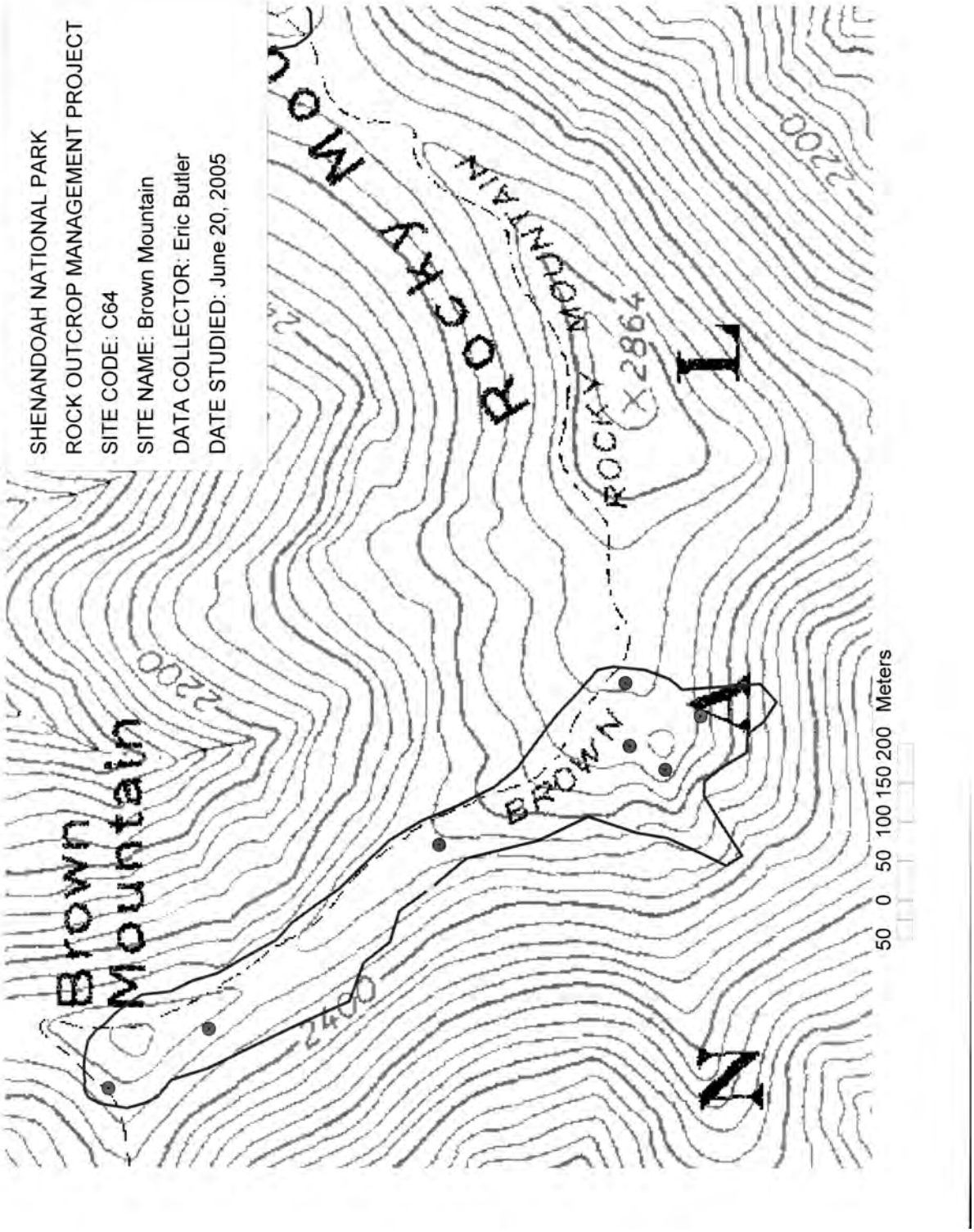
C64 - Brown Mountain (continued...)

Detail sketch map



C64 - Brown Mountain (continued...)

Area sketch map



C64 - Brown Mountain (continued...)



SHEN_C64_G_20050523_001.jpg Azmuth: 130

View SE toward Rockytop Overlook from quartzite rib near G014



SHEN_C64_G_20050523_002.jpg Azmuth: 130

View SE toward Rockytop Overlook from quartzite rib near G014



SHEN_C64_G_20050523_003.jpg Azmuth:

Flatrock in forest on western summit of Rocky Mountain



SHEN_C64_G_20050620_001.jpg Azmuth:

EB studying talus field near G063

C64 - Brown Mountain (continued...)



SHEN_C64_G_20050620_002.jpg Azmuth: 215

Talus slope divided by trees



SHEN_C64_G_20050620_003.jpg Azmuth:

Fracture patterns in talus, controlled by skolithos. Pencil indicates original vertical orientation of skolithos burrows.



SHEN_C64_G_20050620_004.jpg Azmuth: 165

View along talus slope, 20m SE of G063. Note how tree growth divides slope into smaller segments, even though the entire slope is covered in the same talus.



SHEN_C64_G_20050620_005.jpg Azmuth: 130

View SE toward Rockytop Overlook from talus below G014

C64 - Brown Mountain (continued...)



SHEN_C64_G_20050620_006.jpg Azmuth: 35

View NE toward cliffs below G064, talus in foreground

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C65 - Trayfoot Saddle boulderfields - east

Site Code: C65
Site Name: Trayfoot Saddle boulderfields - east
Data Collector Butler, Eric
Date Studied: 28-Feb-06

Polygon Centroid: **E:** 696876 **N:** 4233537
UTM (Zone 17 NAD83)
Dimensions (m): 130 x 280 (GIS est.)
Elevation Range (ft): 2840 to 3120

Physical Characteristics

Location Acces

Park at Blackrock Summit Parking Area, just north of Mile 85. Follow the Appalachian Trail (AT) to the Blackrock boulderfield (C05), then turn right onto the Trayfoot Mountain trail. This will lead about 1.1 km down into a saddle and back up the flank of Trayfoot Mountain, before reaching a junction with the Furnace Mountain trail, where the Trayfoot trail turns sharply left and the Furnace trail continues straight. Take the latter trail a few hundred more meters to a small, open talus field next to the trail. This is point G216; C49 lies to the west, and C65 to the east.

Physical Description:

C65 consists of a set of open talus fields that flank the east side of a ridge extending north from Trayfoot Mountain. A similar set of talus fields on the west side of the ridge makes up C49. Within C65, there is one very large expanse of open, unvegetated talus, with three other smaller fields separated from it by small patches of forest. Within the forest, the ground is still very rocky, and the boundaries of open vs. forested are simply defined by tree/vegetation cover over similar surfaces. One of the smaller open areas seems to extend outside the site boundary, but is still included (G219) as it is directly adjacent to the trail. All of these talus areas are composed of angular rock fragments averaging 10cm to over 1m wide, distributed across the slope in thick deposits of unclear depth. No in-place bedrock is present anywhere within the site.

Vegetation: Moderate

There are patches of dense undergrowth, but most of the forest immediately surrounding the open talus is fairly open. The thickest growths are often right on the edge of the open rock areas, and can screen these from view within the forest.

Human Effects

Impacts: Pristine

No evidence of human visitation to these sites could be observed. The largest talus field is not visible from the trail, and no obvious social trails lead to it. This site is visible from the Blackrock boulderfield to the east, but nothing in the local area invites or suggests access. Within the three smaller areas which are adjacent to the trail, lichen coverage seemed thick, no trash was found, and no other indications of visitation were observed. Although it seems likely that these are traversed by visitors on occasion, there are no views from these three visible areas, and so no real reason to venture out onto them. Assessing impact to talus fields is difficult, though, and there may be more impact or use than is easily observable.

Access Difficult

The total trail distance to these sites is just over 2km with a total elevation gain/loss of around 700'. Although the trails have a relatively gentle grade for most of the distance, the route takes more commitment than a quick jaunt from Skyline Drive, and it is doubtful that most visitors continue past Blackrock.

Geologic Characteristics

Lithology: **Rock Type** Quartzite

This site (and its neighbor, C49) contains no in-place bedrock, consisting entirely of quartzite boulders arranged loosely on the slopes. The rocks are fine-medium-grained quartzite, ranging in color from darker blue-grey to white-tan. Most of the blocks contain no visible structures, but a few have sets of thin, black layers that create a banded appearance in the rock. These are likely formed from thin deposits of darker minerals laid down between thicker units of quartz sand. In general, these rocks are originally thick units of quartz sand likely deposited near an ocean shore, and since fused and hardened by later metamorphism into a solid and resistant mass.

In appearance and composition, these rocks seem to be a compromise between the commonly dark grey/blue, finely layered quartzites of the Hampton Formation (i.e. C05 Blackrock) and the white-clear, unstructured quartzites with abundant skolithos fossils of the Erwin Formation (i.e. C44 Rocky Mountain & C64 Brown Mountain). Gathright (1976) mapped this area as

C65 - Trayfoot Saddle boulderfields - east (continued...)

Hampton, and the rocks do appear closer in character to that formation than to the brilliantly white Erwin rocks that show up clearly on the flanks of Furnace Mountain further to the west. The surrounding lithologies, mostly fine-grained siltstones and phyllites (as uncovered in loose float on surrounding slopes) also fits the Hampton Formation best.

Structure:

In addition to the occasional fine layers of dark minerals within quartzite blocks, a few blocks preserve evidence of cross-bedding, an internal structure formed by cross-cutting sediment layers, usually formed in currents or dunes. The rocks are, of course, very heavily fractured to form the angular boulders present here, but with no exposed bedrock.

Other:

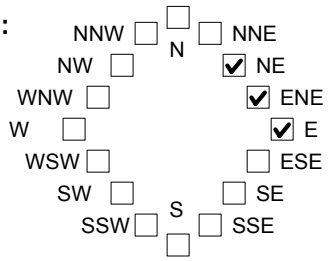
Deposits of metallic iron oxide minerals are relatively common, usually occurring as dark red/brown minerals in veins within the boulders, or as thin skins on the surfaces of boulders where these veins have cracked open. Generally these minerals have a rounded, almost bubbly formation, suggesting that they may be the mineral hematite.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	0.0	0.0	0.0	0.0	100.0	100
Max relief(m):	0	0	0	0	60	

Maximum Slope: 30 **Texture:** Fractured

Aspects:



Setting:

This site and its neighbor, C49, share the same history and interpretation. While large areas of talus unrelated to any visible bedrock are generally unusual, this is a common pattern within Shenandoah NP, particularly within the quartzite areas of the South District. The Hampton Formation in particular seems to create this pattern. Such large fields of boulders are likely the result of bedrock rapidly eroding and crumbling more or less in place, rather than the more common pattern of talus collecting below a cliff.

Evidence for this interpretation can be found at C05 Blackrock, where some bedrock is present at various places within the boulders, where it appears heavily fractured and weathered. Most of the quartzite areas within the park are very heavily fractured, likely a relict of the intense deformation these rocks suffered during the building of the Appalachians (the numerous large-scale folds in the bedrock, visible through the South District, attest to these pressure). These fractures provide a perfect conduit for physical weathering processes such as frost wedging to split the otherwise resistant bedrock and produce many large, angular boulders. These processes were likely extremely active and effective during the extreme climate variations during the last glacial period. Other reports and researchers have suggested that many of the large talus fields of the South District (like Blackrock) were at least partially shaped by such periglacial forces, and such an interpretation fits at this site.

In other words, it is likely that this ridge was once a resistant area of quartzite bedrock, which has since crumbled into talus during intense periods of weathering. Standing at Blackrock, one can look west toward Trayfoot Mountain and see a series of quartzite talus fields extending across the slope of the mountain from south to north, most likely reflecting the location of this particular quartzite bed within the greater stratigraphy. This site and its nearby companion are simply the northernmost exposure of this unit, before the deeply eroded valley of Madison Run to the north eliminates it.

Stability: Loose

The entire site consists of loose talus collected on steep slopes, and these boulders often shift underfoot; once disturbed, some will move quite a distance.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
2/28/2006	G216-C65	696829	4233493	3100	Small talus field along trail
2/28/2006	G217-C65	696866	4233551	3020	Upper corner in large field
2/28/2006	G218-C65	696850	4233632	2920	Lower portion of farthest N field
2/28/2006	G219-C65	696805	4233569	3060	Small field partially outside site boundary

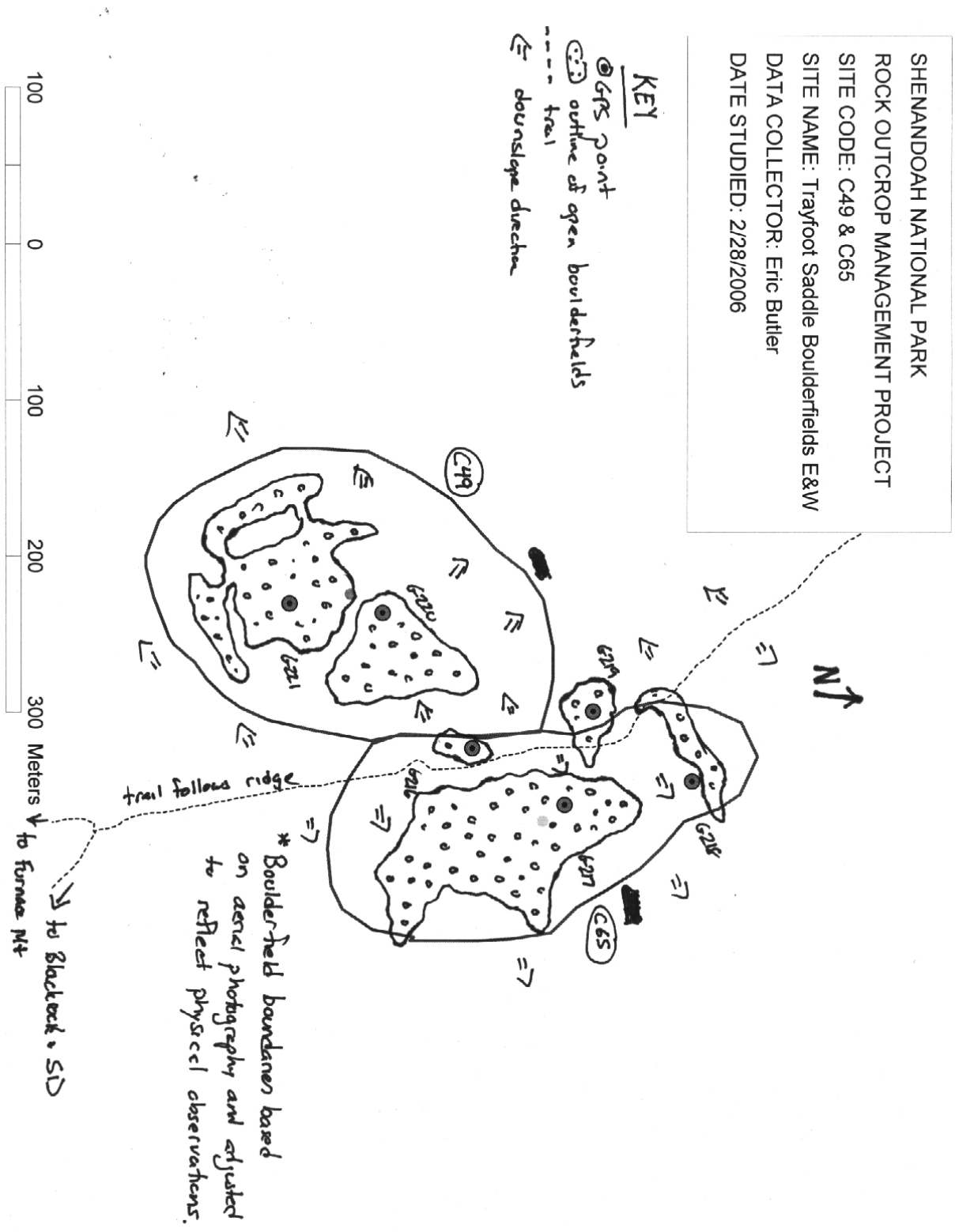
C65 - Trayfoot Saddle boulderfields - east (continued...)

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
2/28/2006	G217-C65	SHEN_C65_G_20060228_001.jpg	100	Butler, Eric	Looking down main boulder field
2/28/2006	G217-C65	SHEN_C65_G_20060228_002.jpg	170	Butler, Eric	Looking across main boulder field
2/28/2006	G217-C65	SHEN_C65_G_20060228_003.jpg	125	Butler, Eric	Angled view across boulder field to Blackrock in background
2/28/2006	G217-C65	SHEN_C65_G_20060228_004.jpg		Butler, Eric	Preserved layering in quartzite
2/28/2006	G217-C65	SHEN_C65_G_20060228_005.jpg		Butler, Eric	Faintly preserved cross-bedded layering in quartzite
2/28/2006	G218-C65	SHEN_C65_G_20060228_006.jpg		Butler, Eric	Looking north across smaller boulder field toward Austin Mt.

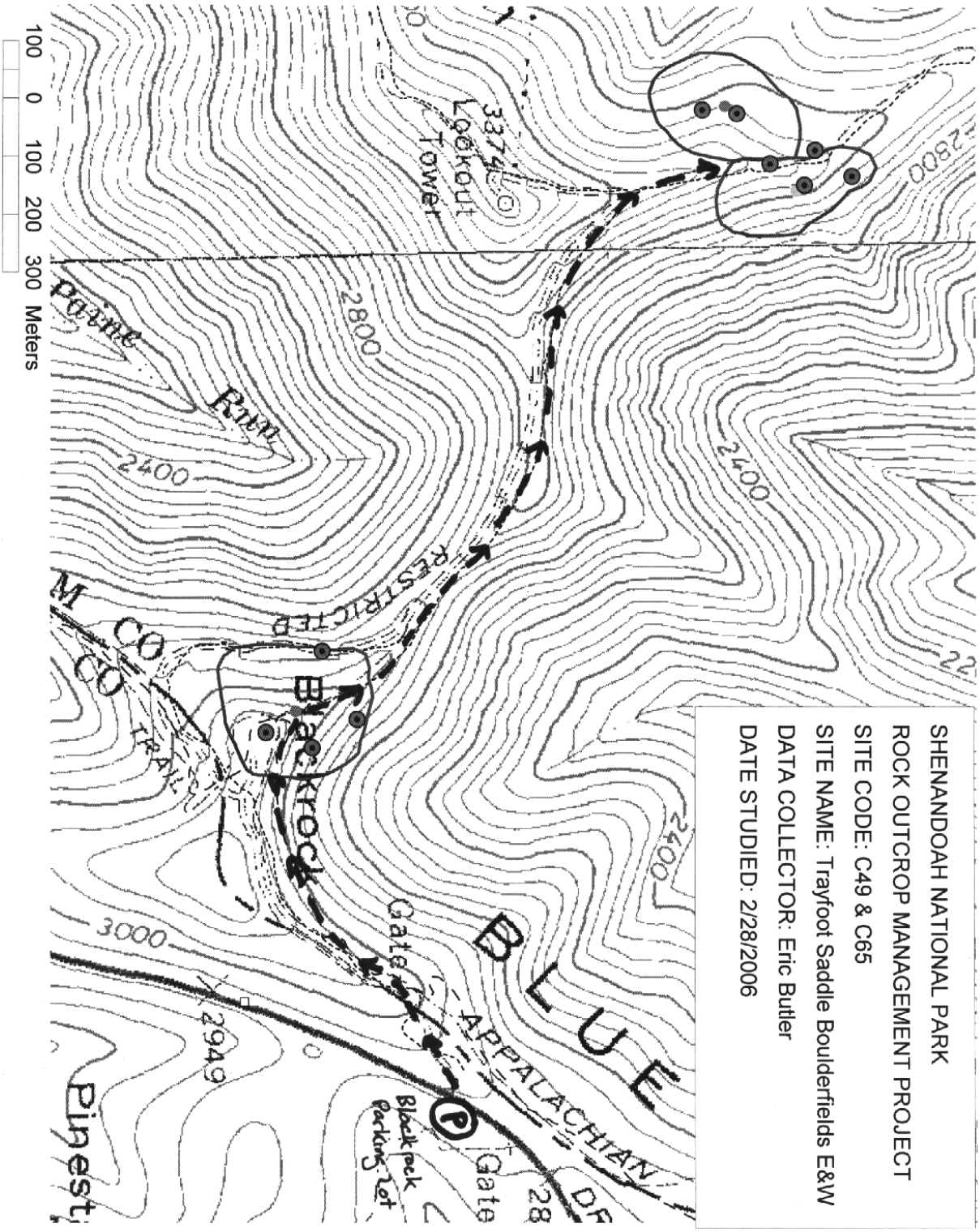
C65 - Trayfoot Saddle boulderfields - east (continued...)

Detail map



C65 - Trayfoot Saddle boulderfields - east (continued...)

Area map



C65 - Trayfoot Saddle boulderfields - east (continued...)



SHEN_C65_G_20060228_001.jpg Azmuth: 100

Looking down main boulder field



SHEN_C65_G_20060228_002.jpg Azmuth: 170

Looking across main boulder field



SHEN_C65_G_20060228_003.jpg Azmuth: 125

Angled view across boulder field to Blackrock in background



SHEN_C65_G_20060228_004.jpg Azmuth:

Preserved layering in quartzite

C65 - Trayfoot Saddle boulderfields - east (continued...)



SHEN_C65_G_20060228_005.jpg Azmuth:

Faintly preserved cross-bedded layering in quartzite



SHEN_C65_G_20060228_006.jpg Azmuth:

Looking north across smaller boulder field toward Austin Mt.

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C66 - Field Hollow Cliff

Site Code: C66
Site Name: Field Hollow Cliff
Data Collector Butler, Eric
Date Studied: 01-Feb-06

Polygon Centroid: **E:** 717863 **N:** 4253895
UTM (Zone 17 NAD83)
Dimensions (m): 220 x 760 (GIS est.)
Elevation Range (ft): 2600 to 3200

Physical Characteristics

Location Acces

Park at Bald Face Mountain Overlook (Milepost 61.2). Hike north along Skyline Drive a short distance, until the short gap in the rock wall. Leave the road here, and descend through the woods, heading due north. The slope will become steep, rocky, and wet as the route crosses a drainage. Beyond this drainage, a single large cliff may be seen in the woods to the east, but this is not part of the site (if you pass near this cliff, bear further NW from this point). Continue descending the bouldery slope until a smaller line of cliffs begins at around 3040'. This is the beginning of the southern portion of the site, and forms a fairly continuous line of rock exposure for about 500m north. This access route is covered in tall nettles during the summer, and can be difficult to negotiate due to slippery, uneven boulders and the lack of ground visibility caused by the nettles. Upon reaching the site, the vegetation opens up and is less problematic. To reach the northern portion of the site, continue along the base of these cliffs, being careful not to ascend through several angled chutes that lead above the rocks, until reaching G189, where the cliffs terminate in a gentle, seepy slope. From here, continue a short distance north through the woods toward an open ledge atop a large, sheer cliff that forms the northern portion of the site.

As an alternative, the site could be approached from the east by hiking farther north along Skyline Drive, then descending along the gentler slope above the site. This approach, however, contains very few landmarks, and may make it more difficult to identify when the site is reached. It does make a good exit route from the northern end of the site.

Physical Description:

This is a large and complex site, comprising two main sections. The southern section is a long, mostly continuous cliff 10-30m high, angling gently down the slope to the north. This cliff is generally very ledgy, creating more of a staircase of rock than a real cliff in many places. This is a very wet area, and several large, seepy springs/streams begin above this cliff and tumble down over its numerous ledges, creating moist, lush habitats. The cliff is broken by several large "chutes", where the bedrock disappears locally and narrow slots or slopes of talus and soil descend. These can be confusing to navigation; because the cliff gently descends to the north, and these chutes often lead up to the northeast, it is easy to follow one up onto the cliff top when one is intending to remain at the base of the cliff. Near the southern end of this cliff, a second cliff area occurs directly above and to the east (G192), with an impressive pile of cabin-sized boulders separating the two and creating a significant rock shelter. Farther north, a bit south of G189, a small cave at the base of the cliff extends vertically into the bedrock much farther than it appears from the outside. This portion of the site ends in yet another seepy area, where the cliff dwindles and vanishes into a gentle slope.

The northern portion of the site is comprised of a single, very large sheer cliff with open ledges along the top. This cliff is located just N-NNW of the end of the southern portion, though it may not be visible from there during the summer (due to vegetation). This cliff has a very different character than the southern portion; it is much drier, much larger, and contains far fewer ledgy areas, though there is a seepy area near the northern end. On the southern end, it dwindles slowly into the woods, while it ends rather abruptly to the north. Both ends are forested, with the only open rock occurring in the higher, more sheer middle portion.

Vegetation: Dense

The approach to this site from the south involves a thick carpet of nettles, though these are rare within the site itself. The forest is mostly open within the site, but the many wet, seepy areas create thick areas of vegetation along and above the southern cliff. The northern cliff is much drier, and laurel thickets are common along the base. In general, navigation is straightforward away from the cliffs, but locally problematic near them.

Human Effects

Impacts: Pristine

No evidence of human visitation to this site was found. No trash, trails, or graffiti were present, and the thick vegetation and lichens appeared undisturbed.

C66 - Field Hollow Cliff (continued...)

Access Remote

There is no trail to this area, and no evidence or indication of its existence to visitors. Despite the short distance between Skyline Drive and the site, the initial access is difficult enough to dissuade lighter exploration, and from the road the entire area appears as thick forest. There would be no reason for visitors to attempt access to this site.

Geologic Characteristics

Lithology: **Rock Type** Greenstone

This site is underlain by several greenstone lava flows. The southern portion of the site contains mostly fine-grained greenstone with centimeter-scale flow layering common. Much of this texture is locally obliterated by well-developed cleavage, but can be clearly seen in a few places. There is an obvious contact zone between lava flows running along the base of the southern cliff(s), composed of vesicular basalt, volcanic breccia, and very epidotized rock in a unit 1-3m thick. This unit is usually seen as loose float below the cliffs, but outcrops occasionally in the bedrock (such as near G187), and as several large boulders and abundant float on the gentle slope between G189 and G190. Below this unit, the greenstone changes character noticeably, consisting of coarser-grained, blockier rock, with little to no cleavage but more planar fractures. The large cliff in the northern portion of the site occurs within this unit. Abundant moss, lichen, and plant coverage on the upper (southern) cliffs, and tall, sheer exposures on the lower (northern) cliffs, make it difficult to observe smaller-scale features within the rock, but the larger-scale differences in composition and structure make the two types distinct.

Structure:

Cleavage and flow layering are common in the southern portion of the site, often mingling together to form numerous ledges that break up the profile of the cliffs. The layering is similar to that seen at North Marshall (C35). The cleavage planes generally dip to the east at around 45 degrees, creating protruding ledge areas, while the layering creates more horizontal ledge areas. The cleavage is most common at the top and bottom of the cliff area, while the layering is most common in the middle. The lower cliff in the northern portion of the site is more solid, but still contains some minor cleavage or fractures that create smooth, planar cliff surfaces without the numerous ledges (except at the very top).

Other:

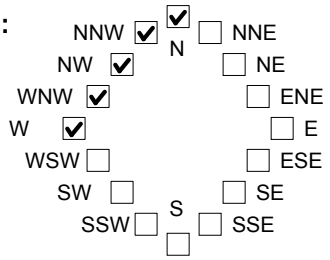
This site is very wet; in at least four places along the southern cliffs, seeps or streams cascade over the rocks, creating extensive areas of lush vegetation. This water generally sources from springs just above the main cliff unit. In one place, a small cave south of G189, water is dripping down through the rocks and pooling within the cave/overhang floor.

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	50.0	20.0	0.0	30.0	0.0	100
Max relief(m):	50	10	0	2	0	

Maximum Slope: 25 **Texture:** Rough

Aspects:



Setting:

This site presents several interesting challenges to geologic interpretation. The cliff area in the southern portion of the site rambles over some significant changes in topography, raising the question of whether it is composed of a single flow that changes its elevation and/or orientation, or several flows with alternating exposures. It is clear that the northern cliff occurs within the lowest flow in the site, as it is capped by a gentle topographic bench covered in volcanic breccia talus, typical of flow boundaries throughout the park. The clear contact zone at the base of the southern cliffs corresponds nicely to this breccia zone, and so it seems clear that this lowest flow forms the base of the sequence throughout the site.

Despite the significant changes in topography along the southern cliff line, no evidence of flow boundaries can be found within the exposures along this line. The rocks are consistently the same in composition, texture, and outcrop pattern from G185 to G189, and it seems most likely that all of these exposures are the same lava flow, which either flowed onto a very uneven paleosurface, or has since been deformed or tilted so that the southern end of the cliffs are quite higher than the northern.

The only significant rock exposures above this cliff line occur near the southern end of the site, at G192, where a second cliff

C66 - Field Hollow Cliff (continued...)

line protrudes from the slope at a higher elevation. No evidence of a flow boundary can be found between this cliff, and the more continuous unit below it, and the rocks are of similar composition and texture. However, it seems likely that this highest cliff is formed in a third lava flow, as there is a noticeable topographic bench between these two cliffs. More importantly, all the springs/seeps along the southern cliffs are sourced at the same topographic level, which is a common indication of a flow boundary (the contact areas between flows are often more fractured and thus carry groundwater and produce springs). Without more evidence, however, this cannot be determined for certain.

The unusual pile of very large boulders just west of and below G192 seem to have cracked away from the highest cliff and rolled a short distance down the slope, where they are stacked to form a significant rock shelter. The cavity in the cliff formed by these events is very noticeable, and creates an unusually sheltered area between the cliff and the boulders.

The several “chutes” which break up the southern cliff are difficult to explain; the most likely interpretation is that they represent the traces of large joints, along which erosion has broken up the cliffs and reduced them to sloping rubble fields that create ramps to the cliff top. This cannot be proven, however, as similarly oriented joints are not visible within the surrounding bedrock.

The significant difference in texture and outcrop pattern between the southern (upper) and northern (lower) cliffs is caused by their compositional and structural differences. The northern cliff contains far less cleavage and is much more smooth and solid, which suggests a composition richer in epidote than chlorite. On the other hand, the southern cliffs have a dominant cleavage which is typically associated with a more chlorite-rich rock, as well as some fine flow layering. Both minerals are common in greenstones, but their relative abundance and resulting structures have significant effects on outcrop pattern in many places within the park. In this case, as in many others, the flows containing a great deal of cleavage produce staircase-like cliffs with many ledges, while the more solid, unfractured lavas create tall, sheer cliffs with only a few fractures.

Stability: Stable

The bedrock is very solid, despite the numerous fractures and ledges. There is very little fresh talus in the area, and the numerous ledges generally create a relatively low-angle rock exposure that is not conducive to active erosion. The southern cliff is likely more active, but the upper ledges are safe to walk on.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
2/1/2006	G185-C66	717731	4253306	3040	Southern end of cliffs within site
2/1/2006	G186-C66	717756	4253349	3040	Wet, seepy area set into cliff
2/1/2006	G187-C66	717752	4253455	3000	Wet, seepy area along cliff
2/1/2006	G188-C66	717760	4253551	2980	Wet, seepy area along cliff
2/1/2006	G189-C66	717724	4253737	2920	Northern end of this cliff line
2/1/2006	G190-C66	717707	4253853	2800	Open ledges atop very large cliff at northern end of site
2/1/2006	G191-C66	717729	4253930	2760	Wet, seepy area along large northern cliff
2/1/2006	G192-C66	717826	4253421	3140	Ledges atop isolated cliff above main cliff unit; overlooking large bould

Site Photos

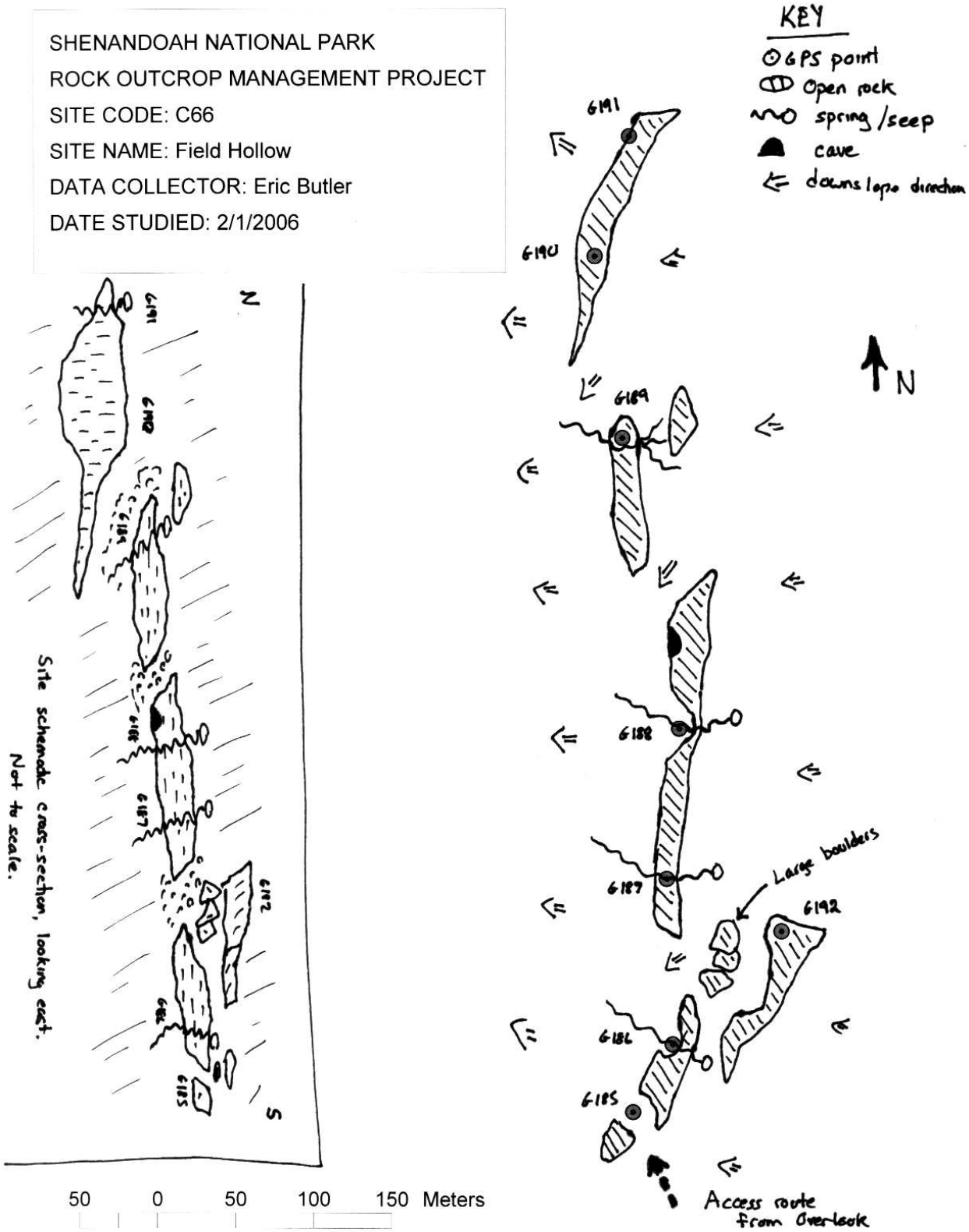
Image Date	GPS Point	File Name	Azmuth	Taken By	Description
5/17/2005	G189-C66	SHEN_C66_G_20050517_001.jpg		Butler, Eric	Vegetated ledges at seepy area near northern end of southern cliffs
5/17/2005		SHEN_C66_G_20050517_002.jpg		Butler, Eric	Vegetated ledges in seep; location uncertain but possibly at G87 but
5/17/2005	G186-C66	SHEN_C66_G_20050517_003.jpg	140	Butler, Eric	Summer view of seeps at G186
2/1/2006	G186-C66	SHEN_C66_G_20060201_001.jpg	140	Butler, Eric	Winter view of seeps at G186
2/1/2006	G186-C66	SHEN_C66_G_20060201_002.jpg	160	Butler, Eric	Wide view of seeps in eroded notch into cliff
2/1/2006	G187-C66	SHEN_C66_G_20060201_003.jpg	0	Butler, Eric	Contact zone between two lava flows; note cleavage above and solid, blocky texture below
2/1/2006	G188-C66	SHEN_C66_G_20060201_004.jpg	145	Butler, Eric	Seeps on southern cliff

C66 - Field Hollow Cliff (continued...)

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
2/1/2006	G188-C66	SHEN_C66_G_20060201_005.jpg	15	Butler, Eric	Typical exposure of southern cliff
2/1/2006	G188-C66	SHEN_C66_G_20060201_006.jpg	180	Butler, Eric	Typical ledge formations along cliff, just north of G188
2/1/2006	G189-C66	SHEN_C66_G_20060201_007.jpg	0	Butler, Eric	Volcanic breccia in boulder north of G189, typical of boundary material beneath flow forming southern cliffs.
2/1/2006	G190-C66	SHEN_C66_G_20060201_008.jpg	10	Butler, Eric	Pristine ledges atop northern cliff
2/1/2006	G190-C66	SHEN_C66_G_20060201_009.jpg		Butler, Eric	View up at sheer, overhanging cliff below G190; note differences from southern cliff areas

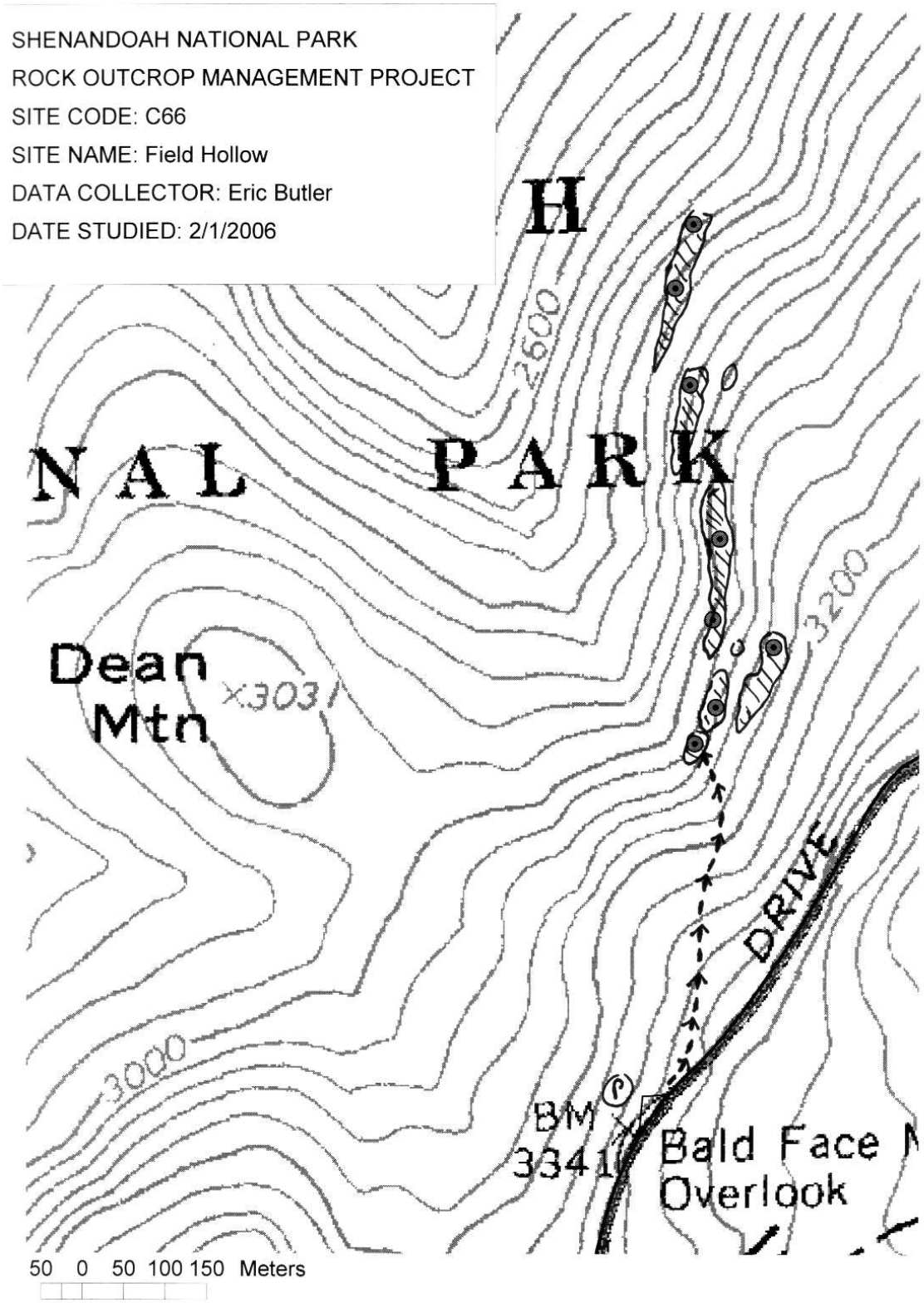
C66 - Field Hollow Cliff (continued...)

Detail sketch map



C66 - Field Hollow Cliff (continued...)

Area sketch map



C66 - Field Hollow Cliff (continued...)



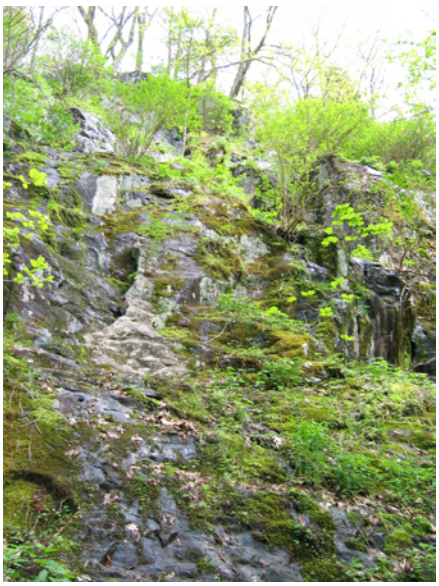
SHEN_C66_G_20050517_001.jpg Azmuth:

Vegetated ledges at seepy area near northern end of southern cliffs



SHEN_C66_G_20050517_002.jpg Azmuth:

Vegetated ledges in seep; location uncertain but possibly at G87 but



SHEN_C66_G_20050517_003.jpg Azmuth: 140

Summer view of seeps at G186



SHEN_C66_G_20060201_001.jpg Azmuth: 140

Winter view of seeps at G186

C66 - Field Hollow Cliff (continued...)



SHEN_C66_G_20060201_002.jpg Azmuth: 160

Wide view of seeps in eroded notch into cliff



SHEN_C66_G_20060201_003.jpg Azmuth: 0

Contact zone between two lava flows; note cleavage above and solid, blocky texture below



SHEN_C66_G_20060201_004.jpg Azmuth: 145

Seeps on southern cliff



SHEN_C66_G_20060201_005.jpg Azmuth: 15

Typical exposure of southern cliff

C66 - Field Hollow Cliff (continued...)



SHEN_C66_G_20060201_006.jpg Azmuth: 180

Typical ledge formations along cliff, just north of G188



SHEN_C66_G_20060201_007.jpg Azmuth: 0

Volcanic breccia in boulder north of G189, typical of boundary material beneath flow forming southern cliffs.



SHEN_C66_G_20060201_008.jpg Azmuth: 10

Pristine ledges atop northern cliff



SHEN_C66_G_20060201_009.jpg Azmuth:

View up at sheer, overhanging cliff below G190; note differences from southern cliff areas

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C67 - Bearfence Mountain

Site Code:	C67	**Polygon Centroid:**	**E:** **N:**
Site Name:	Bearfence Mountain		UTM (Zone 17 NAD83)
Data Collector	Butler, Eric	**Dimensions (m):**	100 x 540 (GIS est.)
Date Studied:	08-Feb-06	**Elevation Range (ft):**	3400 to 3560

Physical Characteristics

Location Acces

Park at the Bearfence Mountain parking area, Milepost 56.4. Take a short access trail east to a junction with the Appalachian Trail (AT). The AT runs through the woods along the base of the site, while the Bearfence Loop Trail (or Bearfence Rock Scramble) runs along, through, and around the rugged rock ridge that extends south for 300m. The loop trail circles the summit of Bearfence Mountain before rejoining the AT to the south; several cutoff trails also provide access between the two trails.

Physical Description:

Bearfence Mountain consists of a 300m long north-south rib of protruding rock, with sharp dropoffs to the west and a combination of dropoffs and gentler slopes to the east. This rib caps a narrow ridge that climbs up to the summit, where other open rocks offer views to the north, west, and south. The height of the cliffs varies significantly along the length of the site, from 15m sheer dropoffs to smaller, ledgy exposures. The character of the rocks is also variable, from sharply angled, smooth, platy protrusions, to more rounded, rough, and rugged exposures. Some talus areas are present along the base of the cliffs, though mostly forested. In a few places, gaps in the rock rib allow social trails to descent talus chutes to connect the Appalachian Trail and the loop trail.

Vegetation: Dense

Thickets of briars and other undergrowth are common all over the rocks, as well as thick stands of trees in a few places. The trails generally offer good access, but leaving the trail can be difficult.

Human Effects

Impacts: Heavy

It is clear that many people visit and use this site. Many of the ledges are bare of soil and/or vegetation, and social trails wind around and throughout the exposures. Trash is also common, most often as various bottles apparently thrown from the upper portions of the exposures. Rock graffiti can also be found in many places. The loop trail itself runs along bare rock for much of its distance, contributing to the widespread impacts. This can hardly be avoided, as the purpose of the trail itself is to access and explore the rocks (hence the name “Bearfence Rock Scramble”).

Access Difficult

Although this site is very near Skyline Drive, and has two established trails running through it (the AT and the Bearfence Loop Trail), the name “Bearfence Rock Scramble” is apt. The loop trail winds up and down the rock exposures, often requiring visitors to haul themselves up or down ledges, through cracks, and generally to negotiate rugged local topography that is beyond the demands of regular trail hikes. The distance is short, but anyone with mobility limitations will not be able to access much of the rock exposure areas; conversely, most of the impacted areas require negotiation of some rock scramble areas to reach. This trail and site remains popular, with a well-signed parking lot assigned to it, and much coverage in interpretive guides, which seems to overcome the difficulty in a similar way as Old Rag Mountain.

Geologic Characteristics

Lithology: **Rock Type** Greenstone

The site is underlain by several greenstone lava flows. These rocks are typical of the Catoctin Formation; dark grey-green, fine-grained metabasalts forming individual flows tens of meters thick. In this site, the two flows are separated by a thick, very uneven volcanic breccia layer. This breccia is composed of greenstone fragments cemented by an epidotized matrix, and is identifiable by the rough, chaotic-appearing surface texture it produces (in contrast to the smooth, platy greenstones). Unlike many areas within the Catoctin, in which these boundary breccia layers are fairly even and predictable, the contact between this breccia unit and the surrounding greenstone layers is very uneven and unpredictable, with the breccia ranging from 5 or more meters thick to missing within short distances. It is very difficult to trace a specific layer any distance, or to specifically identify

C67 - Bearfence Mountain (continued...)

the contact between the breccia and the surrounding greenstones (the contact often appears gradational, or is obscured by lichens and weathering). However, as one follows the ridge south, the trail begins in jointed, cleaved greenstone, climbs into breccia, then climbs back into greenstone with far few columnar joints, and more prominent cleavage, giving a large-scale view of the stratigraphy here. The breccia is most prominent between G204 and G205, where it caps the ridge for some distance and creates a very different exposure morphology, surface texture, and habitat area than the purely greenstone areas to the north and south.

Metasediments of the Swift Run Formation are present within the site, though they do not form any bedrock exposures. At the base of the long rock rib that constitutes the site, there is a long, broad topographic bench leading to the west. Along this bench, particularly west of the Appalachian Trail (AT), most loose rock on the ground consists of a grey-white quartzite that is similar in appearance to rocks of the Erwin Formation. These rocks, however, are located below the Catoctin greenstone flows, and so are part of the Swift Run Formation. Similar rocks and other metasediments can be found all along the trail descending from the AT to the Bearfence parking lot.

Structure:

Both cleavage and columnar jointing are dominant structures within this site. Where cleavage is present, it creates a series of near-parallel fractures that generally dip east around 45-60 degrees, forming thin plates of rock that often protrude sharply from the ground or surrounding rock. Where columnar joints are present, they create smooth-sided, polygonal rock columns that aid in cliff formation. Columnar joints initially form in a vertical orientation (relative to the lava flow), but at this site the columns are often tilted, curved, or otherwise deformed, creating unusually complicated structures and outcrop patterns in the rocks. Most columns are found in the lower of the two flows present here, while the cleavage is most prominent in the upper flow.

Other:

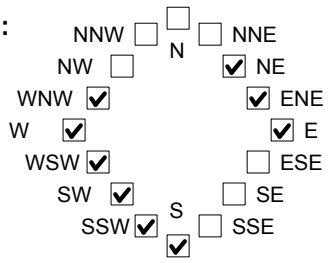
Amygdules filled with quartz and epidote are common within the Catoctin, but at this site many amygdules of chlorite can be found, which is far less common. These appear as small pockets within the rock (1-5mm), filled with a dark green, almost black mineral (as opposed to white quartz or pistachio-green epidote).

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	50.0	20.0	0.0	30.0	10.0	110
Max relief(m):	15	5	0	2	5	

Maximum Slope: 20 **Texture:** Fractured

Aspects:



Setting:

The presence of Swift Run Formation metasediments along the base of the bedrock outcrops at this site means that Bearfence is formed from the first lava flows of the Catoctin Formation to affect this area. This may help explain several of the unusual features within this site, such as the unusually oriented columnar joints in the lower flow and the highly variable breccia unit between flows. Badger's (1999) suggestion that the titled columnar joints are the result of erosion and undermining of a lava flow is especially relevant since this flow sits on what would have then been loose sand and sediments (the original nature of the Swift Run quartzite). Existing stream/river systems dammed or diverted by the first lava flow might very well have eroded away these sediments, easily undermining the cooled, jointed lavas and causing large blocks to tilt, collapse, or otherwise change orientation. This theory also helps explain the nature of the overlying volcanic breccia unit; the same processes would have resulted in a very uneven surface atop the lower flow (as might continued water erosion before the next eruption), such that when the next flow advanced, the breccia created by this process might have filled in large surface gaps where present, while leaving little or no trace of breccia in other places. The curved columns seen in at least one place within the site (photo 005) are likely the result of deformation within a still-cooling, partially molten flow.

The overall nature of the site, consisting of a long, protruding rib of rock capping a narrow ridge, is unusual within the Catoctin. Generally, these lava flows form staircase-like structures, with a series of cliffs or dropoffs in one direction, and a series of gentle slopes descending in the opposite direction, all related to the local orientation of the lava flows. The rocks at Bearfence do follow this pattern to a lesser extent, as most of the steeper exposures are to the west, but the site is still unusual. The answer comes in the bedrock geology of the surrounding area; this peak is an erosional remnant of the lava flows that once would have capped the entire area, but have now been mostly eroded away. Much like a butte in the desert southwest,

C67 - Bearfence Mountain (continued...)

Bearfence is formed by a core of resistant greenstone, with the underlying Swift Run Formation and basement granitic gneisses almost completely surrounding the peak at lower elevations. Thus, the rocks on this narrow ridge are being eroded from all sides, helping create the protruding rib present today, although the eastward dip of the cleavage and a likely regional eastward dip of the flows themselves help create the western preference for taller cliffs that is still present.

Stability: Moderate

Predominant cleavage makes some areas more likely to shear away, especially at places with overhanging slabs. The talus is especially slippery and prone to shifting, due to the thin, platy slabs created by the cleavage.

GPS Points

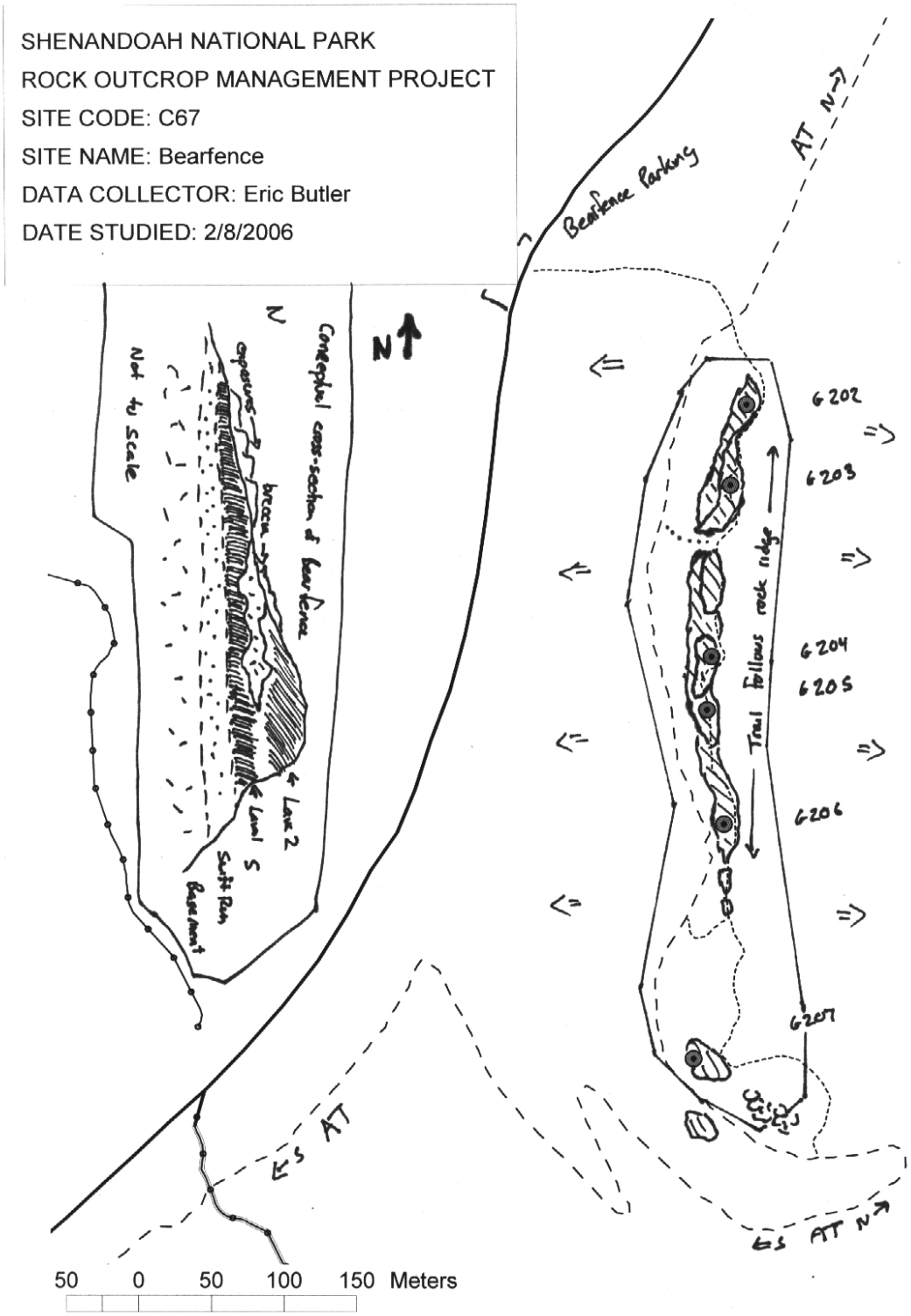
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
2/8/2006	G202-C67	721192	4258954	3420	North end of rock ridge exposures within site
2/8/2006	G203-C67	721181	4258898	3440	Impacted high point along trail
2/8/2006	G204-C67	721167	4258778	3460	Beginning of breccia-capped area along ridgetop, reached by social tr
2/8/2006	G205-C67	721164	4258741	3480	High point on impacted ledges along loop trail
2/8/2006	G206-C67	721176	4258661	3480	End of major rock exposures along ridgeline to south
2/8/2006	G207-C67	721154	4258497	3520	Impacted ledges at outcrop exposure near summit

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
2/8/2006	G202-C67	SHEN_C67_G_20060208_001.jpg	230	Butler, Eric	Tilted columnar joints near north end of trail.
2/8/2006	G203-C67	SHEN_C67_G_20060208_002.jpg	190	Butler, Eric	Large cliff defined by columnar joints
2/8/2006	G203-C67	SHEN_C67_G_20060208_003.jpg	190	Butler, Eric	Typical dominant cleavage, creating platy slabs of greenstone
2/8/2006	G203-C67	SHEN_C67_G_20060208_004.jpg	345	Butler, Eric	Contact between greenstone with columnar jointing (below) and volcanic breccia (above)
2/8/2006		SHEN_C67_G_20060208_005.jpg		Butler, Eric	Deformed (curved) columnar joints cut by cleavage
2/8/2006		SHEN_C67_G_20060208_006.jpg		Butler, Eric	Large cliff defining north end of gap in rock ridge, south of G203. Note uneven contact between volcanic breccia (foreground) and greenstone (background)
2/8/2006	G204-C67	SHEN_C67_G_20060208_007.jpg	15	Butler, Eric	Portion of ridge capped by breccia; note rugged, chaotic structure compared to smooth, angular greenstone exposures in other places
2/8/2006	G204-C67	SHEN_C67_G_20060208_008.jpg	180	Butler, Eric	Portion of ridge capped by breccia, accessed by social trail. Notice difference in texture compared to greenstone
2/8/2006	G205-C67	SHEN_C67_G_20060208_009.jpg	180	Butler, Eric	Cleavage-dominated ledges atop ridge, with park trail along rocks
2/8/2006	G205-C67	SHEN_C67_G_20060208_010.jpg		Butler, Eric	Impacted exposure along trail; cleavage-formed ledge with stripped soil and no vegetation
2/8/2006	G205-C67	SHEN_C67_G_20060208_011.jpg		Butler, Eric	Chlorite-filled amygdules in greenstone
2/8/2006	G205-C67	SHEN_C67_G_20060208_012.jpg		Butler, Eric	Chlorite-filled amygdules in greenstone
2/8/2006	G207-C67	SHEN_C67_G_20060208_013.jpg	295	Butler, Eric	Impacted ledge area atop outcrop near summit, reached by short social trail
2/8/2006	G207-C67	SHEN_C67_G_20060208_014.jpg	50	Butler, Eric	Well-developed cleavage below G207 outcrop, seen from AT

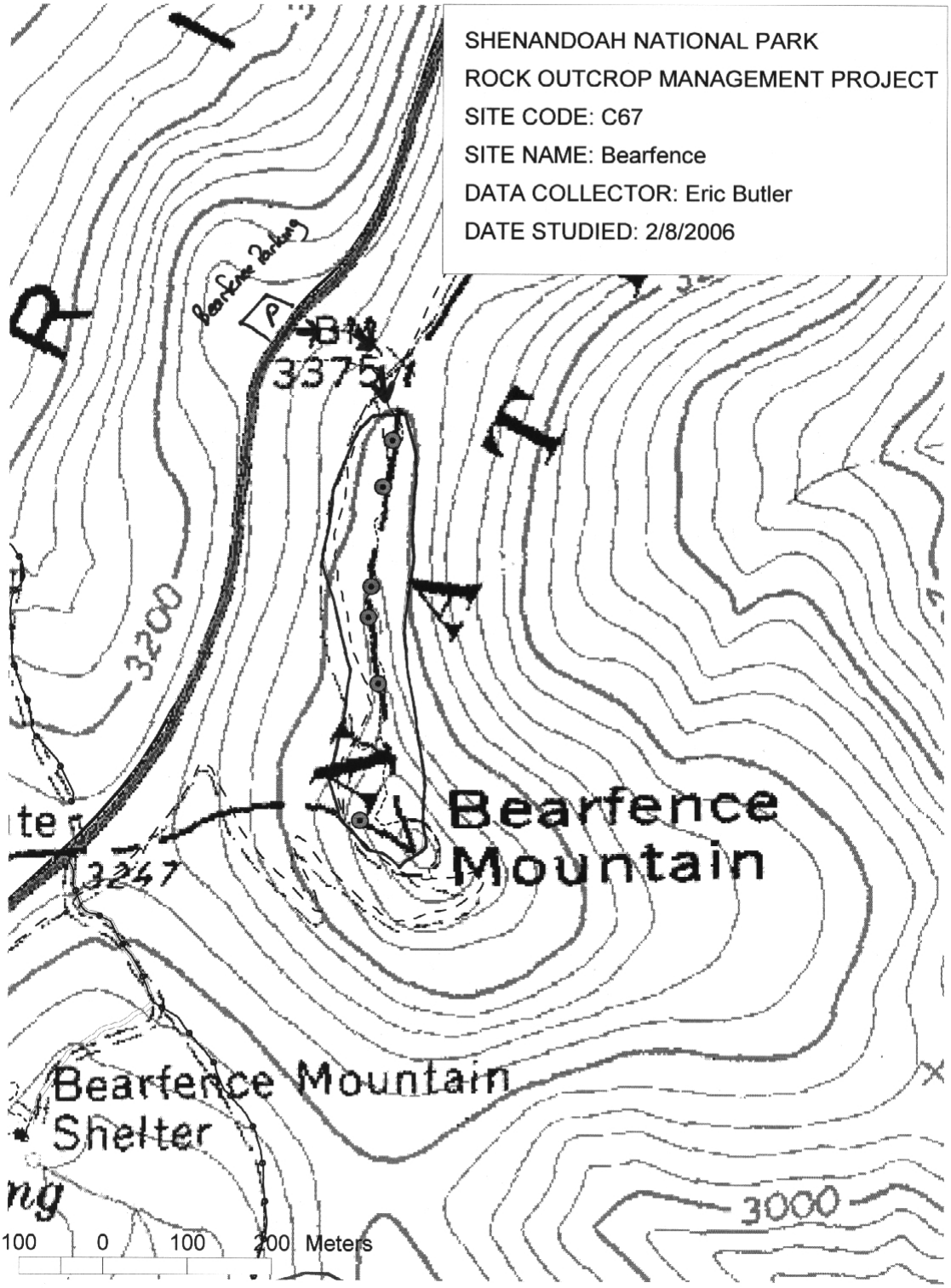
C67 - Bearfence Mountain (continued...)

Detail map



C67 - Bearfence Mountain (continued...)

Area map



C67 - Bearfence Mountain (continued...)



SHEN_C67_G_20060208_001.jpg Azmuth: 230

Tilted columnar joints near north end of trail.



SHEN_C67_G_20060208_002.jpg Azmuth: 190

Large cliff defined by columnar joints



SHEN_C67_G_20060208_003.jpg Azmuth: 190

Typical dominant cleavage, creating platy slabs of greenstone



SHEN_C67_G_20060208_004.jpg Azmuth: 345

Contact between greenstone with columnar jointing (below) and volcanic breccia (above)

C67 - Bearfence Mountain (continued...)



SHEN_C67_G_20060208_005.jpg Azmuth:

Deformed (curved) columnar joints cut by cleavage



SHEN_C67_G_20060208_006.jpg Azmuth:

Large cliff defining north end of gap in rock ridge, south of G203. Note uneven contact between volcanic breccia (foreground) and greenstone (background)



SHEN_C67_G_20060208_007.jpg Azmuth: 15

Portion of ridge capped by breccia; note rugged, chaotic structure compared to smooth, angular greenstone exposures in other places.



SHEN_C67_G_20060208_008.jpg Azmuth: 180

Portion of ridge capped by breccia, accessed by social trail. Notice difference in texture compared to greenstone.

C67 - Bearfence Mountain (continued...)



SHEN_C67_G_20060208_009.jpg Azmuth: 180

Cleavage-dominated ledges atop ridge, with park trail along rocks



SHEN_C67_G_20060208_010.jpg Azmuth:

Impacted exposure along trail; cleavage-formed ledge with stripped soil and no vegetation



SHEN_C67_G_20060208_011.jpg Azmuth:

Chlorite-filled amygdules in greenstone



SHEN_C67_G_20060208_012.jpg Azmuth:

Chlorite-filled amygdules in greenstone

C67 - Bearfence Mountain (continued...)



SHEN_C67_G_20060208_013.jpg Azmuth: 295

Impacted ledge area atop outcrop near summit, reached by short social trail



SHEN_C67_G_20060208_014.jpg Azmuth: 50

Well-developed cleavage below G207 outcrop, seen from AT

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C68 - Rose River Cliffs

Site Code:	C68	**Polygon Centroid:**	**E:** **N:**
Site Name:	Rose River Cliffs		UTM (Zone 17 NAD83)
Data Collector	Butler, Eric	**Dimensions (m):**	210 x 560 (GIS est.)
Date Studied:	29-Aug-06	**Elevation Range (ft):**	1800 to 2400

Physical Characteristics

Location Acces

This site is best reached from outside the park, along the Rose River Fire Road; either park at the public lot and walk in along the road, or drive in if a 4WD vehicle and gate key are available. In either case, travel appx. 1.8km to reach a bridge over a side stream, then another 200m to the point where the fire road leaves the river and begins to climb a series of switchbacks. At this point a social trail leads down to the river, across it, and a short distance along the opposite bank. From here, hike NNW, angling up the slope to reach the first exposures, and continue up at the same bearing to reach the rest.

Physical Description:

This site is dominated by one very large, long rock exposure (G258-G260) made up of near-vertical cliffs at the base which grade up into a variety of ledges, and rounded faces above. One especially big portion of this continuous exposure is found at G258, where a broad expanse of smooth, sloping, open rock curves down from smooth ledges into sheer cliff. North and upslope from here, another good-sized exposure is similar, though with a higher percentage of ledges breaking up the smooth rock faces. A few smaller exposure areas are found to the south, scattered along and down the slope. These open areas are linked by other lines of bedrock that are exposed but vegetated, and so not mapped in this survey. The overall slope is moderate to steep, and the linear exposures appear to angle a bit upslope to the north.

Vegetation: Open

Most of the surrounding forest, including the hike in, is fairly open; there are few thickets or other vegetative barriers. The exposures are very accessible and are not hidden or blocked by any significant vegetation.

Human Effects

Impacts: Pristine

Despite finding a very old beer can near one of the exposures, there was no evidence that this site receives any meaningful human visitation. Possible signs of historical visitation exist, including a faint trace of an old road across the slope between G260 and G259, but it does not appear that visitors are reaching the site now.

Access Remote

This site is located far from the nearest trail or road. The largest exposures are somewhat visible from certain areas along the Rose River Fire Road, but reaching them requires crossing the Rose River and climbing 400’ to 600’ of elevation up steep slopes with no visible sign of the exposures ahead. It seems very unlikely that any visitor would bother to reach these exposures.

Geologic Characteristics

Lithology: **Rock Type** Greenstone

There are at least two distinct greenstone lava flows here, and almost certainly more. The main exposure area at G258 is underlain by a single very thick (20m?) flow which contains few structures of any kind. There may be some subtle layering within the flow (photo 008), and small, rounded pods of epidote and quartz are scattered throughout the flow (photo 005), but overall this flow is unusual in its thickness, homogeneity, and lack of structures. No evidence of any flow boundaries or changes in lithology were observed within this very large exposure, and so it is likely underlain by a single unit. In the forest above this level some amygdaloidal material can be found, so the contact is likely in the topographic bench there. The other major exposure, at G259, is underlain by a more typical greenstone unit, with well-developed cleavage and many veins of epidote. No evidence of contact zones between flows was found in-place within the site, but the surrounding slopes are littered with amygdaloidal, brecciated, and epidote-rich greenstone, so these contact zones are likely forming the intervening topographic benches between exposures and are simply hidden beneath talus (as is common in greenstone areas). Given the difference in elevation between the two exposure areas, there may very well be an intervening flow that does not form significant exposures for whatever reason. One fairly unusual lithology was common in loose rock just above G260; this consisted of greenstone with

C68 - Rose River Cliffs (continued...)

abundant white phenocrysts of plagioclase feldspar (see photo 011). These crystals began to grow while the basaltic magma was still beneath the surface, and were erupted along with the rest of the lava onto the surface, forming an unusual texture of large (<1cm) well-formed plagioclase surrounded by the usual fine-grained greenstone. None of this material was found in-place, but it was abundant just above the ledges at G260, and so likely has a source nearby.

Structure:

The thick flow forming the major exposure between G258 and G260 is notable for its relative lack of any structures (columnar jointing, cleavage, other fractures, etc.) and thus forms a single massive unit. Above and below this flow, other bedrock areas have more typical amounts of cleavage and fracturing, though no columnar jointing was observed anywhere near the site. The sequence of flows here appears to be dipping gently to the east, as demonstrated by the tendency of individual lines of cliffs or outcrops to angle up the slope with the intervening topographic benches forming gentle ramps up the ridge. The angle here is less than found in similar exposures at Halfmile Cliff (C20), but the situation is similar.

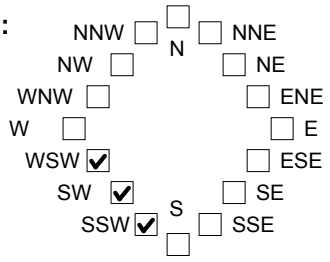
Other:

Geomorphic Characteristics

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	30.0	20.0	30.0	20.0	0.0	100
Max relief(m):	15	10	20	2	0	

Maximum Slope: 40 **Texture:** Smooth

Aspects:



Setting:

The series of cliff lines angling across this site are formed from a series of east-dipping greenstone lava flows. Through most of the Central and North Districts, the lava flows dip to the east or southeast at gentle angles (estimated at 10-20 degrees by other sources). As in most other greenstone areas, the centers of flows tend to produce linear exposures across slopes, with topographic benches forming between flows. Where these flows protrude from west-facing slopes, they produce a near-horizontal staircase-like series of cliffs and benches, e.g. Stony Man and Mt Marshall. Where these flows are exposed within deeply incised canyons cutting across the dip of the flows, however, they produce angled cliff lines like those seen at Halfmile Cliff and Rose River. At this site, the dip of the flows appears to be gentler than at Halfmile Cliff, and so the "staircase" here runs nearly parallel to the slope with only a slight angle upward to the west.

The most striking exposure here is found at G258, consisting of an open expanse of smooth rock gradually sloping down to form a steep cliff at its base. This exposure is a classic "face", and looks exactly like those normally found in basement rock areas such as Old Rag Mountain. It is rather unusual to find such a large, smooth, sloping face in greenstone, which usually has too many intervening structural features (cleavage, columnar jointing, layering) to form such an exposure. In this case, the rock here is unusually massive (structureless) and homogenous for greenstone, and the local flow seems to be very thick, allowing the exfoliation process usually reserved for granitic areas to operate here. Exfoliation is the process through which massive crystalline rock slowly fractures into curved slabs as it gradually expands and contracts with temperature fluctuations; a clear example can be seen in photo 003. Just to the west, however, along the same exposure, the face area gradually vanishes and is replaced by a more traditional ledge complex above a single large cliff. Further west, this cliff recedes back towards a sloping face again near G260. It is not at all clear what drives these changes, as the central cliff area does not appear to contain strong cleavage, though it is a bit more fractured than its surrounding exposures.

The other notable examples of greenstone faces identified in ROMP occur within C18 (Goat Ridge) and C45 (Sawlog Ridge), both of which occur within a different setting. There, the greenstone flows are dipping steeply at the same angle as the surrounding topography, so that the exposures are formed on the angled surface of the flow. Rose River is quite different, as the faces here are formed within a cross-cut of the flow, and are that much more unusual for it. The local flow's homogeneity and lack of any significant structures seems to be the dominant factor here, rather than the overall orientation of the flow as at C18 and C45.

C68 - Rose River Cliffs (continued...)

The upper exposure at G259 is more typical of greenstone areas, with well-developed cleavage producing a very ledge-rich exposure that descends into cliff. Again, no evidence of contacts with surrounding flows was found within the bedrock, though amygdaloidal and brecciated rock are present within the loose material on surrounding slopes. Thus, this exposure is also likely formed from a single lava flow, with more typical characteristics and thus a more typical exposure pattern.

A series of smaller and more sporadic exposures (e.g. G256, G257) are found below these main exposures to the south, outside the initial site boundary but likely of interest due to their open nature. These too follow typical greenstone exposure patterns, with abundant cleavage and other fractures producing ledge-rich outcrops and small cliffs. These small exposures are part of a larger pattern of bedrock that is exposed but not open; these follow the area's pattern of linear rock exposures angling up the slope, and make it clear that the overall structure is a gently east-southeast dipping sequence of lava flows.

Stability: Stable

There are very few fractures or other places of weakness within the rocks here, and the exposures are quite sturdy to walk on, as long as soil, lichens, and moss are taken into account. The surrounding slopes not overly steep and so loose rock is not a major concern either.

GPS Points

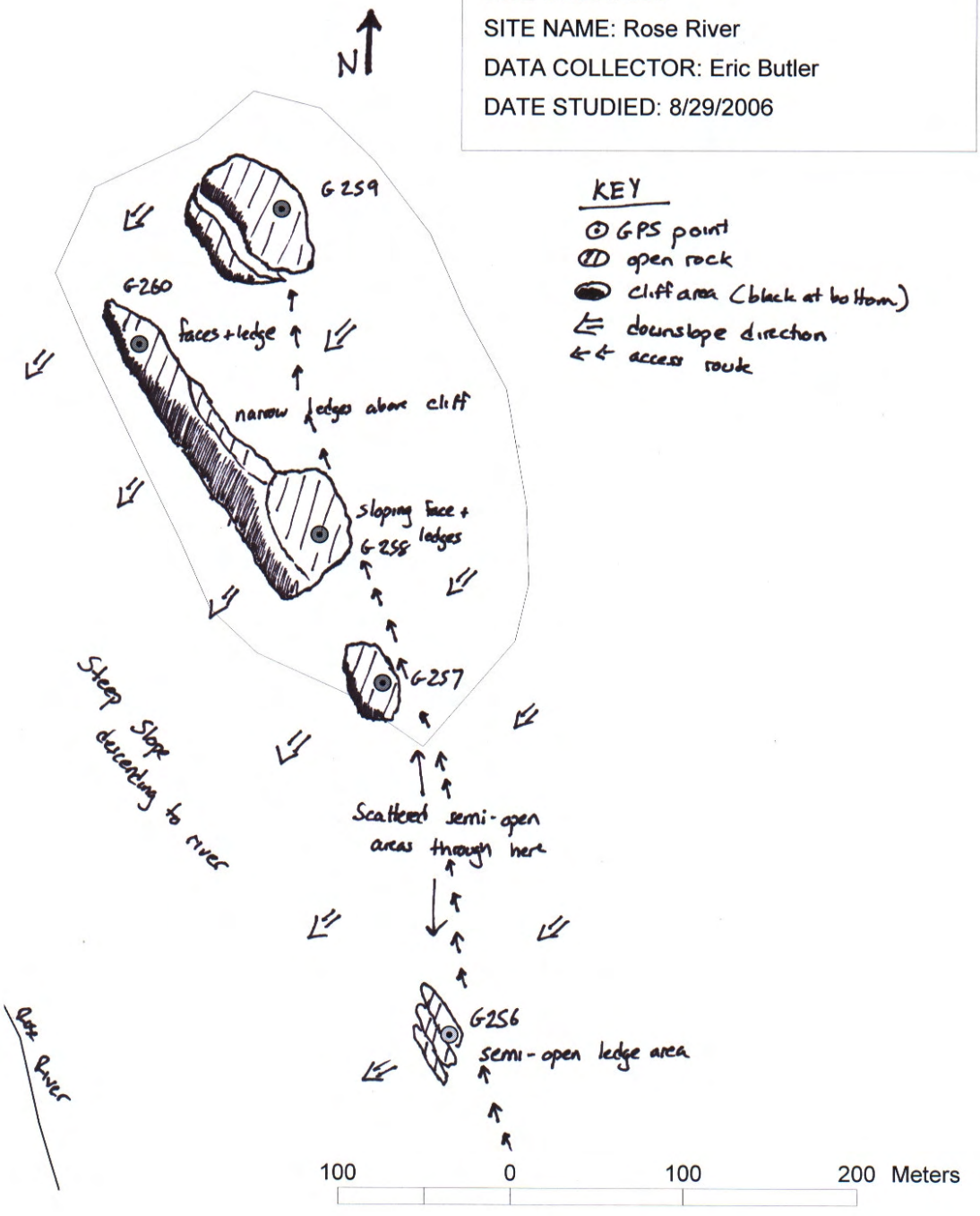
Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
8/29/2006	G256-C68	727827	4266207	1800	Lowest-elevation open area; cedar glade on rock ledges
8/29/2006	G257-C68	727788	4266412	2000	Small sloping semi-open rock face
8/29/2006	G258-C68	727752	4266498	2120	Upper eastern end of very large open rock face
8/29/2006	G259-C68	727730	4266690	2200	Top of highest-elevation open area; broad ledgy outcrops
8/29/2006	G260-C68	727647	4266610	2360	Western extent of linear exposures stretching back to G258

Site Photos

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
8/29/2006	G256-C68	SHEN_C68_G_20060829_001.jpg	320	Butler, Eric	Partially open vegetated ledges
8/29/2006	G256-C68	SHEN_C68_G_20060829_002.jpg		Butler, Eric	Amygdaloidal greenstone filled with quartz, common throughout the site
8/29/2006	G258-C68	SHEN_C68_G_20060829_003.jpg	335	Butler, Eric	Exfoliating slabs of greenstone at the east end of the large open face below G258
8/29/2006	G258-C68	SHEN_C68_G_20060829_004.jpg	335	Butler, Eric	Sloping, open greenstone rock faces at G258; note lack of ledges or structures
8/29/2006	G258-C68	SHEN_C68_G_20060829_005.jpg		Butler, Eric	Small pockets of epidote and quartz typical of those scattered throughout the rock at G258
8/29/2006	G258-C68	SHEN_C68_G_20060829_006.jpg	315	Butler, Eric	Upper portion of sloping greenstone faces at G258; note wet seep area in foreground.
8/29/2006	G258-C68	SHEN_C68_G_20060829_007.jpg	330	Butler, Eric	View from center of large cliff/face exposure, west of G258, looking NW as exposure steepens into true cliff.
8/29/2006	G258-C68	SHEN_C68_G_20060829_008.jpg		Butler, Eric	Subtle planar texture within greenstone that may be internal layering within the flow
8/29/2006	G259-C68	SHEN_C68_G_20060829_009.jpg		Butler, Eric	Ledges at top of G259 exposure
8/29/2006	G259-C68	SHEN_C68_G_20060829_010.jpg		Butler, Eric	Sloping faces/ledges at G259
8/29/2006	G260-C68	SHEN_C68_G_20060829_011.jpg		Butler, Eric	Abundant phenocrysts of plagioclase feldspar within greenstone; very common in loose rock just above G260 exposures
8/29/2006		SHEN_C68_G_20060829_012.jpg	160	Butler, Eric	Ledges atop large, sheer cliff between G260 and G258.

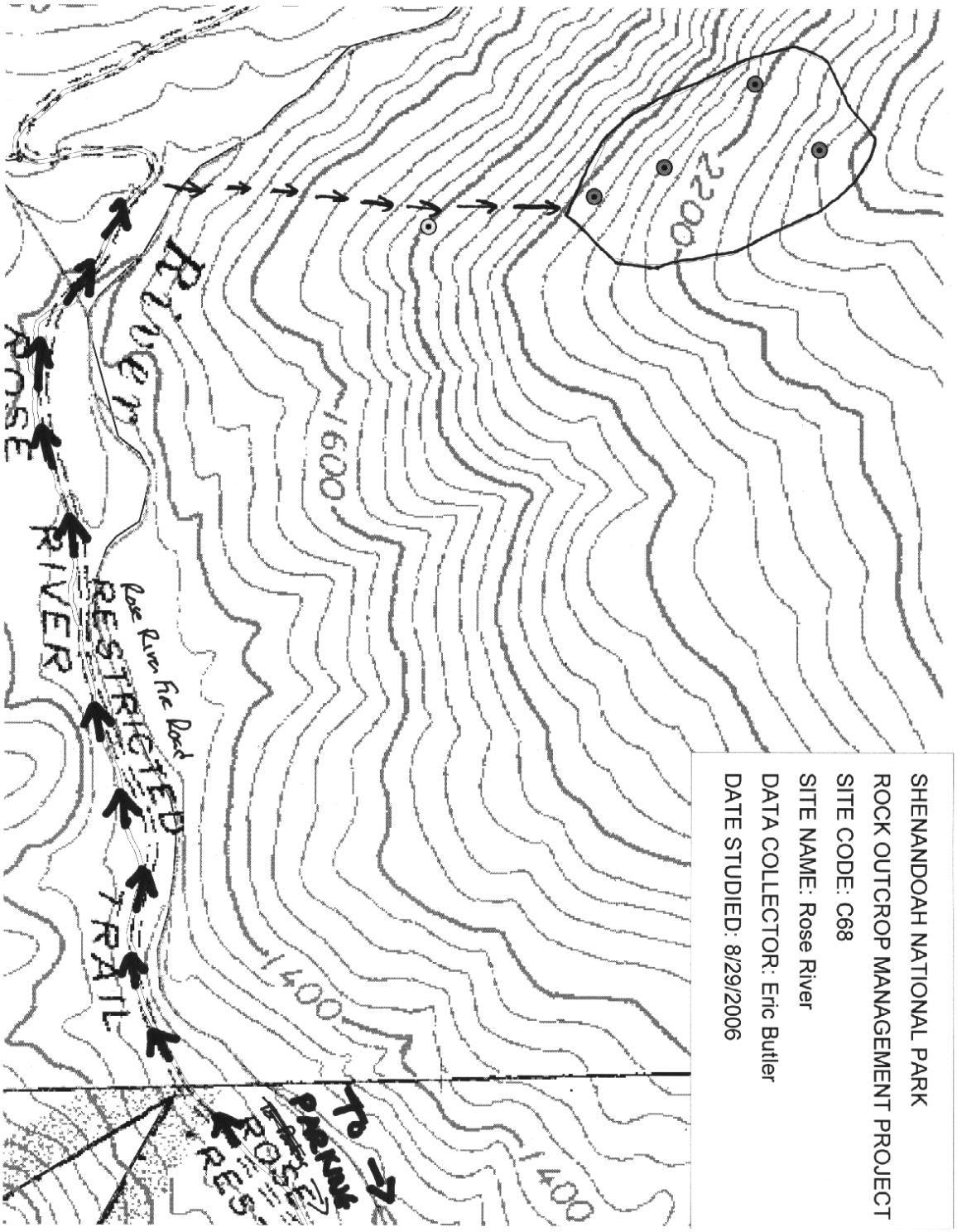
C68 - Rose River Cliffs (continued...)

Detail map



C68 - Rose River Cliffs (continued...)

Area map



C68 - Rose River Cliffs (continued...)



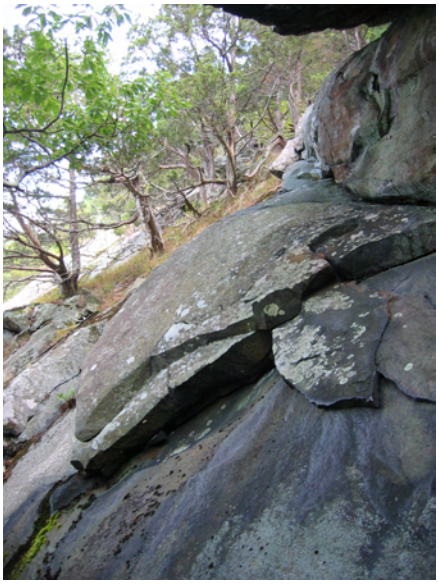
SHEN_C68_G_20060829_001.jpg Azmuth: 320

Partially open vegetated ledges



SHEN_C68_G_20060829_002.jpg Azmuth:

Amygdaloidal greenstone filled with quartz, common throughout the site



SHEN_C68_G_20060829_003.jpg Azmuth: 335

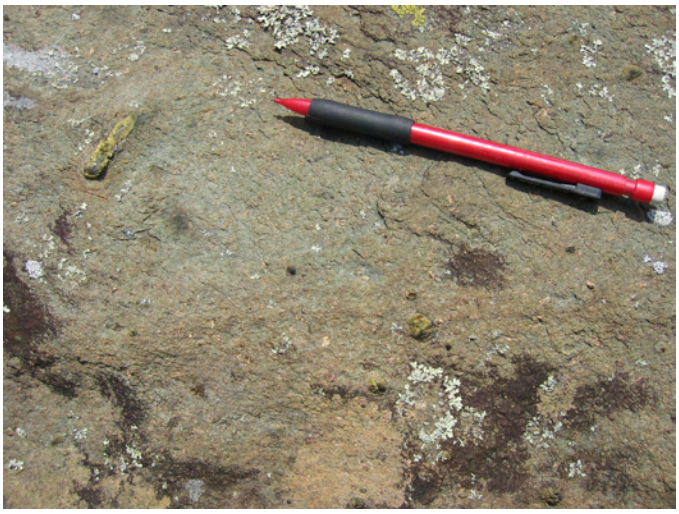
Exfoliating slabs of greenstone at the east end of the large open face below G258



SHEN_C68_G_20060829_004.jpg Azmuth: 335

Sloping, open greenstone rock faces at G258; note lack of ledges or structures

C68 - Rose River Cliffs (continued...)



SHEN_C68_G_20060829_005.jpg Azmuth:

Small pockets of epidote and quartz typical of those scattered throughout the rock at G258



SHEN_C68_G_20060829_006.jpg Azmuth: 315

Upper portion of sloping greenstone faces at G258; note wet seep area in foreground.



SHEN_C68_G_20060829_007.jpg Azmuth: 330

View from center of large cliff/face exposure, west of G258, looking NW as exposure steepens into true cliff.



SHEN_C68_G_20060829_008.jpg Azmuth:

Subtle planar texture within greenstone that may be internal layering within the flow

C68 - Rose River Cliffs (continued...)



SHEN_C68_G_20060829_009.jpg Azmuth:

Ledges at top of G259 exposure



SHEN_C68_G_20060829_010.jpg Azmuth:

Sloping faces/ledges at G259



SHEN_C68_G_20060829_011.jpg Azmuth:

Abundant phenocrysts of plagioclase feldspar within greenstone; very common in loose rock just above G260 exposures.



SHEN_C68_G_20060829_012.jpg Azmuth: 160

Ledges atop large, sheer cliff between G260 and G258.

Rock Outcrop Management Project
Geologic Site Report

National Park Service
U. S. Department of the Interior
Shenandoah National Park

C69 - Whiteoak Canyon

Site Code: C69
Site Name: Whiteoak Canyon
Data Collector Butler, Eric
Date Studied: 22-Aug-06

Polygon Centroid: **E:** **N:**
UTM (Zone 17 NAD83)
Dimensions (m): 130 x 230 (GIS est.)
Elevation Range (ft): 1600 to 1920

Physical Characteristics

Location Acces

The site is located just above the lowest falls in Whiteoak Canyon. The easiest access is from the lower Whiteoak parking lot, accessed from Berry Hollow outside the park. From there, hike about 2km along the Whiteoak Canyon trail, passing the lowest falls and ascending several switchbacks before reaching the first open rock faces.

Physical Description:

This site contains two different rock exposure areas. On the eastern, lower end of the site, scattered partially shaded exposures create small glades above and below the trail. The larger of these areas are marked on the map. Further west and up along the trail, a large, open expanse of smooth rock slopes down into cliffs descending to stream level. These cliffs wrap around to form a waterfall.

Vegetation: Moderate

Thick, difficult vegetation is present in places, but access between glades is generally not constrained by this growth.

Human Effects

Impacts: Mild

Although a major and highly visited trail runs directly through the site, these exposures seem surprisingly undisturbed. Some are just off the trail and partially screened by vegetation, and the main attraction in the region is the falls. It is likely that some visitors reach the upper portions of the larger open rock faces, but it is difficult to determine how impacted these areas are (there are few lichens, so higher impact than obvious is possible). No trash or other obvious signs of disturbance were observed.

Access Moderate

Despite the 2km hike and steep, rocky path in places, this trail is heavily used and widely known.

Geologic Characteristics

Lithology: **Rock Type** Greenstone and granite

There are two different lithologies present within this site. Most of Whiteoak Canyon is underlain by greenstone lava flows, in a thick sequence that creates the numerous waterfalls as the stream cuts through individual flows. However, within and near this site, a small area is underlain by granitic rock, with greenstone all around. Exposures of the latter are fairly small, but consist of average-looking greenstone, often with strong cleavage developed. Epidote is also common, and some evidence of contact material between flows can be found (such as quartz pebbles reworked into the lava). The granitic rock is composed mostly of quartz and plagioclase feldspar, with variable amounts of orthoclase feldspar and few mafic (dark) minerals. In some places the granite has been partially altered by epidote, forming unakite, likely from the influence of the nearby lava flows. Veins of both quartz and epidote are common, and chlorite and/or actinolite was observed in one quartz vein.

Structure:

The granitic rock is relatively structureless, though some subtle foliation can be observed in places. There is little fracturing, and exfoliation seems to be the main erosive agent. The greenstones nearby contain a good deal of cleavage, which results in many platy boulders and exposures.

Other:

The presence of epidote and possibly of chlorite and/or actinolite within veins and the granite itself (altered to unakite) suggests that these rocks were very near to the surface during the period of Catoctin volcanism. These minerals are commonly produced by localized metamorphism when basaltic lava flows come into contact with granitic bedrock, as likely happened here.

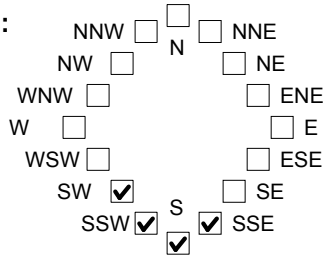
Geomorphic Characteristics

C69 - Whiteoak Canyon (continued...)

	Cliff	Outcrop	Face	Ledge	Talus	Total
Exposure (%):	20.0	20.0	50.0	10.0	0.0	100
Max relief(m):	15	5	5	1		

Maximum Slope: 30 **Texture:** Smooth

Aspects:



Setting:

The presence of a small pocket of granitic bedrock within the greenstones needs explanation, as the greenstone lava flows are normally found above the older granites over which they originally flowed. There are two distinct possibilities: that one or more faults has raised this section of granitic material up into contact with the overlying greenstone, or that this area represents a high point in the old landscape over which the lavas originally flowed. After carefully tracing the contact between the two units from the trail near G249 all the way down to the stream, it is clear that the latter explanation is correct. In several places the exact contact can be seen within in-place bedrock, preserving the lower granite and a partially eroded and altered contact zone which grades gradually up into pure greenstone. No evidence of any sort of faulting was observed. In addition, the presence of granitic zones altered to unakite and veins of epidote and other minerals associated with localized basaltic metamorphism strongly implies that these granites were very near the surface at the time the lavas formed, as opposed to being faulting up into contact at a later date. It is likely that this unusual exposure pattern simply reflects the presence of an old high point in the Catoctin-era topography, a hill around which the lavas flowed and eventually overtopped. As the current canyon eroded, it eventually reached this hilltop and exposed it as an island of granite within the surrounding greenstone. A similar pattern and interpretation can be found near the top of Big Devil's Stairs (C03). See the site map for a rough sketch of how this could occur.

The presence of two different lithologies within the site creates very different exposure patterns. The granitic areas follow a typical morphology for this rock type, forming large, rounded faces which slope down to form near-sheer cliffs at their base. Some ledges are present, but the overall smooth, rounded nature of the exposures is typical of granitic weathering patterns. Conversely, the greenstone exposures tend to be rougher, more angled, and ledgier, due to the influence of pervasive cleavage. Bench-like cliff/ledge combinations are also more common within the greenstone areas due to the planar nature of the individual lava flows. The lava flows in this area are tilted to the east, and so many of the linear greenstone exposures are angled up the slope, reflecting the overall tilt of the beds. A similar and more dramatic example of this pattern can be found nearby along Halfmile Cliff (C20).

Stability: Stable

The majority of open rock exposures within the site are found on granitic bedrock, which here is very solid with few fractures, and thus is quite stable. Although the greenstone is heavily cleaved, these exposures are also stable.

GPS Points

Gps Date	Point_ID	Easting X	NorthingY	Elev. ft	Point Comments
8/22/2006	G248-C69	730654	4270895	1680	Easternmost of several small greenstone glades near trail
8/22/2006	G249-C69	730557	4271004	1840	Top of large, open granitic face stretching from trail to river

Site Photos

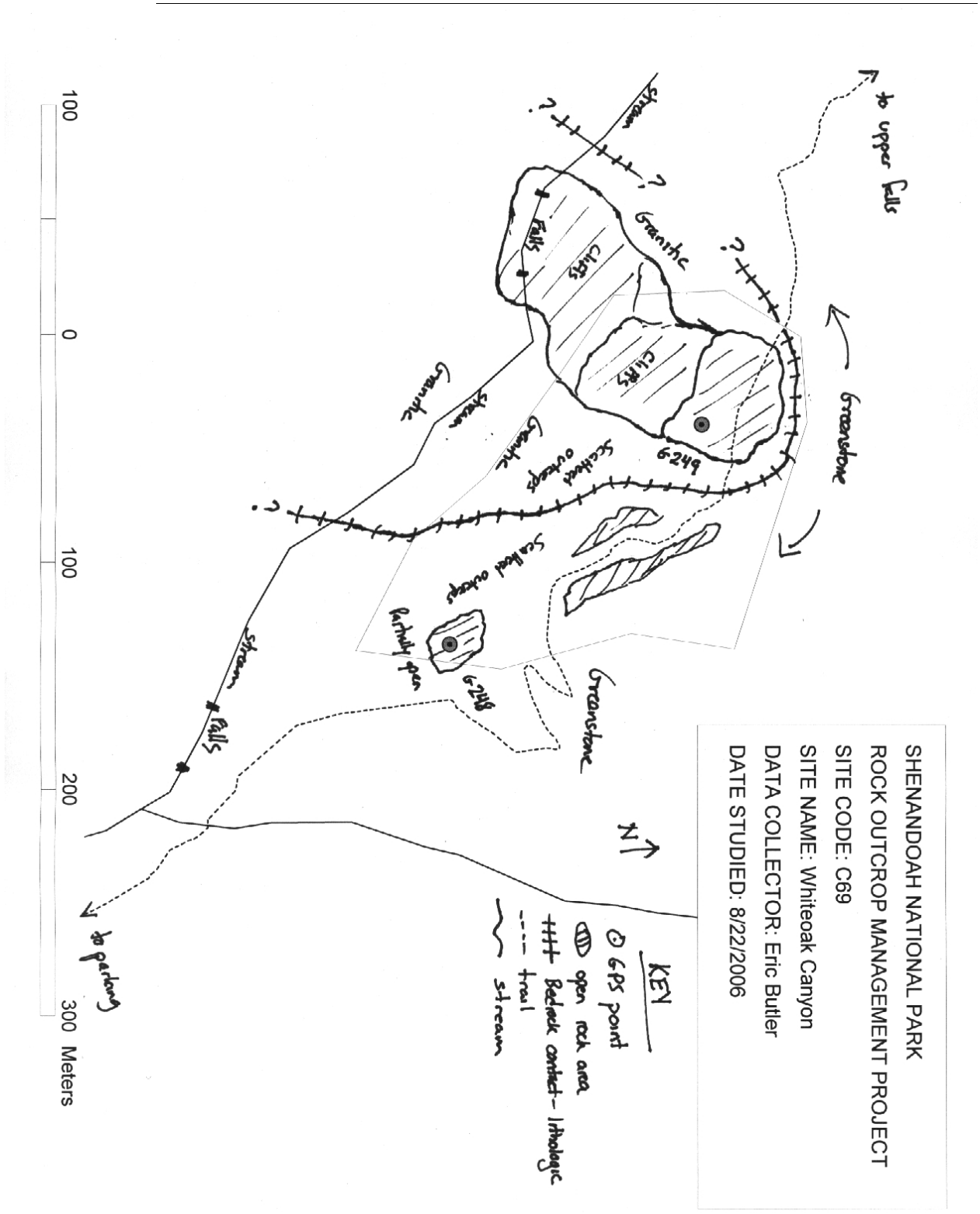
Image Date	GPS Point	File Name	Azmuth	Taken By	Description
8/22/2006	G248-C69	SHEN_C69_G_20060822_001.jpg	260	Butler, Eric	Small partially open greenstone glade near trail
8/22/2006	G248-C69	SHEN_C69_G_20060822_002.jpg		Butler, Eric	Quartz pebbles (not amygdules) mixed into greenstone
8/22/2006	G249-C69	SHEN_C69_G_20060822_003.jpg	255	Butler, Eric	Open granite faces above river
8/22/2006	G249-C69	SHEN_C69_G_20060822_004.jpg		Butler, Eric	Closeup of typical granite near G249
8/22/2006	G249-C69	SHEN_C69_G_20060822_005.jpg	20	Butler, Eric	View up granite face toward trail

C69 - Whiteoak Canyon (continued...)

Image Date	GPS Point	File Name	Azmuth	Taken By	Description
8/22/2006	G249-C69	SHEN_C69_G_20060822_006.jpg	200	Butler, Eric	View down granite face toward river
8/22/2006	G249-C69	SHEN_C69_G_20060822_007.jpg		Butler, Eric	Granite altered to unakite and associated epidote vein - evidence that local rock is near contact with greenstone
8/22/2006	G249-C69	SHEN_C69_G_20060822_008.jpg	350	Butler, Eric	Cliff at base of granite face below G249; falls to left

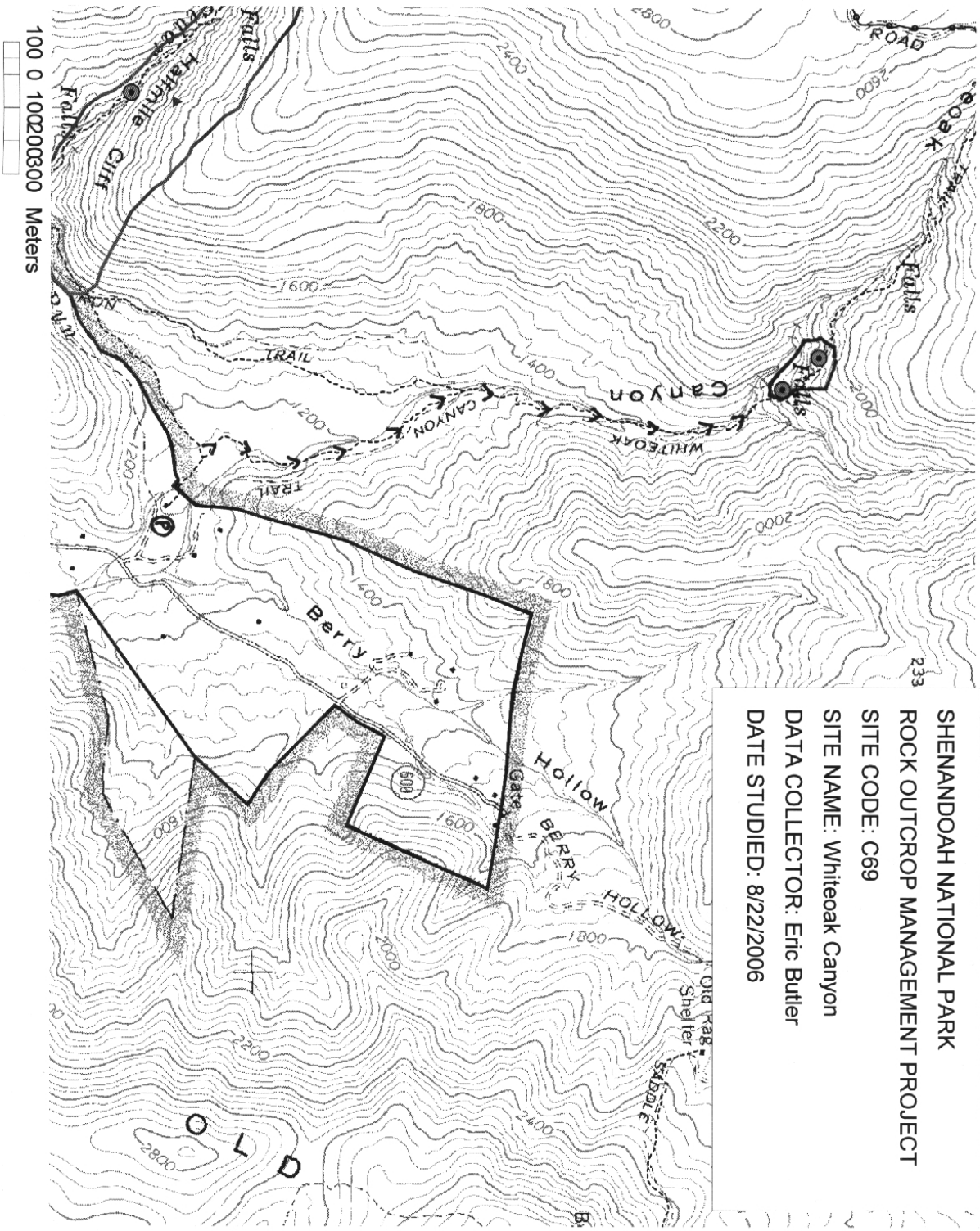
C69 - Whiteoak Canyon (continued...)

Detail map



C69 - Whiteoak Canyon (continued...)

Area map



C69 - Whiteoak Canyon (continued...)



SHEN_C69_G_20060822_001.jpg Azmuth: 260

Small partially open greenstone glade near trail



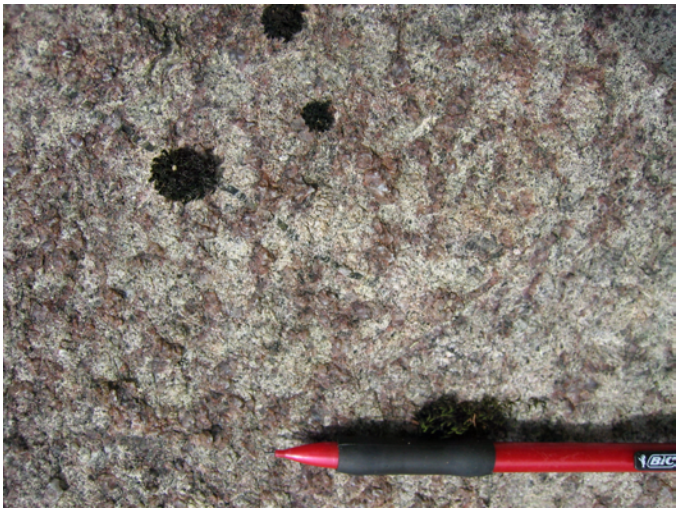
SHEN_C69_G_20060822_002.jpg Azmuth:

Quartz pebbles (not amygdules) mixed into greenstone



SHEN_C69_G_20060822_003.jpg Azmuth: 255

Open granite faces above river



SHEN_C69_G_20060822_004.jpg Azmuth:

Closeup of typical granite near G249

C69 - Whiteoak Canyon (continued...)



SHEN_C69_G_20060822_005.jpg Azmuth: 20

View up granite face toward trail



SHEN_C69_G_20060822_006.jpg Azmuth: 200

View down granite face toward river



SHEN_C69_G_20060822_007.jpg Azmuth:

Granite altered to unakite and associated epidote vein - evidence that local rock is near contact with greenstone



SHEN_C69_G_20060822_008.jpg Azmuth: 350

Cliff at base of granite face below G249; falls to left