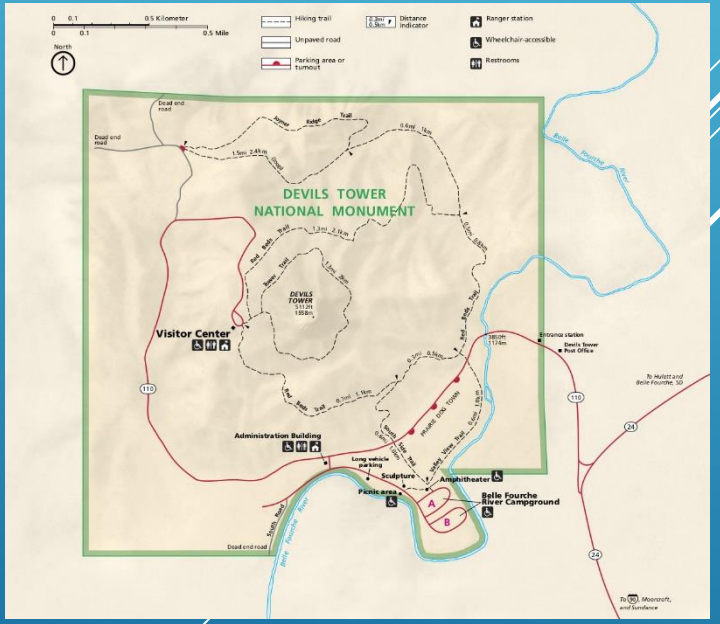
DEVILS TOWER PHONOLITE

By: Devin Foster

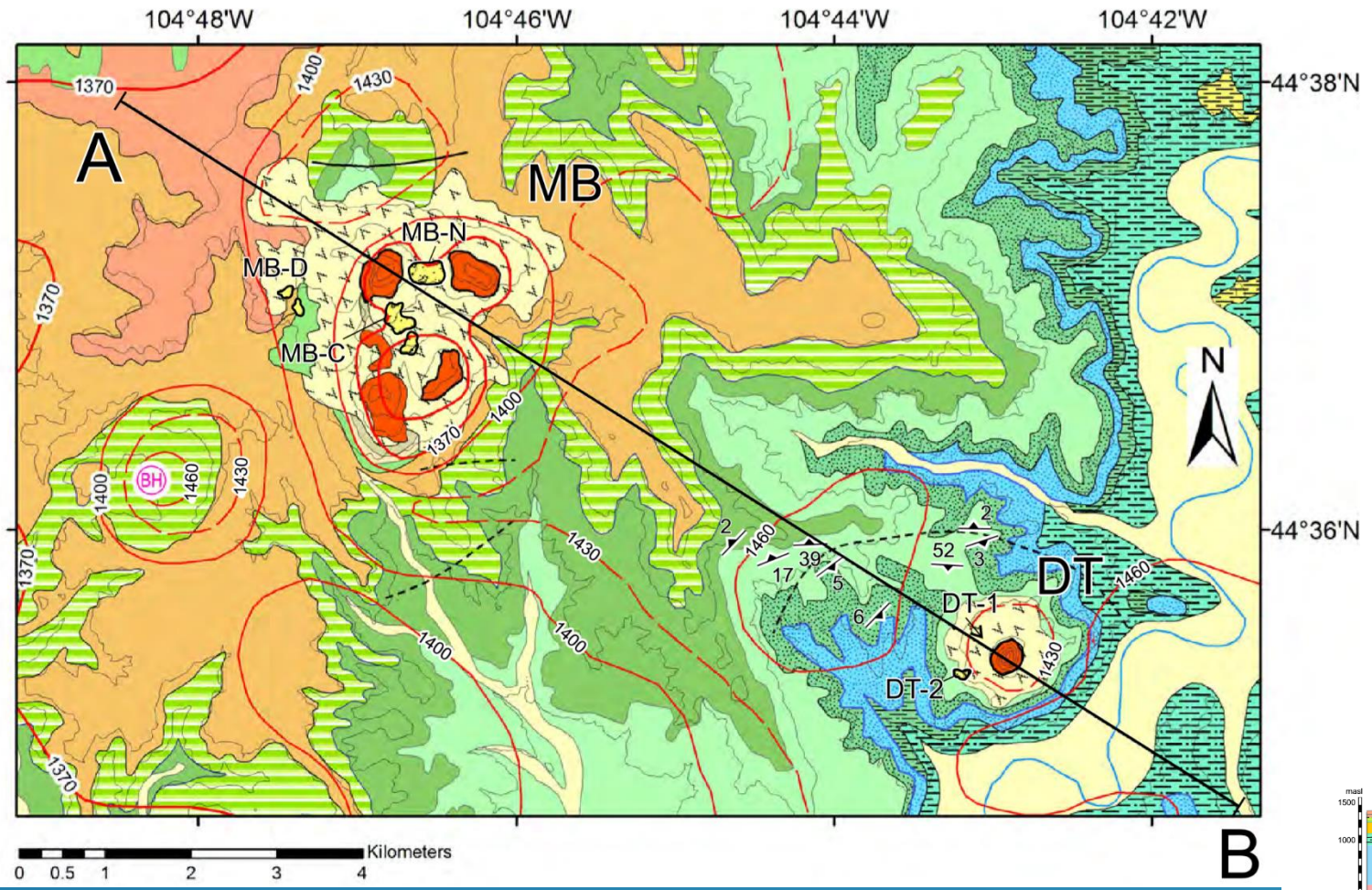
DEVILS TOWER LOCATION

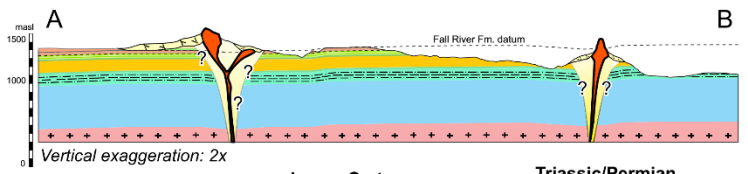
- Located in Northeastern Wyoming



DEVILS TOWER IGNEOUS COMPLEX

- Made up of a Phonolite Porphyry monolith
- The analcime phonolite forming Devils Tower is holocrystalline and coarsely porphyritic with a gray to olive-gray aphanitic and trachytic groundmass around phenocrysts of anorthoclase as much as 16 mm long (average 30 vol%), aegirine-augite (6 vol%) zoned to aegirine, sphene (1.2 vol%), and rare amphibole. (Zavada, 2015)
- Cenozoic in age roughly 50 mya
- Part of the Black Hills uplift
- Rises almost 250m above the underlying sedimentary strata which sits in a basin





Quaternary
- Alluvium
- Talus
- Stream terrace deposits

Tertiary
- White River Formation
- Analcime phonolite
- Foid-bearing alkali trachyte
- Phreatomagmatic deposits

Upper Cretaceous
- Mowry Shale

Lower Cretaceous
- Newcastle Sandstone
- Skull Creek Shale
- Fall River Formation
- Lakota Formation

Jurassic
- Morrison Formation
- Redwater Shale and Lak Member
- Hulett Member
- Stockade Beaver Shale
- Gypsum Spring Formation
- Sundance Formation (only in section)

Triassic/Permian
- Spearfish Formation

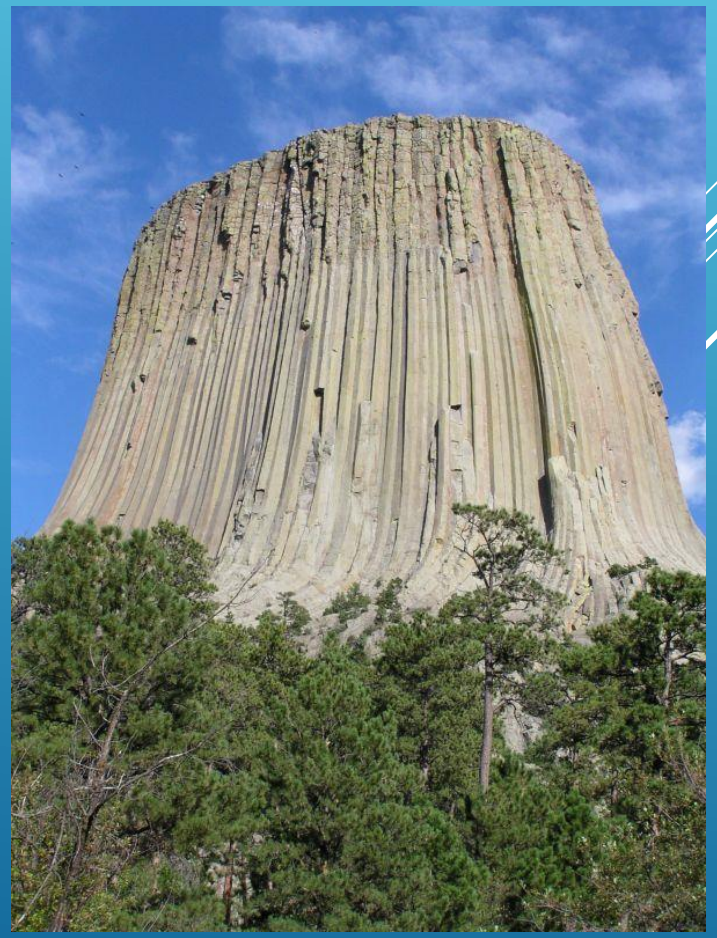
Paleozoic
- Limestones (only in section)

Precambrian
- Granites and gneisses (only in section)

- normal fault
- inferred normal fault
- BH Borehole
- 2 Dip direction mark with indicated dip angle

DEVILS TOWER IGNEOUS COMPLEX CONT.

- Shows exceptional columnar jointing in phonolite
- "Previous studies concluded that Devils Tower was formed from a remnant of an intrusive body in the form of a magmatic stock"(Zavada, 2015)



GUIDING QUESTION

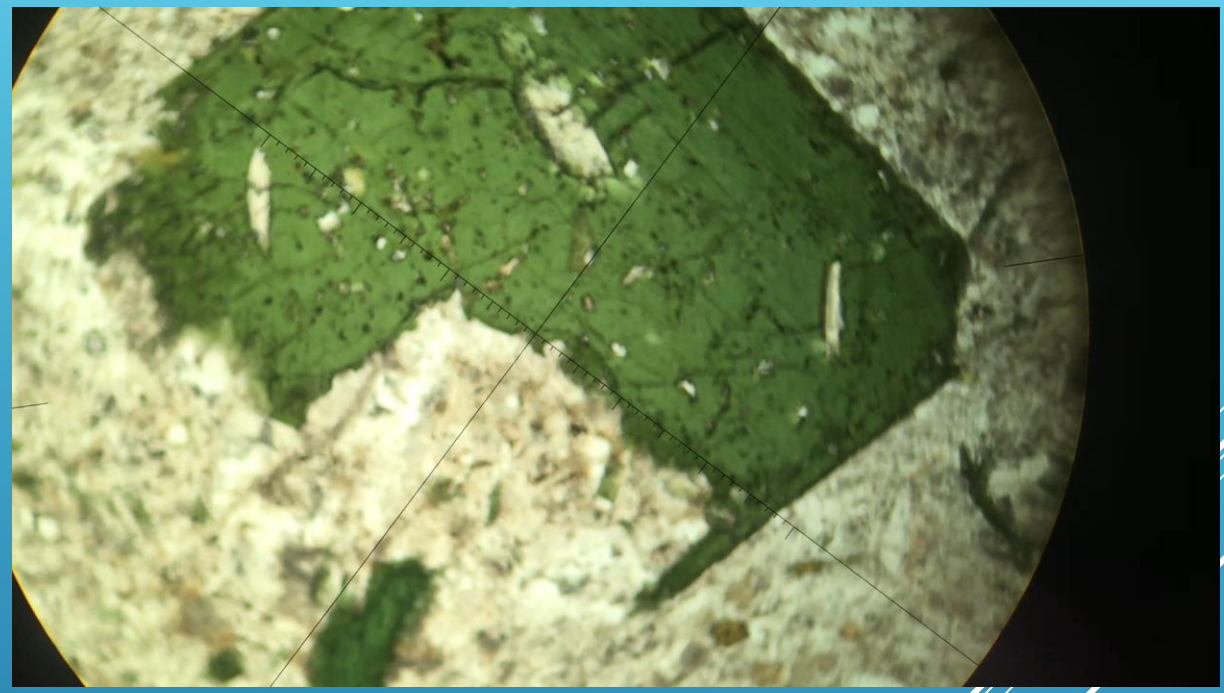
- How does the phonolites found at Devils Tower compare to Phonolites found elsewhere in the world?

THIN SECTION IMAGES

- Thin section BH-18 collected under permit.
- Sample shows Devils Tower phonolite with “alloclastic breccia (xenoliths)”

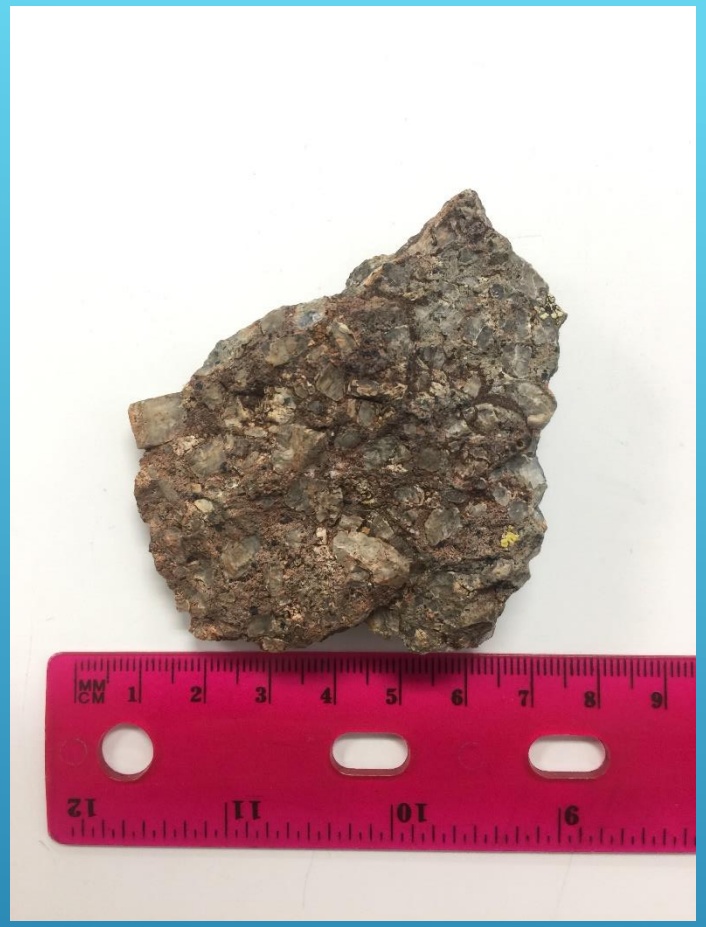
AEGIRINE AUGITE IN THIN SECTION

- Aegirine is an interesting pyroxene.
- Chemical formula – $NaFe^{+3}(SiO_3)_2$ to $(Na,Ca)(Fe+3,Fe^{+2},Mg,Al)(SiO_3)_2$
- Exhibits Pleochroism in PPL fading from bright green to yellow in color.



HAND SAMPLE

- This hand sample is of the alloclastic breccia showing xenoliths of carbonate
- Collected under same permit



METHODS

- Using point count analysis as well as gathering other research on phonolite chemical compositions.
- Looked at data from three different localities, Devils Tower, Canary Islands, as well as Western Antarctica

TABLE 2

MODAL ANALYSES OF DEVILS TOWER PHONOLITE

Sample Number	T16	T31	T32	T26	T14	T122	T112	T101	T23	T115	T11	T12	T13
Phenocrysts													
Anorthoclase	31.2	23.4	24.4	37.2	36.0	17.5	29.3	33.6	32.4	21.6	34.9	26.9	28.5
Aegirine-augite	5.4	7.0	5.2	2.8	6.6	4.2	9.2	8.0	6.4	7.1	5.6	6.5	7.4
Sphene	0.6	0.2	1.2	X	X	0.8	0.4	X	0.4	X	X	X	0.3
Nepheline	0.5	X	X	X	X	X	X	X	X	X	X	X	X
Nosean	0.8	X	X	X	X	X	X	X	X	X	X	X	X
Groundmass and microphenocrysts	49.9	50.0	62.4	45.6	49.6	56.7	39.5	44.4	42.4	62.5	47.5	59.8	52.4
Albite and microcline	17.4	X	X	X	X	X	X	X	X	X	X	X	X
Analcime	19.7	X	X	X	X	X	X	X	X	X	X	X	X
Aegirine	12.8	X	X	X	X	X	X	X	X	X	X	X	X
Veins, pore-filling, and replacement													
Analcime	9.2	10.0	4.0	12.0	5.8	11.2	14.8	8.0	12.8	7.2	10.2	6.0	6.9
Calcite	2.2	0.6	X		0.6	3.2	0.8	0.4	4.0	0.4	1.0	X	4.3
Zeolite		4.4	X	0.8		1.6	0.4	2.4		0.6	0.6	0.8	X
Hematite	0.2	0.6	2.0		1.4		X	X	0.4	0.6	0.2		0.2
Clay		3.4	0.8	1.0		4.8	5.6	3.2	1.2				

X present but not point-counted.

DEVILS TOWER PHONOLITE ANALYSIS

- The basanite to phonolite lava suite found at Erebus volcano and termed the "Erebus Lineage" (EL), is alkaline and strongly Si-undersaturated (Kyle et al., 1992).
- This undersaturation matches what we see in the Devils Tower phonolites as well.

PHONOLITE ANALYSES AT MOUNT EREBUS IN ANTARCTICA

Sample:	T1-17-12	T5-16-7	T1-17-2	T1-27-4	T1-21-0	T1-18-9	T1-29-6	TPVG-1	T1-18-10b
Unit:	pv^5	pv^6	t^2	tf^1	t^3	t^1	t^2	t^1	t^{1b}
SiO_2	54·95	57·20	58·97	60·42	59·76	57·82	60·46	55·47	49·60
Al_2O_3	18·83	19·62	18·82	19·01	18·60	18·90	19·14	18·95	17·11
TiO_2	1·70	1·12	0·68	0·75	0·75	1·22	0·77	1·59	2·73
Fe_2O_3*	6·05	4·92	3·78	3·40	3·82	4·45	3·50	5·82	9·64
MgO	1·71	0·96	0·40	0·53	0·55	1·13	0·51	1·80	3·51
CaO	3·93	2·06	0·84	1·28	1·22	2·56	1·02	3·47	7·73
Na_2O	7·61	7·96	9·80	8·31	9·04	7·88	8·09	7·22	5·49
K_2O	3·80	4·80	5·43	5·19	5·16	4·87	5·36	4·62	2·37
MnO	0·21	0·18	0·20	0·15	0·17	0·16	0·17	0·15	0·22
P_2O_5	0·47	0·22	0·10	0·11	0·14	0·26	0·13	0·38	1·13
LOI	0·05	0·76	0·38	0·38	0·23	0·38	0·75	0·25	−0·08
Total	99·31	99·80	99·40	99·53	99·44	99·63	99·90	99·72	99·45

PHONOLITE ANALYSIS OF TEIDE–PICO VIEJO VOLCANIC COMPLEX, TENERIFE, CANARY ISLANDS

FUTURE WORK

- Perform XRD or XRF to determine exact chemical make up at Devils Tower
- Collect samples at two other localities and run them through XRD analysis to see if they match the data viewed in the papers.

RESOURCES

- Halvorson, D., 1980, Geology and Petrology of the Devils Tower, Missouri Buttes, and Barlow Canyon Area, Crook County, Wyoming: University of North Dakota Dissertation, p. 1-123.
- Závada, P., DČdeþek, P., Lexa, J., and Keller, G.K., 2015, Devils Tower (Wyoming, USA): A lava coulée emplaced into a maar-diatreme volcano?: Geosphere, p. 1-22.
- Kelley, P., Kyle, P., Dunbar, N., and Simms, K., 2007, Geochemistry and mineralogy of the phonolite lava lake, Erebus volcano, Antarctica: 1972 – 2004 and comparison with older lavas: Erebus Volcano, Journal of Volcanology and Geothermal Research, p. 1-55.
- Ablay, G., Carroll, M., Palmer, M., Marti, J., and Sparks, R., 1998, Basanite–Phonolite Lineages of the Teide–Pico Viejo Volcanic Complex, Tenerife, Canary Islands: Journal of Petrology, v. 39, p. 905-936.