Museum Notes

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Death at a 19 Million Year-old Waterhole: The Bonebed at Agate Fossil Beds National Monument, Western Nebraska

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The air is still, without wind, and the heat oppressive. A vast grassland plain stretches far to the horizon, spanned by a sky brilliant and cloudless. Along dry river channels, scattered herds of mammals are clustered at shrinking waterholes. Many grazing mammals have already perished, their bloated carcasses packed together in the shallow mud of the depressions; the living stand and stare vacantly, awaiting an end. Drought has settled upon the plains and decimated these herds, which were unable to escape westward to better watered and more verdant terrain. The rains will fail to come, and the last survivors will ultimately expire near these dwindling water sources.

The great mammalian bonebed at Agate Fossil Beds National Monument is thought to have resulted from such a drought. Hundreds of skeletons of small rhinoceroses and huge horselike chalicotheres (kal-ik-o-theers) are buried together in the shallow waterhole where they died along a wide ephemeral stream about 19 million years ago. Devastating droughts probably occurred many times during Nebraska's prehistory, but few are registered in the state's geologic record. After drought, a grassland may be littered with the carcasses of thousands of animals. Soon, however, evidence of the disaster will disappear as the bones disintegrate under the ravages of sun, soil, scavengers and vegetation. But on rare occasions, entire or partial carcasses may be buried rapidly and deeply by sediments before decomposition has progressed too far—and it is these assemblages that have the potential of becoming "bonebeds." Dramatic as such death events would be to witness, the history of the discovery and excavation of the Agate bonebed is equally compelling.

DISCOVERY AND INITIAL EXCAVATIONS OF THE BONEBED

The great bonebed at Agate, in Sioux County, Nebraska, is one of the most impressive and scientifically interesting paleontological sites in North America. First recognized in August 1904 by Carnegie Museum paleontologist O.A. Peterson, the bonebed yielded thousands of rhinoceros and

Fig. 1. The mammalian bonebed at Carnegie Hill, Agate Fossil Beds National Monument, contains hundreds of skeletons of rhinoceros and chalicothere that died presumably in a drought around a waterhole 19 million years ago.

Fig. 2 *The Agate Hills: A, Carnivore den site; B, Carnegie Hill; C, University Hill; D, North Ridge (Quarry A); E, Cook Ranch and Agate postoffice; F, National Monument Visitor Center.*

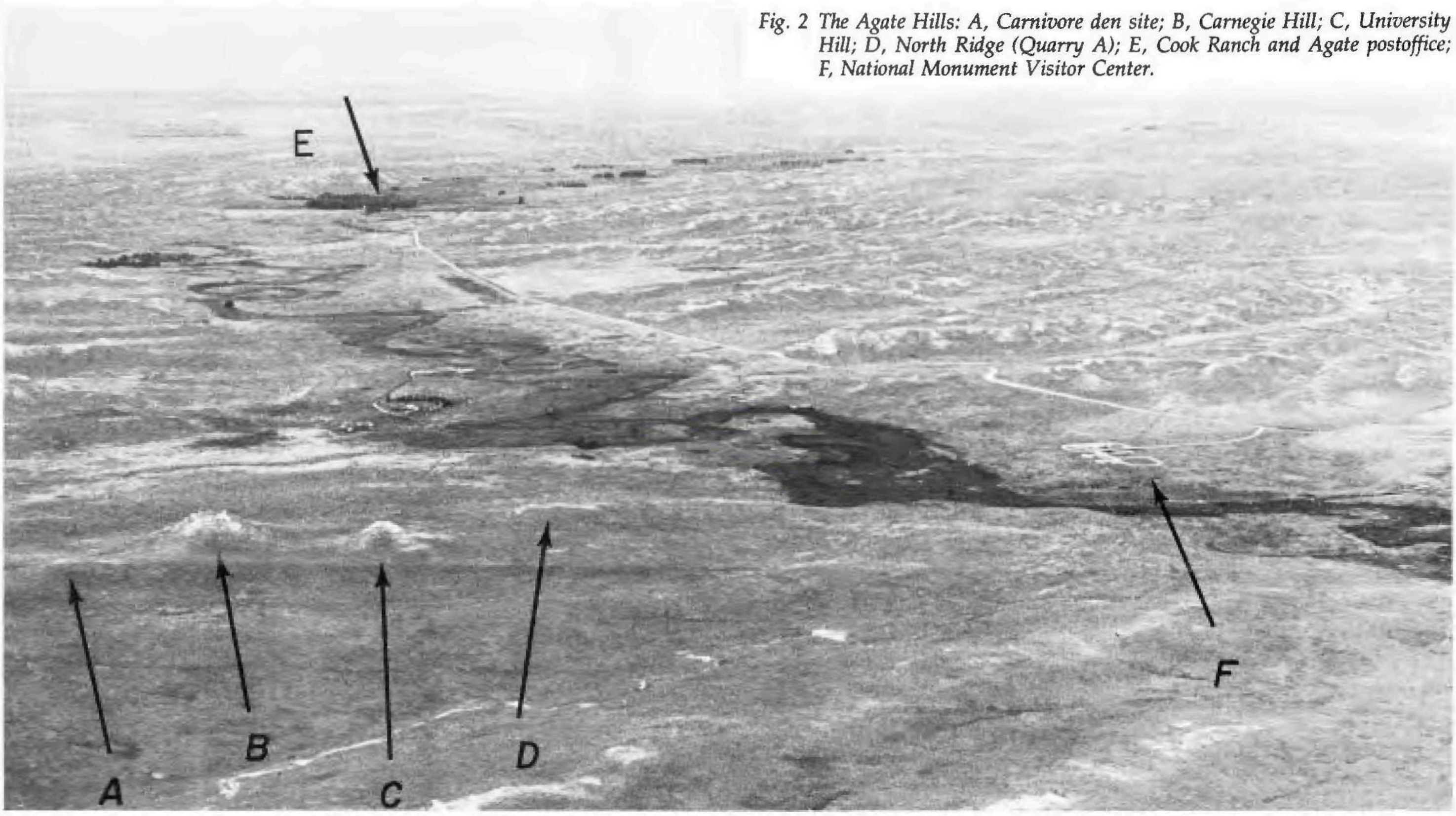


Fig. 3. E.H. Barbour and students during the 1892 Morrill Expedition to northwest Nebraska.

chalicothere bones during excavations conducted from 1904 to 1923 by the Carnegie Museum (Pittsburgh), University of Nebraska (Lincoln), Amherst College (Amherst), Yale University (New Haven), and the American Museum (New York). Most bones were concentrated in a two-foot layer of rock exposed at the base of two conical buttes, named Carnegie Hill and University Hill by E.H. Barbour of the University of Nebraska, one of the first paleontologists to work the locality. Barbour himself narrowly missed the chance to realize the discovery of the Agate bonebed when one of his students brought him bones from the site in 1892. Unwilling to visit the locality and eager to move on to new fossil fields, he broke camp at Agate and left behind the find of a lifetime. It was over a decade after Barbour's visit before Peterson reached Agate and was shown the bones in the Agate hills by the James Cook family near their ranch in the Niobrara valley.

KENYON, BARBOUR, AND PETERSON: RECOGNITION OF THE AGATE BONEBED

Scientific discoveries often result from chance, but are favored by the prepared mind and a willingness to take advantage of opportunity. The search for fossils is often accompanied by human drama, and the discovery of the Agate bonebed was no exception: Nebraska's Barbour might easily have been the discoverer of the great bonebed had it not been for his preoccupation with the "devil's corkscrews," a name locally given to enormous sandstone spirals—sometimes 10 feet in height—and of unknown origin.

Barbour became fascinated with these gigantic fossils on his first visit to Sioux County in 1891. On June 29-30 of that year, C.E. Holmes, a local resident of Harrison, Nebraska, escorted Barbour to the Pine Ridge, a short distance north of town. There he observed the sandstone spirals in

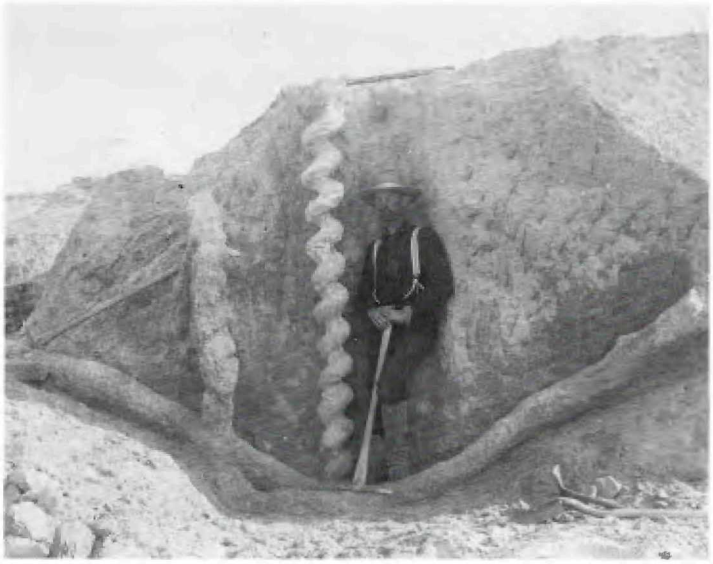


Fig. 4. F.C. Kenyon and two "devil's corkscrews," the natural casts of rodent burrows excavated in Sioux County in June 1892 immediately prior to Barbour's ill-fated expedition to Agate.

unusual abundance. Later, Barbour came to believe that these were fossils of huge plants, largely because plant cells were found in dense concentrations around the spiral cast and within its interior. He fielded his first major expedition to collect the corkscrews in the summer of 1892, accompanied by several of his students, securing one ton of these casts for the museum.

James Cook of Agate, hearing of Barbour's interest in the corkscrews, invited him to visit Agate to see the ones found at his ranch. On July 7, 1892, Barbour and his party traveled 25 miles south to the Cook homestead at Agate, arriving in an intense rainstorm. On the following day, the Cook family guided Barbour to rock outcrops near the ranch containing superb examples of the sandstone spirals. On July 9th, Barbour and his men excavated some of these corkscrews in the draws extending north from the Niobrara River.

On the same day, one of Barbour's students, F.C. Kenyon, during a brief exploration of the hills on the south side of the river, made the discovery that could have given Barbour first entrance into the Agate bonebed. An entry by Barbour in his personal field notebook for Saturday, July 9, 1892, records the event: "Kenyon visited two hills 4 m. E [miles east] of Cooks where the bones of Indian horses are reported to have been petrified. He finds Oreodon, Hyracodon [a small rhinoceros], and other animals in considerable abundance, all are fragmentary however. Visit at another time." In darker ink written near this entry appear two State Museum field numbers given to fossils found on July 9, 1892. The first number (UNSM 15-9-7-92) bears a red stamp "Discarded" above it, but was located in the museum collections in 1991: it proves to be a chalicothere jaw fragment with tooth sockets still intact. A second number, UNSM 16-9-7-92, reads "Claw-Megatherium-Mylodon [extinct ground sloths]. Probably belongs to higher beds." This specimen, also conserved in the museum's paleontology collections, is in fact the clawlike terminal toe bone (ungual phalanx) of a large chalicothere. Because these chalicothere bones bear field numbers indicating that both were found on July 9, 1892, there is little doubt that these are the fossils collected by Kenyon and brought to Barbour. Because bone #16 was mistaken for a sloth claw, it was assumed it must come from higher (younger) beds since no sloths were known from rocks as old as those forming the hills at Agate. Color and other preservational features of Kenyon's fossils also indicate that they came from the Agate bonebed.

Anxious to move north to the Pine Ridge into the White River badlands, Barbour's party left the Cook Ranch late on the afternoon of July 9th, reaching the town of Harrison shortly after midnight. They rested the next day in Harrison, some attending church, others writing letters, eventually traveling north into the badlands on Monday, July 11th.

Barbour was not the only paleontologist with a developing interest in the fossils and geology of Sioux County. The Carnegie Museum's resourceful John Bell Hatcher, known for his superb skills as a field paleontologist, passed through northwest Nebraska on several occasions from 1886 to 1895, spending much effort in the White River badlands to the north of the Pine Ridge. A keen judge of fossil prospects, Hatcher saw the extraordinary potential of the Pine Ridge country. In 1901, he assigned to his brother-in-law, O.A. Peterson, the task of amassing a collection of fossils from the White River badlands, the Pine Ridge, and the tableland to the south. Peterson worked vigorously in the region during the summers of 1901 and 1902.

In late May 1904, Peterson again returned to Sioux County with Hatcher's encouragement. During the summer of 1904 both success and personal tragedy befell Peterson: by a combination of pure chance and shrewd

Fig. 5. O.A. Peterson (right), Carnegie Museum paleontologist, with a colleague in Pittsburgh, at the time of his excavations in the Agate quarries.

observation he was able to solve the mystery of the enigmatic "devil's corkscrews" and, shortly thereafter, discovered the Agate bonebed as a result of a similar marriage of intellect and luck.

On July 4, 1904, Peterson located a large group of corkscrews along the Niobrara River in Wyoming near the town of Van Tassell. His notes reflect his excitement: "I had not remained very long in this locality before I became convinced of the origin of the [corkscrews]. I found remains of rodents, not only one case but 6 or 7 cases, and in two instances I found nearly the complete skeletons lay in the weathered-out inside of the corkscrew! Not once did I find the rodent remains attached to the outside surface of the burrow, or corkscrew, but always on the weathered-out inside of the casts. The fact that rodent remains are thus found in these casts of burrows or Cork Screws and seldom ever found in the soft sandstone separate from the burrows is alone evidence of their true origin." From this time, Peterson never doubted that the origin of the corkscrews was attributable to the rodents found in them. His observations have been confirmed by later more detailed investigations that established the identity of the rodents as terrestrial beavers belonging to the genus *Paleocastor.*

Peterson left excellent sketches and notes of the *Paleocastor* burrows in 1904 but field notes describing the remainder of his work have not been found. This seems the result of a tragic event that occurred in early July 1904, for after that time he apparently made no detailed field notes. Unknown to Peterson, in late June his brother-in-law Hatcher had contracted typhoid fever in Pittsburgh and quickly became gravely ill. Probably weakened by years of sustained overexertion in fieldwork and research in the western United States and South America, Hatcher failed to recover and died on July 3rd at the age of 42 years. Peterson learned of Hatcher's death on the same day as his discovery of the origin of the corkscrew burrows near Van Tassell. As he returned to town on horseback, elated by his new knowledge, Peterson was met by one of his men who carried the fateful telegram. Concerned for his sister, he immediately wrote the Carnegie Museum's director, W.J. Holland, that he wished to return to the East. Holland, a singularly unsympathetic man, refused and urged Peterson to continue exploration in the region. Intensely disappointed, Peterson wrote his former employer, H.F. Osborn, that "I have no heart to do work as I did formerly. Dr. Holland . . . is not capable of the sympathy a field man craves in connection with paleontology."

Fig. 6. John B. Hatcher, Curator of Vertebrate Fossils at the Carnegie Museum, Pittsburgh, until his premature death from typhoid fever in 1904.

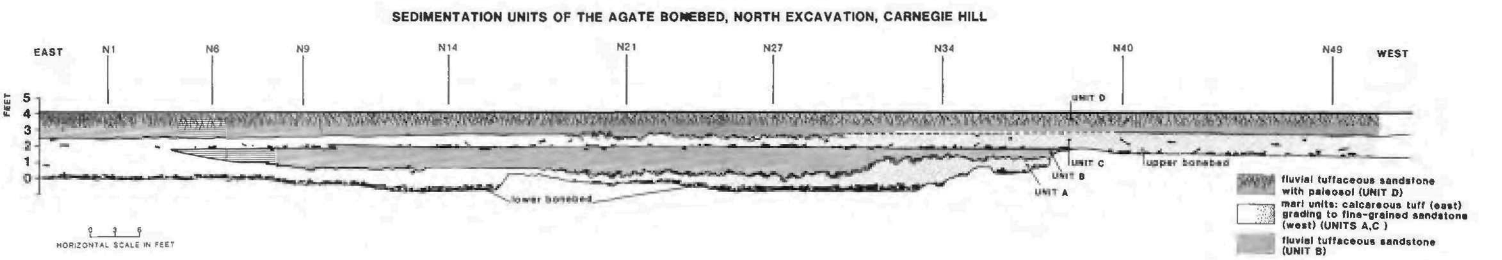
Against this background of events, Peterson prepared to travel to Agate to look over the region in the vicinity of the James Cook ranch. His emotional state could hardly have been less conducive to careful observation of the area and the detailed recording of his finds. We know that Peterson reached Agate during the first days of August after a brief illness. He left no field notes on Agate at the Carnegie Museum: however he reported some details of this momentous discovery of the bonebed in his publications (Peterson, 1906, 1909; Holland & Peterson, 1914). Hatcher's death and the conflict with Holland very likely contributed to Peterson's deteriorating physical and mental state. As a result, one of the most important paleontological discoveries in North America remains without detailed documentation.

Despite these events, Peterson immediately realized the importance of the bonebed, and supervised a program of excavations for the Carnegie Museum from 1904 to 1909. However, disagreements with the Cooks and with the American Museum eventually led to the abandonment of his quarries on Carnegie Hill. H. F. Osborn of the American Museum needed no urging to take immediate advantage of this opening. Osborn reached an agreement with the Cooks, and initiated highly productive excavations on Carnegie Hill in 1911. During this work, supervised by the able Albert (Bill) Thomson, the American Museum acquired the best preserved sample of chalicotheres ever discovered, as well as large quantities of rhinoceros material. At the conclusion of these excavations in 1923, the major effort in the Agate hills came to an end. Thereafter, only smaller scale, sporadic digging took place under the supervision of the Cooks who had gained ownership of the bone hills. In 1965 the Agate hills became a national monument administered by the National Park Service which controls access to these paleontological sites in the public interest.

UNIVERSITY EXCAVATIONS, 1981 TO 1990: AGE AND ORIGIN OF BONEBEDS

My interest in the Agate quarries began in 1971 with a research visit to the hills during study of the regional geology. It had often been assumed that the bone deposits in the Agate hills were of the same age. Our excavations in 1985-86 indeed confirmed that the Carnegie and University Hill quarries all exploited a single bonebed of the same age; in essence a waterhole that had filled with volcanic ash, fine sand, limy mud, and bones. The bones are primarily those of a pony-sized rhinoceros, *Menoceras ari-*

Fig. 7. Vertical profile of the waterhole bonebed resulting from the 1986 University of Nebraska excavations at Carnegie Hill that demonstrated two levels of bone accumulation, termed the upper and lower bonebeds.



karense, and represent hundreds of individuals. Other than these rhinoceroses, the only animal found in any abundance in this bonebed is the chalicothere, *Moropus elatus*.

The distribution of chalicotheres in the waterhole proved to be a significant clue to the origin of the bonebed: 17 to 20 of these large plant-eaters were found by Bill Thomson of the American Museum in the deepest part of the waterhole, clustered together. The group included males and females, mature adults and youthful juveniles. Because of their large size (a thigh bone from the upper hindleg is 2 feet long!), their carcasses would not have been easily transported by water to the site, so it seems improbable that the chalicotheres were washed into the depression; more likely they traveled to the waterhole and perished as a group. Because both young and mature individuals are present in some abundance, we know that healthy cross-sections of these rhinoceros and chalicothere populations died at the site, and so we postulated a catastrophic cause of death for the mammals in the main bonebed. In our investigations we have found that there are other waterhole deposits in Sioux County extremely similar to Agate, and of the same age, leading us to believe that a regional phenomenon of some sort led to the deaths of so many plains mammals. Drought produces bonebeds of this type today in Africa and seems a plausible explanation for the incredible concentrations of bones found in these contemporaneous waterhole sediments.

Following the death event, the skeletons were scavanged by carnivores and large entelodonts who left hundreds of broken bones with tooth marks as evidence of their activity. Tracks of the great scavenging entelodonts (*Dinohyus hollandi*) were found in the waterhole mud during our 1986 excavations, and chalicothere bones displayed the imprint of their enormous teeth.

About 600 feet southeast of the main bonebed at Carnegie Hill is a smaller hill in which Peterson found abundant carnivore bones in 1905. In 1981 we relocated Peterson's quarry and discovered that it contained almost nothing but carnivore bones, belonging to five species, found within their own dens (most bones were those of large wolflike beardogs, predators that became extinct about 8-9 million years ago). This proved to be the oldest record of denning behavior by large carnivores known anywhere in the world, prompting our excavations of these burrows from 1981 to 1990. The age of the den site is slightly younger than the main bonebed at Carnegie Hill; in fact the beardogs had burrowed into sediments which had filled the old waterhole along its south margin.

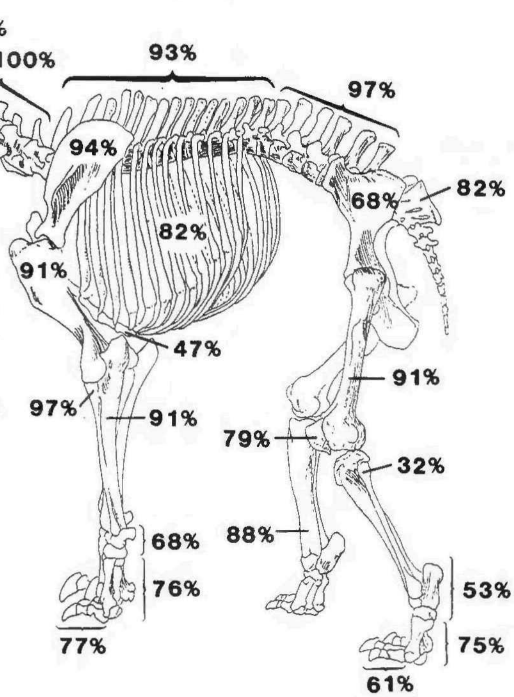


Fig. 8. A group of remarkably complete chalicothere skeletons was discovered in the Agate bonebed during American Museum excavations by Bill Thomson at Carnegie Hill. Seventeen individuals averaged a skeletal completeness of 76%: percentages indicate the representation of the various parts of their skeletons in the American Museum quarry.

Fig. 9. ***A**, Tracks of large scavenging entelodonts (t) were found in the Agate bonebed on Carnegie Hill by University of Nebraska paleontologists in 1986; **B**, chalicothere limb bones with tooth marks of large entelodonts demonstrate their probable role as scavengers in the Agate waterhole.*

Another site believed by some workers to be the same age as the main bonebed is Carnegie Quarry A, found at North Ridge about 1200 feet north and slightly west of Carnegie Hill. Careful study has shown this site to be much older than the main bonebed. It produced a different suite of mammals, dominated by the larger rhinoceros *Diceratherium niobrarense.* We believe that Quarry A and the Stenomylus Quarry (located 1.5 miles east of Carnegie Hill and yielding numerous skeletons of the little gazelle-camel, *Stenomylus hitchcocki*) are both about the same age, somewhat older than the main bonebed and dens. Future work in the Agate quarries is planned to interpret these classic sites for the general public and the scientific community.

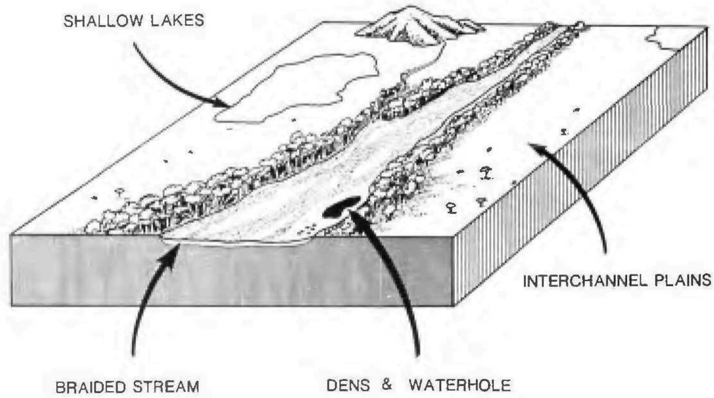


Fig. 10. Paleontologists reconstruct the environment of western Nebraska 19 million years ago as a semiarid plain stretching to the Rocky Mountains, traversed by ephemeral streams. During droughts these shallow stream valleys would have contained diminishing waterholes where water-dependent mammals died in large numbers, producing fossil deposits like those in the Agate hills. Carnivores may have exploited these mass deaths and built den communities in proximity.

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