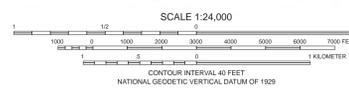
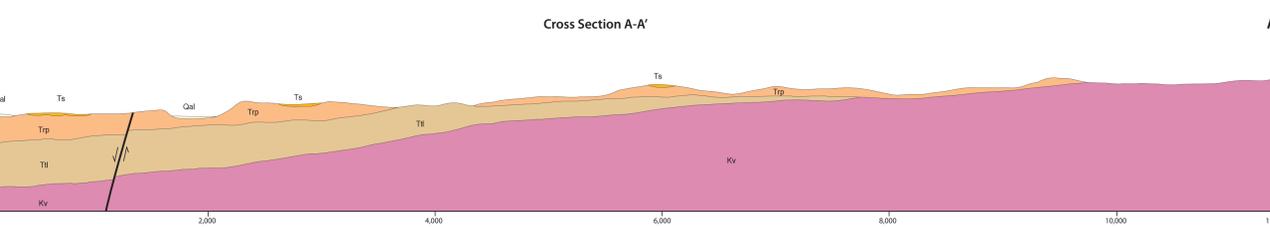


Base from U.S. Geological Survey
Avon 7.5' topographic quadrangle
Map date: 1989
Projection: UTM zone 12; 1927 NAD
UTM grid declination: 1°08' West
1989 Magnetic North Declination: 16°30' East



Maps may be obtained from: Publications Office
Montana Bureau of Mines and Geology
1300 West Park Street
Butte, Montana 59701-6997
Phone: (406) 496-4174
Fax: (406) 496-4451
http://www.bmng.mtech.edu



No vertical exaggeration.
Qc and some Qal are not shown because they are too thin to show at this scale.

Introduction

The geology of the Avon quadrangle was mapped in 1986 (Trombetta, 1987) in conjunction with the mapping of four 7.5' quadrangles to the south that were combined and released at a scale of 1:48,000 (Derkey and others, 1993). The volcanic geology of the Avon quadrangle shown here is essentially the work of Trombetta with some additions to the Tertiary and Quaternary geology by Berg in 2010. For detailed petrographic descriptions, see Trombetta (1987).

The Avon volcanic complex exposed in the Avon 7.5' quadrangle is one of many Eocene volcanic sequences in the northern Rocky Mountains. K-Ar data on sandine separated from the rhyolite porphyry exposed 2.9 km (1.8 miles) west of Avon along U.S. Highway 12 is reported to be 39.4 ± 1.6 Ma (Chadwick, 1981). Twenty-eight U/Pb dates on individual zircons from volcanic rocks exposed in the Avon quadrangle and surrounding area give a mean age of 48.98 ± 0.44 Ma (J. Brian Mahoney, U. of Wisconsin, Eau Claire, written commun., 2012). Ages for the Helena volcanic field east of the Avon volcanic complex range from 37 to 36 Ma (Chadwick, 1981). ⁴⁰Ar/³⁹Ar determinations on mineral separates from the Lowland Creek Volcanics northwest of Butte yield ages that range from 52.9 to 48.6 Ma (Dudás and others, 2010). Dacite and andesite from the Garnet Range west of Avon give K-Ar dates of 43.7 ± 2.2 Ma and 44.8 ± 2.2 Ma, respectively (Callmeyer, 1984). Biotite separated from a rhyolite in the Rock Creek volcanic field 100 km (60 miles) west of Avon gives an ⁴⁰Ar/³⁹Ar age of 50.2 ± 0.43 Ma (Berg, 2011).

Descriptions of Map Units

- Qal** Alluvium of modern channels and floodplains—Gravel, sand, and silt along the Little Blackfoot River and its tributaries.
- Qaf** Alluvial fan deposits—Present at the mouths of some tributaries of Snowshoe Creek and Spotted Dog Creek
- Qls** Landslide deposit—Developed in Tertiary sedimentary beds.
- Qc** Colluvium—Generally, a thin layer of transported material that obscures bedrock.
- Tgr** Gravel on pediments—Remnants of gravel, presumably of Tertiary age, cover the large pediments east of Spotted Dog Creek. It is estimated that 50 to 60 percent of the clasts in this gravel are volcanic rock, both rhyolite and basalt. The remainder are quartzite and to a lesser extent siltite, probably derived from the Belt Supergroup exposed approximately 10 miles to the north. Lack of sections through the gravel precludes estimates of thickness; however, the gravel appears to be thin, perhaps less than 3 m (10 ft) thick in most of the area.
- Ts** Sedimentary beds—The best exposures are shown by "T" on the map, where poorly indurated sandstone, bentonite, and gravel are exposed. A fossil tooth recovered from the exposure west of Trout Creek in sec. 35, T. 10 N., R. 8 W. was identified as probably being of Chadronian age (Alan Tabrum, oral commun., 2011). Beds at this location are considered equivalent to the Eocene Climbing Arrow Member of the Renova Formation of southwestern Montana (Susan Yuke, oral commun., 2011).
- Tb** Basalt—Porphyritic black basalt is dull gray to red on a weathered surface. Phenocrysts of labradorite, olivine, augite, and hypersthene constitute 20 percent of the basalt, with labradorite microlites and microcrystalline material forming the groundmass. Quartz xenocrysts are sparse. The basalt is interpreted to overlie unconformably the lower member of the rhyolite porphyry and red tuff. Estimated maximum exposed thickness is 200 m (60 ft).
- Ta** Crystal-poor andesite—There are two small exposures of crystal-poor andesite near the eastern border of the Avon quadrangle, but an exogenous dome of this andesite is well exposed along U.S. Highway 12 about 1.3 km (0.8 miles) east of the Avon quadrangle. This exogenous dome intruded the lower member of the rhyolite porphyry and is overlain by the upper part of the rhyolite porphyry. The extrusive facies exposed in the Avon quadrangle consist of as much as 5 percent phenocrysts of quartz, sanidine, oligoclase, opaque minerals, hypersthene, and augite in a matrix of plagioclase microlites and magnetite. This rock contains a sufficiently large concentration of magnetite to deflect the compass needle. Inclusions of highly weathered clasts of the underlying lapilli tuff and rhyolite porphyry occur at the base. The estimated maximum thickness is 120 m (400 ft) in exposures along U.S. Highway 12 east of the Avon quadrangle.

MAP SYMBOLS

- Contact. Dashed where approximately located
- Interflow contacts (sec. 33, T. 10 N., R. 8 W.)
- Strike and dip of inclined beds
- Strike and dip of volcanic flow foliation
- Strike and dip of cleavage
- Strike of vertical cleavage
- Strike and dip of joints
- Steeply dipping fault. Ball and bar on down-dropped side. Dashed where approximately located, dotted where covered.
- Volcanic breccia
- Volcanic flow indicator
- Bi-directional volcanic flow indicator
- Spring
- Exposure of Tertiary sedimentary beds

- Trp** Rhyolite porphyry—This is the most extensive volcanic unit in the Avon quadrangle and for the purpose of this description is divided into lower and upper members. The lower member is flow foliated with up to 28 percent phenocrysts of quartz, sanidine, oligoclase, biotite, amphibole, and opaque minerals in a matrix composed of glass, cryptocrystalline material, and clay. Lithophyses are locally abundant and partly filled with chalcedony. Heterolithic breccia along the basal contact of the upper member contains clasts of rhyolite and sedimentary rock. Three separate flows in the lower member are separated by discontinuous zones of vitrophyre and flow tuff. In ascending order, the maximum thicknesses of these flows are 100 m (300 ft), 200 m (600 ft), and 120 m (360 ft). The upper member is also flow foliated and contains up to 19 percent phenocrysts of quartz, sanidine, oligoclase, biotite, amphibole, zircon, and opaque minerals in a matrix of cryptocrystalline material and glass. The erosional unconformity between the upper and lower members has up to 300 m (1,000 ft) of relief. The upper member has a maximum thickness of 130 m (400 ft) and is interpreted to be a single flow.
- Trt** Glassy rhyolite—The only exposure of glassy rhyolite in the Avon quadrangle is along the south side of the Little Blackfoot River near the eastern boundary of the quadrangle where vertical flow foliation is pronounced. This unit contains up to 15 percent quartz, sanidine, oligoclase, amphibole, and opaque phenocrysts in glassy, perlitic matrix.
- Tlc** Lapilli tuff—This crystal-rich tuff is divided into an upper and lower member for the purpose of this description. The upper member contains 5 to 15 percent rhyolite and fine-grained sedimentary rock clasts. Crystals and crystal fragments of quartz, sanidine, oligoclase, biotite, amphibole, and opaque minerals account for as much as 10 percent of this rock. The matrix consists of glass shards, pumice fragments, and clay. The upper member is very poorly exposed. The lower member is typically variably indurated whereas the upper member is not indurated. Pumice lapilli and lithic fragments constitute 25 percent of the lower member, which has thin zones of dense welding at the base and the top. The densely welded zone at the base contains abundant black hamme. Quartz, sanidine, oligoclase, biotite, amphibole, opaque minerals, and zircon make up the crystal fraction of the lower member, which has a maximum exposed thickness of 200 m (600 ft).
- Ttr** Red tuff—The red tuff is a crystal-rich, poorly sorted, clast-supported to matrix-supported, rhyolite pyroclastic tuff breccia. The matrix contains up to 16 percent fragments of crystals of quartz, sanidine, and opaque minerals. Red tuff grades laterally from pyroclastic tuff-breccia to a densely welded crystal-rich tuff.
- Ttw** White tuff—There are two small exposures of white tuff in the Avon quadrangle, both west of Spotted Dog Creek. This clast-supported volcanic breccia facies contains fragments of rhyolite, and sedimentary or volcanoclastic rock.
- Kv** Volcanic rocks, undivided—These rocks are thought to belong to the Elkhorn Mountains Volcanics, a widespread sequence considered comagmatic with the Boulder Batholith in the Butte-Helena area. To the west of the Avon quadrangle in the Deer Lodge area, the Elkhorn Mountains Volcanics include andesite flows, flow breccias, ash-flow tuff, and densely welded ash-flow tuff (Derkey and others, 1993).
- Kk** Kootenai Formation—This formation is estimated to be 365 m (1,200 ft) thick in this general area and consists of conglomerate, sandstone, siltstone, shale, and limestone (Schmidt and others, 1994).
- M** Mine tailings—Gravel remaining from placer mining along Carpenter Creek.

Acknowledgments

Reviews by Phyllis Hargrave, Tom Patton, Ed Deal, and Frank Dudás have improved this map and are appreciated.

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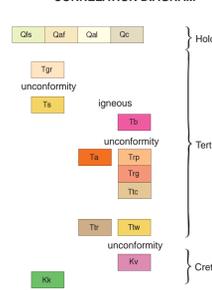
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CORRELATION DIAGRAM



Unit Symbol	Sample Number	Major Elements %										Trace Elements ppm									
		SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃	FeO	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	L.O.I.	Total	Cr	Rb	Sr	Y	Zr	Nb	Ba
Td	TA1044	66.9	0.46	16	3.16	nd	0.04	0.77	2.99	4.39	3.52	0.2	1.54	100.4	40	70	1200	<10	130	40	2430
Ta	TA902	60.4	1.33	14	8.45	nd	0.1	1.34	3.72	3.69	3.82	0.56	1.23	98.9	20	130	370	60	330	40	890
Tb	TA1036	52.8	1.34	16.4	8.89	nd	0.16	4.67	8.09	3.44	2.16	0.51	0.77	99.5	170	30	840	30	120	40	1380
Ttw	TA901	74	0.04	15.2	0.53	nd	0.06	0.01	0.08	4.9	4.41	0.02	0.54	100	20	1710	<10	<10	60	100	170
Trt	TA903	78.3	0.13	10.5	1.42	nd	0.01	0.02	0.18	1.49	6.8	0.05	0.23	99.2	20	350	30	60	180	50	270
Tl	TA1027	80	0.09	9.2	1.16	nd	0.02	0.14	0.39	2.49	4.26	0.04	1.62	99.9	20	200	20	40	140	60	150
Trp	TA914	74.4	0.23	12.9	2.03	nd	0.02	0.05	0.75	3	5.62	0.05	0.7	99.9	20	190	80	20	340	50	510
Trp	TA1941	75.8	0.11	12.7	1.73	nd	0.02	0.01	0.33	4.16	4.9	0.03	0.54	100.4	20	260	<10	70	240	90	80
Trp	TA932	75.11	0.13	12.18	0.93	0.24	0.01	0.31	0.4	1.95	5.24	0.16	nd	98.51	12	nd	44	nd	118	nd	nd
Trp	TA519	75.34	0.17	11.49	1.84	0.11	0.02	0.23	0.82	2.93	4.96	0.17	nd	99.49	9	nd	91	nd	340	nd	nd

nd = not determined

Sample TA519 was analyzed by the Montana Bureau of Mines and Geology. Major element analyses were by lithium tetraborate fusion, dilute hydrochloric acid dissolution, and inductively coupled argon plasma analysis (ICAP). Trace element determinations were by ICP following acid dissolution. The other samples were analyzed by X-Ray Assay Laboratories Limited, Don Mills, Ontario. All major and trace element analyses were by X-ray fluorescence. The unit symbols are those shown on the map with the exception of Td (aphanitic dacite), not exposed in the Avon quadrangle. Sample TA1044 is from an exposure 2 km (1.3 miles) west of the Avon quadrangle.

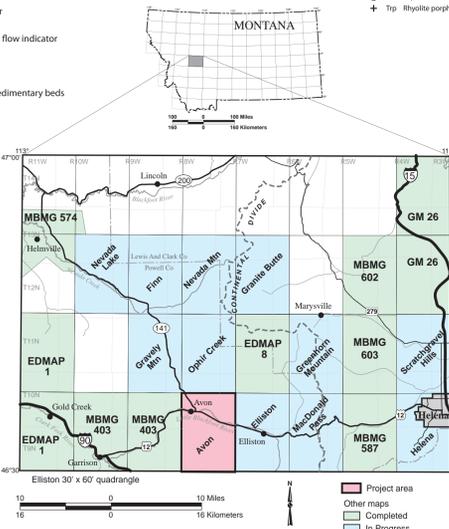
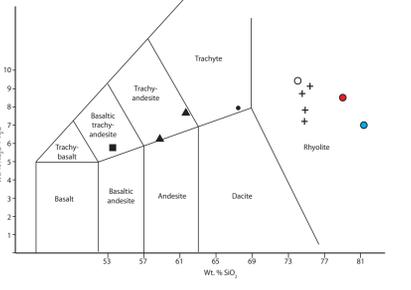


Figure 1. Location map of the Avon 7.5' quadrangle. Completed maps are available at the Montana Bureau of Mines and Geology Publications Office and online at www.bmng.mtech.edu. GM 26 is only available in paper format.

- EDMAP 1; Brooks, J.A., and Sears, J.W., 2009
- EDMAP 8; Balgord, E.A., and others, 2010
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Plot of chemical analyses on alkali-silica diagram after Le Bas and others, 1986.



Geologic Map 63

Geologic Map of the Avon 7.5' Quadrangle Powell County, Montana

Michael J. Trombetta and Richard B. Berg