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Isochron/West, Bulletin of Isotopic Geochronology, v. 54, pp. 8-10

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ISOTOPE DATA, AGES AND GEOLOGY OF THE HOG HEAVEN VOLCANIC FIELD, NORTHWESTERN MONTANA

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The 36 Ma to 31 Ma Hog Heaven volcanic field (HHVF) is located 20 km west of Flathead Lake in northwestern Montana near the crest of the Purcell anticline. The dissected volcanic field covers approximately 50 km² and rests unconformably on gently folded Ravalli Group arenites of the Mid to Late Proterozoic Belt Supergroup (fig. 1). The nearest Tertiary volcanic rocks with dates of 36 and 27 Ma occur 180 km to the southeast near Lincoln, Montana. The Hog Heaven volcanic field is the setting of the historic Flathead Mine, currently under development by CoCa Mines.

The volcanic assemblage consists of poorly to moderately welded basal ash-flow tuffs, an overlying sequence of bedded and nonbedded volcaniclastic rocks, and flow-dome complexes which are the source of the ash flows. A few alkali basalt dikes cut Belt Supergroup, the ash flow and volcaniclastic units. Eruptions apparently began after north-northwest-striking basin and range normal faults created the Little Bitterroot Valley and a paleotopography similar to that found today. Small dome complexes up to hundreds of meters in diameter tend to be situated along the north-northwest-striking normal faults (Zehner, 1987).

The three largest flow-dome complexes are aligned along a northeast trend, which may represent a deep-seated basement structure, and occur where the trend intersects north-northwest basin and range faults. Prominent flow jointing present in some of the domes demonstrates their complexity and multiple stages of growth. The bulk of the tuff erupted from these larger complexes traveled south into lowland areas, some being reworked as volcaniclastic material. The Flathead and several smaller mines and prospects are located in the easternmost dome complex.

The ash-flow tuffs contain several types of clasts. Poorly vesiculated pumice, rhyolite flow rock, and Ravalli Group and Prichard Formation clasts, both of the Belt Supergroup, are very common. Rare quartz monzonite and very rare biotite schist clasts are interpreted as xenoliths from depth because source areas do not outcrop in the region.

The volcanic rocks are geochemically homogeneous and plot as high-K dacites or rhyolites with silica compositions ranging from 63%–69%. Sanidine and biotite phenocrysts are ubiquitous; quartz phenocrysts are common. No obvious differentiation trends are present. REE patterns show LREE enrichment and HREE depletion relative to MORB. Ba and Sr values are high, averaging 1980 and 1280 ppm, respectively; Ni averages 7 ppm.

RESULTS

The isotopic results of this study are found in table 1 together with data gathered by other workers. The K/Ar age of the diabase dike is 33.8 ± 1.6 Ma and within the range of previously published HHVF ages.

The initial Sr values of two flow rock samples, 0.7039 and 0.7046, are low and distinctly different from values obtained for Belt Supergroup rocks (Obradovich and Peterman, 1968) and other Cretaceous and Tertiary igneous rocks found in western Montana (Tilling and others, 1968). The lead isotope values from sanidine are unradiogenic, distinct from all other Belt Supergroup-hosted ore deposits but very similar to values obtained by Zartman and Stacey (1971) from galena from three mines found within the HHVF (table 1). Furthermore, the $^{207}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ values lie on the 2.5 Ga secondary isochron derived from Yellowstone region basalts to the southeast by Doe and others (1982).

DISCUSSION

The paucity of outcrops and chemical homogeneity of the volcanic materials has limited correlations between ash flow units and ash flow units and vents. Furthermore, neither the process of magma generation or magma source is known and any model of magma genesis must take into account geochemical characteristics of the felsic rocks including the low initial Sr values as well as the unradiogenic nature of the lead isotopes and the high K content of the basalt dikes (and felsic rocks). These data are consistent with partial melting of mafic-intermediate Archean (?) lower crustal rocks by mantle-derived high-K magmas such as those found in the Montana alkalic province to the east.

ACKNOWLEDGEMENTS

This study was financed in part by two University of Montana grants.

SAMPLE DESCRIPTIONS

1. *FH157* (Geochron No. R-7890) K-Ar
   Slightly chloritically altered alkali basalt (hilltop outcrop; NE¼ SE¼ S13,T25N,R25W; 47°55′56″N, 114°45′56″W; Murr Peak 7.5′ quad., Flathead County, MT) with fine-grained aligned plagioclase microlites, augite, and sparse orthopyroxene phenocrysts. *Analytical data:* (whole rock) K = 1.487%; ^{40}Ar = .003514 ppm, $^{40}Ar/\Sigma^{40}Ar$ = 46.6%. *Collected by:* I. M. Lange. *Dated by:* Geochron Laboratories, Inc.
   (whole rock) 33.8 ± 1.6 Ma

2. *ZN002B* (Geochron No. SS-836) Rb-Sr
   Dacite porphyry (Battle Butte outcrop; SW¼ NE¼ S20,T25N,R23W; 47°54′10″N, 114°35′30″W; Kofford Ridge 7.5′ quad., Flathead County, MT) consisting of plagioclase, sanidine, biotite phenocrysts and trace amounts of sphene, zircon, apatite, and opaques. *Analytical data:* (whole rock) Rb = 120 ppm, Sr = 1200.4 ppm, measured $^{87}Sr/^{86}Sr$ = .70402 ± .00006, initial $^{87}Sr/^{86}Sr$ = .70390 ± .00006. *Collected by:* I. M. Lange. *Dated by:* Geochron Laboratories, Inc.

3. *HH-217* (Geochron No. SS-1092) Rb-Sr
   Dacite porphyry (outcrop; SW¼ SW¼ S30,T25N, R23W; 47°38′40″N, 114°36′34″W; Kofford Ridge 7.5′ quad., Flathead County, MT) consisting of plagioclase, sanidine, biotite, opaques. *Analytical data:*

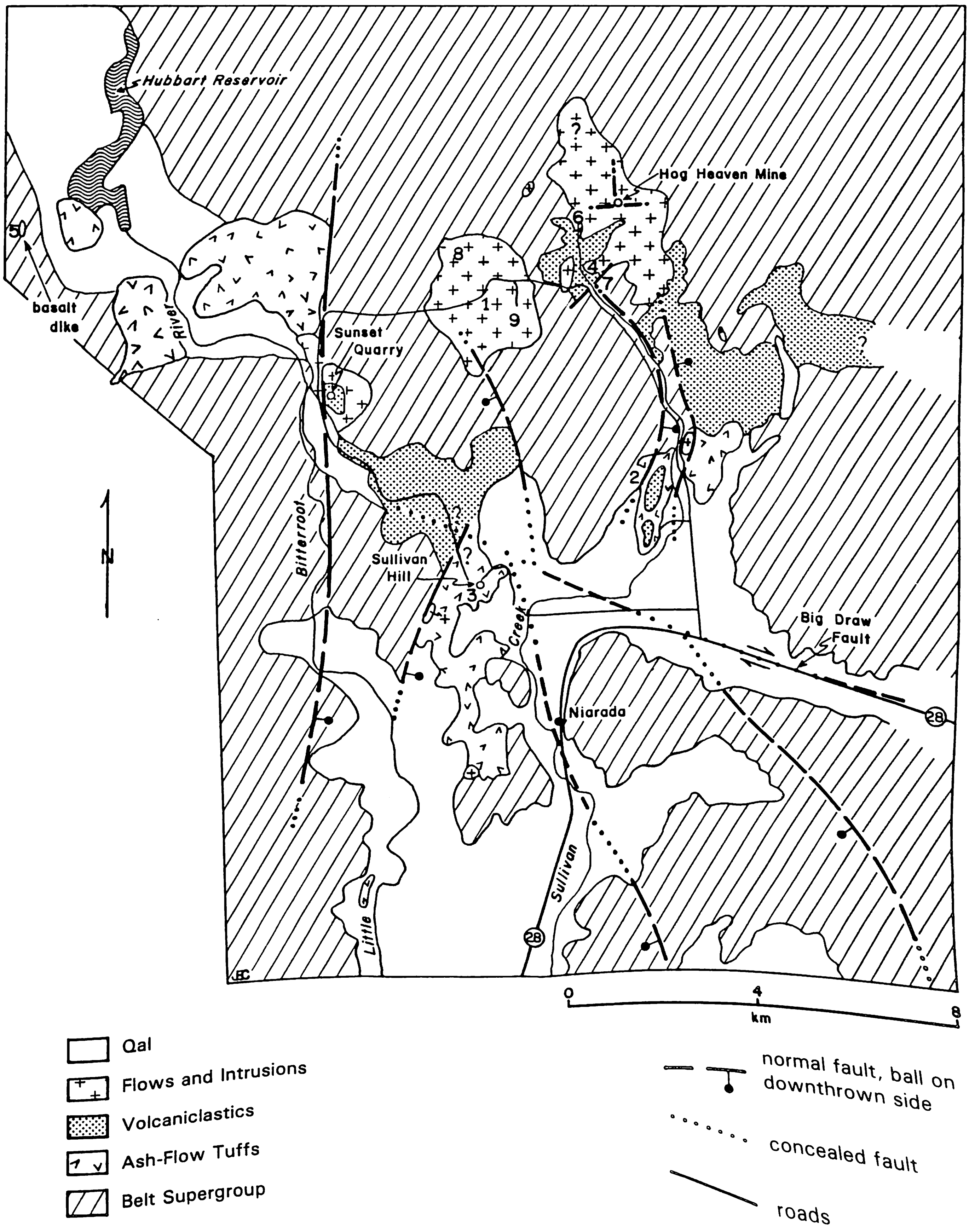

FIGURE 1. Hog Heaven volcanic field.

TABLE 1. Isotope data of the Hog Heaven volcanic field.

K-Ar biotite age dates

Rock name		Location[1]	Reference
"Andesite" porphyry flow	a) 35.5 ± 0.8 b) 36.0 ± 0.8	1	Marvin and others, 1984
"Andesite" tuff	31.3 ± 0.6	2	Marvin and others, 1984
"Andesite" tuff	34.9 ± 0.6	3	Marvin and others, 1984
Battle Butte "latite"	30.8 ± 2.4	4	Daniel and Berg, 1981
Basalt dike	33.8 ± 1.6	5	this study

Pb isotope data[2]

Location[1]	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$	
Flathead Mine (galena)	6	16.831	15.299	36.857
West Flathead (galena)	6	16.794	15.296	36.797
Battle Butte Mine (galena)	7	16.818	15.299	36.811
Sanidine	8	16.772	15.330	36.885

$^{87}Sr/^{86}Sr$ data

Sample	Rb-ppm	Sr-ppm	Measured $^{87}Sr/^{86}Sr$	Initial $^{87}Sr/^{86}Sr$	Location[1]
ZN002B	120	1,200	0.70402	0.70390	4
HH217	80	1,100	0.70475	0.70465	9

[1]See figure 1 for locations.
[2]Galena data from Zartman and Stacey (1971).

(whole rock) Rb = 80 ppm, Sr = 110 ppm, measured $^{87}Sr/^{86}Sr$ = .70475 ± .00004, initial $^{87}Sr/^{86}Sr$ = .70465 ± .00004. *Collected by:* I. M. Lange. *Dated by:* Geochron Laboratories, Inc.

4. *HH-222* (Amdel G-7726/89) Pb-Pb
Dacite porphyry (outcrop; NW¼ SE¼ S24,T25N, R24W; 47°54′55″N, 114°37′50″W; Hubbart Reservoir 7.5′ quad., Flathead County, MT) consisting of plagioclase, sanidine, quartz, biotite, opaques. *Analytical data:* (sanidine) $^{208}Pb/^{206}Pb$ = 2.1992 ± 0.001, $^{207}Pb/^{206}Pb$ = 0.9140 ± 0.0001, $^{206}Pb/^{204}Pb$ = 16.772 ± 0.007, $^{207}Pb/^{204}Pb$ = 15.330 ± 0.006, $^{208}Pb/^{204}Pb$ = 36.885 ± 0.015. *Collected by:* I. M. Lange. *Dated by:* Amdel Ltd., Australia.

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