The youngest known volcanic rocks of the Markagunt Megabreccia (latest Oligocene or earliest Miocene), High Plateaus, southwestern Utah: the missing link to the birth and true age of the mystical creature

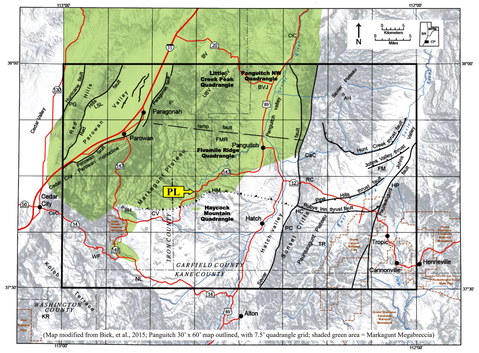
Harry F. Filkorn, Department of Physics and Planetary Sciences, Pierce College, Woodland Hills, California 91371 FilkornH@piercecollege.edu

New investigations of the Markagunt Megabreccia (MM) deposits exposed in roadcuts of state highway 143 along the northeastern margin of Panguitch Lake have revealed a distinct volcanic component which has yielded the youngest known rocks of the MM. This newly recognized volcanic component is interpreted as evidence of an eruption that was coeval with the MM depositional event, thus it is the missing link that connects the formation of the MM to a previously unknown volcanic event and its age is the true age of the MM.

These youngest volcanic rocks are composed of gray-black, poorly sorted (pebble to boulder), minutely vesicular, glassy, phenocryst-rich clasts in a gray-tan, fine- to coarse-grained, crystal-rich, pyroclastic matrix. X-ray diffraction indicates that the clasts are hypocrystalline and composed mainly of plagioclase phenocrysts (microphenocrysts, microlites), with augite and enstatite, and 35% glass. The rocks are andesite (geochemistry: total alkali - silica). The $^{40}Ar/^{39}Ar$ isochron ages of plagioclase from samples collected at two sites are 22.99 ± 0.21 Ma and 23.02 ± 0.21 Ma (Nevada Isotope Geochronology Laboratory).

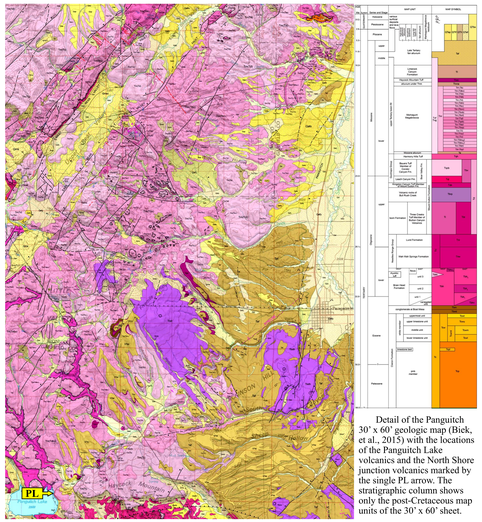
The lithologic characteristics and field relationships of the volcanic component indicate that it may be part of a block-and-ash flow or pyroclastic density current from an eruption that occurred during the formation of the MM. The contacts between the volcanic component and the adjacent, previously lithified, allochthonous blocks of the MM (mostly Bear Valley Formation volcaniclastic arenite and tuff) indicate that it was neither lithified nor consolidated prior to formation of the MM because it appears to have filled the spaces between the lithified blocks during the MM depositional event. Therefore, the volcanic component is interpreted as evidence of an eruption that was concurrent with the fragmentation, transportation and deposition of the allochthonous MM blocks.

In summary, this newly studied volcanic component of the MM is significant because it is the missing link that connects the genesis of the MM to an eruptive event during the early developmental history of the unit and its age constrains the oldest possible depositional age of the MM to about 23 Ma. Based upon this new evidence, the 23 Ma age of these volcanic rocks is here proposed to also be the true depositional age of the MM.

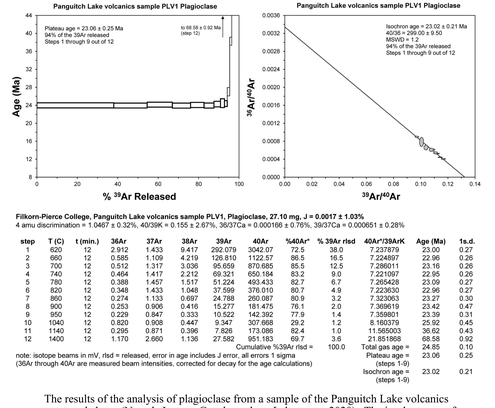


(Map modified from Biek, et al., 2015; Panguitch 30' x 60' map outlined, with 7.5' quadrangle grid; shaded green area = Markagunt Megabreccia)

The Markagunt Megabreccia is an areally extensive and relatively thick formation that is composed of allochthonous blocks of mostly Tertiary (pre-Miocene) volcanic and volcaniclastic rocks. Anderson (1993) named this unit and described its nature of occurrence on the Markagunt Plateau. The volcanic rocks investigated for this report are from the roadcuts for Utah highway 143 at the northeastern end of Panguitch Lake (marked by the PL arrow on the map). These roadcuts have been adjusted recently by the Utah Department of Transportation (probably during UDOT PIN 11379 in 2013), so the rock exposures have fresh surfaces. It is important to note that the rocks of the Markagunt Megabreccia have always been exposed at these roadcuts, but now they are presented in outstanding cross-section views that reveal more details than the former surfaces. In addition, much of the rock removed during the recent roadcut work, including some of the volcanics, was dumped in piles (subsequently relocated as of September 2021) at an open space along Coal Pit Wash Road, NF 074, just southeast of its junction with highway 143 and about 6.2 km northeast of the roadcut sites.



Detail of the Panguitch 30' x 60' geologic map (Biek, et al., 2015) with the locations of the Panguitch Lake volcanics and the North Shore junction volcanics marked by the single PL arrow. The stratigraphic column shows only the post-Cretaceous map units of the 30' x 60' sheet.



Filkorn-Pierce College, Panguitch Lake volcanics sample PLV1, Plagioclase, 27.10 mg, J = 0.0017 ± 1.03%
4 amu discrimination = 1.0467 ± 0.32%, 40/39K = 0.155 ± 2.67%, 36/37Ca = 0.000166 ± 0.76%, 39/37Ca = 0.000651 ± 0.28%

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	40Ar*/39ArK	Age (Ma)	1s.d.
1	620	12	2.912	1.433	9.417	292.079	3042.07	72.5	38.0	7.237879	23.00	0.27
2	660	12	0.585	1.109	4.219	126.810	1122.57	86.5	16.5	7.224897	22.96	0.26
3	700	12	0.512	1.317	3.036	95.659	870.685	85.5	12.5	7.286011	23.16	0.26
4	740	12	0.464	1.417	2.212	69.321	650.184	83.2	9.0	7.221097	22.95	0.26
5	780	12	0.388	1.457	1.517	51.224	493.433	82.7	6.7	7.265428	23.09	0.27
6	820	12	0.348	1.433	1.048	37.599	376.010	80.7	4.9	7.223630	22.96	0.27
7	860	12	0.274	1.133	0.697	24.788	260.687	80.9	3.2	7.323063	23.27	0.30
8	900	12	0.253	0.906	0.416	15.277	181.475	76.1	2.0	7.369619	23.42	0.47
9	950	12	0.229	0.847	0.333	10.522	142.392	77.9	1.4	7.356801	23.39	0.31
10	1040	12	0.820	0.908	0.447	9.347	307.668	29.2	1.2	8.160379	25.92	0.45
11	1140	12	0.295	0.871	0.396	7.826	173.086	82.4	1.0	11.565003	36.62	0.43
12	1400	12	1.170	2.660	1.136	27.582	951.183	69.7	3.6	21.851868	68.58	0.92
							Cumulative %39Ar rlsd =		100.0	Total gas age =	24.85	0.10
										Plateau age =	23.06	0.25
										(steps 1-9)		
										Isochron age =	23.02	0.21
										(steps 1-9)		

note: isotope beams in mV, rlsd = released, error in age includes J error, all errors 1 sigma
(36Ar through 40Ar are measured beam intensities, corrected for decay for the age calculations)

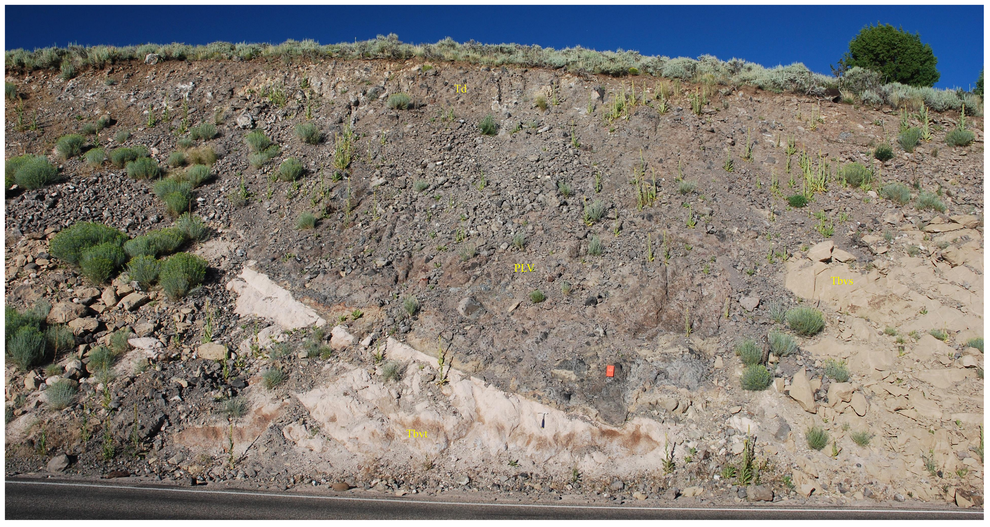
The results of the analysis of plagioclase from a sample of the Panguitch Lake volcanics are presented above (Nevada Isotope Geochronology Laboratory, 2020). The isochron age of 23.02 ± 0.21 Ma is one of the youngest reported isochron ages for a volcanic rock from the Markagunt Megabreccia. This age is nearly identical to the age of a sample from the North Shore junction volcanics site (shown in the panel to the right), which is about 300 m north of the Panguitch Lake volcanics site. Based upon the similarities of occurrence, lithology and age, these deposits are correlated and interpreted to be of the same origin. Pieces of the same sample, PLV1, also were used in the other aspects of this study, including the geochemical analysis, mineralogical analysis by x-ray diffraction, and thin sections for light microscopy.

Filkorn-Pierce College, North Shore junction sample NSJ1, Plagioclase, 36.90 mg, J = 0.0017 ± 1.08%
4 amu discrimination = 1.0467 ± 0.32%, 40/39K = 0.155 ± 2.67%, 36/37Ca = 0.000166 ± 0.76%, 39/37Ca = 0.000651 ± 0.28%

step	T (C)	t (min.)	36Ar	37Ar	38Ar	39Ar	40Ar	%40Ar*	% 39Ar rlsd	40Ar*/39ArK	Age (Ma)	1s.d.
1	500	12	4.489	0.441	9.709	356.299	3890.92	66.7	21.8	6.976097	22.26	0.27
2	530	12	1.366	0.355	5.786	219.664	1997.72	80.6	13.4	6.965563	22.23	0.26
3	560	12	1.153	0.440	5.298	203.384	1827.07	82.2	12.4	7.011063	22.38	0.27
4	590	12	1.069	0.615	4.710	182.784	1653.93	82.0	11.2	7.029665	22.43	0.27
5	640	12	1.214	1.095	5.457	204.144	1861.54	81.6	12.5	7.095241	22.55	0.27
6	700	12	1.293	1.960	4.676	185.637	1735.21	79.1	11.4	7.013270	22.38	0.26
7	760	12	1.120	2.433	3.111	128.504	1258.12	75.7	7.9	6.983849	22.29	0.27
8	820	12	0.829	2.315	1.666	73.414	745.314	70.9	4.5	6.679789	21.32	0.27
9	920	12	0.640	2.172	0.994	42.107	444.096	63.8	2.6	6.679197	19.42	0.24
10	1020	12	0.536	1.355	0.637	16.063	231.819	42.5	1.0	4.904103	15.68	0.32
11	1150	12	0.423	1.272	0.980	9.260	163.181	45.0	0.6	4.852590	15.52	0.35
12	1400	12	0.739	2.552	1.940	12.581	269.178	29.9	0.8	4.822751	15.42	0.35
							Cumulative %39Ar rlsd =		100.0	Total gas age =	22.07	0.09
										Plateau age =	22.37	0.26
										(steps 1-7)		
										Isochron age =	22.99	0.21
										(steps 1-7)		

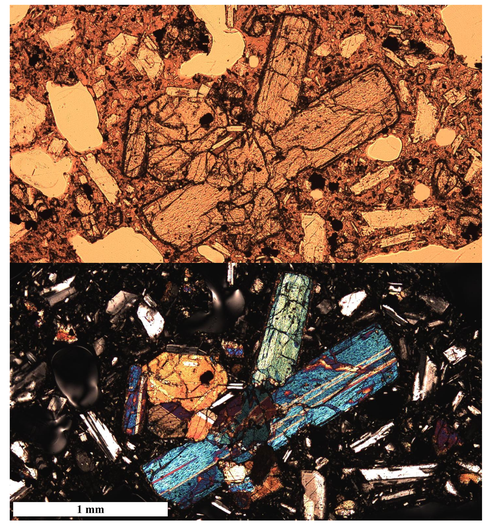
note: isotope beams in mV, rlsd = released, error in age includes J error, all errors 1 sigma
(36Ar through 40Ar are measured beam intensities, corrected for decay for the age calculations)

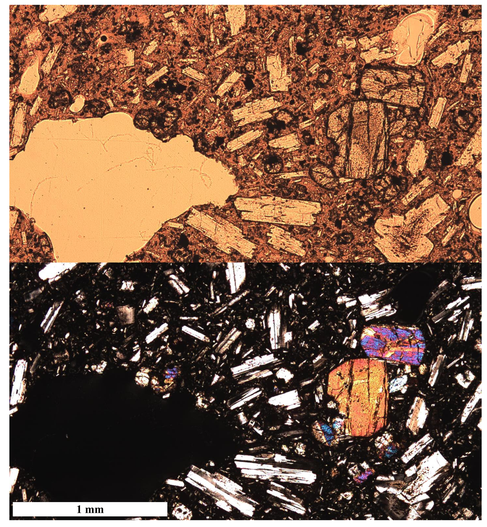
The results of the analysis of plagioclase from the North Shore junction volcanics are presented above (Nevada Isotope Geochronology Laboratory, 2020). The isochron age of 22.99 ± 0.21 Ma is one of the youngest reported isochron ages for a volcanic rock from the Markagunt Megabreccia. This age is nearly identical to the age of a sample from the Panguitch Lake volcanics site (shown in the panel to the left), which is located about 300 m south of the North Shore junction site. Based upon the similarities of occurrence, lithology and age, these deposits are correlated and interpreted to be of the same origin. Pieces of the same sample, NSJ1, also were used in the other aspects of this study, including the geochemical analysis, mineralogical analysis by x-ray diffraction, and thin sections for light microscopy.



The southern roadcut along this section of the highway is shown in the images to the left and directly above, view toward the east (hammer and field notebook for scale; photographs taken in August, 2019). The main rock units are Bear Valley Formation tuff (white, Tbvt) and volcaniclastic arenite (tan-brown, Tbvs) and the volcanic rocks, here referred to as the Panguitch Lake volcanics (gray, labeled PLV), which appear to be gradational upward to what would otherwise be mapped as Mount Dutton Formation (brown, Td) debris flow in this area. Note that fragments of the allochthonous Bear Valley units are included in the volcanics near their shared contacts and the volcanics seem to fill the space between the lithified blocks, all of which is evidence that the volcanics were present, but not lithified, while the blocks were being transported. The volcanics directly overlie both kinds of Bear Valley rocks in the highway roadcuts. A close-up view of part of the contact of the volcanics and the Tbvt is shown above.

Petrographic microscope images (in polarized light and crossed nicols) of thin sections of a clast from this horizon (sample PLV1: thin sections PLV1A and PLV1B) are shown in the two panels on the right to illustrate the mineralogy (plagioclase, pyroxene) and texture (porphyritic, vesicular, hypocrystalline) of the rock.

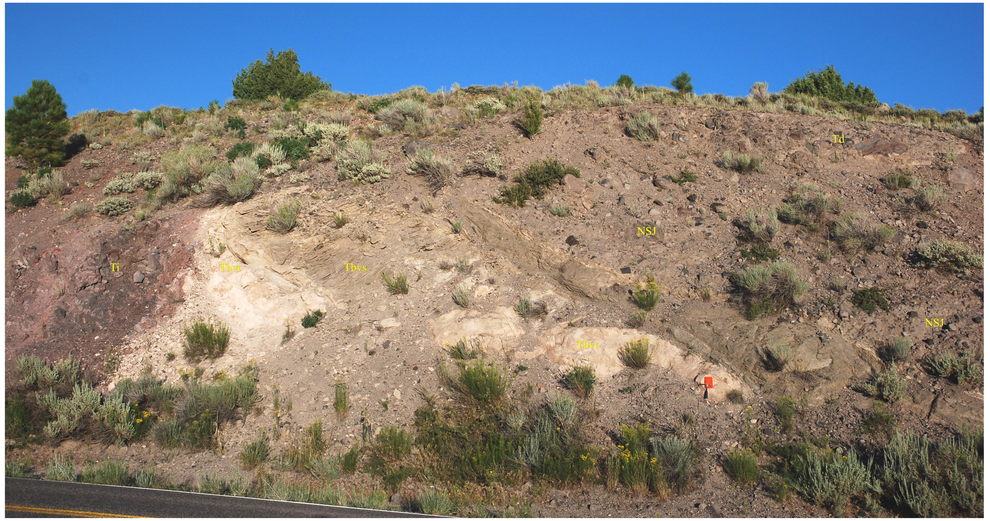




The rocks at these roadcuts have been mapped as Markagunt Megabreccia, undivided, unit Tm, on recent maps of this area, including the geologic maps of the adjoining Panguitch Lake and Haycock Mountain 7.5' quadrangles (Biek, et al., 2014) and the Panguitch 30' x 60' quadrangle (Biek, et al., 2015). Notably, many outcrops in this region are composed of Mount Dutton Formation debris flows that have been erosionally stripped of their matrix and in effect reduced to surfaces covered with a layer of dark volcanic rocks which, at least in outcrop view, makes them all appear to be indistinct or monotonous.

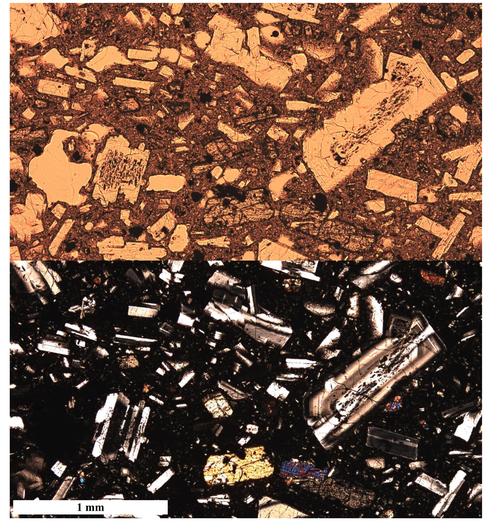
The consistent clast lithology and pyroclastic matrix of the studied volcanic rocks indicate that they were derived from one source and likely a single eruption. This interpretation is further supported by the two nearly identical isochron ages of the rocks: 22.99 ± 0.21 Ma and 23.02 ± 0.21 Ma. These ages are virtually the same as the two youngest zircon ages reported previously from a basal layer of the Markagunt Megabreccia at Panguitch Lake and Haycock Mountain (23.02 ± 0.15 Ma and 23.02 ± 0.2 Ma, respectively; Mayback, et al., 2019), but the igneous source of the zircons was neither recognized nor identified and they noted that their data could not distinguish if there was an eruption-related event for the formation of the megabreccia. Based upon the evidence presented herein, the studied andesitic volcanic rocks may be the source of the young zircons and the geological record of an eruption that was approximately synchronous with the Markagunt Megabreccia depositional event.

The age of the Markagunt Megabreccia is further constrained by the age of the overlying Haycock Mountain Tuff which most recently has yielded an age of 22.76 ± 0.02 Ma ($^{40}Ar/^{39}Ar$, sanidine, unpublished; Filkorn, 2019), therefore the megabreccia depositional event occurred between 23 and 22.76 Ma. However, the identical ages of the plagioclase and zircons noted above is strong evidence that the andesite of PLV and NSJ is the missing link that connects the formation of the megabreccia to a coeval eruption, therefore the 23 Ma age is the true age of the Markagunt Megabreccia depositional event.



The northern roadcut along this section of the highway is shown in the images to the left and directly above, view toward the east (hammer and field notebook for scale). The main rocks are Isom Formation (red-gray-black, Ti), Bear Valley Formation tuff (white, Tbvt) and volcaniclastic arenite (tan-brown, gray, Tbvs), the volcanic rocks, here referred to as the North Shore junction volcanics (gray, NSJ), and what appears in outcrop view to be Mount Dutton Formation debris flow (brown, Td), but which may be the same as or gradational with the NSJ volcanics. The allochthonous blocks of Ti, Tbvt and Tbvs are deformed and fragmented, which is typical of the Markagunt Megabreccia, whereas the other rocks are not deformed in the same way. The field and structural relationships indicate that the volcanics were present while the allochthonous blocks were being transported and that the Mount Dutton debris flow facies was involved in the megabreccia depositional event (Filkorn, 2017, 2018). A close-up view of part of the contact between the NSJ volcanics and a fractured block of gray Tbvs is shown above.

Petrographic microscope images (in polarized light and crossed nicols) of a thin section of sample NSJ1 (thin section NSJ1B) in the next panel on the right illustrate the mineralogy (plagioclase, pyroxene) and texture (porphyritic, vesicular, hypocrystalline) of the rock.



Acknowledgments: I thank Kathleen Zanetti, Nevada Isotope Geochronology Laboratory, for the analyses of the plagioclase and the resulting data. In addition, I thank the Utah DOT for their recent work on these roadcuts.

Anderson, J.J., 1993, The Markagunt Megabreccia: large Miocene gravity slides mantling the northern Markagunt Plateau, southwestern Utah: Utah Geological Survey Miscellaneous Publication 93-2, 37 p.
Biek, R.F., Anderson, J.J., Sable, E.G., and Rowley, P.D., 2014, Geologic maps of the Panguitch Lake and Haycock Mountain quadrangles, Garfield and Iron counties, Utah: Utah Geological Survey Map 268DM & Map 269DM, 36 p., 4 pl., scale 1:24,000.
Biek, R.F., Rowley, P.D., Anderson, J.J., Maldonado, F., Moore, D.W., Hacker, D.B., Eaton, J.G., Hereford, R., Sable, E.G., Filkorn, H.F., and Matyjasik, B., 2015, Geologic map of the Panguitch 30' x 60' quadrangle, Garfield, Iron, and Kane counties, Utah: Utah Geological Survey Map 270DM, 164 p., 3 pl., scale 1:62,500.
Filkorn, H.F., 2017, Markagunt Megabreccia (Miocene) and Mount Dutton Formation debris flow depositional contacts, Fivemile Ridge quadrangle and vicinity, High Plateaus, Utah: one head of the Mystical Creature: GSA, Abstracts with Programs, v. 49(5), 17-11.
Filkorn, H.F., 2018, New discoveries of volcanics in the Sea of Lost Rocks, Markagunt Megabreccia (Miocene), High Plateaus, southwestern Utah: GSA, Abstracts with Programs, v. 50(5), 13-8.
Filkorn, H.F., 2019, Geochemical evidence for a common magmatic source of some different post-Markagunt Megabreccia volcanic rocks (Miocene), High Plateaus, southwestern Utah: GSA, Abstracts with Programs, v. 51(4), 25-8.
Mayback, D., Malone, D.H., Biek, R.F., Hacker, D.B., and Rowley, P.D., 2019, Zircon geochronology of the basal layer of the Markagunt gravity slide, Marysvale volcanic field, Utah, USA: GSA, Abstracts with Programs, v. 51(5), 183-19.