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D.C. Noble, E.H. McKee, and S.I. Weiss

Isochron/West, Bulletin of Isotopic Geochronology, v. 51, pp. 25-28

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NATURE AND TIMING OF PYROCLASTIC AND HYDROTHERMAL ACTIVITY AND MINERALIZATION AT THE STONEWALL MOUNTAIN VOLCANIC CENTER, SOUTHWESTERN NEVADA

DONALD C. NOBLE *Mackay School of Mines, University of Nevada-Reno, Reno, NV 89557*
EDWIN H. McKEE *U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025*
STEVEN I. WEISS *Mackay School of Mines, University of Nevada-Reno, Reno, NV 89557*

The Stonewall Mountain volcanic center (fig. 1) is the youngest of the many caldera centers of the late Cenozoic southern Nevada volcanic field (Foley, 1978; Noble and others, 1984; Weiss, 1987; Weiss and Noble, 1988). We present K-Ar age determinations that constrain the timing of large-volume pyroclastic activity at the center and show that widespread, intense hydrothermal activity directly northwest of the center took place shortly after ash-flow eruption, and we briefly discuss the metallogenetic relations and mineral potential of the nearby Cuprite district.

TIME BETWEEN ERUPTION OF CIVET CAT CANYON AND SPEARHEAD MEMBERS

The Civet Cat Canyon Member is the younger of the two major silicic ash-flow sheets that make up the Stonewall Flat Tuff, which includes the ash-flow sheets related to the Stonewall Mountain center (Noble and others, 1984; Weiss, 1987; Weiss and Noble, 1988). K-Ar age determinations on phenocrystic sanidine from four specimens (nos. 1–4) from the outflow sheet of this unit directly

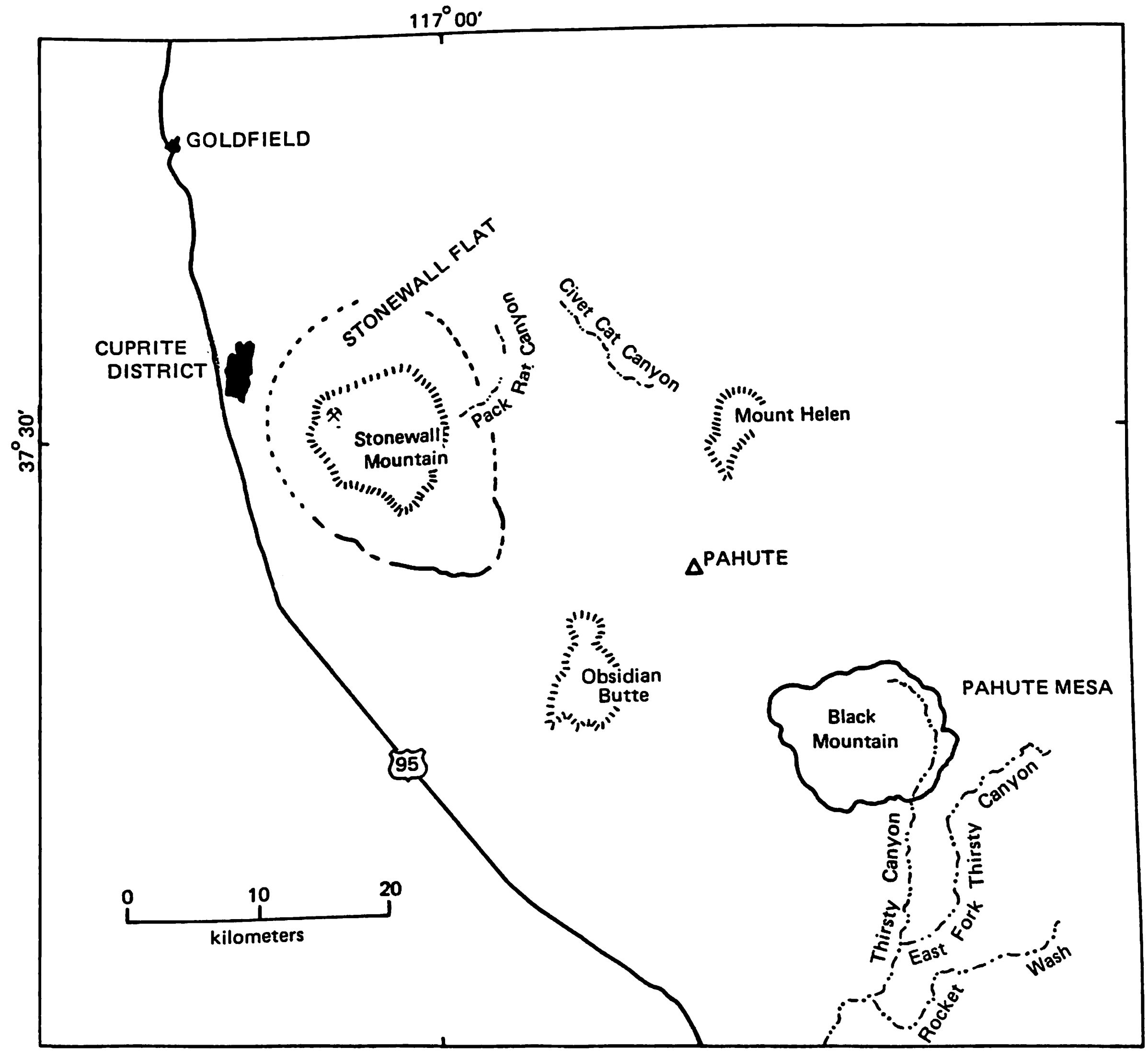

Figure 1. Location of the Cuprite mining district and the Stonewall Mountain volcanic center. Solid black area indicates strong hydrothermal alteration in the eastern part of the Cuprite district (from Abrams and others, 1977; Ashley and Abrams, 1980).

south of Stonewall Mountain give a mean age of 6.4 Ma that is identical within the limits of analytical uncertainty to the average age of 6.3 ± 0.2 Ma reported by Noble and others (1984) for the underlying Spearhead Member. It thus appears that very little time elapsed between eruption of the two major ash-flow sheets of the Stonewall Mountain center. Intervals of 0.5 Ma or less between episodes of large-volume pyroclastic activity have been documented at other centers of the southern Nevada volcanic field (Byers and others, 1976; Carr and others, 1986).

HYDROTHERMAL ACTIVITY AT THE CUPRITE DISTRICT

The Cuprite district, located directly northwest of the inferred buried topographic wall of the Stonewall Mountain caldera (fig. 1), includes one of the more spectacular areas of hydrothermal alteration in the western United States. Rocks have been pervasively altered over an area of 6 km² east of U.S. Highway 95 (Cornwall, 1972; Ashley, 1977; Ashley and Abrams, 1980). Alteration affected outflow facies ash-flow tuffs of the Stonewall Flat Tuff as well as a thick unnamed underlying sequence of poorly to moderately welded phenocryst-rich rhyolitic ash-flow tuff.

The older tuffs contain approximately equal amounts of sanidine, plagioclase and distinctive highly irregular "wormy" quartz phenocrysts with deep tubular cavities, and lesser amounts of biotite, and are in places separated from the overlying Stonewall Flat Tuff by flows of olivine basalt. The Stonewall Flat Tuff, in contrast, contains little or no phenocrystic quartz and has readily discernable biotite only in certain flow units in the uppermost parts of the ash-flow sheets. A potassium-argon age of 19.8 ± 0.6 Ma on sanidine from an unaltered specimen (no. 5) of the older tuff shows that the unit is much older than, and unrelated to, the Stonewall Mountain center.

Porous leached rock composed largely of opal with local concentrations of sulfur and alunite and dense rock with quartz, alunite, and opal, are common within the area of intense alteration (Abrams and others, 1977; Ashley and Abrams, 1980). Kaolinite and montmorillonite are also present, particularly along the margins of the altered area. The alteration is so readily discernable that studies of the area have been carried out to promote the use of remote sensing techniques to recognize areas of hydrothermal alteration (Rowan and others, 1976; Abrams and others, 1977; Ashley and Abrams, 1980; Borengasser and Taranik, 1985).

The zone of hydrothermal alteration is notably devoid of base and precious metals. Ball (1907) mentioned gold-bearing veins in Tertiary rhyolite in the northeastern end of the district, and Ashley (1977, 1978) considered that the area has a moderate to low potential for gold and mercury. Minor amounts of sulfur, silica, and clay have been mined, but the alunitic rock is not of sufficient alunite content for commercial use (Ashley, 1978).

West of the hydrothermally altered area described above, the Cuprite district includes an area characterized by polymetallic veins in lower Paleozoic limestone (Ball, 1907; Albers and Stewart, 1972). There is no evidence that these deposits formed at the same time the late Miocene volcanic rocks were hydrothermally altered, and Ashley (1978) considered that mineralization was probably of Mesozoic age.

AGE OF HYDROTHERMAL ACTIVITY AT CUPRITE AND ITS RELATION TO THE STONEWALL MOUNTAIN CENTER

An age of 6.0 ± 0.3 Ma was determined on coarse crystalline alunite (specimen 6) from the southeastern part of the Cuprite district. This age, which dates the main stage of hydrothermal activity in the eastern part of the district, is the same, within the limits of analytical uncertainty, as the ages obtained on the Spearhead and Civet Cat Canyon Members of the Stonewall Flat Tuff. The ages obtained on the major pyroclastic units of the Stonewall Mountain center and alteration at Cuprite suggest that hydrothermal activity in the district is genetically related to magmatic activity of the center. Hydrothermal activity is reasonably interpreted as belonging to the final stage of the caldera cycle as described by Smith and Bailey (1968), and is presumably related to magma remaining in the chamber after caldera collapse.

HYDROTHERMAL ACTIVITY AFFECTING THE INTRACALDERA TUFF PRISM OF THE STONEWALL MOUNTAIN CENTER

Precious-metal-bearing veins on the northwestern slope of Stonewall Mountain (Cornwall, 1972; Smith and Tingley, 1983) southeast of the Cuprite district are hosted by uplifted intracaldera tuff (6.3 Ma) of the Stonewall Flat center (Foley, 1978; Noble and others, 1984). Adularia from hydrothermally altered tuff from this area yielded an age of 12 Ma, about twice that of the Stonewall Mountain center; this may represent the presence of excess radiogenic argon in abundant fluid inclusions within the adularia (Silberman and Noble, 1977; Roedder, 1984; E. H. McKee, unpub. data).

MINERALIZATION RELATED TO PERALKALINE SILICIC MAGMATISM

It is well known that certain types of mineralization are genetically associated with particular types of magmas. The two ash-flow sheets of the Stonewall Mountain volcanic center consist almost entirely of slightly peralkaline rhyolite (comendite) (Noble and others, 1984; Weiss and Noble, 1988). Some peralkaline centers possess deposits of U, Hg, and/or Li (Rytuba and Glanzman, 1979; Wallace and Roper, 1981), and in a number of volcanic to subvolcanic complexes subalkaline rocks hosting Mo ± W or Sn are closely associated with peralkaline silicic rocks. (Bowden and Jones, 1978). Although peralkaline magmas are not generally thought to be related to precious-metal mineralization (Henry and Price, 1984), at least one hot-springs type gold deposit closely associated with peralkaline magmatism is known at Hog Ranch in northwestern Nevada (Harvey and others, 1986), and precious-metal veins are present on Stonewall Mountain. Moreover, basalt and their intermediate-composition derivatives, which in general have a higher gold content than silicic magmas (Zentilli and others, 1985) and which are closely associated in time with a number of precious-metal deposits of Neogene age in the northwestern Great Basin (Noble and others, 1988), were directly involved in the eruption of the Civet Cat Canyon Member (Weiss and Noble, 1984). The peralkaline character of the Stonewall Mountain center should therefore not be considered to rule out the possibility of a mineral deposit at depth beneath the barren silicified and leached-silica rock of the Cuprite district. The possibility of a mineral deposit at depth beneath the barren silicified and leached-silica rock of the Cuprite district therefore should not be ruled out because of the peralkaline character of the Stonewall Mountain center.

ANALYTICAL METHODS

Age determinations were done in the laboratories of the U.S. Geological Survey, Menlo Park, California, using standard isotope-dilution procedures as described by Dalrymple and Lanphere (1969). The analyses were performed on mineral concentrates prepared by heavy liquid, magnetic, and hand-picking procedures. Potassium was analyzed by lithium metaborate flux fusion-flame photometry techniques, the lithium serving as an internal standard (Ingamells, 1970). Argon analyses were conducted using a 60° sector, 15.2 cm-radius, Nier-type mass spectometer or on a five-collector mass spectometer (Stacey and others, 1981). The precision of the data, shown as the ± value, is the estimated analytical uncertainty at one standard deviation (σ). It represents uncertainty in the measurement of radiogenic ^{40}Ar and K_2O in the sample and is based on experience with replicate analyses in the Menlo Park laboratories. The decay constants used for ^{40}K and the $^{40}K/K$ abundance ratio are those adopted by the International Union of Geological Sciences Subcommission on Geochronology (Steiger and Jager, 1977).

ACKNOWLEDGMENTS

Work on the Stonewall Mountain volcanic center has been partially supported by grants from the Geological Society of America, the National Science Foundation, and the Nevada Nuclear Waste Project Office. We thank Roger P. Ashley, Maureen Johnson, and Daniel R. Shawe for constructive reviews of the manuscript.

SAMPLE DESCRIPTIONS

1. *PM7-Tcc* K-Ar
Civet Cat Canyon Member of Stonewall Flat Tuff (37°25'38"N, 117°01'09"W; N wall of Dickensheets Draw; Scottys Junction NE 7.5' quad, Nye County, NV); densely welded and primarily devitrified ash-flow tuff from upper crystal-rich caprock. *Analytical data:* K_2O = 7.20 wt. %; $^{40}Ar^*$ = 0.62336 × 10^{-10} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 32.9 %. *Collected by:* Weiss.
(sanidine) 6.0 ± 0.2 Ma

2. *PM8-Tcc* K-Ar
Civet Cat Canyon Member of Stonewall Flat Tuff (37°25'34"N, 117°01'09"W; N wall of Dickensheets Draw; Scottys Junction NE 7.5' quad, Nye County, NV); densely welded and primarily devitrified ash-flow tuff from central part of unit. *Analytical data:* K_2O = 7.225 wt. %; $^{40}Ar^*$ = 0.69982 × 10^{-10} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 60.2 %. *Collected by:* Weiss.
(sanidine) 6.7 ± 0.2 Ma

3. *Tcc-7* K-Ar
Civet Cat Canyon Member of Stonewall Flat Tuff (37°31'42"N, 116°56'30"W; upper part of Pack Rat Canyon; Cactus Spring 15' quad, Nye County, NV); densely welded and primarily devitrified ash-flow tuff. *Analytical data:* K_2O = 7.65 wt. %; $^{40}Ar^*$ = 0.67333 × 10^{-10} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 58.1 %. *Collected by:* Weiss and Noble.
(sanidine) 6.1 ± 0.2 Ma

4. *PM-5B* K-Ar
Civet Cat Canyon Member of Stonewall Flat Tuff (37°25'11"N, 117°01'15"W; S wall of Dickensheets Draw; Scottys Junction NE 7.5' quad, Nye County, NV); densely welded hydrated glassy ash-flow tuff from basal vitrophyre. *Analytical data:* K_2O = 7.12 wt. %; $^{40}Ar^*$ = 0.67344 × 10^{-10} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 61.0 %. *Collected by:* Weiss.
(sanidine) 6.6 ± 0.2 Ma

5. *87-BST* K-Ar
Unnamed phenocryst-rich rhyolitic ash-flow tuff (37°34'05"N, 117°10'12"W; Goldfield 15' quad, Nye County, NV); underlying a olivine-bearing, intermediate to mafic lava flow that in turn is overlain by the Spearhead Member of the Stonewall Flat Tuff. *Analytical data:* K_2O = 10.74 wt. %; $^{40}Ar^*$ = 3.0726 × 10^{-10} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 91.8 %. *Collected by:* Noble.
(sanidine) 19.8 ± 0.6 Ma

6. *CUPRITE ALUNITE* K-Ar
Coarse-grained hydrothermal alunite from quarry (37°32'00"N, 117°10'30"W; Goldfield 15' quad, Nye County, NV); from a veinlet in porous, highly acid-leached and silica-rich, ash-flow tuff. *Analytical data:* K_2O = 10.39 wt. %; $^{40}Ar^*$ = 0.89453 × 10^{-10} mol/g; $^{40}Ar^*/\Sigma^{40}Ar$ = 12.1%. *Collected by:* Noble.
(alunite) 6.0 ± 0.3 Ma

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