Major 10.2-Ma Rhyolitic Volcanism in the Eastern Snake River Plain, Idaho—Isotopic Age and Stratigraphic Setting of the Arbon Valley Tuff Member of the Starlight Formation

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ABSTRACT

The Arbon Valley Tuff Member of the Starlight Formation, formally named in this report, is a prominent rhyolite ash-flow tuff that is exposed at many localities along the southeastern margin of the eastern Snake River Plain. Where it occurs, the unit makes up the entire middle member of the Starlight Formation and extends from at least Rockland Valley on the southwest to the Blackfoot Mountains on the northeast, a distance of more than 125 km. The tuff is also recognized at one locality on the northwestern margin of the 80-km-wide plain in the southern Lemhi Range. The tuff is crystal rich, containing quartz, sanidine, plagioclase, and biotite. It is petrographically and geochemically distinct from younger ash-flow tuffs of the eastern Snake River Plain.

New $^{40}Ar/^{39}Ar$ isotope dates from sanidine indicate that the Arbon Valley Tuff Member was erupted about 10.20+0.06 Ma; these new dates resolve conflicting previously reported ages for the unit. A source for the Arbon Valley Tuff Member may have been a caldera near Blackfoot and Pocatello, as suggested by the following observations: (1) two rhyolite lava flows that have potassium-argon ages of 9.8±0.9 Ma and 9.1±0.3 Ma occur south of Blackfoot and may have erupted from caldera ring fractures, (2) the observed thickness of the Arbon Valley Tuff Member is greatest (about 60 meters) near Blackfoot, (3) a resistivity low that is at least 6 km (kilometers) deep coincides with a gravity low that extends about 15 km northwest from Blackfoot, and (4) there is a lack of basaltic volcanic vents in the area of the inferred caldera, possibly indicating low-density rock that acted as a barrier to the ascent of basaltic magma.

The age and chemically distinct nature of the Arbon Valley Tuff Member support previously proposed models for cycles of rhyolitic magmatism in volcanic fields of the eastern Snake River Plain. Each cycle lasted for several million years, and magmatism migrated northeastward toward the Yellowstone plateau.

INTRODUCTION

Evidence is accumulating that the Snake River Plain is underlain and partly surrounded by a sequence of rhyolitic ash-flow tuffs that represent the preserved deposits of large, caldera-forming eruptions (Prostka, 1979; Morgan and others, 1984; Morgan, 1988, 1992). An overall pattern of successively younger tuffs to the northeast toward the Yellowstone Plateau may reflect the southwestward movement of the North American plate over a thermal mantle plume (Armstrong and others, 1975; Rodgers and others, 1990; Pierce and Morgan, 1992). Furthermore, there is evidence that rhyolitic volcanism may occur in cycles, each lasting several million years (Pierce and Morgan, 1992; Morgan, 1992); three major rhyolitic volcanic fields that existed in the eastern Snake River Plain during the past 10 m.y. (million years) are successively younger toward the northeast. These fields are (1) the approximately 10.2-Ma Picabo volcanic field (this age assignment is based almost entirely on isotopic dates from the Arbon Valley Tuff Member in this report), (2) the 6.7–4.3-Ma Heise volcanic field, and (3) the 2.0-Ma to-present Yellowstone plateau volcanic field.

A veneer of Pliocene to Holocene olivine basalt, as thick as 1–2 km, mantles and obscures both the rhyolites under the plain and their inferred source calderas (Doherty and others, 1979; Embree and others, 1982). Only on the

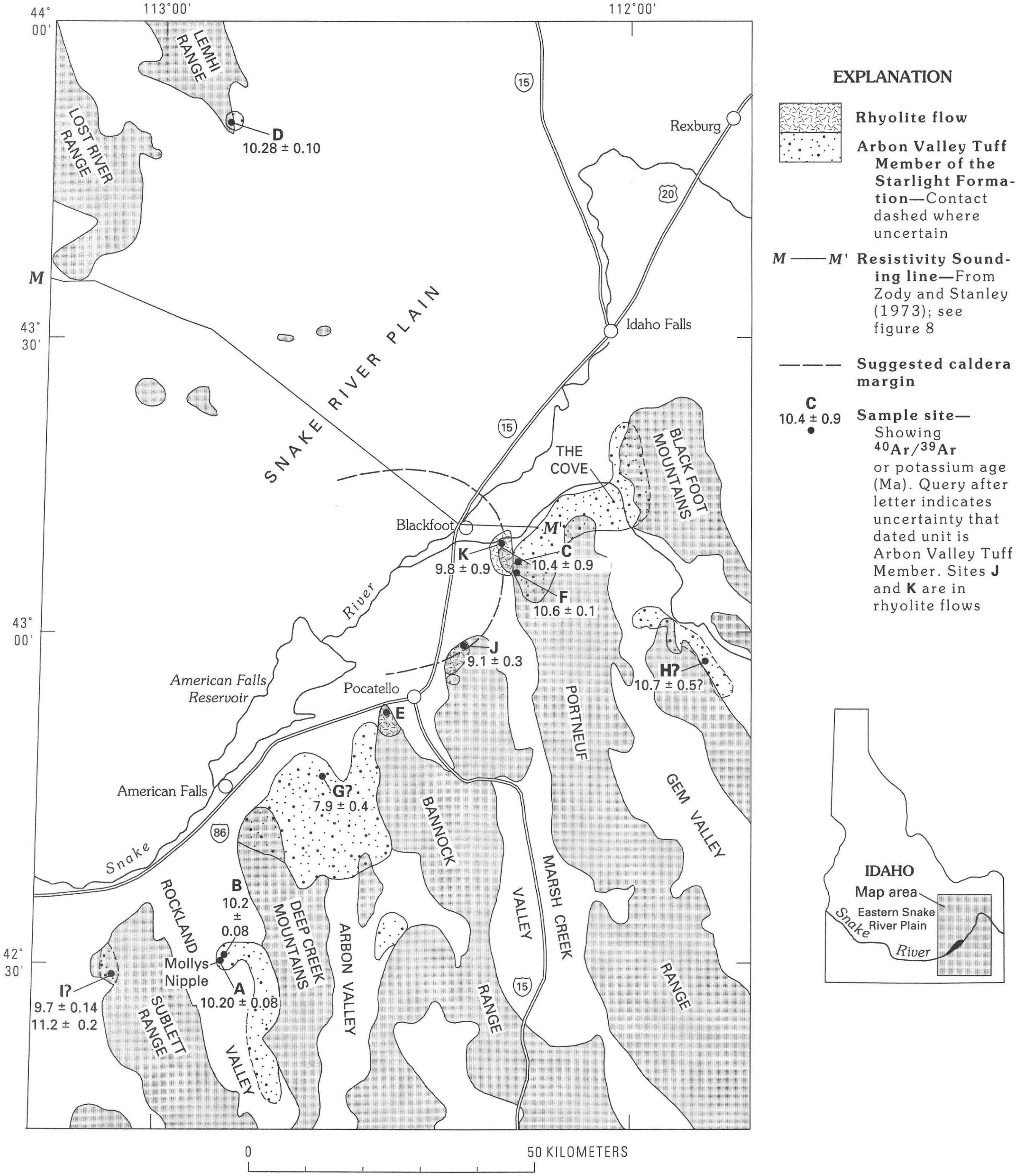

Figure 1. Location map showing the known extent of the Arbon Valley Tuff Member and three rhyolite lave flows in Idaho. New isotopic ages (for samples sites A-E) and previously reported ages (for samples sites F-K) are shown and reported in tables 3 and 4. Sources of mapping used in this compilation are Trimble (1976), Trimble and Carr (1976), Hladky and others (1991), and unpublished data (K.S. Kellogg, 1987).

Yellowstone plateau, at the northeastern end of the Snake River Plain immediately northeast of the area of this report, are both the rhyolites and structural features of the parent calderas clearly exposed. This exposure is due to the young age (2 Ma or less) of the caldera-forming events and to the lack of an obscuring cover of basaltic rocks.

Early Pliocene and late Miocene caldera-forming events associated with the formation of the Snake River Plain are best recognized by their outflow tuffs exposed in the hills marginal to the plain (Leeman, 1982; Morgan and others, 1984; Kellogg and Marvin, 1988; Morgan, 1992). Determining the ages, location, timing, and character of the calderas hidden under the plain has met with limited success. Some constraints on the approximate locations of the source calderas is provided by petrographic, geochemical, isotopic, geophysical, and paleomagnetic studies (Morgan, 1988, 1992). In addition, the location of calderas hidden beneath basaltic flows of the plain may be indicated by areas that lack basaltic vents (Kuntz and others, 1982); such areas may be underlain by low-density rock that acted as a barrier to the ascent and eruption of basaltic magma.

This study is concerned primarily with the isotopic dating of the Arbon Valley Tuff Member of the Starlight Formation, its stratigraphic setting along the southeastern margin of the Snake River Plain, and a brief chemical and petrographic description of the unit. Additional isotopic dates from several overlying rhyolitic units are also given, and their stratigraphic significance is discussed. Anticipated future studies will describe the various facies of the Arbon Valley Tuff Member and characterize the chemical and petrographic zonation within the unit; such studies will help to constrain more accurately the location of the source region.

Rocks assigned herein to the Arbon Valley Tuff Member have previously been described from their extensive exposures along the southeastern margin of the Snake River Plain (Carr and Trimble, 1963; Trimble and Carr, 1976; Trimble, 1976, 1982; Kellogg and Embree, 1986; Kellogg and Marvin, 1988; Kellogg and others, 1989). The total known and inferred extent of the Arbon Valley Tuff Member is shown on figure 1.

The Arbon Valley Tuff Member was originally named the middle, vitric-crystal tuff member of the Starlight Formation (Carr and Trimble, 1963) and was subsequently named the tuff of Arbon Valley by Trimble and Carr (1976) for exposures in the area of Arbon Valley in southeastern Idaho. The middle member of the Starlight Formation was described as a sequence of "ash-flow tuffs and minor bedded air-fall tuff," although the tuff of Arbon Valley "at many places * * * makes up the entire middle member" (Trimble and Carr, 1976, p. 35). Tuff beds that "probably are about the same age and chemical composition as the tuff of Arbon Valley" are included in their middle member (Trimble and Carr, 1976, p. 38), although in such places it is not clear to us where the top or base of the middle member occurs. Partly for this reason, we redefine the middle member in the next section and propose the formal name "Arbon Valley Tuff Member of the Starlight Formation."

The Arbon Valley Tuff Member is a distinctive, crystal-rich, conspicuously biotite-bearing ash-flow tuff that crops out extensively along the southeastern margin of the Snake River Plain (fig. 1). It has also recently been recognized at one locality (sample site D, fig. 1) along the northern margin of the plain (Kellogg and others, 1989). The unit is the oldest dated ignimbrite in the eastern Snake River Plain and is similar in thickness, extent, and physical characteristics to other major tuffs with known or suspected caldera sources, such as the 2.0-Ma Huckleberry Ridge tuff (Christiansen and Blank, 1972) and the tuffs of the Heise volcanic field (Morgan and others, 1984).

Until now, the age of the Arbon Valley Tuff Member had been equivocal, although it was generally considered to be 7.9±0.1 Ma (Trimble and Carr, 1976; Trimble, 1976; Kellogg and Marvin, 1988), based on one potassium-argon feldspar (type undefined) age from the northern Deep Creek Mountains (locality G, fig. 1; Armstrong and others, 1975). Another sample ("crystal tuff of Cosgrove Rd."; locality F, fig. 1), collected near Blackfoot was thought to be Arbon Valley Tuff Member, but it yielded a potassium-argon age of 10.6±0.1 Ma on "feldspar" (Armstrong and others, 1975). This date was suspected to be too old due to contamination by excess ^{40}Ar. These disparate dates (table 4) led us to recollect the Arbon Valley Tuff Member from known, well-studied outcrops for isotopic dating. Two samples were collected from Rockland Valley, from a section described by Trimble and Carr (1976), one sample was collected from a well-mapped area about 10 km southeast of Blackfoot (Kellogg and Embree, and one sample was collected from a well-mapped area about 10 km southeast of Blackfoot (Kellogg and Embree, 1986).

DESCRIPTION OF THE ARBON VALLEY TUFF MEMBER

We herein formally propose the name Arbon Valley Tuff Member of the Starlight Formation. We also define the Arbon Valley Tuff Member as comprising the entire middle member of the Starlight Formation, a designation that we feel is less ambiguous than that used by Trimble and Carr (1976). The complete exposed sections of the tuff are not in Arbon Valley but are in The Cove (figs. 1 and 2), about 25 km east of Blackfoot. A type section is proposed in SE¼ sec. 18, T. 2 S., R. 38 E. Incomplete reference sections of the Arbon Valley Tuff Member were described by Trimble (1976, p. 37).

At the type section, the Arbon Valley Tuff Member consists of a lower, poorly to moderately welded, poorly

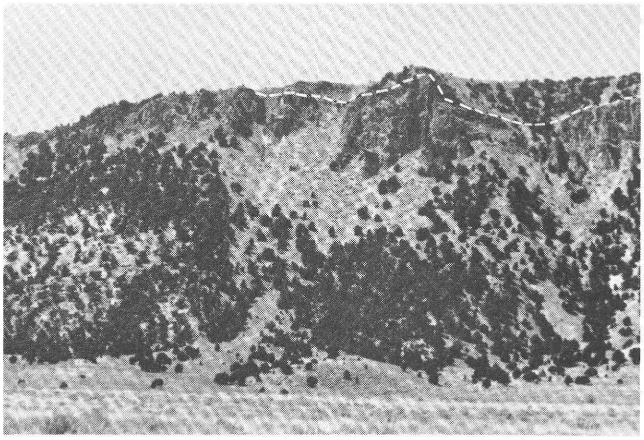

Figure 2. Arbon Valley Tuff Member in The Cove, northeast of Blackfoot, Idaho (SE¼ sec. 18, T. 2 S., R. 38 E.). The top of the unit is shown by the dashed line; the base is mostly obscured by talus. Rocks above and below the Arbon Valley Tuff Member are largely tuffaceous sandstone interbedded with a few thin basalt flows. Vertical relief, from lowest trees to right skyline, is about 210 m. View to the west. Photograph by K.S. Kellogg.

sorted, pumiceous, massive, sparsely crystal bearing (about 2–3 percent crystals as large as 1 mm (millimeter) of broken feldspar and quartz), very pale tan, tuff that grades upward into a pale-tan, planar-bedded, moderately welded tuff (fig. 3). The massive pumiceous tuff is about 15 to 20 m thick, locally contains tree casts, and is interpreted as an air-fall deposit; the overlying planar-bedded tuff is about 1.5 m thick and is interpreted as a pyroclastic-surge deposit. The interpreted surge deposit is disconformably overlain by a massive, more strongly welded, highly crystal rich, light-yellowish-gray ash-flow tuff that is about 40 m thick; the base of the upper ash-flow tuff is shown in figure 3.

In the upper ash-flow zone, the tuff contains abundant inflated to collapsed pumice fragments, and crystals compose as much as 35 percent of rock volume. Of the crystals, about 50 percent are stubby, partly resorbed and broken quartz as large as 3 mm, 30 percent are plagioclase as large as 2 mm, 10 percent are sanidine as large as 2 mm, as much as 5 percent are conspicuous biotite flakes as large as 3 mm, and about 2 percent are clinopyroxene as large as about 2 mm. The matrix is entirely devitrified, although Trimble and Carr (1976) described the equivalent unit in the north end of the Deep Creek Mountains as vitric in part. An uppermost vapor-phase or lithophysal zone has not been observed, although at most localities the upper part of the unit is eroded or poorly exposed. The extremely crystal rich nature of the ash-flow zone and the presence of abundant stubby quartz and biotite crystals are unique to the Arbon Valley Tuff

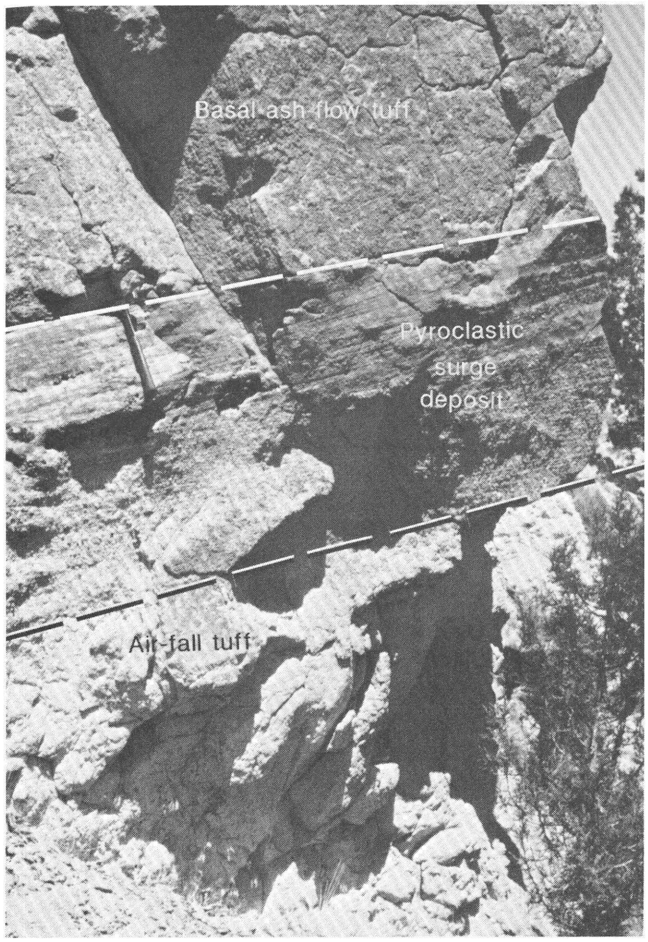

Figure 3. The base of the Arbon Valley Tuff Member in The Cove, northeast of Blackfoot, Idaho, showing a moderately welded, massive, pumiceous deposit interpreted as air-fall ash grading upward into a cross-bedded unit interpreted as a pyroclastic-surge deposit that is, in turn, overlain with a sharp disconformity by massive, strongly welded tuff. Hammer shows scale. View to the north. Photograph by K.S. Kellogg.

Member and make it readily distinguishable from other rhyolitic tuffs of the Snake River Plain.

At sample site C (fig. 1), 8 km southeast of Blackfoot, the thickness of the Arbon Valley Tuff Member is about 60 m, similar to the thickness at The Cove. In Rockland Valley and at the northern end of the Deep Creek Mountains, the Arbon Valley Tuff Member is at least 25 m thick (Trimble and Carr, 1976). Near Blackfoot, the tuff appears to be a single cooling unit, although at some localities at the northern end of the Deep Creek Mountains, at least two cooling units exist (Trimble and Carr, 1976). At all localities, total crystal content appears to increase upward. Magnetic polarity, as

Table 1. Measured production ratios for potassium and calcium-derived argon isotopes for the U.S. Geological Survey TRIGA reactor, Denver, Colo.

[Determination of production ratios is based on irradiated salts K_2SO_4 for potassium-derived argon and CaF_2 for calcium-derived argon]

Irradiation package No. (irradiation time)	$(^{37}Ar/^{39}Ar)K$ $\times10^{-4}$	$(^{38}Ar/^{39}Ar)K$ $\times10^{-2}$	$(^{40}Ar/^{39}Ar)K$ $\times10^{-2}$	$(^{39}Ar/^{37}Ar)Ca$ $\times10^{-3}$	$(^{36}Ar/^{37}Ar)Ca$ $\times10^{-4}$	$(^{38}Ar/^{37}Ar)Ca$ $\times10^{-5}$
DD26 (30 hours) ---------	1.1	1.31	8.78	0.66	2.69	3.50
DO5 (25 hours) ---------	1.10	1.31	.77	.64	2.63	6.35

determined by a hand-held flux-gate magnetometer, is normal (Kellogg and Marvin, 1988).

NEW ISOTOPIC AGES FOR THE ARBON VALLEY TUFF MEMBER

SAMPLING

Four samples of the Arbon Valley Tuff Member were collected for potassium-argon and $^{40}Ar/^{39}Ar$ age determinations. One sample (FH87BB01) was collected about 8 km southeast of Blackfoot (sample site C, fig. 1) and two others (TSMA-1 and TSMA-2) were collected about 90 km southwest of Blackfoot in Rockland Valley, on and near a small hill called Mollys Nipple (sample sites A and B, fig. 1).

Arbon Valley Tuff Member has been tentatively identified at one locality (sample site D, fig. 1) on the northern margin of the Snake River Plain, in the southern Lemhi Range. Sample DR724D3, collected at this locality, gave a $^{40}Ar/^{39}Ar$ date on sanidine of 10.30±0.04 (Kellogg and others, 1989), a date that is slightly reinterpreted in this report.

METHODOLOGY

Sanidine and biotite mineral separates and neutron flux monitors for $^{40}Ar/^{39}Ar$ dating were wrapped in aluminum foil and irradiated for either 20 or 25 hours in the U.S. Geological Survey TRIGA reactor, Denver, Colo. (samples TSMA-1 and -2) or in the Oregon State University reactor, Corvallis (sample DR724D3). Variations in neutron fluence within the irradiated packages were monitored by placing 6 to 10 standards along the length of each vial; the monitor used in this study was hornblende MMhb-1, which has an assigned potassium-argon age of 520.4 Ma (Alexander and others, 1978; Dalrymple and others, 1981; Sampson and Alexander, 1987). Corrections for interfering isotopes were made by measuring the argon isotopes of K_2SO_4 and CaF_2 irradiated in each package; calculated production ratios are summarized in table 1. With the exception of biotite from sample TSMA-2, which was fused in a single step, each sample was heated in a double vacuum furnace for 20 minutes in a series of 7 to 12 steps to a maximum temperature of 1,450°C. Five naturally occurring and radiogenic isotopes of argon (^{40}Ar, ^{39}Ar, ^{38}Ar, ^{37}Ar, and ^{36}Ar) were measured at each step, and isotopic compositions were corrected for mass discrimination. All samples were analyzed using a Mass Analyzer-Products MAP 215 rare-gas mass spectrometer operated in the static mode. Apparent ages were calculated using the decay constants recommended by Steiger and Jäger (1977). Age plateaus, where appropriate, were determined using the critical value test of Dalrymple and Lanphere (1969). A detailed description of the analytical procedures used in this study is in appendix 1 of Tysdal and others (1990). $^{40}Ar/^{39}Ar$ age-spectrum data are reported in table 2; estimated analytical uncertainty for the apparent age from each heating step is reported as $\pm1\sigma$. However, to facilitate comparison with potassium-argon dates, the estimated analytical error in the summary of $^{40}Ar/^{39}Ar$ plateau and isochron dates (table 3) are reported as $\pm2\sigma$.

Potassium analyses for potassium-argon dating were performed by E.H. Brandt using a lithium metaborate flux fusion-flame photometry method (Ingamells, 1970). Argon extraction and purification techniques used in this study are similar to those described by Dalrymple and Lanphere (1969). Argon isotopes were analyzed using standard isotope dilution procedures using a 60°-sector, 15.2-cm (centimeter)-radius Nier-type mass spectrometer operated in the static mode. The estimated analytical uncertainty for the calculated potassium-argon age is reported as $\pm2\sigma$.

Table 2 (below and facing page). $^{40}Ar/^{39}Ar$ age-spectrum data for the Arbon Valley Tuff Member of the Starlight Formation, eastern Snake River Plain, Idaho.

[$^{40}Ar_R$, abundance of radiogenic ^{40}Ar reported in volts of signal on a Faraday detector; $^{39}Ar_K$, abundance of radiogenic (potassium-derived) ^{39}Ar reported in volts of signal; F, ratio of $^{40}Ar_R$ to $^{39}Ar_K$ after correction for mass discrimination and interfering isotopes; $^{39}Ar/^{37}Ar$, ratio of $^{39}Ar_K$ to $^{37}Ar_{Ca}$ (this value can be converted to the approximate potassium/calcium by multiplying by 0.5); percent $^{40}Ar_R$ and percent ^{39}Ar, percent of radiogenic ^{40}Ar and percent of total ^{39}Ar released in each temperature step; $^{40}Ar/^{36}Ar_a$, measured atmospheric argon ratio used for mass discrimination at time of analysis; J value, neutron flux parameter; P, temperature steps used in the calculation of plateau or weighted mean ages; mg, milligram; 1σ, one standard deviation]

Temperature (°C)	$^{40}Ar_R$	$^{39}Ar_K$	F	$^{39}Ar/^{37}Ar$	$^{40}Ar_R$ (percent)	^{39}Ar (percent)	Apparent age (Ma at 1σ)
			Sample TSMA-1/DD26, sanidine				
750 ------------	0.72977	0.80135	0.911	17.71	45.8	3.1	10.33±0.08
925P-----------	2.58593	2.89676	.893	36.80	92.2	11.3	10.13±0.04
1,050P ---------	5.44387	6.10064	.891	56.57	96.3	23.8	10.11±0.04
1,125P ---------	5.71608	6.39102	.894	72.25	97.3	25.0	10.15±0.04
1,175P ---------	7.50813	8.35358	.899	81.28	97.8	32.6	10.20±0.03
1,200----------	.77473	.85292	.908	59.15	95.6	3.3	10.31±0.08
1,450----------	.20098	.18972	1.059	27.13	81.9	.7	12.01±0.26
Total gas ------			0.897				10.18±0.04
			Sample TSMA-1/DD26, biotite				
600 ------------	0.02222	0.01671	1.330	13.61	9.3	0.1	15.04±1.11
700 ------------	.06617	.08806	.751	26.40	9.8	.7	8.52±0.35
750 ------------	.24334	.26574	.916	107.43	35.3	2.2	10.37±0.20
800P-----------	.81191	.88915	.913	242.90	60.5	7.3	10.34±0.05
850P-----------	1.24399	1.36917	.909	396.49	77.5	11.3	10.29±0.05
900P-----------	1.24933	1.36676	.914	430.42	81.1	11.3	10.35±0.05
950P-----------	1.39505	1.52089	.917	231.31	72.2	12.5	10.39±0.05
1,000P ---------	1.27934	1.39266	.919	30.89	55.4	11.5	10.41±0.05
1,050P ---------	1.99034	2.17140	.917	26.08	47.1	17.9	10.38±0.05
1,100P ---------	1.94584	2.11503	.920	116.80	56.7	17.4	10.42±0.05
1,250----------	.12297	.12735	.966	8.61	72.5	1.1	10.94±0.34
1,150P ---------	.73930	.80460	.919	48.21	66.4	6.6	10.41±0.08
Total gas ------			0.916				10.38±0.06

Potassium-argon ages and analytical data for the Arbon Valley Tuff Member and several other rhyolitic units from the eastern Snake River Plain are given in table 4.

RESULTS OF $^{40}AR/^{39}AR$ ANALYSIS

The samples from Rockland Valley (TSMA-1 and -2; sample sites A and B, fig. 1) yield largely concordant $^{40}Ar/^{39}Ar$ age spectra (figs. 4*A*–4*D*; table 2). Sanidine age spectra from the two samples are similar and are concordant at intermediate temperature steps but also show a tendency toward older apparent ages at higher temperatures. Sanidine from sample TSMA-1 gives similar plateau and isochron dates (fig. 5*A*) of 10.15±0.08 Ma and 10.20±0.08 Ma, respectively. The isochron from this sample yields an initial $^{40}Ar/^{36}Ar$ intercept of 282±54 that is identical within analytical uncertainty to the atmospheric value of 295.5. Sanidine from sample TSMA-2 gives a plateau age of 10.22±0.06 Ma (fig. 4*C*), an isochron age of 10.21±0.08 Ma, and an initial $^{40}Ar/^{36}Ar$ value of 307±11 (fig. 5*C*). The age spectra for biotite from sample TSMA-1 is concordant over 95 percent of the ^{39}Ar released and gives a plateau age of 10.38±0.04 Ma (fig. 4*A*). The isochron age from this sample is 10.35±0.04 Ma, with an initial $^{40}Ar/^{39}Ar$ value of 297±1 that is essentially identical to atmospheric composition. A total-fusion $^{40}Ar/^{39}Ar$ date from biotite from sample TSMA-2, largely analogous to the conventional potassium-argon dates

Temperature (°C)	$^{40}Ar_R$	$^{39}Ar_K$	F	$^{39}Ar/^{37}Ar$	$^{40}Ar_R$ (percent)	^{39}Ar (percent)	Apparent age (Ma at 1σ)
			Sample TSMA-2/DD26, sanidine				
750	1.05434	1.18772	0.888	9.81	50.7	4.8	10.04±0.03
925P	2.98041	3.31239	.900	10.24	86.1	13.4	10.18±0.03
1,050P	5.33740	5.91695	.902	19.76	88.3	23.9	10.20±0.04
1,125P	5.22751	5.77619	.905	37.79	92.2	23.3	10.24±0.03
1,175P	6.25376	6.90363	.906	54.08	95.0	27.9	10.24±0.03
1,225	.84547	.92310	.916	19.22	83.7	3.7	10.36±0.04
1,450	.69711	.74707	.933	17.85	75.6	3.0	10.55±0.05
Total gas			0.904				10.23±0.03
			Sample TSMA-2/DD26, biotite				
1,250	0.93755	1.01232	0.926	113.12	52.6	100.0	10.34±0.05
			Sample DR724D3/DO5, sanidine				
600	0.16304	0.18443	0.884	14.34	31.1	1.3	11.50±0.66
700	.40978	.53065	.772	27.37	79.2	3.7	10.05±0.12
800P	.80322	1.02427	.784	37.06	89.9	7.1	10.21±0.06
850P	.96063	1.22677	.783	44.22	91.7	8.6	10.19±0.03
900P	1.39954	1.79025	.782	51.75	94.5	12.5	10.18±0.05
950P	1.25230	1.56660	.799	58.55	97.7	10.9	10.40±0.06
1,000P	2.25125	2.86723	.785	67.12	96.2	20.0	10.22±0.04
1,050P	3.49659	4.39068	.796	73.09	97.8	30.6	10.37±0..05
1,150	.42797	.51600	.829	45.93	50.9	3.6	10.79±0.14
1,250	.20634	.23540	.877	48.05	27.3	1.6	11.41±0.48
Total gas			0.793				10.33±0.07

SAMPLE DATA

1. TSMA-1/DD26: sanidine; 177.3 mg; measured $^{40}Ar/^{36}Ar_a$=298.9; J value = 0.006308±0.25 percent (1σ).
2. TSMA-1/DD26: biotite; 103.0 mg; measured $^{40}Ar/^{36}Ar_a$ = 298.9; J value = 0.006297±0.25 percent (1σ).
3. TSMA-2/DD26: sanidine; 199.4 mg; measured $^{40}Ar/^{36}Ar_a$ = 298.9; J value 0.006287±0.25 percent (1σ).
4. TSMA-2/DD26: biotite; 11.5 mg; measured $^{40}Ar/^{36}Ar_a$ = 298.9; J value = 0.006205±0.25 percent (1σ).
5. DR724D3/DO5: sanidine; 81.2 mg; measured $^{40}Ar/^{36}Ar_a$ = 298.9; J value = 0.007236±0.25 percent (1σ).

reported below, gives an apparent age of 10.34±0.10 Ma. A summary of the plateau and isochron dating results is given in table 3.

Both the biotite $^{40}Ar/^{39}Ar$ apparent ages from TSMA-1 and TSMA-2 are slightly older than those from the coexisting sanidines. This apparent discordance may reflect either ^{40}Ar loss from the sanidines or contamination of the biotites by excess ^{40}Ar. The sanidine age spectra show no evidence of apparent ^{40}Ar loss nor does the biotite initial $^{40}Ar/^{36}Ar$ value from sample TSMA-1 suggest the presence of excess ^{40}Ar (fig. 5*B*). Because several recent $^{40}Ar/^{39}Ar$ studies indicate that sanidine from ignimbrites typically yields reliable and reproducible dates, whereas biotites tend to be less dependable (for example, McIntosh and others, 1990), we consider the plateau ages derived from the sanidines to best represent the age of the Arbon Valley Tuff Member at this locality. Calculation of a weighted mean for the two sanidines following Taylor (1982) results in an apparent age of 10.19±0.04 Ma.

$^{40}Ar/^{39}Ar$ dating of sanidine from sample DR724D3, collected north of the Snake River Plain (sample site D, fig. 1) gave a somewhat discordant, U-shaped age spectra (fig. 4*D*). Although the age spectra do not satisfy the requirement for a plateau date, a weighted mean age of 10.20±0.06 Ma can be calculated for the intermediate temperature steps (table 3), using the criteria of Dalrymple and Lanphere (1969). The U-shaped spectra suggest the presence of excess ^{40}Ar, and an isochron from this sample yields an initial $^{40}Ar/^{36}Ar$ value of 309±3 (fig. 5*D*) that is significantly greater than the atmospheric value of 295.5. Consequently, the

Table 3. Summary of $^{40}Ar/^{39}Ar$ dating results for the Arbon Valley Tuff Member of the Starlight Formation, Snake River Plain, Idaho.

[^{39}Ar, percent of total potassium-derived ^{39}Ar, and (steps), number of steps used in the calculation of the plateau age; $^{40}Ar/^{36}Ar_i$, initial $^{40}Ar/^{36}Ar$ ratio determined from the isochron analysis; BT, biotite; S, sanidine; --, no data]

Sample No.	Sample site (fig. 1)	Latitude, longitude	Mineral dated	Fusion age (Ma)	Plateau results		Isochron results	
					^{39}Ar (steps)	Age (Ma)	$^{40}Ar/^{36}Ar_i$	Age (Ma)
TSMA-1 ---------	A	42°31'10"N., 112°51'47"W.	S	--	92.7 (4 of 7)	10.15± 0.08	282±54	10.20 ± 0.08
TSMA-1 ----------	A	42°31'10"N., 112°51'47"W.	BT	--	95.8 (8 of 12)	10.38± 0.10	297±1	10.35 ± 0.04
TSMA-2 ----------	B	42°31'20"N., 112°51'39"W.	S	--	88.5 (4 of 7)	10.22± 0.06	307±11	10.21 ± 0.08
TSMA-2 ----------	B	42°31'20"N., 112°51'39"W.	BT	10.34 ± 0.10	--	--	--	--
DR724D-3 -------	D	43°49'00"N., 112°51'30"W.	S	--	89.8 (6 of 10)	10.28± 0.10	309±3	10.22 ± 0.06

isochron age of 10.22±0.06 Ma probably best represents the age of the sample, although the dates calculated by either method are statistically indistinguishable at the 95-percent confidence level. The apparent age from this sample is in excellent agreement with the $^{40}Ar/^{39}Ar$ dates from sanidines from the southeastern part of the Snake River Plain.

RESULTS OF POTASSIUM-ARGON ANALYSIS

The analytical results of potassium-argon analysis of three samples of the Arbon Valley Tuff Member are given in table 4. Sample FH87BB01, collected near Blackfoot (sample site C, fig. 1) gave concordant potassium-argon dates on biotite, sanidine, and plagioclase; the mean of three determinations is 10.2±0.9 Ma. Sample TSMA-1 from Rockland Valley gave a potassium-argon biotite date with very large uncertainty (9.7±3.4 Ma) due to a low percentage (6.0 percent) of radiogenic argon. The potassium-argon biotite age from TSMA-2 is 10.4±0.6 Ma.

Several other tuffs from the southeastern margin of the Snake River Plain that were dated by the potassium-argon method may also be Arbon Valley Tuff Member. Hutsinpiller and Parry (1985) reported a date of 10.7±0.5 Ma (mineral separate unspecified) on a well-exposed but uncorrelated tuff (sample site H, fig. 1; table 4) that is within the known range of outcrop of the Arbon Valley Tuff Member. At the north end of the Sublette Range (sample site I, fig. 1), a biotite-bearing "vitric tuff" from the base of a section of rhyolite yielded potassium-argon ages of 11.1±0.2 Ma for biotite and 9.7±0.14 Ma for feldspar (type unspecified) (Armstrong, 1975; table 4). The suggested correlation of this unit with the Arbon Valley Tuff Member is based not only on the similarity of the ages, but also on the observation that very few other ignimbrites in the eastern Snake River Plain are biotite bearing.

Until the identity of the dated units can be verified, the areas of outcrop for the Arbon Valley Tuff Member shown surrounding sample sites H and I on figure 1 are considered tentative.

ESTIMATED AGE OF THE ARBON VALLEY TUFF MEMBER

The $^{40}Ar/^{39}Ar$ dates obtained from sanidines from the northern and southeastern margins of the Snake River Plain (sample sites A and D, fig. 1; table 3) are identical at the 95-percent confidence level and are concordant with the potassium-argon age determinations (table 4). Combining the two sanidine $^{40}Ar/^{39}Ar$ plateau dates from the southeastern margin of the Snake River Plain with the isochron date from the Lemhi Range locality on the northern margin of the plain, we obtained a weighted mean date of 10.20±0.06 Ma, which we consider best represents the age of emplacement of the Arbon Valley Tuff Member of the Starlight Formation.

Table 4. Summary of potassium-argon ages for the Arbon Valley Tuff Member of the Starlight Formation and several other rhyolitic units from the eastern Snake River Plain, Idaho.

[BT, biotite; S, sanidine; P, plagioclase; FS, feldspar (type unspecified); WR, whole rock. Constants used: λ_ε=0.581×10^{-10}/yr; λ_β=4.962×10^{-10}/yr; atomic abundance of ^{40}K/K=1.67×10^{-4}mole/mole. Dates for sample sites C and E were previously reported in Kellogg and others (1989) without analytical details. Ages of Armstrong and others (1975) are corrected for new decay constants of Steiger and Jäger (1977). Leaders (--), no data or data given in original reference

Unit sampled	Sample No.	Sample site (fig. 1)	Latitude, longitude	Material dated	K_2O (percent)	^{40}Ar (10^{10} mole/gram)	^{40}Ar (percent)	Age (Ma) ±2σ
New ages:								
Arbon Valley Tuff Member ------------	TSMA-1	A	42°31'10"N., 112°51'47"W.	S	10.8	1.5760	77.1	10.1± 0.3
Arbon Valley Tuff Member ------------	TSMA-1	A	42°31'10"N., 112°51'47"W.	BT	8.74	1.2149	6.0	9.7± 3.4
Arbon Valley Tuff Member ------------	TSMA-2	B	42°31'20"N., 112°51'39"W.	S	9.46	1.3701	47.2	10.0± 0.4
Arbon Valley Tuff Member ------------	TSMA-2	B	42°31'20"N., 112°51'39"W.	BT	8.69	1.2885	40.2	10.4± 0.6
Arbon Valley Tuff Member ------------	FH87BB01	C	43°07'15"N., 112°15'36"W.	S	11.45	1.234	55.1	9.4± 0.5
Arbon Valley Tuff Member ------------	FH87BB01	C	43°07'15"N., 112°15'36"W.	BT	8.79	3.005	30.1	10.4± 0.9
Arbon Valley Tuff Member ------------	FH87BB01	C	43°07'15"N., 112°15'36"W.	P	.89	.0999	56.6	10.8± 0.7
Rhyolite of west Pocatello --------------	FH86-2685B	E	42°54'20"N., 112°30'38"W.	P	1.14	.1295	31.7	7.9± 0.7
Rhyolite of west Pocatello --------------	FH86-2685B	E	42°54'20"N., 112°30'38"W.	WR	4.73	.5377	53.1	7.9± 0.4
Previously reported ages:								
Tuff of Arbon Valley[1] --------------------- ("crystal tuff, Congrove Rd")	-------	F	---	FS	---	---	---	10.6± 0.1
Tuff of Arbon Valley[1] --------------------	-------	G	---	FS	---	---	---	7.9± 0.4
Tuff of Arbon Valley?[2] ------------------	-------	H	---	---	---	---	---	10.7± 0.5
Tuff of Arbon Valley?[1] -------------------- ("vitric ash flow" at base of section) -	-------	I	---	BT	---	---	---	11.1± 0.2
Tuff of Arbon Valley?[1] ------------------ ("vitric ash flow" at base of section)	-------	I	---	FS	---	---	---	9.7 0.14
Rhyolite of Two-and-a-Half-Mile Creek[3] -------		J	---	BT	---	---	---	9.1± 0.3
Rhyolite of Stevens Peak[4] --------------	-------	K	---	---	---	---	---	9.8± 0.9

[1]Armstrong and others (1975).
[2]Hutsinpiller and Parry (1985); analyzed mineral not specified.
[3]Kellogg and Marvin (1988).
[4]Karlo and Jorgenson (1979); analyzed mineral not specified.

STRATIGRAPHY OF THE SOUTHEASTERN MARGIN OF THE SNAKE RIVER PLAIN

The stratigraphic position and setting of the Arbon Valley Tuff Member, along the southeastern margin of the Snake River Plain, shown diagramatically between about American Falls on the southwest and Blackfoot on the northeast (fig. 6), is based largely on the new dates for the Arbon Valley Tuff Member and is a revision of the stratigraphy proposed by Kellogg and Marvin (1988). The pre-Tertiary rocks, strongly deformed during late Mesozoic thrusting, extend less than several kilometers to the northwest under

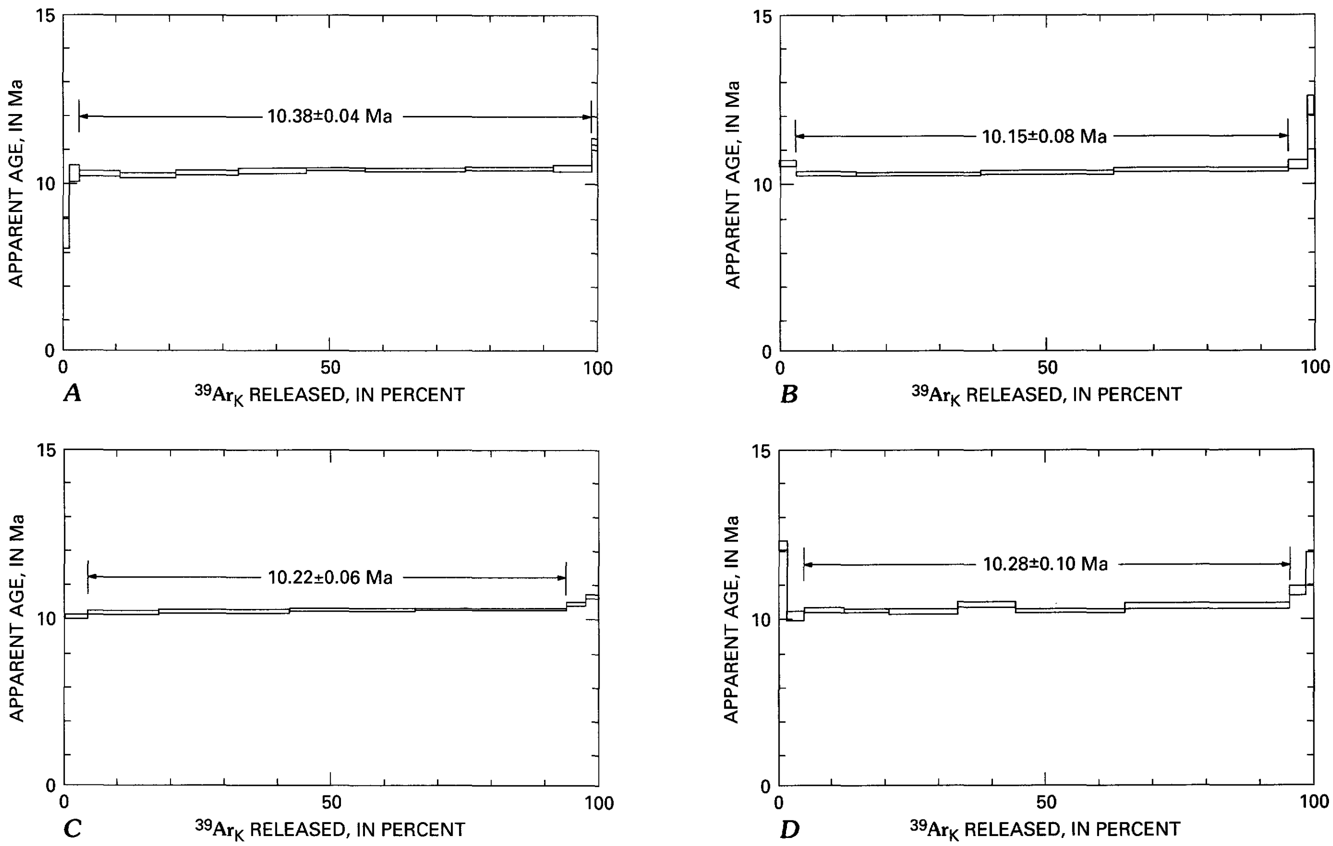

Figure 4. $^{40}Ar/^{39}Ar$ age spectra for sanidine and biotite from the Arbon Valley Tuff Member, Idaho. *A*, sanidine from sample TSMA-1; *B*, biotite from sample TSMA-1; *C*, sanidine from sample TSMA-2; and *D*, sanidine from sample DR724D3. Interpretation of these types of diagrams is discussed by McDougall and Harrison (1988).

the eastern Snake River Plain (Sparlin and others, 1982). Farther to the east, about 27 km east of Blackfoot, steeply northeast dipping andesitic flows and volcanic breccias (not shown on fig. 6), dated about 40–47 Ma (Armstrong, 1972), overlie thrust-faulted Mesozoic rocks. These volcanic rocks are coeval with the widespread rocks of the Eocene Challis volcanic rocks of central Idaho (for example, McIntyre and others, 1982).

The 10.20±0.06-Ma date for the Arbon Valley Tuff Member is the oldest Miocene isotopic age yet recorded east of the Sublett Range along the southeastern margin of the plain (Armstrong, 1975). However, several hundred meters of mostly rhyolitic ash and rhyolitic water-lain sediments beneath the Arbon Valley Tuff Member (correlated with the lower member of the Starlight Formation of Trimble and Carr, 1976) suggest that nearby rhyolitic volcanism began before 10.2 Ma. The source for these older rhyolitic deposits is unknown but may be related in part to early stages of eruption of the caldera that produced the Arbon Valley Tuff Member.

Two rhyolite lava flows exposed between Blackfoot and Pocatello, the rhyolite of Two-and-a-Half-Mile Creek and the rhyolite of Stevens Peak, give potassium-argon ages of 9.1 and 9.8 Ma, respectively (sample sites J and K, fig. 1; table 4). As discussed in the next section, these flows are interpreted as resulting from ring-fracture eruptions of the source caldera for the Arbon Valley Tuff Member (Kellogg and others, 1989). A rhyolite flow ("trachyandesite porphyry" of Trimble, 1976) from the upper Starlight Formation is exposed in a railroad cut immediately west of Pocatello and was collected for isotopic dating (locality E, fig. 1). This unit, herein informally named the rhyolite of west Pocatello, is not genetically related to the Arbon Valley Tuff Member, but is discussed here to define better the stratigraphic setting of the southeastern margin of the Snake River Plain. Its major-element composition is similar to other rhyolites of the

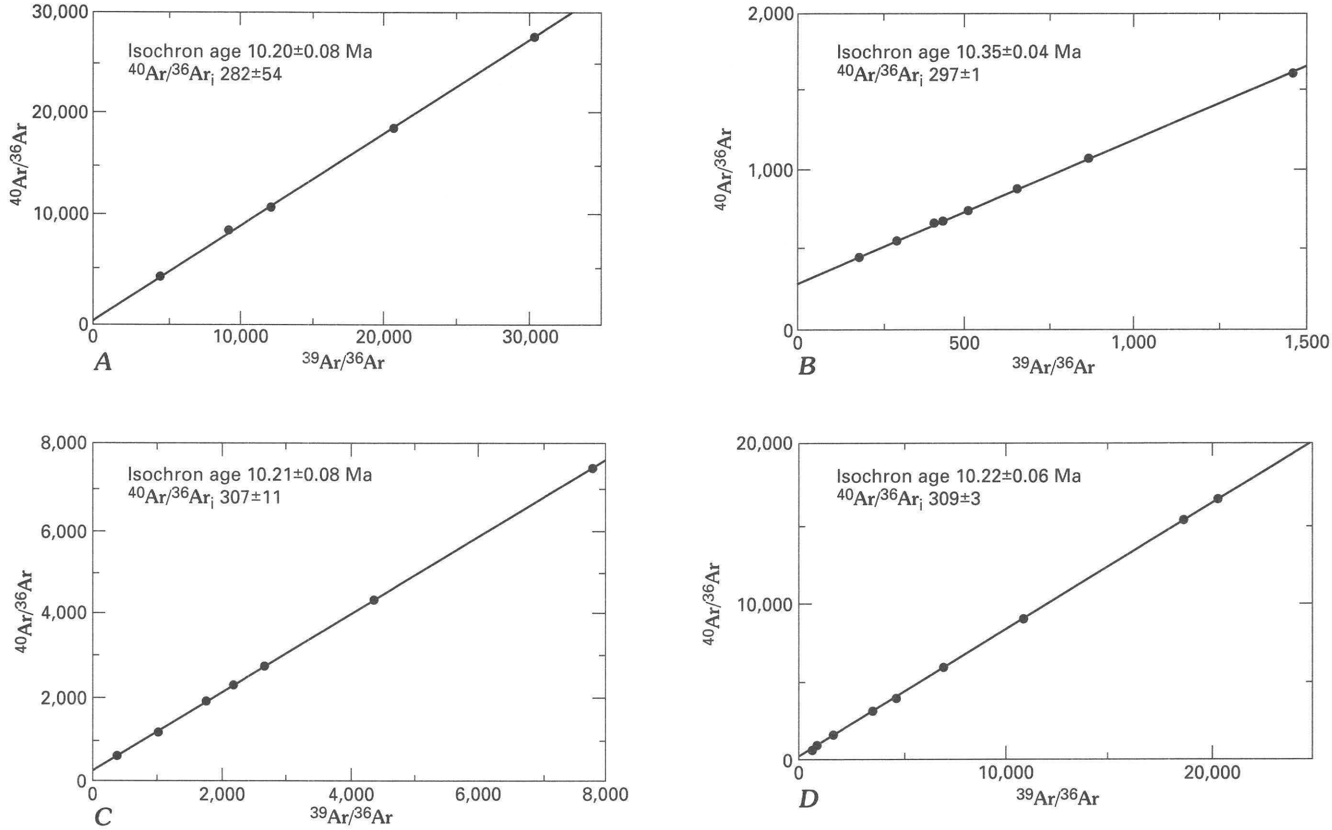

Figure 5. $^{40}Ar/^{36}Ar$-$^{39}Ar/^{36}Ar$ isochron diagrams for sanidine and biotite from samples of the Arbon Valley Tuff Member, Idaho. *A*, sanidine from sample TSMA-1; *B*, biotite from sample TSMA-1; *C*, sanidine from sample TSMA-2; and *D*, sanidine from sample DR724D3. Interpretation of these types of diagrams is discussed by McDougall and Harrison (1988).

Snake River Plain (compare analysis in table 5 with those reported in table 4 of Kellogg and Marvin, 1988). Up to now, the only isotopically dated unit in the upper Starlight Formation is a basalt flow, which yielded a date of 7.0±0.3 Ma (Kellogg and Marvin, 1988). The rhyolite of west Pocatello is dark gray and contains conspicuous light-gray phenocrysts of plagioclase. The flow gave a potassium-argon plagioclase age of 7.9±0.7 Ma and a potassium-argon whole-rock age of 7.9±0.4 Ma (new ages reported in table 4).

The Starlight Formation is overlain by a coarse boulder diamictite, interpreted as deposited as debris flows derived from an eastern tectonic escarpment during rapid basin-and-range uplift (Kellogg and Marvin, 1988). The diamictite is, in turn, overlain by three crystal-poor rhyolitic ash-flow tuffs of the Heise volcanic field (Morgan and others, 1984), erupted between 7.6 and 4.3 Ma. These tuffs represent the final phase of rhyolitic volcanism near Blackfoot before an abrupt change occurred between 4.3 and 3.7 Ma to basaltic volcanism, marked by the eruption of olivine basalt of predominantly tholeiitic composition (Kellogg and Marvin, 1988).

GEOCHEMISTRY OF THE ARBON VALLEY TUFF MEMBER

Major-element geochemical analysis of three samples from the basal part of the upper massive, welded zone of the Arbon Valley Tuff Member shows that the unit is mildly peraluminous, as are the tuffs of the Heise volcanic field (Kellogg and Marvin, 1988, table 4). These analyses were performed on whole-rock samples and may reflect some contamination acquired during transport. Perhaps partly due to this limitation, major-element chemical analysis is not a particularly useful method for discriminating the different rhyolite tuffs of the Snake River Plain (Kellogg and Marvin, 1988). However, trace-element geochemical analysis of 11

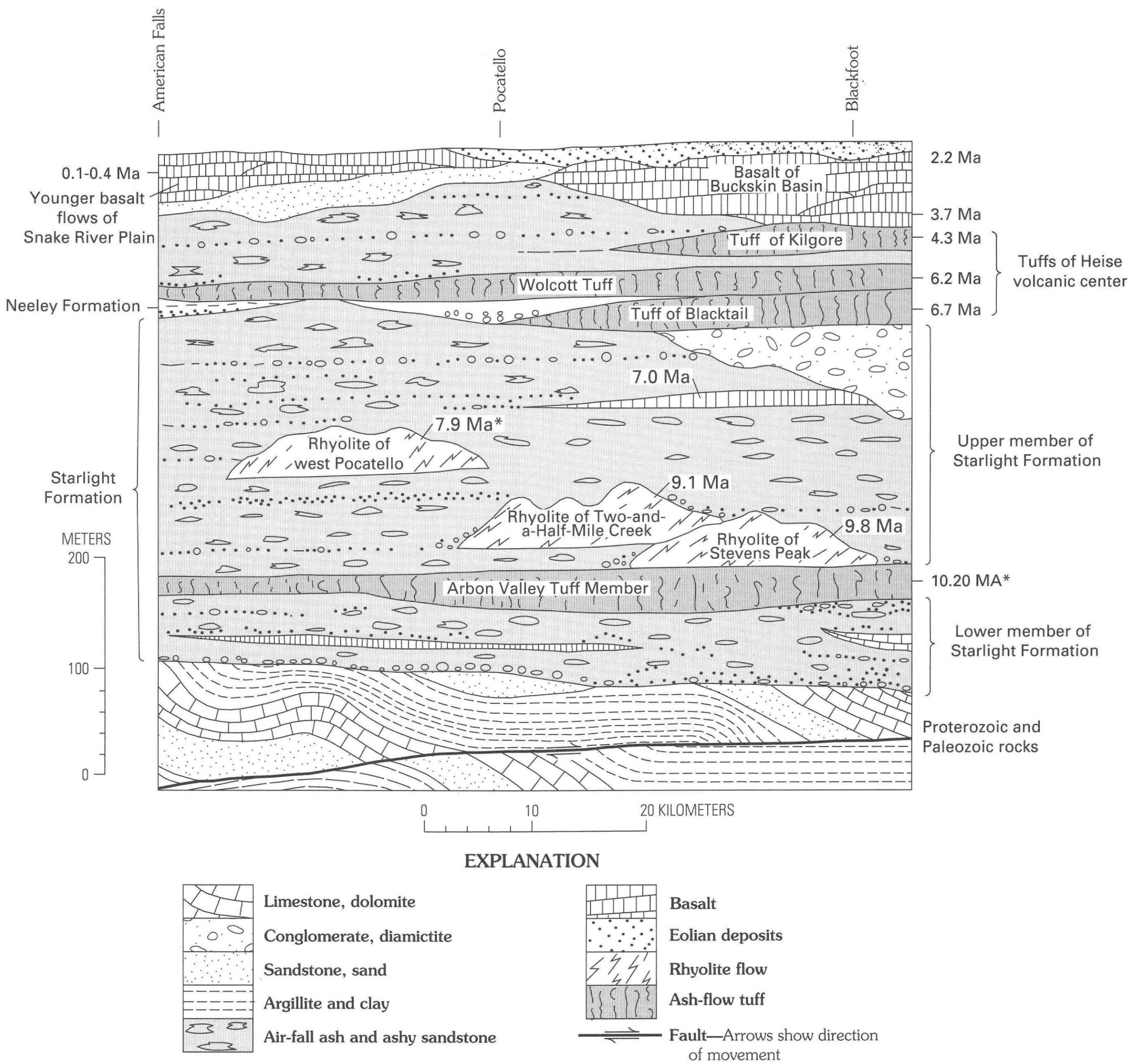

Figure 6. Diagrammatic stratigraphic cross section of units along the southeastern margin of the Snake River Plain between about Blackfoot and American Falls, Idaho. Section is oriented parallel to the margin of the Snake River Plain. Thicknesses are approximate and are based on Trimble (1982), Kellogg and Marvin (1988), and results of this study. New isotopic ages from this study are noted by an asterisk.

samples of the Arbon Valley Tuff Member does show consistent differences from the trace-element analysis of samples from the Heise volcanic field (fig. 7, table 6).

Relative abundances of rubidium, strontium, and zirconium serve to distinguish the Arbon Valley Tuff Member from the tuffs of the Heise volcanic field (fig. 7). Samples from near Blackfoot provide most of the analyses for the Arbon Valley Tuff Member; two samples from Rockland Valley and one from the Lemhi Range on the northwestern side of the plain are also plotted. Compared to the Heise tuffs, the Arbon Valley Tuff Member is enriched in strontium relative to zirconium and rubidium. The spread of analytical values is due to several factors, of which the two most important may be chemical zonation within the Arbon Valley Tuff Member and contamination of the tuff by foreign material during transport.

Trace-element abundances for the rhyolites of Stevens Peak and Two-and-a-Half-Mile Creek are distinct from the upper, massive welded zone of the Arbon Valley Tuff Member; their relationships in the rubidium-strontium-zirco-

Table 5. Major-oxide chemical analysis of rhyolite of west Pocatello, Idaho.

[Sample FH86–2685B; sample site E, fig. 1]

Oxide	Weight percent
SiO_2	73.3
Al_2O_3	12.4
Total iron (as FeO)	2.91
MgO	.20
CaO	.96
Na_2O	3.19
K_2O	4.80
TiO_2	.39
P_2O_5	.08
MnO	.02
LOI (loss on ignition)	.83
Total	99.08

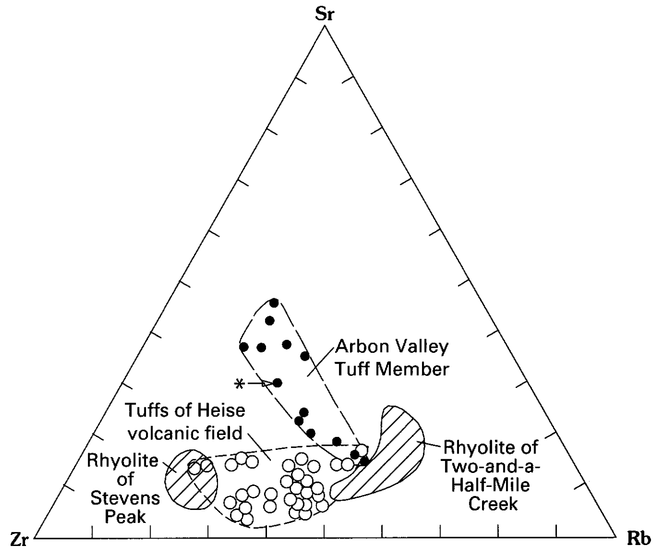

Figure 7. Strontium-rubidium-zirconium (Sr-Rb-Zr) ternary diagram comparing samples from tuffs of the Heise volcanic field (open circles; 6.7 to 4.3 Ma; Kellogg and Marvin, 1988) with those from the Arbon Valley Tuff Member (solid circles; 10.2 Ma), Snake River Plain, Idaho. Also shown are fields for the rhyolite of Stevens Peak and the rhyolite of Two-and-a-Half-Mile Creek (Kellogg and Marvin, 1988). Star with arrow indicates sample DR724D3 from sample site D (fig. 1), the only sample analyzed from the northern margin of the Snake River Plain. Data are given in table 6.

nium system are also shown on figure 7. Compared to the Arbon Valley Tuff Member, the two rhyolite flows are relatively low in strontium relative to zirconium and rubidium. Major-element abundances, however, are not significantly different between the two flows and the Arbon Valley Tuff Member (Kellogg and Marvin, 1988, fig. 6). The two flows are also distinct from each other in their trace-element (but not major-element) geochemistry; compared to the rhyolite of Two-and-a-Half-Mile Creek (as well as the Arbon Valley Tuff Member), the rhyolite of Stevens Peak is significantly enriched in zirconium relative to strontium and rubidium.

SOURCE OF THE ARBON VALLEY TUFF MEMBER

The source of the Arbon Valley Tuff Member is not known, although several lines of evidence suggest that it may have erupted from a now-buried caldera north and(or) west of Blackfoot. The lines of evidence suggesting a buried caldera are:

1. The tuff is thickest (about 60 m) between about 25 km east and 5 km south of Blackfoot. Preliminary observations suggest that maximum lithic-clast size also occurs in the region of maximum thickness, indicating a proximal facies.

2. Determined ages for the Arbon Valley Tuff Member are slightly older than the ages of two rhyolite flows south of Blackfoot, which suggests that the flows may represent fissure eruptions from ring dikes that formed the margin of the caldera. However, trace-element contents of the flows are distinct from those of the Arbon Valley Tuff Member. This difference may be due to tapping of different levels of a zoned magma chamber.

3. A resistivity sounding profile across the Snake River Plain through Blackfoot revealed a deep, approximately 15 km wide resistivity low that extends to a depth of at least 6 km (fig. 8). Zohdy and Stanley (1973) suggested that this zone of low resistivity is a structural trough that may be a buried caldera. This interpretation is consistent with the observation that intracaldera regions are commonly hydrothermally altered (Christiansen and Blank, 1972; Lipman and Sawyer, 1985); the presence of hydrothermal clay substantially lowers the resistivity of a rock.

4. The resistivity low coincides closely with an approximately 20 milligal Bouguer-gravity low determined by a detailed gravity survey along the same line of profile (D.R. Mabey, U.S. Geological Survey, retired, oral commun., 1991, based on unpub. data, 1973). The gravity data may also reflect a thick, hydrothermally altered intracaldera tuff. Regional Bouguer gravity data from the same area (Bankey and Kleinkopf, 1988), which did not incorporate Mabey's unpublished gravity profile, do not reveal an obvious circular or oval gravity low, although their map of the horizontal gravity gradient does reveal a subtle ring of high gradients that approximately coincides with the proposed limits of the caldera shown on figure 1. Mabey (1978) pointed out, however, that calderas are not always expressed by a gravity low, as demonstrated by the Henrys Fork (formerly Island

Table 6 (below and facing page). Selected trace-element abundances for samples of the Arbon Valley Tuff Member of the Starlight Formation, rhyolites of Two-and-a-Half-Mile Creek and Stevens Peak, and tuffs of the Heise volcanic field, Idaho.

[The tuff of Blue Creek was sampled southeast of Rexburg, Idaho, and does not crop out near Blackfoot. Major-element analyses for some of these samples are in Kellogg and Marvin (1988). Samples analyzed on a Kevex X-ray fluorescence analyzer. Analysts: K.S. Kellogg and R.A. Yeoman. Values are in parts per million]

Sample No.	Rb	Sr	Y	Zr	Nb	Zn
Arbon Valley Tuff Member						
YS 621	166	46	37	125	39	64
YS 622	127	71	23	160	25	58
K 659	77	196	28	197	24	54
BB 667	84	175	17	221	20	9
BB 671	160	54	37	134	39	15
BB 672	103	174	22	194	23	9
BB 675	60	183	10	160	21	26
GO 763	124	167	35	187	22	24
Rhyolite of Two-and-a-Half-Mile Creek						
BB 609A	207	61	28	123	12	41
BB 609B	211	61	30	125	13	50
FH 611	181	104	25	119	13	46
BB 715	189	52	25	110	16	15
BB 716	193	60	28	116	21	23
BB 720	188	96	28	110	22	26
BB 721	188	55	34	121	18	22
FH 726	182	66	29	123	15	26
FH 727	193	65	26	114	18	21
BB 728	187	66	25	121	14	35
BB 729	187	37	42	216	38	22
FH 732	189	53	28	113	17	30
BB 736	189	60	27	123	17	33
BB 738	192	52	31	123	19	16
BB 739	200	65	25	117	19	23
BB 743	192	60	20	121	18	12
Rhyolite of Stevens Peak						
BF 601	157	81	64	411	40	83
BF 602	165	69	61	414	44	83
BF 606	162	96	64	477	44	87
BF 624	163	92	53	435	47	37
BF 625	165	90	57	425	49	35
BF 639	144	116	53	408	39	24
BF 650	168	98	52	442	43	31
BF 651	159	99	51	402	45	37
BF 690	162	84	49	413	50	47
BF 691	173	95	50	438	49	57
BF 692	150	91	48	413	45	50

Sample No.	Rb	Sr	Y	Zr	Nb	Zn
			Heise volcanic field Tuff of Blacktail (Morgan, 1992)			
K 612	195	49	34	176	37	69
K 623	204	45	40	254	33	72
K 631	185	78	40	244	40	29
K 632	191	67	36	234	33	28
BF 663	208	39	26	249	41	23
BF 664	205	57	25	121	19	41
BF 706	201	53	52	239	38	14
BF 707	194	59	31	259	44	26
BF 710	171	58	37	213	41	18
BF 731	193	48	29	113	18	25
BF 752	197	46	49	235	41	33
K 761	197	66	42	225	40	2
K 762	182	74	44	236	38	26
			Heise volcanic field Tuff of Blue Creek (Morgan and others, 1984)			
K 614	173	21	62	183	52	74
K 633	174	36	55	209	42	21
			Heise volcanic field Tuff of Kilgore (Morgan and others, 1984)			
BF 603	183	29	57	234	42	74
BF 604	172	48	51	219	39	71
K 616	170	21	61	328	45	87
K 617	180	38	67	383	48	73
K 618	148	95	56	452	42	87
BF 620	171	17	61	327	46	63
BF 626	175	22	46	223	45	33
BF 627	180	33	45	340	53	39
BF 629	170	18	59	315	51	31
BF 630	166	42	53	328	54	34
K 634	167	28	49	216	45	31
BF 643	179	39	47	206	44	58
BF 644	162	24	49	196	44	47
BF 649	164	92	59	372	50	33
BF 709	180	61	54	208	47	32
YS 711	199	37	43	221	37	38

Park) caldera in the northeastern Snake River Plain (Blank and Gettings, 1974; Bankey and Kleinkopf, 1988).

5. The region underlain by the proposed caldera is devoid of known basaltic vents, the lack of which may be due to the presence of low-density rhyolitic intracaldera fill that acted as a buttress to ascending basaltic magma (Kuntz and Covington, 1979; Kuntz and others, 1992). Kuntz and Covington (1979) suggested the name "Tabor caldera" for the proposed buried feature, although no outflow tuff from the caldera was identified.

Although the evidence for a caldera near Blackfoot remains somewhat speculative, we present, as a working hypothesis, the location of part of a caldera rim on figure 1, based on the locations of the two silicic lava flows, the coincidence of the two limits of the resistivity and gravity lows, and the area of no known basaltic vents.

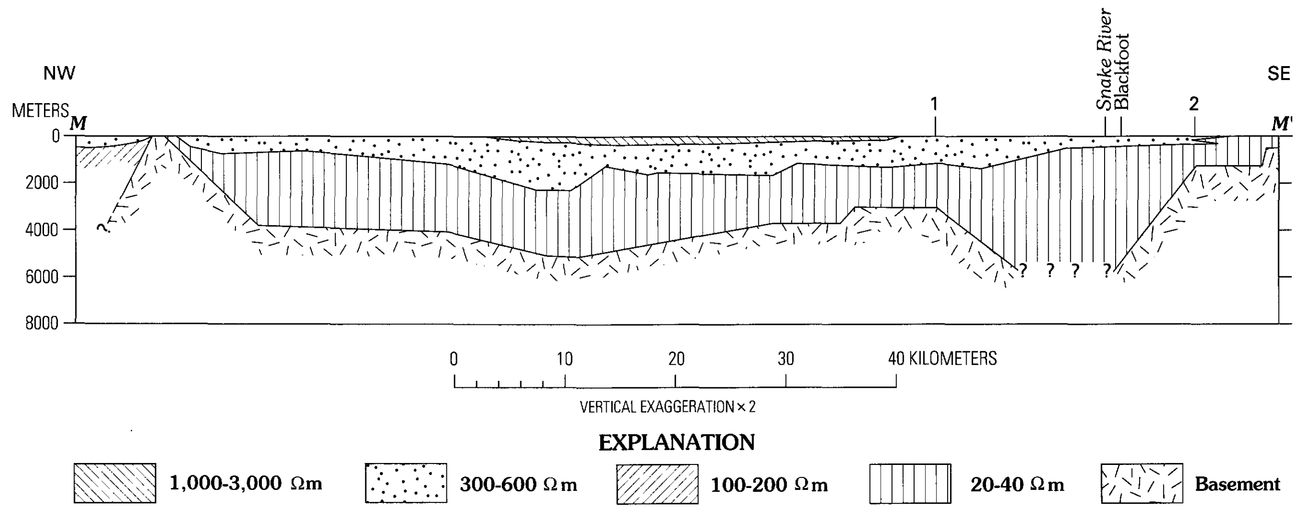

Figure 8. Cross section along the resistivity sounding line across the eastern Snake River Plain, Idaho (fig. 1; from Zohdy and Stanley. 1973). Points 1 and 2 are shown on both the cross section and on figure 1 for reference. Resistivity is given in ohm-meters (Ω-m). BASEMENT is low-resistivity rock below the resolution of the resistivity method. Queries indicate resistivity boundary not resolved.

CONCLUSIONS

A major ash-flow eruption in the eastern Snake River Plain deposited the crystal-rich, biotite-bearing Arbon Valley Tuff Member of the Starlight Formation about 10.20±0.06 Ma and presumably reflects the formation of a major caldera. Trace-element data indicate that the Arbon Valley Tuff Member is chemically distinct from rocks of the Heise volcanic field, the next younger rhyolitic volcanic field in the eastern Snake River Plain, which was active between 7.9 and 4.3 Ma. The location of the source caldera for the Arbon Valley Tuff Member remains speculative, but a variety of field and geophysical evidence suggests that Blackfoot, Idaho, is above the northeastern part of the approximately 40 km diameter caldera. Following Kuntz and Covington (1979), we suggest the name "Tabor caldera" for this mostly buried feature.

The chemical and petrologic character of the Arbon Valley Tuff Member supports the idea of chemically distinct magmatic cycles of rhyolitic volcanism, each of several million years duration (Morgan and others, 1984; Pierce and Morgan, 1992), that migrated northeastward along the Snake River Plain. Thus, the Arbon Valley Tuff Member is part of the speculative, approximately 10.2 Ma Picabo volcanic field of Pierce and Morgan (1990), which was emplaced several million years before the 6.7-4.3-Ma Heise volcanic field, which in turn was followed by the 2.0-Ma to present Yellowstone plateau volcanic field (Christiansen and Blank, 1972).

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