Potassium- Argon dates for Trachytic rocks on Sao Miguel, Azores

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POTASSIUM-ARGON DATES FOR TRACHYTIC ROCKS ON SÃO MIGUEL, AZORES

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Recent geological mapping (Moore, 1991), augmented by stratigraphic studies and radiocarbon and K-Ar dating, is used by Moore (1990) to evaluate the eruptive frequency of São Miguel, the largest island in the Azores. The radiocarbon ages are reported by Moore and Rubin (1991); the K-Ar ages are reported here. All rocks dated for Moore's studies are Pleistocene in age.

São Miguel is the largest (about 62 × 13 km) and most populous (about 150,000 inhabitants) of the nine Azores Islands (fig. 1). Most of the islands have been volcanically active in historic time, and five eruptions have taken place on São Miguel in the past 500 years.

The Azores lie on both sides of the mid-Atlantic ridge near the triple junction of the North America, Eurasia, and Africa plates (fig. 2). An active spreading center, the NW-trending Terceira rift, cuts the western part of São Miguel (Searle, 1980). South of São Miguel, the E-trending inactive east Azores fracture zone may mark the pre-Azores, Eurasian-African plate boundary (Krause and Watkins, 1970).

São Miguel is comprised of four major volcanoes and a number of small cinder cones and local lava flows (fig. 3). The three western volcanoes (Sete Cidades, Agua de Pau, and Furnas) are stratovolcanoes and are mostly trachytic; the eastern volcano (Nordeste) is a shield of alkali basalt with minor trachyte. The cinder cones and local lava flows are alkali basalt with minor trachyte and tristanite.

The western stratovolcanoes are Quaternary in age and many of the lava and pyroclastic units have been dated by radiocarbon techniques using roots and plant material associated with them (Shotton and others, 1968; Shotton and Williams, 1969, 1971; Moore and Rubin, 1991). The Nordeste shield volcano is deeply eroded and is Pliocene and Pleistocene in age (Moore, 1990). K-Ar ages as old as about 4 Ma and as young as about 1 Ma have been reported from this volcano (Abdel-Monem and others, 1975).

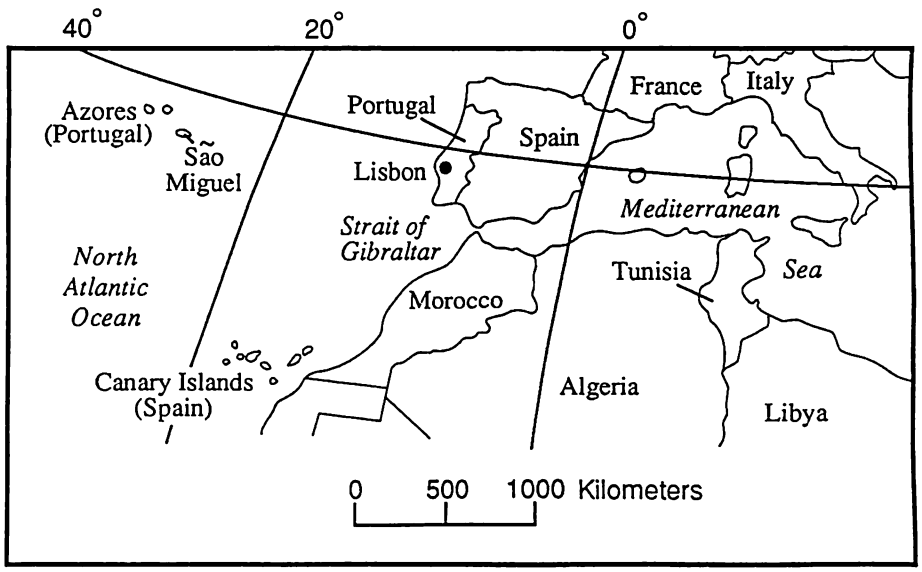

FIGURE 1. Location of the Azores west of Portugal in the North Atlantic Ocean (after Moore, 1990)

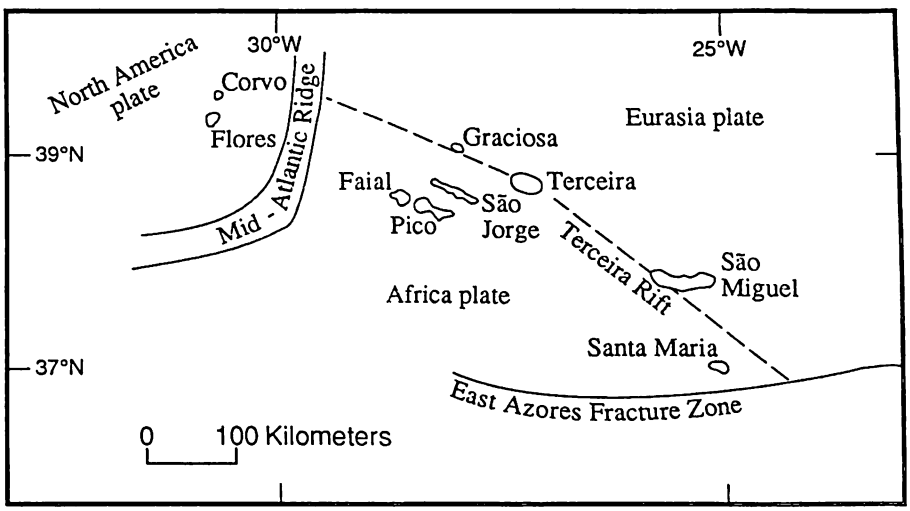

FIGURE 2. Azores and the major tectonic elements in its vicinity (after Searle, 1980).

ROCKS DATED

Two lava flows from each of the three western stratovolcanoes, Sete Cidades, Agua de Pau, and Furnas, were dated by K-Ar to establish the age of the older parts of these volcanoes. Radiocarbon dates were used to outline the young history of each volcano and to provide data to interpret eruption frequency (Moore, 1990). One sample of a xenolith from the Furnas volcano was dated by K-Ar. This xenolith is assumed to be from the buried shield of the Nordeste volcano directly east of the Furnas volcano. The lava flows were dated using specially prepared whole rock samples (see sample preparation); the xenolith was dated using a K-feldspar mineral separate.

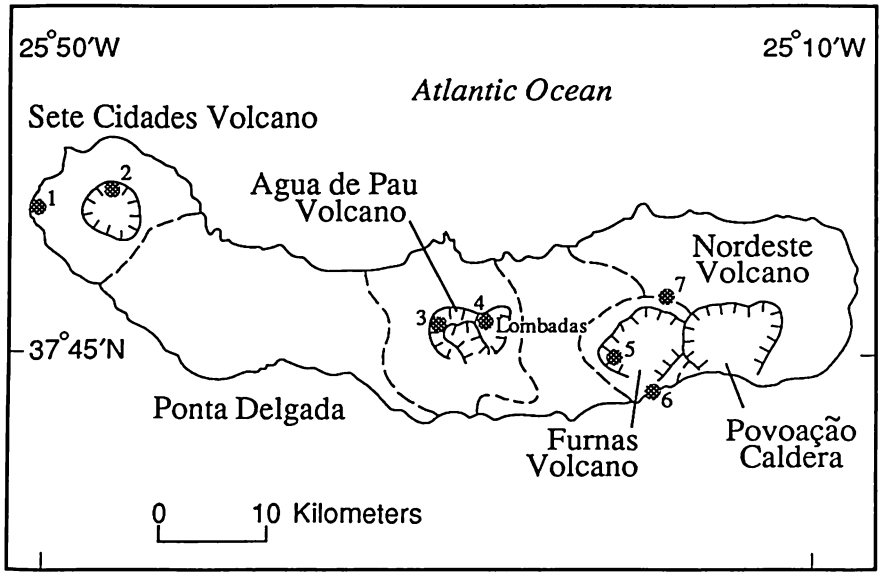

FIGURE 3. São Miguel Island with its four major volcanoes. Sample localities for K-Ar age analyses are numbered (after Moore, 1990).

SAMPLE PREPARATION

Because of the known young age of the lava flows from the three stratovolcanoes (less than 250,000 yrs B.P.), special care was taken to maximize the amount of radiogenically produced ^{40}Ar from the sample related to ^{40}Ar from atmospheric contamination in the sample. Geologically young samples normally yield very low ratios of sample-produced radiogenic ^{40}Ar ($^{40}Ar^*$) to atmospheric ^{40}Ar. This small percentage of sample radiogenic ^{40}Ar leads to a very large error factor (± value), often as large as 100% of the calculated age. To eliminate as much atmospheric Ar as possible, a procedure of boiling a crushed, acid treated sample was employed. The rock was crushed, sieved to 60–100 mesh and washed in distilled H_2O. Next it was placed in a 14% solution of nitric acid for 30 minutes after which it was washed in water and immersed in a 5% solution of concentrated (52%) HF for 2 minutes. After a final, thorough, washing in water the sample was dried under a heat lamp for several hours with periodic stirring. The sample was then weighed and sealed in a molybdenum crucible and boiled in distilled water for 12 hours. The crucible with sample was loaded directly in the ultra-high-vacuum extraction line after a short drain period but while still wet and still warm, then pumped out to vacuum. Bake-out of the extraction lines and extraction of the Ar were done in the usual manner as described by Dalrymple and Lanphere (1969). The $^{40}Ar^*/\Sigma^{40}Ar$ ranged from 39.9% to 4.79%, which yielded ± values of 2.9 and 9.7% of the calculated age.

ANALYTICAL METHODS

The sample preparation and analyses were done in the laboratories of the U.S. Geological Survey, Menlo Park, California. Analyses were by standard isotope dilution procedures as described by Dalrymple and Lanphere (1969). Potassium analyses were performed by lithium-metaborate flux fusion flame-photometry techniques, the lithium serving as an internal standard (Ingamells, 1970). Argon analyses were performed using a five-collector mass spectrometer (Stacey and others, 1981). The precision of the data, indicated by the ± value, is the estimated analytical uncertainty at one standard deviation. It represents uncertainties in the measurement of radiogenic ^{40}Ar and K_2O based on experience with hundreds of replicated analyses in the Menlo Park laboratories. The constants used in age determination are those from the Subcommission on Geochronology (Steiger and Jager, 1977).

SAMPLE DESCRIPTIONS

Sete Cidades volcano

1. *MF-81-43* K-Ar
Tristanite flow (from base of the sea cliff on the western edge of São Miguel Island, Azores; locality 1 on figure 3). *Analytical data:* K_2O = 4.24%; $^{40}Ar^*$ = 4.49203 × 10^{-13} mol/gm; $^{40}Ar^*/\Sigma^{40}Ar$ = 8.82%. *Collected by:* R. B. Moore.
(whole rock) 74,000 ± 6,000 yrs B.P.

2. *MF-81-75* K-Ar
Trachyte flow (base of the northern caldera wall, locality 2 on figure 3, São Miguel Island, Azores). *Analytical data:* K_2O = 4.57%; $^{40}Ar^*$ = 1.3599 × 10^{-12} mol/gm; $^{40}Ar^*/\Sigma^{40}Ar$ = 30.1%. *Collected by:* R. B. Moore.
(whole rock) 210,000 ± 8,000 yrs B.P.

Aqua de Pau volcano

3. *MF-83-15* K-Ar
Peralkaline trachyte flow (from the upper part of the western flank of the stratovolcano, locality 3 on figure 3, São Miguel Island, Azores). *Analytical data:* K_2O = 5.38%; $^{40}Ar^*$ = 9.3769 × 10^{-13} mol/gm; $^{40}Ar^*/\Sigma^{40}Ar$ = 13.01%. *Collected by:* R. B. Moore.
(whole rock) 121,000 ± 5,000 yrs B.P.

4. *MF-83-79* K-Ar
Trachyte flow (Lombadas, locality 4 on figure 3, São Miguel Island, Azores). *Analytical data:* K_2O = 6.02%; $^{40}Ar^*$ = 3.96551 × 10^{-13} mol/gm; $^{40}Ar^*/\Sigma^{40}Ar$ = 16.67%. *Collected by:* R. B. Moore.
(whole rock) 46,000 ± 6,000 yrs B.P.

Furnas volcano

5. *MF-81-153* K-Ar
Trachyte flow (from the western wall of the caldera, locality 5 on figure 3, São Miguel Island, Azores). *Analytical data:* K_2O = 6.31%; $^{40}Ar^*$ = 4.30988 × 10^{-13} mol/gm; $^{40}Ar^*/\Sigma^{40}Ar$ = 9.45%. *Collected by:* R. B. Moore.
(whole rock) 48,000 ± 4,000 yrs B.P.

6. *MF-81-14* K-Ar
Tristanite flow (from base of the sea cliff on the southern edge of São Miguel Island, Azores; locality 6 on figure 3). *Analytical data:* K_2O = 5.0%; $^{40}Ar^*$ = 6.69486 × 10^{-13} mol/gm; $^{40}Ar^*/\Sigma^{40}Ar$ = 4.79%. *Collected by:* R. B. Moore.
(whole rock) 93,000 ± 9,000 yrs B.P.

7. *MF-81-162* K-Ar
Syenite xenolith from the Furnas volcano, probably originated from the Nordeste volcano. *Analytical data:* K_2O = 6.95%; $^{40}Ar^*$ = 9.73498 × 10^{-12} mol/gm; $^{40}Ar^*/\Sigma^{40}Ar$ = 39.9%. *Collected by:* R. B. Moore.
(K-feldspar) 973,000 ± 29,000 yrs B.P.

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