Geol

GL02912

Eureka Valley Tuff, East-Central California and Adjacent Nevada

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ABSTRACT

The Eureka Valley Tuff consists of two major ash-flow sheets and a local overlying sequence of ash-flow tuff erupted from vents within the Little Walker caldera 11 mi west-northwest of Bridgeport, in east-central California. The lower of the two major ash-flow sheets, here named the Tollhouse Flat Member, is the "biotite-augite-latite" of Ransome (1898). The overlying By-Day Member can readily be identified by the absence of phenocrystic biotite and by paleomagnetic and other petrographic criteria. The recognition of the distinctive By-Day Member above the Tollhouse Flat Member both in the Bridgeport area and west of the Sierra crest unequivocally demonstrates the generally accepted correlation of the latitic ash-flow tuffs of the two areas. K-Ar age determinations indicate that the three members of the Eureka Valley Tuff were erupted within a very short interval of time about 9.5 m.y. ago.

INTRODUCTION

The Eureka Valley Tuff of the central Sierra Nevada, California, and adjacent Nevada was first studied by Ransome (1898) in the latter part of the 19th century. In 1948 Slemmons (1953) recognized, from the excellent description of the unit given by Ransome, that Ransome's "biotite-augite-latite" was composed of welded tuff. Smith (Ross and Smith, 1961) independently recognized the pyroclastic character of the unit at about the same time. Slemmons (1953) traced the biotite-augite-latite eastward from the Sierra foothills in the vicinity of Sonora, California, across Sonora Pass on the Sierra crest. Johnson (1951), Halsey (1953), Gilbert and others (1968), Chesterman (1968), and Al-Rawi (1969) recognized the unit in the southern Sweetwater Mountains, the Bodie Hills, and other localities to the east of the Sierra Nevada (Fig. 1). Radiometric age determinations by Dalrymple (1963; 1964; Dalrymple and others, 1967) and Al-Rawi (1969; Gilbert and others, 1968) supported these correlations. In his review of the Cenozoic geology of the central Sierra Nevada, Slemmons (1966) formally named the ash-flow sequence that includes the biotite-augite-latite of Ransome the Eureka Valley Member of the Stanislaus Formation.

Reconnaissance mapping in the drainage area of the Little Walker River and vicinity, prompted by consideration of the regional distribution of the Eureka Valley Tuff and other geologic relations, led to the discovery of the Little Walker caldera, located 11 mi west-northwest of Bridgeport, California (Fig. 1; Noble and others, 1969; Priest and others, 1974; W. R. Dickinson and D. C. Noble, unpub. data). The caldera marks the source area of the Eureka Valley Tuff.

This paper describes the stratigraphy, field characteristics, and petrography of the Eureka Valley Tuff and proposes revisions in the stratigraphic nomenclature of the unit. Subsequent papers will discuss the major element, minor element, and isotopic geochemistry of the Eureka Valley Tuff; the geology of the Little Walker caldera; and the geochemistry of genetically related potassium-rich intermediate lavas in the vicinity of the Little Walker caldera.

STRATIGRAPHY AND PHYSICAL CHARACTERISTICS

We have found that the Eureka Valley Member of the Stanislaus Formation of Slemmons (1966) consists of two major, lithologically distinctive ash-flow sheets and a much smaller local overlying unit of ash-flow tuff. The recognition of these two major ash-flow sheets both east and west of the Sierra crest unequivocally proves the previously suggested correlation of the quartz latite ash-flow tuffs of these areas (compare Mackin, 1960; Christiansen and others, 1968).

It is now common practice (for example, see Christiansen and others, 1968) to assign formational status to a sequence of genetically related ash-flow sheets and member status to the individual sheets. We therefore here raise the Eureka Valley Member to formational rank, rename it the Eureka Valley Tuff, and subdivide the new formation into two formal members (the Tollhouse Flat Member and the overlying By-Day Member) and an informal upper member.

Raising the Eureka Valley to formational status requires revision in the nomenclature of associated units. We therefore raise the Table Mountain Latite Member and the Dardanelles Member of the Stanislaus Formation to formational rank, renaming them the Table Mountain Latite and Dardanelles Formation, and we raise the Stanislaus Formation to group rank. The Stanislaus Group thus includes, from bottom to top, the Table Mountain Latite, the Eureka Valley Tuff, and the Dardanelles Formation (Table 1).

The ridge between Bald Peak and Red Mountain in the Dardanelles quadrangle (scale, 1:62,500) was designated as the type locality of the Eureka Valley Member by Slemmons (1966). Because of the relative inaccessibility of this type locality and because rocks of the upper member are not present there, we consider it desirable to designate a reference section. This section is located on the east bank of the West Walker River at Tollhouse Flat (lat 38°25′35″ N., long 119°26′45″ W.; Fig. 1). The Tollhouse Flat and By-Day Members also are well developed at the following selected localities: lat 38°25′05″ N., long

119°25′55″ W.; lat 38°23′20″ N., long 119°21′45″ W.; and lat 38°20′45″ N., long 119°14′45″ W. Figure 1 shows the general present distribution of the Eureka Valley Tuff; details of these exposures are shown on the maps of Ransome (1898), Koenig (1963), Strand and Koenig (1965), Strand (1967), Kleinhampl and others (1974), D. B. Slemmons (unpub.), W. R. Dickinson (unpub.), D. C. Noble (unpub.), and in various of the other references cited here and in the above-listed publications.

Tollhouse Flat Member

The Tollhouse Flat Member, here named for exposures at the reference section located on the east side of Tollhouse Flat, is the most voluminous and widespread ash-flow sheet of the Eureka Valley Tuff; areal extent in an east-west direction is more than 90 mi (Fig. 1). The member is identical with the biotite-augite-latite of Ransome (1898: Table 1). The Tollhouse Flat Member is 210 ft thick at the reference section and locally reaches a thickness of more than 300 ft. The unit varies markedly in thickness because of the unevenness of the surface on which it was deposited, but in general, it thins away from the Little Walker caldera.

The member is composed typically of densely to moderately welded, light- to dark-gray tuff containing abundant phenocrysts and lithic fragments. Eutaxitic structure is strikingly well developed, with some collapsed pumice fragments exceeding a foot in maximum diameter, particularly near the Little Walker caldera. Some of the pumice fragments show relatively little compaction, even in densely welded portions of the unit, and some appear to have been nearly unvesiculated lumps of molten magma (compare Gibson and Tazieff, 1967; Gibson, 1970; Noble and others, 1968; Korringa, 1972). In some intervals, the inner portions of such large equant blocks are primarily devitrified and partly expanded by the release of volatiles on crystallization. This produces large, irregular lithophysal cavities, whereas the margins of the blocks have remained glassy.

Phenocrysts consist of oscillatory-zoned plagioclase (about An_{45})[1] with smaller amounts of biotite, clinopyroxene, magnetite, and apatite. Hornblende laths of apparent intratelluric origin have been observed in several thin sections. No grains of hypersthene, olivine, or quartz have been found in thin sections of collapsed pumice, and thus, rare grains of these minerals observed in some thin sections of tuff are interpreted as accidental material incorporated during eruption and (or) transport. Prisms of apatite typically are included within other phenocryst minerals, as are small grains of magnetite, biotite, and clinopyroxene. Phenocryst minerals commonly occur in incipient glomeroporphyritic clusters in collapsed pumice fragments. Phenocrysts are much less abundant in the pumice fragments (about 15 volume percent) than in the remainder of the nonlithic portion of the welded tuff, indicating that appreciable amounts of fine-grained glassy material were removed during eruption and transport (compare Lipman, 1967; Walker, 1972; Korringa, 1972). Lithic fragments, composed dominately of lavas of intermediate composition, and less common fragments of pre-Cenozoic granitic and metamorphic rocks, make up about 15 to 20 percent of most rocks.

In many outcrop sections, as many as five or more partings between successive ash flows or sequences of ash flows can

[1]The extinction angle measure to (010) in the a-normal position is 30° for plagioclase from the Tollhouse Flat Member and 34° for plagioclase from the By-Day Member.

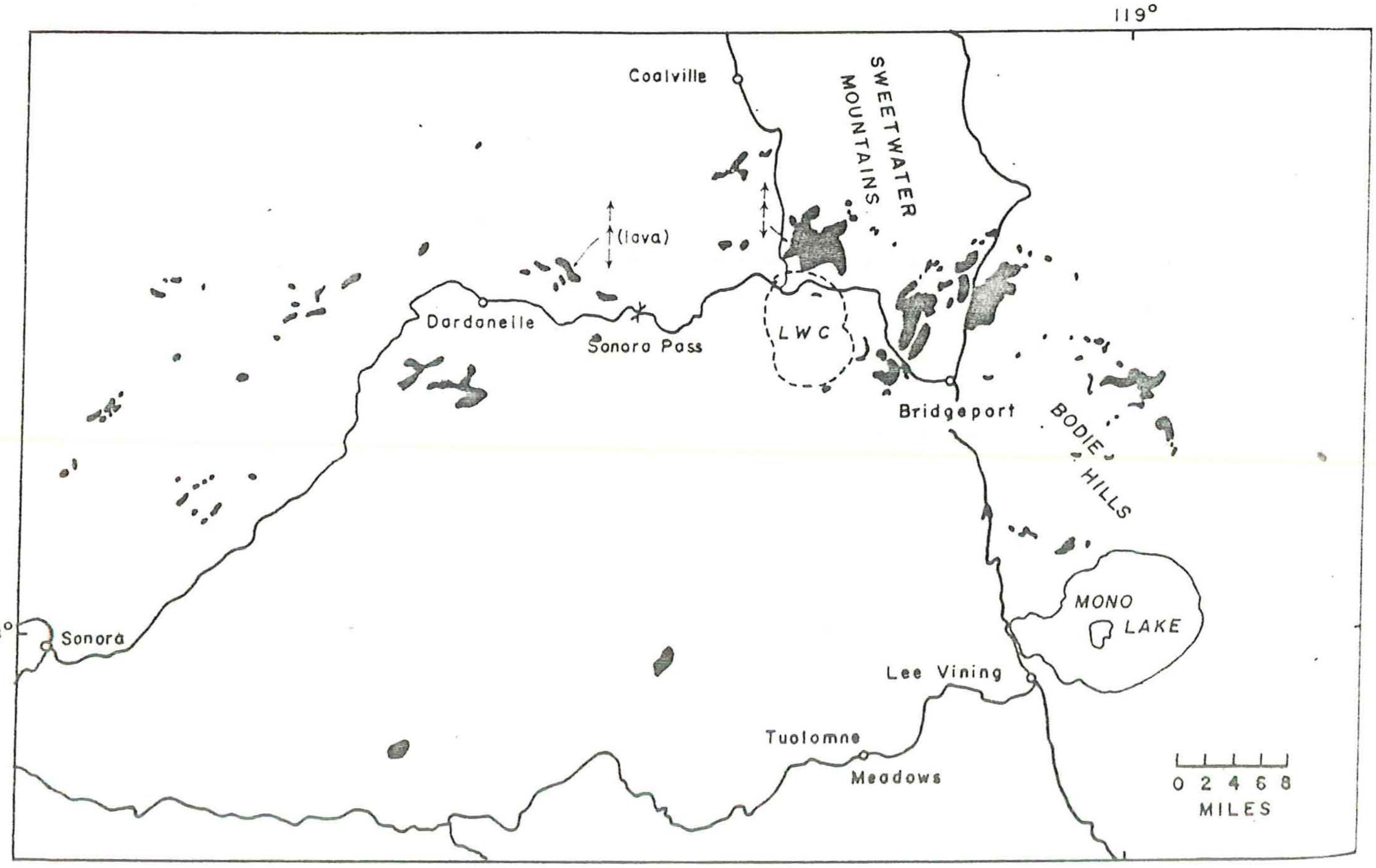

Figure 1. Map showing present distribution of Eureka Valley Tuff. Dashed line marks location of Little Walker caldera (LWC). Arrows show direction of remanent magnetization of units at type (west) and reference sections of Eureka Valley.

TABLE 1. CHART SHOWING EVOLUTION OF NOMENCLATURE OF ROCKS OF THE STANISLAUS GROUP

Ransome (1898)		Slemmons (1966)		This Paper	
Dardanelle flow	Stanislaus Formation	Dardanelles Member	Stanislaus Group	Dardanelles Formation	
		Eureka Valley Member		Eureka Valley Tuff	Upper Member
					By-Day Member
biotite-augite-latite					Tollhouse Flat Member
Table Mountain facies, flow		Table Mountain Latite Member		Table Mountain Latite	

be recognized. At many localities, the upper 5 to 20 ft of the member consists of one or more distinctive ash flows that contain appreciably fewer and smaller phenocrysts, smaller pumice fragments, and a much smaller percentage of lithic fragments than the tuffs which compose most of the unit. No other evidence of vertical compositional zonation has yet been recognized.

Measurement of the direction of natural thermoremanent magnetization by portable flux-gate magnetometer (Al-Rawi, 1969) has shown that the Tollhouse Flat Member has reverse magnetic polarity.

By-Day Member

The By-Day Member is here named for exposures on the north bank of By-Day Creek (lat 38°16'20" N., long 119°18'45" W.; Fig. 1). At the reference section of the Eureka Valley Tuff at Tollhouse Flat, the By-Day Member is 115 ft thick and is separated by about 10 ft of sorted clastic rock of possible base-surge origin from the underlying Tollhouse Flat Member. At the type locality of the Eureka Valley Tuff, the By-Day is separated by a latite lava flow from the underlying Tollhouse Flat Member. At many localities, however, particularly near the Little Walker caldera, the contact between the two members is inconspicuous. Air-fall tuff commonly is absent, and the complete cooling break between the two units may be indicated only by several inches of porous, partly welded glassy ash-flow tuff at the base of the By-Day Member. This thin and relatively nonresistant glassy zone may be hidden by soil, vegetation, and detached blocks of welded tuff; at many places, a careful search must be made to locate the cooling break.

Exposures of the By-Day Member are similar in color and general appearance to those of the Tollhouse Flat Member, although weathered surfaces tend to be somewhat smoother and the average size of pumice fragments somewhat smaller. Rocks of the By-Day Member may be distinguished quickly and unambiguously in the field from those of the Tollhouse Flat Member and upper member by the absence of phenocrystic biotite. Although a flake or two of foreign biotite, probably derived from volcanic or granitic lithic fragments, occasionally may be seen in rocks of the By-Day, biotite has not been observed in collapsed pumice fragments of the unit. (Halsey [1953] was the first to recognize, in the vicinity of Tollhouse Flat, a biotite-free ash-flow unit in the Eureka Valley.)

In thin section, the presence of a second generation of lath-shaped plagioclase microphenocrysts is diagnostic of rocks of the By-Day. The larger first generation of oscillatory-zoned plagioclase phenocrysts is somewhat more calcic (about An_{60}) than those of the Tollhouse Flat Member. First-generation plagioclase and clinopyroxene phenocrysts are slightly smaller and less abundant than those of the Tollhouse Flat Member, and pumice and lithic fragments also are smaller on the average. As in the Tollhouse Flat Member, there is a greater concentration of crystals in the fine-grained portion of the tuff than in the pumice fragments (about 12 percent), indicating winnowing of glass shards and dust-sized particles.

The By-Day Member is composed of at least three, and probably many more, individual ash flows. Maximum observed thickness is about 200 ft. The unit tends to thin away from the Little Walker caldera. Both original areal distribution and volume were less than half that of the Tollhouse Flat Member. For example, the By-Day Member has not yet been recognized northeast of Sonora or in the Bodie Hills.

At the type locality of the Eureka Valley Tuff and in the vicinity of Tollhouse Flat, the By-Day Member is normally magnetized (Al-Rawi, 1969). The direction of remanent magnetization thus may provide yet another method of distinguishing the Tollhouse Flat and By-Day Members.

Upper Member

The upper member of the Eureka Valley Tuff is composed of ash-flow tuffs similar in general appearance to those of the Tollhouse Flat and By-Day Members. Many of the tuffs of the upper member, which is essentially identical to the "pumice tuff-breccia member" of Halsey (1953), are nonwelded or very poorly welded, although densely welded ash flows are interstratified with less compact strata in most sections of the unit. The upper member is best developed north and east of the Little Walker caldera (for example, east of Tollhouse Flat) and locally is intercalated with postcollapse lavas, tuffs, volcanic sandstones, and so forth, within the caldera. The tuffs, which everywhere are separated from the underlying By-Day Member by a complete cooling break, vary in content of phenocrysts and lithic fragments. Most, and perhaps all, of the ash flows of the upper member contain abundant biotite but appear to lack the large, slightly vesiculated pumice blocks found in the Tollhouse Flat Member. Another distinctive feature is the presence of spongy plagioclase phenocrysts comprising from about one-fourth to more than three-fourths of the total plagioclase in the rocks. Finally, an ash flow at or near Tollhouse Flat, apparently belonging to the upper member, has normal magnetic polarity (Al-Rawi, 1969), suggesting that the direction of remanent magnetization may provide a means of distinguishing rocks of the unit from those of the reversely magnetized Tollhouse Flat Member. Although no complete cooling breaks have yet been recognized within the upper member, the lighologic variability of the unit suggests the possibility that it may consist of several distinct small volume ash-flow sheets of limited areal extent.

AGE OF THE EUREKA VALLEY TUFF

K-Ar age determinations on 13 rocks belonging to the Eureka Valley Tuff are available (Table 2). Single age determinations also are available on rocks of the Table Mountain Latite and Dardanelles Formation (Table 2). We have obtained new K-Ar ages of 9.9 ± 0.4 and 10.0 ± 0.3 m.y. on two ash-flow units of the upper member (Table 3), using standard isotope-dilution techniques (Dalrymple and Lanphere, 1969).

The average of the radiometric age determinations on the Eureka Valley Tuff, excepting the two new ages on the upper member and the date of 10.7 m.y. reported by Evernden and others (1961), is 9.2_4 m.y. With the four ages (from 8.8 to 9.2 m.y.) reported by Dalrymple (1963) also excluded, the average is 9.4_3 m.y. Additional information on the age of the Eureka Valley is provided by numerous ages of from 9.1 to 9.5 m.y. obtained by Al-Rawi (1969; Gilbert and others, 1968) and by Silberman and

[illegible] K-AR AGE DETERMINATIONS ON THE [illegible] EUREKA VALLEY TUFF AND [illegible] OF THE [illegible] VALLEY [illegible] GROUP

Sample Number	Age (m.y.)	Reference
[illegible]		
[illegible]	9.3±0.4	1
[illegible]		
[illegible]		
[illegible]-37	10.[illegible]±0.3	2
TF-1[illegible]	9.3±0.4	2
[illegible]		
EA-961	[illegible].8±0.2	3
EA-1124	9.2±0.2	3
W23	9.52±0.38	4
W24	9.19±0.28	4
EA-1907	9.8±0.2	5
EA-1908	9.6±0.3	5
[illegible]*		
EA-132	10.7±[illegible]	6
EA-976	8.9±0.2	3
EA-977	9.0±0.2	3
W25	9.15±0.37 9.01±0.27	4 4
EA-1909	9.5±0.3	5
[illegible]		
EA-1110	9.0±0.2	1

References: 1, Dalrymple (1964); 2, Table 3, this paper; 3, Dalrymple (1963); 4, Dalrymple and others (1967); 5, Gilbert and others (1968), Al-Rawi (1969); 6, Evernden and others (1961).

* These specimens probably all are from the Tollhouse Flat Member.

Chesterman (1972) on lavas of the Mount Biedeman Formation, the Silver Hill Volcanic Series, and related units that overlie the Eureka Valley Tuff in the Bodie Hills. These data suggest that the radiometric age of the Eureka Valley Tuff is approximately 9.5 m.y., slightly greater than previously inferred. According to the Cenozoic time scale of Berggren (1972), the Eureka Valley Tuff is of late Miocene age.

TABLE [illegible]. NEW K-AR AGE DETERMINATIONS ON ROCKS FROM THE UPPER MEMBER OF THE EUREKA VALLEY TUFF

Sample Number	K_2O (wt. [illegible])	Radiogenic Ar^{40} (moles [illegible])	Radiogenic Ar (percent)	Age (m.y.)
[illegible]	7.8[illegible]	1.17x10^{-10}	[illegible]	10.[illegible]±0.3
2	7.[illegible]	[illegible]x10^{-10}	[illegible]	9.[illegible]±0.[illegible]

[illegible]

[illegible] atom

The new age determinations on rocks of the upper member appear to be slightly too old. Nevertheless, they strongly suggest that no appreciable intervals of geologic time elapsed between eruption of the successive ash-flow sheets of the Eureka Valley, thus providing additional support for the close genetic relations of the units.

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ACKNOWLEDGMENTS

Reviewed by H. F. Bonham, Jr.

Noble and Korringa supported by Natio[nal] Science Foundation Grants GA-1546 and GA-35765 and by National Aeronautics an[d] Space Administration Grant NGR-22-007-[illegible] Slemmons' work supported in part by NAS[A] Grant NGR-29-001-015 and by NSF Gran[t] GP-5034; Al-Rawi supported by Ministry o[f] Education, Baghdad, by NSF Grant GP-45[illegible] and by the Department of Geology and Geophysics, University of California, Berke[ley].

MANUSCRIPT RECEIVED DECEMBER [illegible] 1973

MANUSCRIPT ACCEPTED JANUARY 3[illegible] 1974