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K-AR AGES OF MINERAL DEPOSITS AT WONDER, SEVEN TROUGHS, IMLAY, TEN MILE, AND ADELAIDE MINING DISTRICTS IN CENTRAL NEVADA[1]

Miles L. Silberman,
Maureen G. Johnson,
Randolph A. Koski,
and
Ralph J. Roberts
U. S. Geological Survey
Menlo Park, CA 94025

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U. S. Geological Survey

The ages reported here are part of a program of dating hydrothermal mineral deposits in Nevada. Samples used are from epithermal vein deposits in Tertiary host rocks at Wonder and Seven Troughs, vein deposits in pre-Tertiary sedimentary rocks at Adelaide and Ten Mile, and a vein deposit in Mesozoic volcanic rocks at Imlay.

Analytical procedures and equipment are the same as those described in Silberman and McKee (1971a). Plus-minus figures represent estimated analytical uncertainty only, at the one sigma level. Constants used for K-Ar age calculation are: $\lambda_\epsilon = 0.585 \times 10^{-10}\ yr^{-1}$; $\lambda_\beta = 4.72 \times 10^{-10}\ yr^{-1}$; $K^{40}/K_{total} = 1.22 \times 10^{-4}$ gm/gm.

GEOLOGIC DISCUSSION

Individual mining districts are briefly described at the end of this section of the report. Where geochronologic studies have been made in detail on the epithermal ore deposits and their host rocks, as at Bodie (Silberman and others, 1972), Goldfield (Silberman and Ashley, 1970) and Silver City (Pansze, 1972), it can be demonstrated that hydrothermal mineralization is related in time to some recognizable stage of local igneous activity. The assumption will be made that this is true for the ore deposits discussed here, and for the Wonder district, at least, it can be demonstrated.

Materials Used

All of the ore deposits reported here have been dated by the K-Ar method using hydrothermal K-feldspar that formed as a gangue mineral in the ore-bearing veins. Hydrothermal K-feldspar ("adularia") occurs widely in epithermal ore deposits but can vary in structural state and composition. Some initial structural data are presented here for the feldspars; more complete data on structure, chemistry, and stable isotope ratios are now being prepared.

In general, plutonic and volcanic feldspars with sanidine and orthoclase structures (both monoclinic) appear to give reliable ages, at least for rocks of Tertiary and Mesozoic age (Evernden and James, 1964; Evernden and Kistler, 1970). Feldspars with microcline structure (triclinic) do not. Little data are available for the hydrothermal feldspars, which have similar structural states as the plutonic and volcanic feldspars, although they form under different conditions. Fluid-inclusion studies by Nash (1972) indicate that epithermal ore deposits are formed at temperatures that range roughly between 200° and 330°C from fluids that are dilute, having salinities roughly like those of hot springs. Magmatic feldspars, on the other hand, are crystallized under much higher temperatures and at pressures that vary from one atmosphere to many kilobars (Turner and Verhoogen, 1960; Burnham, 1967). Magmas in which feldspars crystallize have much lower fluid contents than the solutions that formed the feldspar-bearing veins.

Regional Relations

Roberts and others (1971) suggested that hydrothermal ore deposits in north-central Nevada formed during five intrusive-metallogenic epochs defined on the basis of age groups of plutons and volcanic rocks in the region (Silberman and McKee, 1971b; McKee and Silberman, 1970). Available K-Ar ages on mineral deposits in central Nevada are basically in good agreement with this concept.

Three of the ore deposits discussed in this paper, Adelaide (14 m.y.), Ten Mile (16 m.y.), and Seven Troughs (14 m.y.), fall within the youngest period of volcanic activity defined for central Nevada, which resulted in emplacement of rhyolite and basalt flows and flow dome complexes from about 16 m.y. to 10 m.y. ago (Mc-Kee and Silberman, 1970). Many other ore deposits of this age occur throughout the region (Roberts and others, 1971; Silberman, unpublished data). Volcanism in this period was small in volume compared with earlier ash-flow activity, yet this time period was very important from the standpoint of mineralization. Both the volcanism and hydrothermal mineralization follow the onset of Basin and Range faulting in the region approximately 17-16 m.y. ago (Noble, 1972). We concur with Noble's (1972) suggestion that breakup of the crust allowed ascent of the magmas and eruption of these volcanic rocks. Basin and Range faulting also promoted deep circulation of meteoric water that later ascended as hydrothermal solutions (fluids) that, in our opinion, were responsible for many of the 16-14 m.y. hydrothermal vein deposits found throughout the region.

In contrast to this younger (16-10 m.y.) epoch, older igneous activity (between about 33 and 20 m.y. ago) was typified by ash-flow eruptions in the central Basin and Range (McKee and others, 1971; Noble, 1972) and was practically devoid of hydrothermal precious metal mineralization. Two exceptions known are the Wonder mining district (this paper) and the Round Mountain mining district (D. R. Shawe and M. L. Silberman, unpublished data). Evidently the processes by which ash flows are generated apparently do not also aid in collecting materials (metals) for formation of epithermal ore deposits in the Basin and Range province.

Mining Districts

The Ten Mile district is in the southern part of the Krumm Hills, west of Winnemucca. The district is underlain by quartzite and mudstone of Triassic age. Tertiary and Quaternary basalt overlies these and other Mesozoic sedimentary rocks in the area. Most of the ore deposits are in quartz veins and stringers that occupy shear zones in the Triassic rocks. The district and two other small districts in the nearby area produced ore worth approximately $1,200,000, mostly from Ag and Au (Willden, 1964).

The Adelaide mining district, located on the eastern flank of the Sonoma Range in Humboldt County, is underlain by limestone, shale, and quartzite of the Cambrian Preble Formation. Tertiary rhyolite to quartz latite ash-flow tuffs in the vicinity of Adelaide erupted at 14 m.y. and 30 m.y. ago (R. L. Erickson and M. L. Silberman, unpublished data). The relation between mineralization at Adelaide and this volcanic activity is not known, as it is not known whether these ash flows are of local origin or are portions of large ash-flow sheets erupted some distance from Adelaide. The major production of the district came from the Adelaide and Crown Mines. At the Adelaide Mine, ore consisted of replacement bodies in limestone where sulfide minerals, pyr-rhotite, sphalerite, and galena occurred in a gangue of silicates and carbonates. The sample collected for dating came from the Crown Mine, where ore occurred in a mineralized, silicified fault zone cutting shale and quartzite. The district produced ore worth approximately $1,500,000, mostly from gold with considerable amounts of silver (Willden, 1964).

The Imlay district in the northern part of the Humboldt Range is underlain by felsites and tuffs of the Triassic Rochester Rhyolite which are intruded by Triassic rhyolite prophyry plugs also classified as part of the Koipato Group. These rocks are overlain by the Prida Formation and the Natchez Pass Formation, both principally limestones of Triassic age. Diabase and diorite dikes intrude the Triassic rocks throughout the district. The sample collected for dating was from a vein consisting of a coarse intergrowth of quartz and K-feldspar showing conspicuous striations. The 73-m.y. age of the K-feldspar is comparable to the 71.4±3.0 m.y. age (M. G. Johnson, unpublished data) of the granodiorite stock of Rocky Canyon, 9 miles south. Both the age of the stock and the gold deposit fall within the youngest Cretaceous pulse of plutonism defined by Silberman and McKee (1971b) for central Nevada. Total production from the district was approximately $1,700,000 mostly from gold (M. G. Johnson, unpublished data).

The Seven Troughs mining district is coextensive with the Seven Troughs Range in western Pershing County. The main gold mining area is along the east flank of the range and centers in Seven Troughs Canyon. The district is credited with a production during the period 1905-1962 of about $4 million in gold and subordinate silver and base metals. The east flank of the Seven Troughs Range is underlain by Tertiary rhyolitic flows which interfinger with and intrude andesitic rocks. In Seven Troughs Canyon, where the volcanic rocks are highly altered to buff-colored massive units, it is difficult to distinguish rhyolite from andesite. The ore deposits occur in a network of veins and veinlets that carry native gold alloyed with considerable silver. The veins consist of crushed brecciated wallrock with quartz filling the interstices.

The Wonder district is located in the southwestern Clan Alpine Mountains. The district is underlain by rhyolite and quartz-latite welded tuffs and flows that are intruded by plugs and dikes of rhyolite to basalt composition. Most of the veins are in the extrusives (Willden and Speed, in press). The volcanic sequence at Wonder is part of an assemblage of lava flows, domes, ash flows, and epiclastic tuff beds predominantly rhyolite in composition, that were emplaced between 22 and 30 m.y. ago in the southern Clan Alpine Mountains (Riehle and others, 1972). The 21.6-m.y. age of the adularia from the Nevada Wonder Mine indicates that mineralization occurred late in, or just after the major rhyolite volcanism.

Ore deposits at Wonder occurred in tabular siliceous veins in fissures and shear zones, mostly in the quartz latite and rhyolite extrusives. Quartz is the principal gangue mineral, frequently associated with adularia, minor fluorite, and brecciated and crushed altered wallrock material. Au and Ag occur chiefly in the quartz-adularia gangue and in their contained rock materials, and also as replacements in wallrock and gangue zones adjacent to the veins. The deposits are oxidized to a depth of 1,300 feet. Ag occurs as argentite, cerargyrite, and halogen salts. Au occurs both as native gold and in combination with argentite (Schrader, 1947).

The Nevada Wonder Mine, from which the dated sample was collected, was the only profitable producer in the district. Recorded production is valued at approximately $6,400,000, mostly from silver but with an appreciable gold production as well (Willden and Speed, in press).

SAMPLE DESCRIPTIONS

Ten Mile District

1. Reo Mine — K-Ar — (adularia, sanidine structure) 16.3±0.5 m.y.
Quartz-adularia vein (SW¼ Sec. 22, T36N, R36E, at Reo Mine shaft, southern Krumm Hills, Humboldt Co., NV). Analytical data: K_2O = 15.57%, $^*Ar^{40} = 3.758 \times 10^{-10}$ moles/gm, $^*Ar^{40}/\Sigma Ar^{40}$ = 84.8%. Collected by: Ralph J. Roberts, U. S. Geological Survey; dated by: M. L. Silberman, U. S. Geological Survey. Comments: The sample collected for dating contained 1.0 ppm Au and 0.4 ppm Ag. The feldspar has the sanidine structure as determined by X-ray diffraction according to the three reflection method of Wright (1968). Although there is no other data to support the age of mineralization, the structural state of the feldspar suggests that the age determined should be reliable.

Adelaide (Gold Run) District

2. Crown Mine — K-Ar — (adularia, sanidine structure) 14.3±0.4 m.y.
Quartz-adularia vein (NW¼ Sec. 19, T34N, R40E, Crown (Adelaide-Crown) Mine, eastern Sonoma Range, Humboldt Co., NV). Light-gray, banded, vuggy vein consisting of fine- to medium-grained quartz, intergrown with fine-grained adularia. Some of this material is replacing calcite. Analytical data: K_2O = 12.48%, $^*Ar^{40} = 2.641 \times 10^{-10}$ moles/gm, $^*Ar^{40}/\Sigma Ar^{40}$ = 64.4%. Collected by: Ralph J. Roberts, U. S. Geological Survey; dated by: M. L. Silberman, U. S. Geological Survey. Comment: No trace-element analyses are available. The feldspar has the sanidine structure, according to the three reflection X-ray diffraction method of Wright (1968). This structure appears to retain argon well.

Imlay District

3. Black Canyon Mine — K-Ar — (adularia, microcline structure) 73.2±2. m.y.
K-feldspar-quartz vein (NE¼ Sec. 19, T31N, R34E, Black Canyon Mine, northern Humboldt Range,

Pershing Co., NV). Coarse-grained white K-feldspar-quartz vein with some manganese oxide staining. Analytical data: K_2O = 15.32%, $^*Ar^{40}$ = 1.688 x 10^{-9} moles/gm, $^*Ar^{40}/\Sigma Ar^{40}$ = 95.0%. Collected by: Ralph J. Roberts, U. S. Geological Survey; dated by: M. L. Silberman, U. S. Geological Survey. Comment: The sample collected for dating assayed only 0.02 ppm Au and 0.4 ppm Ag. Feldspar from this sample has an intermediate microcline structure as determined by the three reflection X-ray diffraction procedure of Wright (1968). Since no other independent data exists to confirm the age of mineralization at Imlay, this date should probably be considered a minimum age because of possible loss of argon by feldspar with this structure.

Seven Troughs District

4. Kindergarten Mine — K-Ar — (adularia, orthoclase structure) 13.7±0.4 m.y.
Quartz-sulfide cemented breccia vein (S/2, Sec. 13, unsurveyed, T30N, R28E, dump of the Kindergarten Shaft, south side of Seven Troughs Canyon, Seven Troughs Range, Pershing Co., NV). Angular fragments of banded rhyolite, 3 mm to 1/2 mm across, cemented by dark-gray fine-grained quartz, with disseminated sulfides. The rhyolite fragments are largely replaced by orthoclase and are nearly free of sulfides. Analytical data: K_2O = 11.58%, $^*Ar^{40}$ = 2.349 x 10^{-10} moles/gm, $^*Ar^{40}/\Sigma Ar^{40}$ = 80.3%. Collected by: M. L. Silberman, U. S. Geological Survey; dated by: M. L. Silberman, U. S. Geological Survey. Comment: The sample collected for dating contained 0.1 ppm Au, 3.5 ppm Ag, and 300 ppm As. The feldspar, which replaces rhyolite fragments in the breccia vein, has an orthoclase structure as determined by the three reflection X-ray diffraction method of Wright (1968).

Wonder District

5. Nevada Wonder Mine — K-Ar — (adularia, orthoclase structure) 21.6±0.6 m.y.
Quartz-adularia vein (SW¼ Sec. 4, T18N, R35E, unsurveyed, ore bin of the Nevada Wonder Mine, Clan Alpine Mountains, Churchill Co., NV). Fine- to medium-grained white intergrowth of quartz and adularia with minor limonite-stained fractures. Analytical data: K_2O = 7.68%, $^*Ar^{40}$ = 2.460 x 10^{-10} mole/gm, $^*Ar^{40}/\Sigma Ar^{40}$ = 81.4%. Collected by: M. L. Silberman, U. S. Geological Survey; dated by: M. L. Silberman, U. S. Geological Survey. Comment: The sample collected for dating contained 160 ppm Ag and 0.4 ppm Au. The feldspar has the orthoclase structure as determined by the three reflection X-ray diffraction procedure of Wright (1968).

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