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Ash-flow fissure vent in west-central Nevada

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ABSTRACT

An east-trending fissure vent filled with welded tuff is well exposed for nearly 1 km on the west flank of Gabbs Valley in northeastern Mineral County, Nevada. In its deepest exposed part, the vent is about 60 m wide. At the top of an exposure, however, where the tuff in the vent merges with an ash-flow tuff cooling unit, the vent is about 460 m wide. The abrupt widening of the vent upward through a vertical distance of only about 400 m from the base of the exposure to the top was probably accomplished by a combination of explosive action and forcible shoving aside of the country rocks.

The ash-flow cooling unit continuous with the tuff in the fissure is the youngest of three genetically related units that are sporadically exposed in the vicinity of Gabbs Valley. Stratigraphic and structural relationships in the vicinity of the fissure suggest that the fissure is located on the west flank of a cauldron that is nearly completely buried in Gabbs Valley. The "vent tuff" and the underlying genetically related units in the Gabbs Valley area are highly differentiated rhyolites characterized by high silica and low Ca and Mg contents. The tuffs were erupted 25 m.y. ago at virtually the same time that other chemically and mineralogically similar tuffs were erupted farther to the east in central and east-central Nevada.

INTRODUCTION

A 25-m.y.-old ash-flow fissure vent is well exposed on the west flank of Gabbs Valley in T. 12 N., R. 34 E., in northeastern Mineral County, Nevada, at lat 38°53′40″N and long 118°11′00″W (Figs. 1 and 2). The fissure is about 460 m wide in its widest exposed part (Figs. 1 and 2) and trends eastward. The northern side is exposed for a distance of 1 km between the lowest (deepest) outcrop at the west end and a fault contact at the east end; the southern side is exposed for a distance of 0.6 km. On the southern side, the fissure merges with a densely welded ash-flow sheet that caps an east-dipping cuesta within which the fissure vent is exposed. The densely welded ash-flow sheet is the youngest of three genetically related cooling units that form an ash-flow field traceable for at least 24 km to the northwest of western Gabbs Valley and for an equal distance to the east. The maximum extent of the ash-flow field in these directions and the distribution of individual cooling units within it have yet to be determined, but their combined volume exceeds several hundred cubic kilometres.

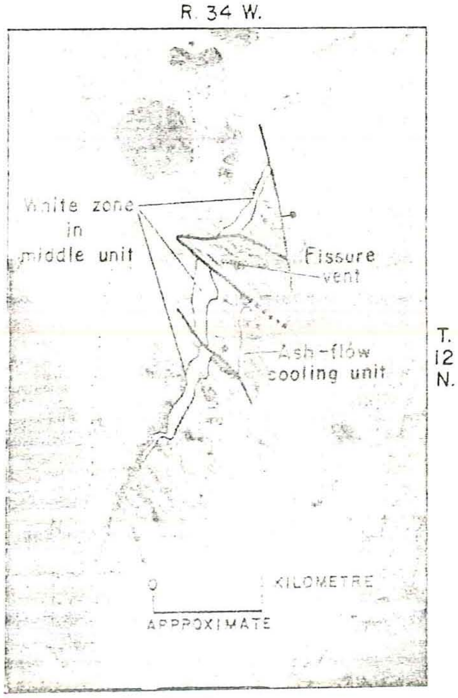


Figure 1. Aerial view of fissure vent and contiguous ash-flow cooling unit in Gabbs Valley, Mineral County, Nevada. For identification of adjacent outcrops see Figure 2.

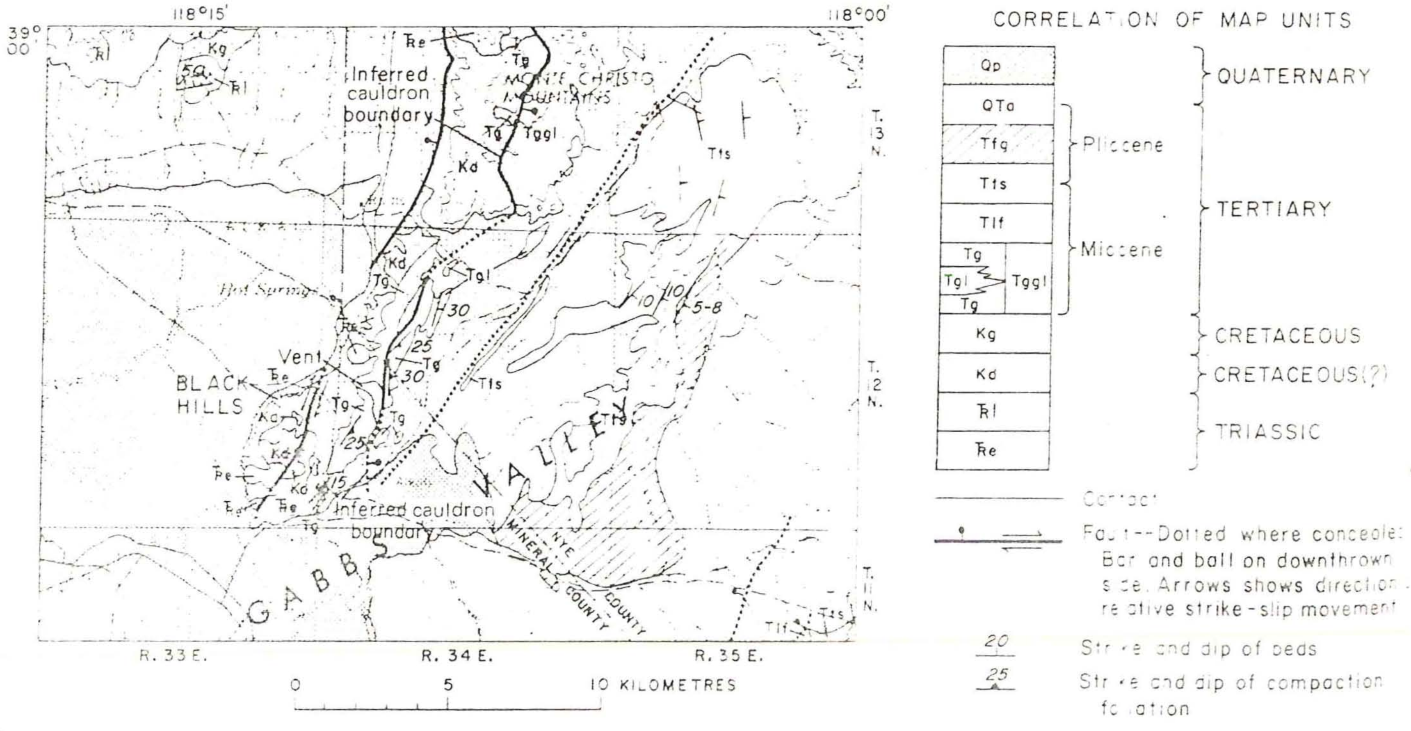
GEOLOGIC SETTING

The fissure vent (Figs. 1 and 2) lies along the west side of Gabbs Valley, just west of a zone of arcuate faults that we believe are cauldron boundary faults. This conclusion is based on relationships near the vent and along the east flank of the Monte Cristo Mountains to the north. Here, two thick (300± m) welded tuff units occur that probably correlate with two much thinner cooling units that underlie the vent tuff just west of the inferred cauldron wall. We think that the increased thickness of these cooling units east of the inferred cauldron wall reflects subsidence of the cauldron concomitant with tuff eruption. North of the vent area, along the east flank of the Monte Cristo Mountains, pyribole-rich lavas of intermediate composition and rhyolitic plugs crop out that are intercalated with the intracauldron ash flows (Fig. 2).

STRUCTURE OF FISSURE AND RELATIONSHIP TO WALL ROCK

The fissure (Figs. 3, 4, and 5) and associated ash-flow units have been tilted approximately 25° eastward. By restoring the beds to horizontal (and the fissure to vertical), it is evident that the fissure is exposed to a depth of about 400 m. Throughout this vertical distance, the fissure-filling rock is densely welded tuff and has a persistent black vitrophyre adjacent to the wall rock on both sides. In the lowest exposure, the fissure is only about 60 m wide, and the rock is nearly all vitrophyre. Here, the eutaxitic foliation is vertical and parallel to the wall-rock contact. In a narrow devitrified central part, the foliation dips about 60° toward the interior from both sides. From this deepest exposure to the topmost (easternmost) exposure, the foliation in the vitrophyre and in the adjacent devitrified part consistently strikes parallel to the contact on both sides; however, the foliation rarely is vertical and generally dips at angles of 45° to 75° toward the interior of the vent. In the topmost exposures of the vent, the dips are as gentle as 30° in places. On the south side, where the vent tuff merges with an ash-flow cooling unit at the surface, the dip gradually changes from northeast within the fissure to east and thence southeast to conform to the attitude in the ash flow, which dips 25° to the southeast. The latter attitude is conformable with the underlying cooling units.

The abrupt widening of the vent from about 60 to 460 m through a vertical distance of about 400 m was probably accomplished by a combination of eruptive events that explosively ejected the country rocks and then forcibly shoved them aside. Near the top of the vent, the country rocks are bulged slightly upward away from the fissure (Figs. 3 and 4) and are



LIST OF MAP UNITS

Qp	Playa deposits (Quaternary)	Tgl	Intermediate lavas and rhyolitic plugs of Gabbs Valley (Miocene)
QTa	Alluvium and colluvium (Quaternary and Tertiary)	Tggl	Tuffs, lavas, and plugs of Gabbs Valley, undivided (Miocene)
Tfg	Fanglomerate (Pliocene)	Kg	Granitic rocks (Cretaceous)
Tts	Tuffaceous sedimentary rocks (Pliocene and Miocene)	Kd	Dioritic rocks (Cretaceous?)
Tlf	Intermediate lavas of Mount Ferguson (Miocene)	Ŧl	Luning Formation (Triassic)
Tg	Ash-flow tuffs of Gabbs Valley (Miocene)	Ŧe	Excelsior(?) Formation (Triassic?)

Figure 2. Reconnaissance geologic map of welded tuff fissure-vent area. (Base from U.S. Geological Survey Walker Lake topographic quadrangle, scale 1:250,000, 1957.)

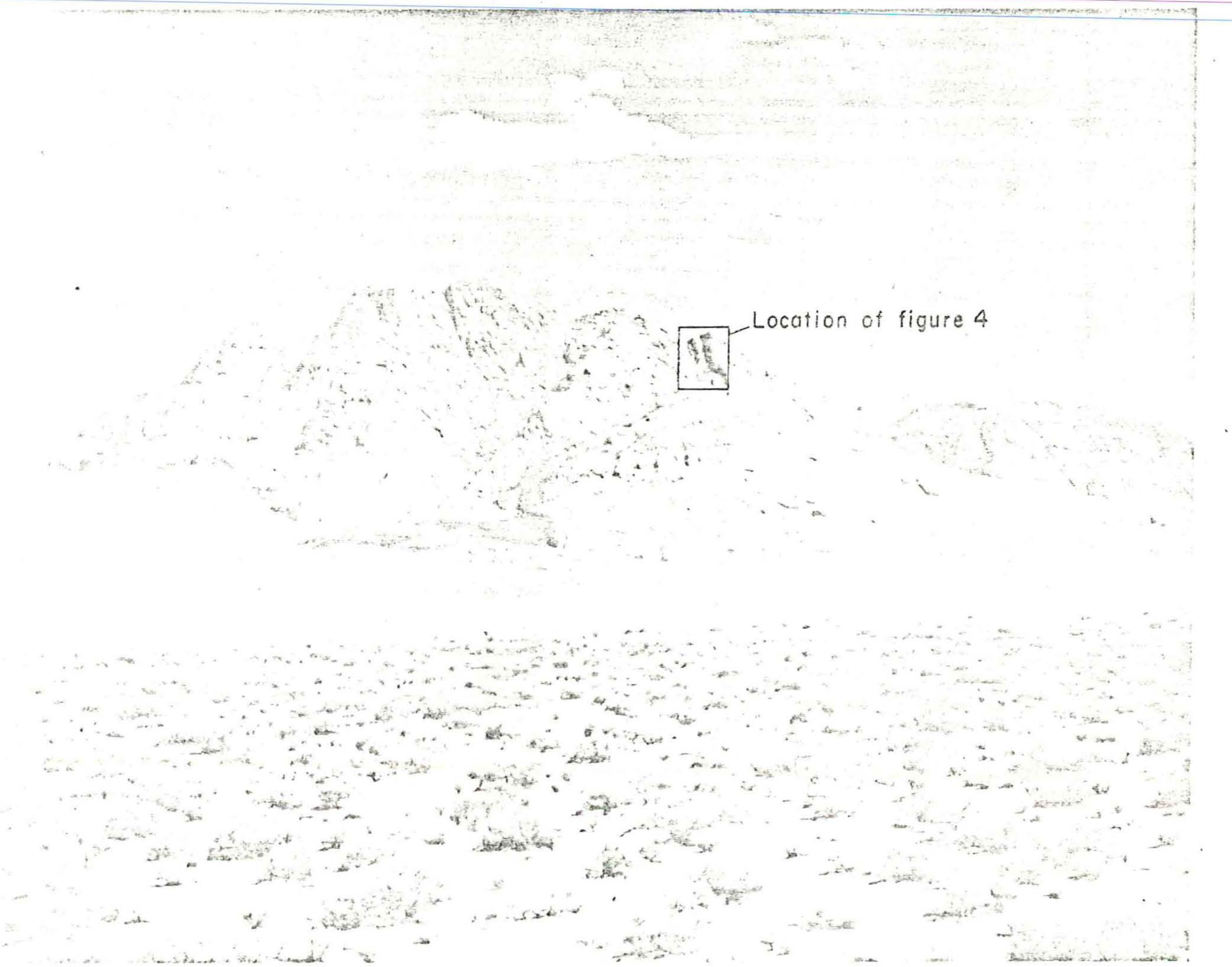


Figure 3. View, looking eastward, of fissure vent filled with welded tuff. Photograph taken about 0.6 km west of vent; relief in photograph is about 180 m. Wall-rock strata comprise three cooling units of welded tuff that dip 25°–30° away from observer. Thin cooling unit at skyline on extreme right of photograph is continuous with vent-filling tuff. View of contact zone along south flank of fissure at skyline is shown on Figure 4.

shattered for a distance of as much as [illegible] m from the vent. In the shattered zone, attitudes are chaotic. In lower exposures, in contrast, the country rocks are not shattered, and strikes and dips that conform to the general attitude of the cuesta are observed within a few metres of the contact with vent tuff.

The foliation defined by collapsed pumice within the fissure (Figs. 5 and 6) does not necessarily indicate that tuff fell back into the fissure zone when eruptions ceased. The internal structure probably results entirely from simple compaction of the inflated magma column. It seems likely that when eruptions ceased, the walls of the fissure closed completely or nearly so at some shallow depth below the present exposure, and access to any deep-seated void created by the explosive tuff eruptions was blocked.

We have considered the possibility that the fissure described herein is a large canyon that was filled by the ash-flow tuff. We reject this hypothesis on the basis of the following observations: (1) the walls are too regular and too steep to be of canyon origin, considering the alternating soft and hard rocks that form the wall rock; (2) no erosional rubble is present along the walls; (3) no erosional origin could logically account for the shatter zones adjacent to the fissure; and (4) no evidence has been found elsewhere of significant erosion between the cooling units that make up the Gabbs Valley ash-flow field.

The drastic thinning of zones within the older units away from the vent area strongly suggests that the fissure coincided closely with an earlier vent that fed the older ash-flow cooling units. For example, a zone of nearly white, partially welded

Figure 4. View of south flank of fissure at skyline of Figure 3. Massive rock on left is devitrified vent-filling tuff. Note shattered appearance of wall rock on right. Relief in photograph is about 45 m.

tuff in the middle unit thins southward from a thickness of about 60 m near the fissure to zero within a distance of about 2 km. It also thins northward but is cut off by a fault (Fig. 1). Other zones in the oldest unit thin in a similar manner.

COMPARISON WITH OTHER TUFF "VENTS"

Exposed vents filled with welded tuff apparently are extremely rare in welded tuff terranes. This is the only vent filled with tuff that we have found during mapping of several thousand square kilometres of volcanic terrane in central and southern Nevada, an area in which hundreds of volcanic centers are exposed. This type of filled vent apparently is equally rare on a world-wide basis, and very few of those that have been described have been well documented, according to Smith (1960, p. 817–818). Several obvious circumstances can account for a paucity of welded tuff vents: (1) many vents probably are still covered by their own ejecta; (2) because the vents close off at such shallow depth, subsequent erosion rapidly obliterates them; (3) many vents that fed ash flows were later filled with liquid lava; and (4) many vents were destroyed by cauldron collapse (R.L. Smith, 1975, written commun.).

We have observed small welded tuff apophyses at several localities in very thick cooling units that we attribute to late-stage "diapiric" resurgence of tuff from near the bases of thick cooling units. Lipman (1964, p. B79) described a small welded tuff dike in southern Nevada as representing an underlying nonwelded tuff that was remobilized and intruded into a dilatant tensional fracture in the still-hot sheet. These small features observed by Lipman and us are obviously not fissure feeders of the thick ash flows they intrude.

Cook (1968, p. 107) described ignimbrite vents in the Hot Creek Range, Nevada. These vents are now filled with rock having textures considered by Cook to be transitional between vitroclastic and fluidal. The Hot Creek Range vicinity has subsequently been mapped in detail by Quinlivan and Rogers (1974), who concur with Cook's observations. They believed that the fissures gave rise to a thick ash-flow sheet, which is termed the tuff of Kiln Canyon (Quinlivan and Rogers, 1974). We have observed the fissures in the Hot Creek Range, and, except for the texture of the fissure rock, they are generally similar to the fissure vent described herein.

Korringa and Noble (1970) and Noble and others (1970) described a linear vent area in northwestern Nevada. The vents are defined both by flow patterns in very fluid comendite lavas that were erupted immediately after the Miocene Soldier Meadow Tuff was erupted and by the local presence of abundant welded air-fall tuff in the upper part of the Soldier Meadow Tuff. According to Noble and others (1970), the lavas are identical with the Soldier Meadow Tuff and, in most places, cooled and crystallized together with the underlying tuff, as the absence of a complete cooling break shows.

MINERALOGY AND PETROLOGY

The tuffs of Gabbs Valley are light red to reddish brown, and most flows are characterized by relatively low phenocryst content (Table 1). The tuffs megascopically and mineralogically resemble the Shingle Pass Tuff (Cook, 1965) and the Bates Mountain Tuff (Sargent and McKee, 1969), although minor but significant petrographic differences indicate that the sequences do not share any cooling units in common. In addition, the known distribution patterns of the three units indicate that they were erupted from different centers. A K-Ar date on sanidine from the "vent tuff" yields a date of 25.3 ± 0.9 m.y. B.P. (R. F. Marvin, 1974, written commun.). This date is about the same as that obtained for the Shingle Pass Tuff in east-central Nevada and is about 2 m.y. older than the date given for the Bates Mountain Tuff of central Nevada (Sargent and McKee, 1969; Ekren and others, 1974; Grommé and others, 1972). These relationships provide another example of tuffs and lavas of very similar composition that were erupted from widely separated volcanic centers in the Great Basin within a very narrow time interval (see, for example, Anderson and Ekren, 1968). Like the Shingle Pass and Bates Mountain

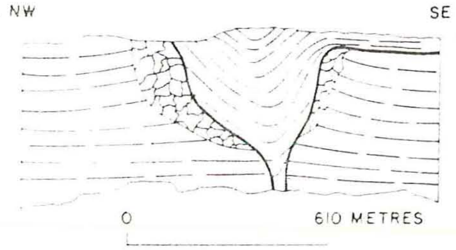


Figure 5. Sketched cross section showing relationships between fissure and wall rock and showing general attitude of foliation within fissure and adjacent wall rock (fissure restored to vertical position; shattered wall rock shown by broken pattern).

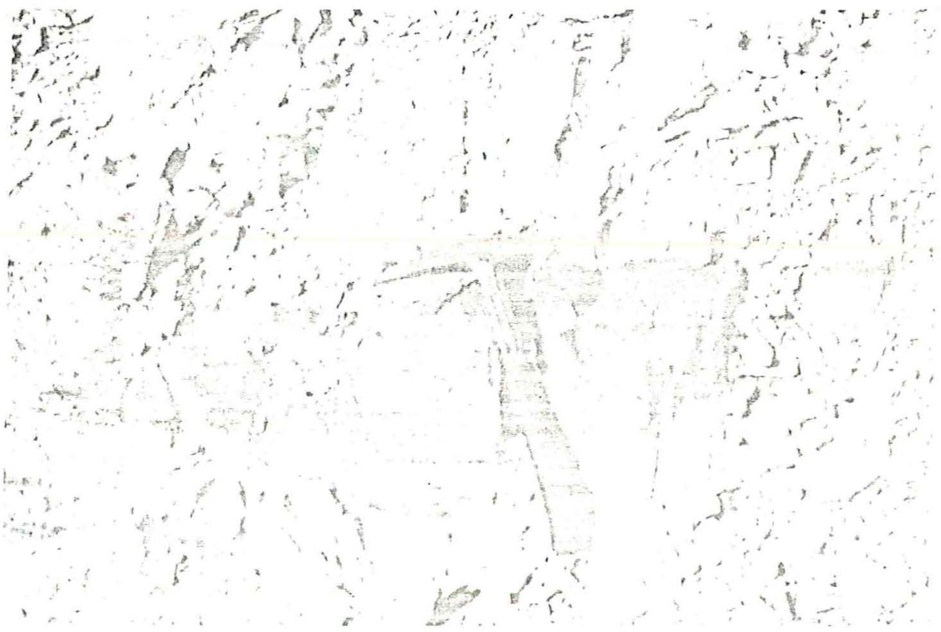


Figure 6. View of large collapsed pumice within vent tuff along south flank of fissure. Pumice strikes parallel to contact with wall rock. Camera held parallel to plane of foliation which dips 45° into outcrop.

TABLE 1. CHEMICAL AND NORMATIVE COMPARATIVE COMPOSITION (IN WEIGHT PERCENT) OF RHYOLITE TUFFS OF GABBS VALLEY AND INTERCALATED INTERMEDIATE LAVA

Sample no.	1	2	3	4
Field no.	762A	762B	774F	778
Laboratory no.	D169996	D169997	D169998	D169999
		Chemical composition		
SiO_2	75.10	74.78	76.82	58.10
Al_2O_3	14.21	14.34	13.50	20.75
FeO	1.19	1.01	1.31	5.51
MgO	0.02	0.02	0.30	2.84
CaO	0.58	0.59	1.12	5.48
Na_2O	3.61	3.98	1.82	4.21
K_2O	5.13	5.11	4.96	2.15
TiO_2	0.13	0.13	0.16	0.85
P_2O_5	..	..	..	..
MnO	0.03	0.02	0.02	0.10
Total	100.00	99.98	100.01	99.99
		Normative composition		
Q	32.284	29.970	43.417	5.349
C	1.666	1.173	3.098	1.536
or	30.287	30.206	29.322	12.692
ab	30.573	33.719	15.372	35.645
an	2.870	2.948	5.562	27.178
en	0.051	0.051	0.750	7.080
fs	2.019	1.680	2.183	8.905
hy	2.07	1.73	2.93	15.99
il	0.251	0.253	0.296	1.616
Total	100.001	100.000	100.000	100.001
Salic group	97.680	98.016	96.771	82.400
Femic group	2.321	1.984	3.229	17.601
Differentiation index	93.144	93.895	88.112	53.686

Note: Values for SiO_2, Al_2O_3, TiO_2, total Fe as FeO, and MnO by X-ray fluorescence; analyst, J. S. Wahlberg. MgO, CaO, Na_2O, K_2O by atomic absorption; analyst, Wayne Mountjoy.

Sample localities and descriptions:

1. Basal vitrophyre of "vent tuff" collected about 200 m south of fissure; homogeneous glass; 10 percent phenocrysts comprising the following percentages of minerals: quartz, 22; alkali feldspar, 47; plagioclase, 27; biotite, 1; opaque minerals, 2.2. Accessories include 1 grain allanite per thin section.
2. "Vent tuff," densely welded, devitrified; collected about 10 m above base and sample 1; 8 percent phenocrysts comprising the following percentages of minerals: quartz, 28; alkali feldspar, 40; plagioclase, 28; biotite, 1.5; opaque minerals, 1.5.
3. Intracauldron tuff, possibly the same cooling unit as that which directly underlies "vent tuff" outside of the cauldron. Tuff that appears to lap onto cauldron wall is composed of pre-Tertiary sedimentary rocks. Outcrop sampled is about 2.4 km north of fissure vent and about 100 m above base of cooling unit. Lithic-rich altered former glassy tuff; 20 percent phenocrysts comprising the following percentages of minerals: quartz, 25; alkali feldspar, 38; plagioclase, 31; biotite, 1; altered mafic minerals, 4. Plagioclase is altered to nearly opaque clay and alkali feldspar.
4. Hornblende-pyroxene trachyandesite lava. Rock crops out about 3 km northeast of fissure vent within the inferred cauldron. It contains about 27 percent phenocrysts comprising the following percentages of minerals: plagioclase, 59; hornblende, 28; clinopyroxene, 6.1; orthopyroxene, 6.9; opaque minerals are confined to dense groundmass.

tuffs of Gabbs Valley (Table 1) differentiated rhyolites charac- high silica and low to very low contents. The higher Mg and nts of sample 3 in Table 1 possibly ed by abundant small lava xeno- termediate composition. Accord- le (1972, p. 143-144), these fferentiated rhyolites are similar ound in areas of bimodal basalt- canism, and they represent a magmatism in the Great n a continuation of -alkalic volcanism.

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