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1982, pp. 187-189. https://doi.org/10.56577/FFC-33.187

in:

Albuquerque Country II, Wells, S. G.; Grambling, J. A.; Callender, J. F.; [eds.], New Mexico Geological Society 33 rd Annual Fall Field Conference Guidebook, 370 p. https://doi.org/10.56577/FFC-33

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RADIOMETRIC AGES OF PRECAMBRIAN ROCKS FROM CENTRAL NEW MEXICO

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INTRODUCTION

Radiometric ages for Precambrian rocks from central New Mexico have been reported by several authors (Brookins, 1974; Brookins and Majumdar, 1982; Brookins and others, 1978; White, 1978; Mukhopadhyay and others, 1975). The early U-Pb and Th-Pb dates by several investigators are summarized in Brookins (1974) and will not be repeated here. The other references deal primarily with Rb-Sr and K-Ar dates, and these are discussed in this paper. It should be pointed out, however, that many of these rocks are under re-investigation, and the dates and interpretations offered here are subject to revision (see Bowring and Condie, 1982).

BRIEF DESCRIPTION OF THE ROCKS

The Ojita pluton is located in Manzano Mountains. According to White (1978), it is a medium-grained, biotite granodiorite intruded into Precambrian metasedimentary rocks and, in turn, intruded by younger basaltic rocks.

The Priest quartz monzonite is a coarse-grained, biotite-quartz-feldspar phanerite (Stark, 1956) with large microcline phenocrysts. The Priest quartz monzonite intrudes metamorphic rocks, and the monzonite contains numerous pegmatites and aplites. The Sevilleta metarhyolite is intercalated with other metavolcanic and metasedimentary rocks; only metarhyolites were studied by Brookins and others (1980). The average modal composition of the rock is K-feldspar, 15-25 percent; plagioclase (mainly albite), 10-20 percent; quartz, 50 percent; and biotite, 1-5 percent; with minor magnetite, apatite, and zircon.

The Los Pinos granite is a porphritic granite with phenocrysts of microcline and quartz in a groundmass of K-feldspar, quartz, and quartz-plagioclase myrmekite. Rapakivi textures occur in places. Modal analysis of the Los Pinos granite yields quartz, 44 percent; K-feldspar, 38 percent; plagioclase, 12 percent; biotite, 4 percent; and magnetite, 1.5 percent. The Ladron pluton consists of quartz monzonite (orthoclase-microcline, quartz, plagioclase, biotite, muscovite with minor magnetite, and apatite). It is intrusive into an older pluton (Capirote pluton) and metamorphics (White, 1978). The Magdalena pluton consists of fine- to coarse-grained granite with major amounts of perthitic K-feldspar, quartz, sodic plagioclase, and biotite. Condie and Budding (1979) have described both the Ladron and Magdalena plutons in more detail.

The outcrops of the Ojita, Priest, Servilleta, Los Pinos, Ladron, and Magdalena rocks are usually severely altered, and collecting fresh samples for geochronologic work is difficult (White, 1978).

The Precambrian rocks of the Pedernal Hills have been described by Gonzales and Woodward (1972) and by Armstrong and Holcombe (this guidebook). The granitic rocks consist of alkali granite, granite gneiss, and some cataclasites, all of which are presumed younger than surrounding quartzites and schists. No direct contact between the granitic rocks and the metamorphics is observable, but the regionally metamorphosed sequence has been contact metamorphosed in places (see Gonzales and Woodward, 1972).

The Precambrian rocks of the Sandia Mountains included for this study are the Cibola gneiss and the Sandia granite. The Cibola gneiss consists of a meta-arkose, quartzite sequence (see Taggart and Brookins, 1975). The Sandia granite is a quartz monzonite with distinctive microcline phenocrysts in a granitoid groundmass of feldspars, quartz, and biotite. The rock is described as a quartz-microcline-oligoclase-biotite granite which plots near the minimum on the quartz-albite-orthoclase ternary (see Enz and others, 1979). There is some controversy as to whether there is more than one pluton in the Sandia Mountains. Most workers have mapped the Sandia granite as one body, but Condie and Budding (1979) have proposed that there are two plutons (North and South Sandia plutons) based on chemical arguments. New results (Brookins and Majumdar, this guidebook) do not support their arguments.

The Precambrian rocks of the Zuni Mountains have been described by Goddard (1966) and Fitzsimmons (1967). Biotite granodiorite occurs in the eastern part of the Zuni Mountains and is coarse- to medium-grained. The biotite is partially altered to chlorite. Feldspars include microcline, microperthite, and partially sausseritized plagioclase. Apatite, Sphene, magnetite, tourmaline, and some zircon are accessories. Metarhyolite is most common in the central part of the Zuni Mountains. It contains K-feldspar and quartz phenocrysts in a quartz-feldspar groundmass. Biotite is altered to chlorite. Fitzsimmons (1967) has proposed that the rocks are pyroclastic. Gneissic granite and aplite make up much of the western core rocks of the Zuni Mountains. The aplite is biotite-poor relative to the biotite granodiorite mentioned above, and the plagioclase more sodic (An,, in aplite; An,„_„ in biotite granodiorite). All the Precambrian rocks are weathered in outcrop, but reasonably fresh samples can be obtained from excavations and from drill core (see Brookins and others, 1978).

GEOCHRONOLOGIC DATA

Mineral K-Ar and Rb-Sr dates from central New Mexico are given in Table 1. Biotites from the Sandia Mountains fall in the range from 1,300 to 1,340 m.y. while muscovites fall in a slightly older range of 1,375 to 1,400 m.y. In addition, Steiger and Wasserburg (1969) have reported a muscovite Rb-Sr date of 1,450 m.y. from pegmatite in Tijeras Canyon. The period of 1,330 to 1,360 (?) m.y. in central New Mexico, including north-central New Mexico, is known as a time of plutonic activity during which many pegmatites were injected (see Register, 1979), and mineral ages, as well as some whole-rock isochrons, were reset to yield dates in the 1,330-1,360 m.y. range. Further, the Oscura Mountains pluton yields an age of 1,338 ± 26 m.y. (White, 1978). RbSr systematics of quartzites and schists of the Pedernal Hills, intruded by 1,471 ± 97 m.y. granitic rocks, yield a possibly reset date of 1,364 ± 27 m.y.; although, the two ages are identical within the stated limits of error. This is also the case for the metarhyolites of the Zuni Mountains (1,385 ± 40 m.y.), which are intruded by 1,485 ± 90 m.y. granitic rocks. The best evidence for resetting comes form the Sandia Mountains where 13 biotites yield an average of 1,328 ± 26 m.y. , clearly younger than the 1,445 ± 40 m.y. whole rock date for the granite. The slightly younger muscovite dates (Table 2) indicate that the thermal event was not of sufficient strength to reset all minerals. Sphene yields a fission track date of 1,400 m.y. (Naeser, 1971) from Tijeras Canyon, which also supports some mineral resetting. More mineral dates are clearly needed

Table 1. K-Ar and Rb-Sr mineral ages from Precambrian rocks, central New Mexico.

Location-Rock Unit	Age (m.y.)	Method	N	Reference
Rincon, Sandia Mountains				
(a) muscovite from pegmatite	1401 ± 29	K-Ar	2	7
(b) muscovite from Juan Tabo series	1376 ± 29	K-Ar	1	7
Sandia Mountains				
Biotite from western side of mountains	1300	K-Ar	1	8
(same as above)	1340	Rb-Sr	1	8
Biotite from orbicular granite	1328 ± 28	K-Ar	3	9
Biotites from granite, several locations	1330 ± 20	Rb-Sr	8	3

Notes: (1) References: 7 = Brookins and Shafiqullah (1975), 8 = Aldrich and others (1958), 9 = Brookins and others (1975), 3 = Brookins and Majumdar (1982). (2) N = number of samples.

to refine the nature of the mineral resetting and to more clearly define the limits of the proposed regional thermal event.

Apparent Paleozoic dates from central New Mexico have been reported by Loring and Armstrong (1980). They report possible Rb-Sr maximum dates of 496 m. y. and 604 m. y. for samples from the Pedernal Hills (N = 4) and from Lobo Hills (N= 1), respectively. A mean age of 469 ± 7 m.y. results by combining the two sets of data. Both occurrences are of syenite emplaced into foliated and metamorphosed Precambrian rocks which have been dated at 1,360-1,470 m.y. (Mukhopadhyay and others, 1975). Loring and Armstrong (1980) propose that these occurrences are related to a regional alkalic-intrusive episode encompassing central Colorado to central New Mexico.

DISCUSSION OF THE WHOLE ROCK GRANITE AGES

The range in ages and initial 'Sr/"Sr ratios (Table 2) for the granitic rocks from New Mexico is large but not unusually so. The very large error in both age and initial ratio (Magdalena, Los Pinos, and Sepultura plutons) is due primarily to scatter about the whole rock isochrons which, in turn, may be due to any of a number of factors. First, any fairly large body of granitic rock may contain more than one reservoir of initial "Sr/"Sr. If more than one reservoir is sampled, then a resultant isochron will be in error. Roddick and Compston (1977) and Brookins (1977) have discussed this problem in more detail. Second, the degree of alteration and its effect on Rb-Sr systematics for Precambrian rocks may be sufficient for some subtle Rb-Sr perturbations. Third, some

Table 2. Rb-Sr whole-rock isochron ages of Precambrian rocks from central New Mexico.

Location-Rock Unit	Rb-Sr Age (m.y.)	$(^{87}Sr/^{86}Sr)_0$	N	Reference
1. Ladron Mountains				
Ladron pluton	1291 ± 51	0.7101 ± 0.0037	7	1
2. Magdalena Mountains				
Magdalena pluton (a)	1326 ± 138	0.7380 ± 0.0202	4	1
(b)	1247 ± 63	0.7160 ± 0.0076	6	1
3. Manzano Mountains				
Ojita pluton	1527 ± 39	0.7016 ± 0.0010	10	1
Priest quartz monzonite	1569 ± 315	0.7029 ± 0.0064	6	2
4. Los Pinos Mountains				
Sevilleta metarhyolite	1599 ± 52	0.7060 ± 0.0007	5	2
Los Pinos granite	1601 ± 239	0.7078 ± 0.0207	6	2
Sepultura granite	1350 ± 106	0.7489 ± 0.0334	6	2
5. Sandia Mountains				
Sandia granite	1445 ± 40	0.7054 ± 0.0005	11	3
Cibola gneiss	1576 ± 73	0.7022 ± 0.0010	6	4
6. Pedernal Hills				
granite	1471 ± 97	0.7060 ± 0.0040	9	5
schist, quartzite	1364 ± 27	0.7046 ± 0.0019	9	5
7. Zuni Mountains				
metarhyolite	1385 ± 40	0.721 ± 0.009	6	6
granite gneiss, aplite, biotite granodiorite	1485 ± 90	0.7062 ± 0.0008	12	6

Notes: (1) All data for $\lambda = 1.42 \times 10^{-11}$/y. (2) References: 1 = White (1978), 2 = Brookins and others (1980), 3 = Brookins and Majumdar (1982), 4 = Taggart and Brookins (1975), 5 = Mukhopadhyay and others (1975), 6 = Brookins and others (1978). (3) N = number of samples used for isochron construction. (4) Older dates for some of these rocks have been reported in preliminary fashion by Bowring and Condie (1982).

granitic rocks subjected to regional metamorphic events may behave locally as mineral systems and be partially or wholly reset to the age of metamorphism, although this factor is probably not important for the granitic rocks of New Mexico.

Of interest is the fact that there is a crude correlation of increasing age with lower "Sr/^{86}Sr ratios, although the Los Pinos pluton data (with very large errors in both age and initial ratio) may be anomalous. Variable "Sr/"Sr ratios in crustal material incorporated into the granitic magmas is indicated, with more radiogenic "Sr possibly incorporated into the younger granites. Multidomain granites (cf. Roddick and Compston, 1977; Brookins, 1977) are indicated by the data for the Magdalena plutons (a and b, Table 2) discussed by White (1978).

No regular age of intrusion as a function of geographic setting is noted. It has been proposed (see discussion in Condie, 1982) that there is a younging of ages of igneous activity southward across New Mexico, but the data for the central New Mexico occurrences are probably too restricted to test this hypothesis. Five rock units (three granites, one metarhyolite, and one meta-arkose) yield dates between 1,520 to 1,600 m.y.; three granites fall between 1,400 to 1,500 m.y.; two granites, metarhyolites, and one quartz-schist unit fall between 1,300 to 1,400 m.y.; and two units fall between 1,200 to 1,300 m.y. Only further to the north (see Brookins, 1974) are granitic rocks older than 1,600 m.y. found, however.

The apparently oldest intrusive rocks are the Sevilleta metarhyolite of the Los Pinos Mountains and the Cibola gneiss in the southern Sandia Mountains; the remaining metarhyolites and quartz-schistose rocks are apparently younger.

Of interest is the fact that the Sandia granite, Pedernal Hills granitic rocks, and the granitic core rocks of the Zuni Mountains are all close in age and initial "Sr/^{86}Sr ratio, implying similar source materials and roughly equal ages of emplacement. These may well be representative of the 1,400 to 1,500 m.y. granites cited as typical for central New Mexico by Condie (1982).

The proposed thermal event of about 1,300 to 1,350 m.y. may have had some effect on whole-rock systematics but not enough to cause more than local age and/or initial-ratio variations. The Sepultura granite, for example, may have been emplaced at the time of this thermal event, as well as the Oscura pluton (White, 1978) further south and the Ladron and Magdalena plutons. All of these show very high initial "Sr/"Sr ratios, which is consistent with a large upper crustal component in the source reservoirs.

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Structural analysis in Precambrian rocks—from little things come grand ideas.