Fission track ages for premineralization volcanic and plutonic rocks of hte Goldfield mining district, Esmeralda and Nye counties, Nevada

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FISSION-TRACK AGES FOR PREMINERALIZATION VOLCANIC AND PLUTONIC ROCKS OF THE GOLDFIELD MINING DISTRICT, ESMERALDA AND NYE COUNTIES, NEVADA[1]

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This article presents 11 fission-track age dates for zircons, sphenes, and apatites from eight samples representing several of the premineralization units in the Goldfield mining district *(Table 1)*. The sample locations are shown in *Figure 1*. Formation, location data, analytical data, and references to potassium-argon dates, where available, are given in the sample descriptions along with the fission-track ages. Stratigraphic terminology is that of Ransome (1909). Unless otherwise noted, samples were collected by the author. The age determinations were made between April 1971 and December 1972.

Table 1 – Summary of fission-track ages for the Goldfield mining district

UNIT	SAMPLE NUMBER	DATE REFLECTING ORIGINAL ROCK AGE (m. y.)	DATE REFLECTING AGE OF HYDROTHERMAL ALTERATION (m. y.)	OTHER AGE DATA[1]
Dacite	203-11	19.8±1.4 (Sphene)		21.4±0.4 (Biotite)
	203-11	20.1±2.0 (Apatite)		
Dacite	Y-47	20.5±1.6 (Apatite)		21.2±0.4 (Biotite)
Kendall Tuff	197-51-2	31.1±3.5 (Apatite)		
Latite	185-115	33.5±4.5 (Apatite)		
	201-116		21.2±2.4 (Apatite)	
Morena Rhyolite	222-36	31.1±2.2 (Zircon)		
	222-36	27.7±3.3 (Apatite)		
Vindicator Rhyolite	199-137	33.0±2.0 (Zircon)		
Quartz monzonite	97VV-368	170±13 (Sphene)	19.6±2.7 (Apatite)	173±6 (Biotite)

[1] See sample descriptions for references

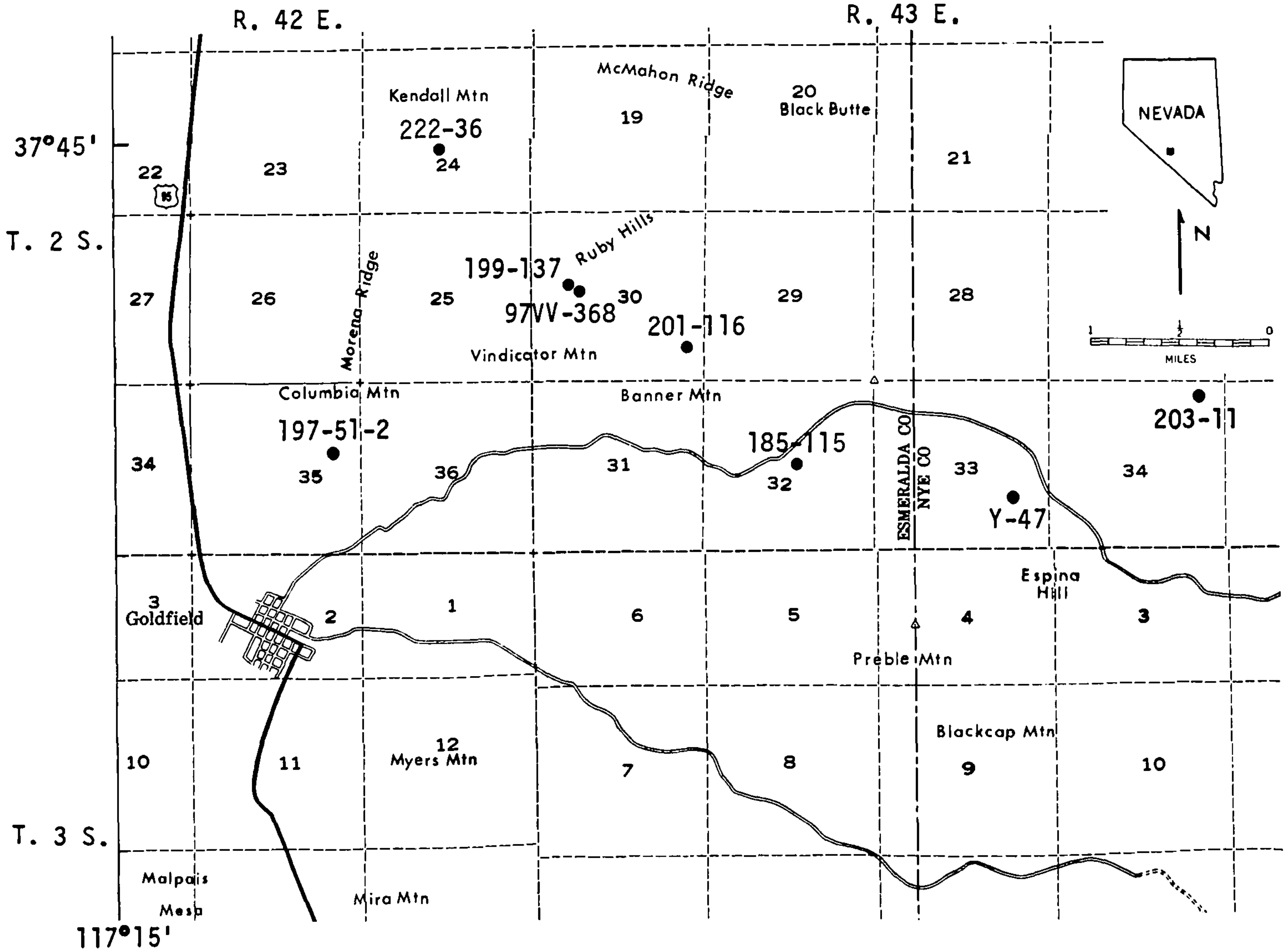

Figure 1. Map showing location of dated samples.

ANALYTICAL METHODS

Preparation techniques used to reveal fossil fission tracks in the separated minerals are similar to those described by Naeser (1967, 1969) and Naeser and Dodge (1969). Before mounting, five of the six apatite samples were split into two portions. One portion of each sample was annealed overnight at 600°C to remove fossil tracks. Annealed splits were irradiated and used to determine induced track densities for these five apatite samples. Sphene and zircon samples, and one apatite sample (185-115) for which relatively few grains were available, were covered with muscovite and irradiated; the muscovite, acting as an external detector, recorded induced fission tracks (Fleischer and others, 1965). Ages were calculated using the equation given by Naeser (1967). The fission decay constant for U^{238} (λ_F) used here is $6.85 \times 10^{-17} yr^{-1}$ (Fleischer and Price, 1964). Error estimates ($\pm 1\sigma$) were calculated by methods currently employed by C. W. Naeser (oral commun., 1973). Error estimates for ages determined using a muscovite detector reflect only counting error, whereas error estimates for annealed apatites reflect both counting error and grain-to-grain variations in uranium content.

Samples were irradiated in the U. S. Geological Survey TRIGA reactor located at Denver, Colo. Neutron-flux values for the reactor runs were determined by including with the samples a glass standard containing about 0.36 ppm uranium, covered with muscovite. The reactor dose was determined from the density of fission tracks produced in the muscovite by U^{235} in the glass.

GEOLOGIC DISCUSSION

Tertiary volcanic rocks dominate the Goldfield mining district and host the bonanza gold ore bodies found there. The oldest volcanic rocks are rhyolite and quartz latite tuffs and flows that probably erupted from local vents. Extensive flows and tuffs predominantly of trachyandesite and rhyodacite overlie the older rhyolitic and quartz latitic rocks. These flows are also probably of local origin. Hydrothermal alteration and ore deposition followed extrusion of these intermediate lavas, but volcanism in the Goldfield district did not cease until a post-mineralization rhyolite flow had been extruded at the eastern edge of the district and a postmineralization trachyandesite flow had been extruded along the southern margin of the district. Ages of the premineralization trachyandesite and rhyodacite, of hydrothermal alteration and associated ore deposition, and of the volcanic units extruded immediately after hydrothermal alteration are all between 20 and 21.5 m.y. (Silberman and Ashley, 1970). The principal purpose of this study was to determine the ages of the older rhyolite and quartz latite tuffs and flows. A second objective was to see whether fission-track dating of apatite might reveal the age of hydrothermal alteration.

Ransome (1909) defined five units comprising the older rhyolite and quartz latite tuffs and flows: Vindicator Rhyolite, latite, Kendall Tuff, Sandstorm Rhyolite, and Morena Rhyolite, in order from oldest to youngest. The Vindicator Rhyolite is composed of a rhyolite ash-flow tuff and an overlying rhyolite flow; the latite is composed of quartz latite tuff and an overlying quartz latite flow; the Kendall Tuff is a quartz latite tuff; the Sandstorm Rhyolite (renamed Sandstorm Formation by Albers and Stewart, 1972) is composed of rhyolite tuff locally overlain by one or more rhyolite flows; and the Morena Rhyolite is a rhyolite ash-flow tuff. Albers and Cornwall (1968) suggested that the Vindicator Rhyolite and Morena Rhyolite are equivalent and that the latite and Kendall Tuff, which are younger than the Vindicator and Morena but older than the Sandstorm Rhyolite, are also equivalent. Ashley (1971) and Albers and Stewart (1972) included the Morena Rhyolite with the Sandstorm Formation. Owing to pervasive diagenetic or deuteric alteration, as well as hydrothermal alteration of these rocks, potassium-argon dating has not been successful. Results of this dating permit the two correlations suggested by Albers and Cornwall because zircons from the Vindicator and Morena gave similar ages, as did apatites from the latite and Kendall Tuff (Table 1). Apatite from the Morena Rhyolite gave an age of 27.7±3.3, not significantly different from the zircon age of 31.1±2.2. The dates indicate that these four units are all close together in age and were probably erupted between about 29 and 33 m.y. ago ($\bar{x}$ for the five dates is 31.3 m.y. and σ is 0.9 m.y.). The Sandstorm Formation has not yet yielded material suitable for either K-Ar or fission-track dating.

Apatite from another sample of the quartz latite tuffs (locality 201-116, part of Ransome's latite unit) gave an age that is the same as the age of hydrothermal alteration in the district (Silberman and Ashley, 1970). Locality 201-116 is about 350 feet from the nearest exposed hydrothermally altered fracture zone, but a poorly exposed area of tuff that is probably weakly to moderately strongly altered appears 50-60 feet away from locality 201-116. Since apatite is readily annealed at relatively low temperatures in relatively short times (Naeser and Faul, 1969), it seems likely that this apatite, formed about 31 m.y. ago, was completely annealed during the pervasive volcanic and hydrothermal event that occurred between 20 and 21.5 m.y. ago. The apatite date for the quartz monzonite (sample 97VV-368), which is part of the prevolcanic basement of the district, also reflects the age of hydrothermal alteration (Table 1). Locality 97VV-368 is about 40 feet from the nearest exposed contact between unaltered rock, from which the sample was collected, and hydrothermally altered rock. Sphene from the same sample gave a fission-track age of 170±13 m.y., which agrees with a potassium-argon age of 173±6 m.y. (2σ error) on biotite from the same unit reported by Edwards and McLaughlin (1972).

Ransome (1909) designated the extensive premineralization trachyandesite and rhyodacite flows the Milltown Andesite. This sequence is intruded and overlain by a distinctive porphyritic rhyodacite recognized as a separate unit by Ransome (called "dacite" by him) and by this author (Ashley, 1971) but included with the

Milltown Andesite by Searls (1948). One potassium-argon date on a flow in the Milltown Andesite (Albers and Stewart, 1972) and several potassium-argon dates on biotites and hornblende from the porphyritic rhyodacite (Silberman and Ashley, 1970, samples Y-47 and 203-11; Albers and Stewart, 1972) range from 20.8±0.4 to 21.6±0.5 m.y. Sphene and apatite from sample 203-11 and apatite from sample Y-47 gave fission-track ages in agreement with the potassium-argon dates (Table 1).

SAMPLE DESCRIPTIONS

1. 97VV-368 — Fission track — (sphene) 170±13; (apatite) 19.6±2.7

   Quartz monzonite (termed "alaskite" by Ransome, 1909, and referred to as "Vindicator pluton" by Edwards and McLaughlin, 1972). (37°44.2'N, 117°12.1'W; SE/4 SW/4 NW/4 Sec. 30, T2S, R43E; Esmeralda Co., NV). Medium-grained biotite quartz monzonite. Analytical data: (Sphene) total fossil tracks counted = 1396, total induced tracks counted = 308 (6 grains), $\rho_s = 1.22 \times 10^7$ tracks/cm², 1/2 $\rho_i = 2.69 \times 10^6$ tracks/cm², $\phi = 1.24 \times 10^{15}$ neutrons/cm². (Apatite) $\rho_s = 1.52 \times 10^5$ tracks/cm² (50 grains), $\rho_i = 1.40 \times 10^6$ tracks/cm² (50 grains), $\phi = 2.96 \times 10^{15}$ neutrons/cm². Collected by: J. P. Albers, U. S. Geological Survey. Comment: Locality the same as that of sample S-EPR4085A/875 of Edwards and McLaughlin (1972), which yielded biotite age of 173±6 m.y. (by K-Ar, 2σ error).

2. 199-137 — Fission track — (zircon) 33.0±2.0

   Vindicator Rhyolite. (37°44.2'N, 117°12.1'W; SE/4 SW/4 NW/4 Sec. 30, T2S, R43E; locality is 350' WNW of 97VV-368; Esmeralda Co., NV). Weakly altered, partly welded rhyolite tuff, near base of ash-flow unit. Analytical data: Total fossil tracks counted = 855, total induced tracks counted = 1394 (7 grains), $\rho_s = 7.75 \times 10^6$ tracks/cm², 1/2 $\rho_i = 2.12 \times 10^7$ tracks/cm², $\phi = 2.96 \times 10^{15}$ tracks/cm².

3. 222-36 — Fission track — (zircon) 31.1±2.2; (apatite) 27.7±3.3

   Morena Rhyolite. (37°45.0'N, 117°12.9'W; NE/4 NE/4 SW/4 Sec. 24, T2S, R42E; Esmeralda Co., NV). Quartz-sanidine-biotite rhyolite ash-flow tuff, densely welded and crystallized. Analytical data: (Zircon) total fossil tracks counted = 604, total induced tracks counted = 738 (7 grains), $\rho_s = 1.61 \times 10^6$ tracks/cm², 1/2 $\rho_i = 1.97 \times 10^6$ tracks/cm², $\phi = 1.24 \times 10^{15}$ tracks/cm². (Apatite) $\rho_s = 5.56 \times 10^4$ tracks/cm² (50 grains), $\rho_i = 3.63 \times 10^5$ tracks/cm² (50 grains), $\phi = 2.96 \times 10^{15}$ neutrons/cm². Comment: See Geologic Discussion.

4. 201-116 — Fission track — (apatite) 21.2±2.4

   Latite (Ransome, 1909). (37°43.9'N, 117°11.3'W; NE/4 SE/4 SE/4 Sec. 30, T2S, R43E; Esmeralda Co., NV). Biotite-hornblende quartz latite lapilli tuff. Shows strong diagenetic alteration to K-mica, iron-montmorillonite, quartz, chlorite, calcite assemblage. Analytical data: $\rho_s = 4.88 \times 10^4$ tracks/cm² (51 grains), $\rho_i = 4.18 \times 10^5$ tracks/cm² (17 grains), $\phi = 2.96 \times 10^{15}$ neutrons/cm². Comment: See Geologic Discussion.

5. 185-115 — Fission track — (apatite) 33.5±4.5

   Latite (Ransome, 1909). (37°43.3'N, 117°10.6'W; SW/4 SW/4 NE/4 Sec. 32, T2S, R43E; Esmeralda Co., NV). Biotite-hornblende quartz latite, locally flow banded. Diagenetic alteration similar to 201-116, except contains appreciable hematite and magnetite and less iron-montmorillonite. Analytical data: Total fossil tracks counted = 86, total induced tracks counted = 232 (6 grains), $\rho_s = 7.38 \times 10^4$ tracks/cm², 1/2 $\rho_i = 1.99 \times 10^5$ tracks/cm², $\phi = 2.96 \times 10^{15}$ neutrons/cm².

6. 197-51-2 — Fission track — (apatite) 31.1±3.5

   Kendall Tuff. (37°43.4'N, 117°13.6'W; SE/4 SE/4 NE/4 Sec. 35, T2S, R42E; Esmeralda Co., NV). Quartz latite lapilli tuff, showing diagenetic alteration similar to 201-116. Analytical data: $\rho_s = 7.05 \times 10^4$ tracks/cm² (50 grains), $\rho_i = 4.11 \times 10^5$ tracks/cm² (50 grains), $\phi = 2.96 \times 10^{15}$ neutrons/cm².

7. Y-47 — Fission track — (apatite) 20.5±1.6

   Dacite (Ransome, 1909). (37°43.1'N, 117°09.3'W; SW/4 NE/4 SE/4 Sec. 33, T2S, R43E; Nye Co., NV). Porphyritic plagioclase-augite-biotite-hornblende rhyodacite with minor quartz. Analytical data: $\rho_s = 9.37 \times 10^4$ tracks/cm² (100 grains), $\rho_i = 7.63 \times 10^5$ tracks/cm² (50 grains), $\phi = 2.72 \times 10^{15}$ neutrons/cm². Comment: Biotite previously dated by K-Ar method at 21.2±0.4 m.y. (Silberman and Ashley, 1970).

8. 203-11 Fission track (sphene) 19.8±1.4
(apatite) 20.1±2.0

Dacite (Ransome, 1909). (37°43.7'N, 117°08.2'W; NW/4 NE/4 NE/4 Sec. 34, T2S, R43E; Esmeralda Co., NV). Porphyritic plagioclase-biotite-augite-hornblende rhyodacite. Analytical data: (Sphene) total fossil tracks counted = 388, total induced tracks counted = 1861 (8 grains), $\rho_s = 3.87 \times 10^5$ tracks/cm^2, 1/2 $\rho_i = 1.78 \times 10^6$ tracks/cm^2, $\phi = 2.96 \times 10^{15}$ neutrons/cm^2. (Apatite) $\rho_s = 9.59 \times 10^4$ tracks/cm^2 (52 grains), $\rho_i = 8.67 \times 10^5$ tracks/cm^2 (51 grains), $\phi = 2.96 \times 10^{15}$ neutrons/cm^2. Collected by: R. P. Ashley and M. L. Silberman. Comment: Biotite previously dated by K-Ar method at 21.4±0.4 m.y. (Silberman and Ashley, 1970).

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