Rb-Sr isochron age of Precambrian plutons of the San Pedro Mountains, north-central New Mexico

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RB-SR ISOCHRON AGE OF PRECAMBRIAN PLUTONS OF THE SAN PEDRO MOUNTAINS, NORTH-CENTRAL NEW MEXICO

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The San Pedro Mountains, at the northern end of the Nacimiento uplift in north-central New Mexico, are underlain predominantly by Precambrian plutonic rocks (figs. 1 and 2). Stocks ranging in composition from ultramafic to granitic intrude quartzose metasedimentary rocks (formerly impure sandstones and argillite) and silicic metavolcanic rocks, some of which appear to be metamorphosed ash-flow tuffs. The Precambrian rocks, which are similar to those of the Nacimiento Mountains to the south, are overlain unconformably by upper Paleozoic sedimentary rocks.

Most of the Precambrian terrane has been investigated for mineral resource potential by the U.S. Geological Survey and U.S. Bureau of Mines (Santos and others, 1975). Most of the area is also covered by geologic maps of the Cuba, Nacimiento Peak, and Gallina 7½-minute quadrangles (Woodward and others, 1972, 1974, 1976), and the chemical and petrologic characteristics of the Precambrian rocks have recently been presented by Woodward, McLelland and Husler (1977). Only two Rb-Sr ages have been published for Precambrian rocks of the area (Brookins, 1974): 1760 ± 50 m.y. for a meta-quartz latite from the pre-intrusive wall rocks and 1800 ± 170 m.y. for a small body of gneissic leucogranodiorite in the northwestern part of the area.

This report provides new Rb-Sr whole-rock ages, determined by Hedge, for seven samples from the two largest plutons of the San Pedro Mountains. Samples were collected by both authors during 1978, as part of the U.S. Geological Survey's mapping of the Aztec 1° x 2° quadrangle. Sampling was generally confined to shallow roadcuts beside a U.S. Forest Service road along the southern margin of the wilderness area. The upland region within the area is deeply weathered, with few outcrops fresh enough for sampling; in addition, some of the rock units take on a hybrid character, deemed unsuitable for radiometric dating, farther to the north.

PLUTONIC ROCKS AND SEQUENCE OF INTRUSION

Woodward, McLelland and Husler (1977) presented chemical data for six intrusive rock units, which they arranged in "probable chronologic order" (oldest to youngest) as follows: ultramafic and melagabbroic rocks, gabbro and diorite, biotite quartz diorite, leucogranodiorite, quartz monzonite, and muscovite-biotite granite. They also described a "hybrid zone" consisting of numerous small bodies of quartz diorite with inclusions of pink porphyry, the latter thought to have formed by recrystallization of the metavolcanics; this zone is mapped as quartz diorite in the present report. The chemical data for these units are summarized in table 1.

A review of the field evidence generally supports this sequence of intrusion. The small bodies of melagabbro, gabbro, and diorite have reacted at their contacts with the younger quartz diorite, which in turn has been intruded by both the quartz monzonite and the muscovite-biotite granite; the latter two units are not in contact with one another, however. The leucogranodiorite, on the other hand, is probably out of place in the sequence and may in fact be the oldest of the plutonic units. Although the contacts of this small body are not exposed, it is the only foliated intrusive rock, bearing the imprint of a period of regional metamorphism which most likely also produced the foliation of the nearby meta-sedimentary and metavolcanic rocks.

The other five of Woodward's plutonic rock units are nonfoliated and thus probably younger than the leucogranodiorite. When averaged chemical analyses of these five units are arranged on a Harker-type variation diagram in chronologic sequence, they show fairly regular decreases in total iron, CaO and MgO and increases in K_2O and Na_2O with increasing silica (fig. 3). There is thus good reason to propose that they are part of a single intrusive series and that the small body of foliated leucogranodiorite is older.

The largest plutons of the San Pedro Mountains are of biotite quartz diorite (tonalite) and quartz monzonite composition.

The reader is referred to Woodward, McLelland and Husler (1977) for petrologic details and descriptions of the plutonic rock units.

GEOCHRONOLOGY AND CORRELATION

Seven samples from the two largest San Pedro Mountains plutons have been dated by whole-rock Rb-Sr methods. These include two samples of quartz diorite, three of porphyritic quartz monzonite, one from a dike of quartz monzonite that cuts the quartz diorite, and one from the fine-grained porphyritic variant of the quartz monzonite (mapped as leucogranite by Woodward and others, 1977). Sample locations are plotted in figure 2; Rb-Sr analytical data are presented in table 2 and are shown on an isochron plot in figure 4.

The seven samples define an isochron age of 1615 ± 15 m.y., with initial Sr^{87}/Sr^{86} of 0.7047 ± 0.0005. This age is somewhat younger than the older of two commonly

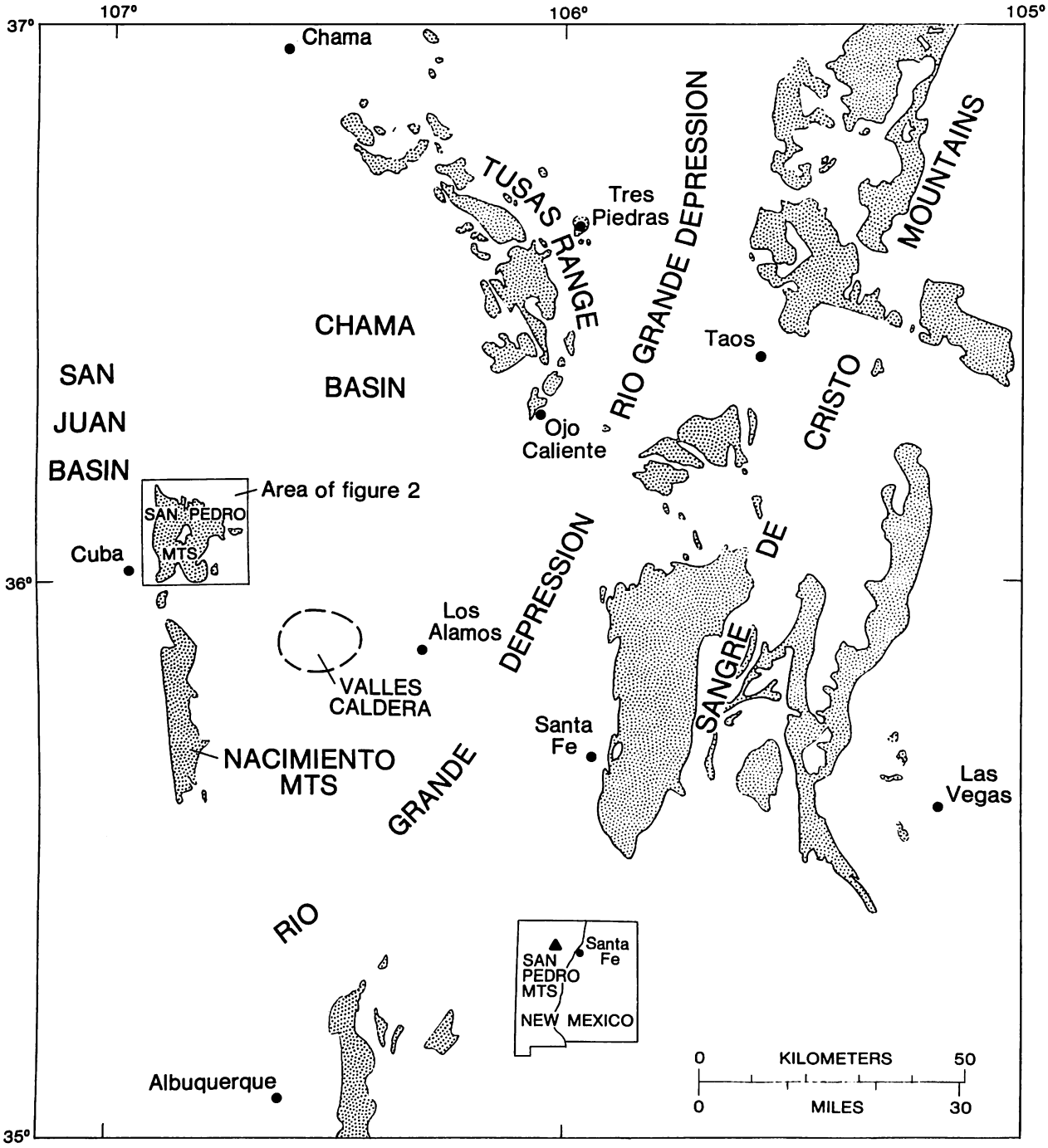

Figure 1. Index map of north-central New Mexico, showing location of San Pedro Mountains. Stippled pattern indicates Precambrian rocks.

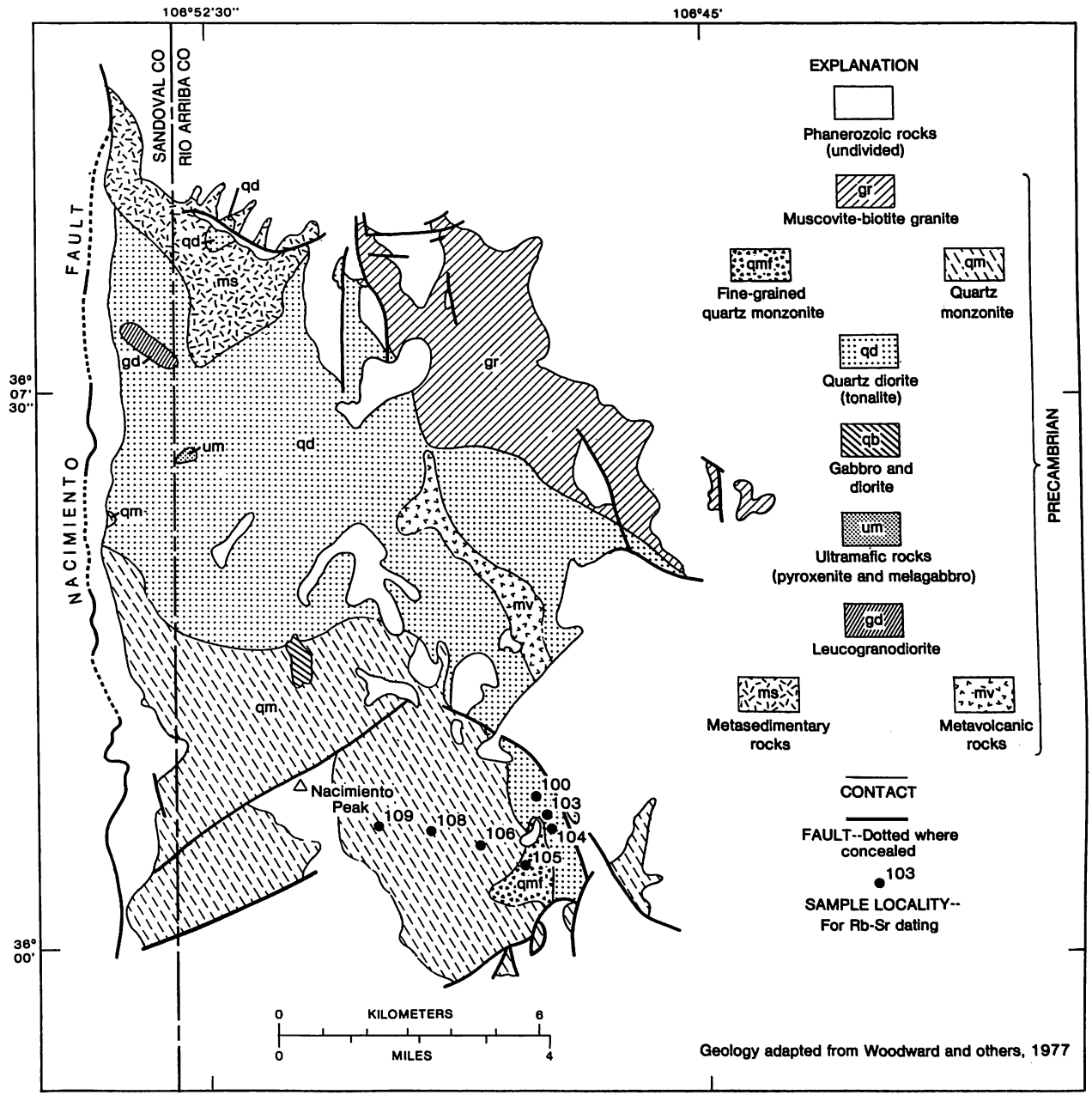

Figure 2. Generalized geologic map of the San Pedro Mountains and vicinity, showing locations of samples for Rb-Sr dating.

Table 1. Averaged chemical data for selected intrusive rocks of the San Pedro Mountains, New Mexico.* Sequence of intrusion (modified from Woodward, McLelland and Husler, 1977).

	Oldest					
	Pre- or syn-tectonic	Post-tectonic intrusive series				
Rock type and number of samples analyzed	Leuco-granodiorite(1) (foliated)	Pyroxenite and melagabbro(4)	Gabbro and diorite(4)	Quartz diorite(2)	Quartz monzonite(1)	Muscovite-biotite granite(1)
Approximate percentage of area of exposed Precambrian plutons	2	1	2	40	30	25
Averaged amounts (in weight percent):						
SiO_2	75.7	46.3	50.8	67.6	71.1	77.5
$FeO + Fe_2O_3$	0.6	11.2	10.0	5.1	2.7	0.5
MgO	0.4	18.0	8.0	1.2	1.0	0.2
CaO	0.9	8.1	9.9	3.1	2.3	0.3
Na_2O	4.1	1.5	2.2	4.1	3.2	3.4
K_2O	3.7	0.7	0.9	1.8	3.5	4.8

*From Woodward, McLelland and Husler (1977).

observed age ranges for major Precambrian intrusive episodes that are widely recognized in Colorado and southern Wyoming (Hedge and others, 1977; Snyder and Hedge, 1978). Batholiths of Boulder Creek age (ca. 1670 m.y.) are typically granodiorite to quartz monzonite; in Colorado these plutons are commonly foliated and most are regarded as syntectonic with the major Precambrian episode of regional metamorphism (Hutchinson and Hedge, 1967; Hawley and Wobus, 1977; Tweto, 1977). Trondhjemitic plutons of this age have been reported in central Colorado and in the Brazos Peak quadrangle of north-central New Mexico, approximately 75 miles (120 km) northeast of the San Pedro area (Barker and others, 1974). Essentially nonfoliated plutons of the same general age have also been recognized, however, indicating that there were local variations in the timing and severity of the major regional metamorphic event in the southern Rocky Mountains. The nearest previously dated example of such a nonfoliated pluton is the 1720 ± 20-m.y.-old Bakers Bridge Granite, located 110 miles (176 km) to the north in the Needle Mountains of southwestern Colorado (Silver and Barker, 1968). Preliminary data indicate that the granite porphyry of Tusas Mountain, 60 miles (96 km) to the northeast in the Aztec quadrangle, is another example of an essentially nonfoliated pluton of Boulder Creek age.

Plutons of the 1400- to 1450-m.y. Silver Plume intrusive episode in the southern Rocky Mountains are most commonly quartz monzonite to granite in composition, although an intrusive series of this age, ranging from gabbro through quartz diorite and granodiorite to granite, occurs in the Needle Mountains (Barker, 1969; R. E. Zartman, unpub. results, 1966; Silver and Barker, 1968). Plutons of this age span are exclusively post-tectonic with respect to the major period of regional metamorphism and are part of a transcontinental intrusive episode recognized from Labrador to Mexico (Silver and others, 1977b). The Sandia Granite of central New Mexico, which gives a whole-rock Rb-Sr age of 1470 ± 15 m.y. (Brookins, 1974), could be considered one of the oldest representatives of this younger intrusive episode.

The plutons of the San Pedro Mountains do not fit definitively, on the basis of age, into either of the two widespread intrusive episodes recognized elsewhere in the Precambrian of the southern Rocky Mountains. Their age and location do place them marginally within a 1610- to 1700-m.y.-old magmatic arc, described by Silver and others (1977a), which lies to the south of the batholiths of Boulder Creek age and extends from southern Arizona into central New Mexico. Other published reports of New Mexico plutons with ages near the younger end of this time span are lacking, however.

CONCLUSIONS

Precambrian plutons of the San Pedro Mountains are of at least two ages within Proterozoic X times. The small body of foliated leucogranodiorite is older, with a broadly defined Rb-Sr age of 1800 ± 170 m.y. as reported by Brookins (1974). In view of the large error factor, this rock could be contemporaneous with granodiorite and trondhjemite plutons of Boulder Creek age (ca. 1670 m.y.) in Colorado and north-central New Mexico. The two largest plutons of the San Pedro Mountains, of quartz diorite and

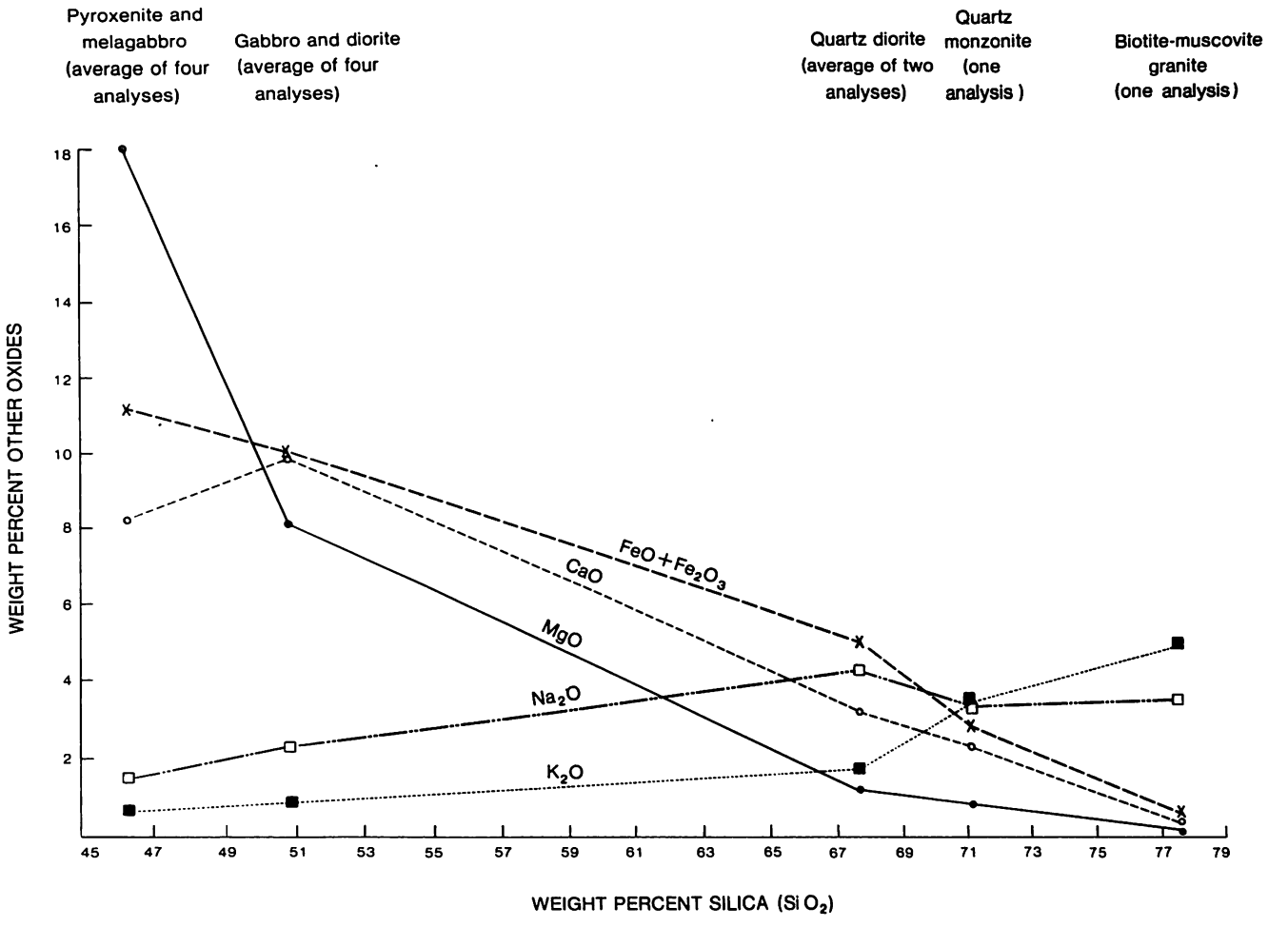

Figure 3. Harker-type variation diagram for chemically analyzed plutonic rocks from the San Pedro Mountains. Chemical analyses for each rock type averaged from Woodward, McLelland and Husler (1977).

Table 2. Rb-Sr data for quartz diorite and quartz monzonite of the San Pedro Mountains.

Sample No.	Rock type	Rb (ppm)	Sr (ppm)	Rb^{87}/Sr^{86}	Sr^{87}/Sr^{86}
SP-100	Quartz diorite	63.0	279	0.6538	0.7196
SP-103	Quartz diorite	76.2	268	0.8261	0.7240
SP-104	Quartz monzonite dike in quartz diorite	83.9	174	1.4007	0.7357
SP-105	Fine-grained quartz monzonite*	204	114	5.2434	0.8255
SP-106	Quartz monzonite	127	234	1.5785	0.7403
SP-108	Quartz monzonite	121	249	1.4100	0.7375
SP-109	Quartz monzonite	134	234	1.6613	0.7423

*leucogranite of Woodward, McLelland and Husler (1977)

Sample locations (see fig. 2)

SP-100 36°02'10"N, 106°47'43"W; Rio Arriba Co., NM
SP-103 36°01'50"N, 106°47'42"W; Rio Arriba Co., NM
SP-104 36°01'42"N, 106°47'42"W; Rio Arriba Co., NM
SP-105 36°01'03"N, 106°47'57"W; Rio Arriba Co., NM
SP-106 36°01'20"N, 106°48'27"W; Rio Arriba Co., NM
SP-108 36°01'23"N, 106°49'23"W; Rio Arriba Co., NM
SP-109 36°01'25"N, 106°49'52"W; Rio Arriba Co., NM

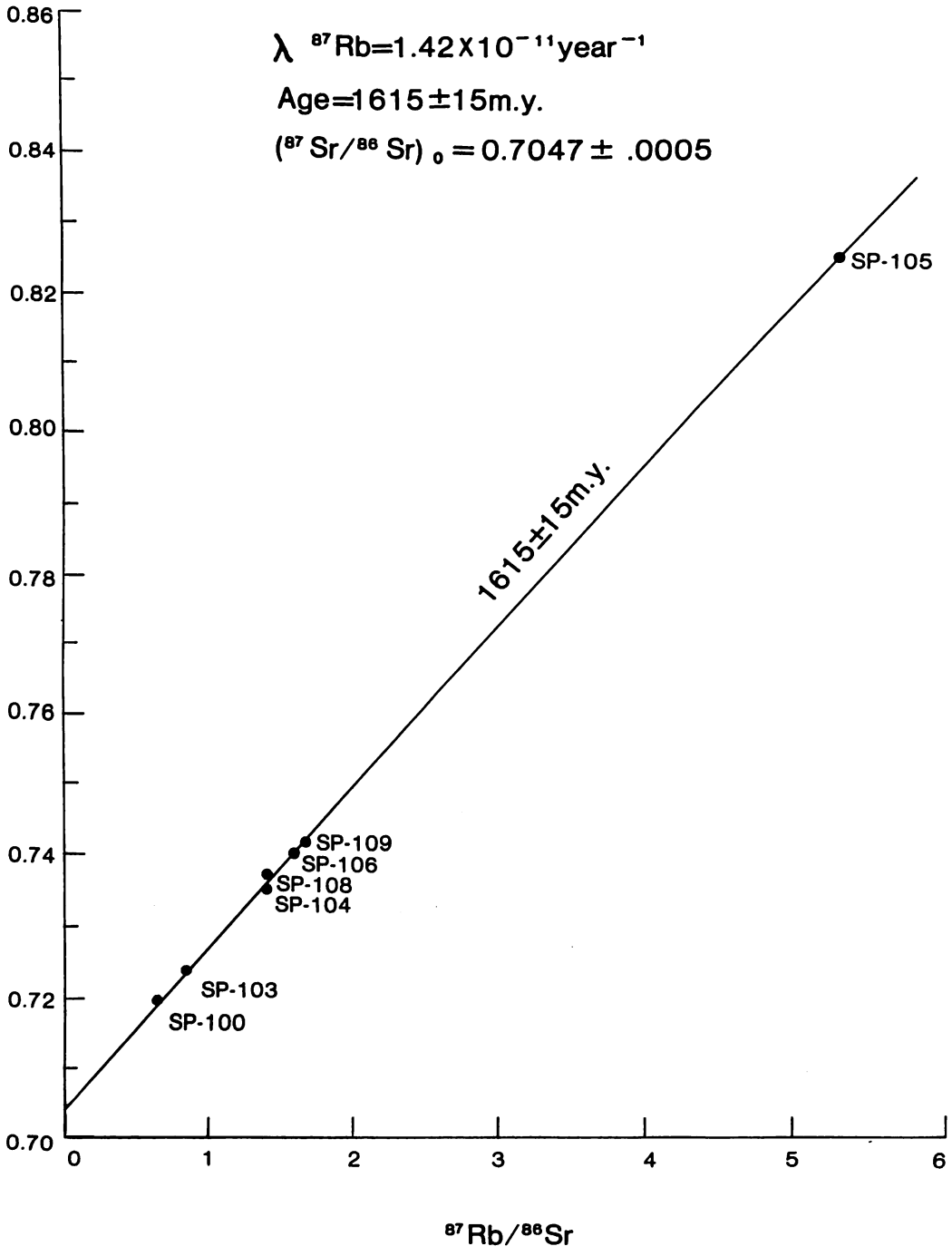

Figure 4. Rb-Sr isochron plot of seven samples of quartz diorite and quartz monzonite from the San Pedro Mountains.

quartz monzonite composition, give an isochron age of 1615 ± 15 m.y.; they are nonfoliated and appear to be part of an intrusive series ranging from ultramafic to granitic. The initial Sr^{87}/Sr^{86} ratio of the quartz diorite and quartz monzonite (0.7047) is not definitive as an indicator of magma source, but the ultramafic and mafic plutonic rocks of the region, which may be co-magmatic with the units dated in this report, must have been produced as partial melts of the mantle.

REFERENCES

Barker, Fred (1969) Precambrian geology of the Needle Mountains, southwestern Colorado: U.S. Geological Survey Professional Paper 644-A..

Barker, Fred, Peterman, Z. E., Henderson, W. T., and Hildreth, R. A. (1974) Rubidium-strontium dating of the trondhjemite of Rio Brazos, New Mexico, and of the Kroenke Granodiorite, Colorado: U.S. Geological Survey Journal of Research, v. 2, p. 705-709.

Brookins, D. G. (1974) Summary of recent Rb-Sr age determinations from Precambrian rocks of north-central New Mexico: New Mexico Geological Society 25th Guidebook, Ghost Ranch, p. 119–121.

Hawley, C. C., and Wobus, R. A. (1977) General geology and petrology of the Precambrian crystalline rocks, Park and Jefferson Counties, Colorado: U.S. Geological Survey Professional Paper 608-B.

Hedge, C. E., Houston, R. L., Tweto, O. L., Reid, R. R., Harrison, J. E., and Peterman, Zell (1977) The Precambrian of the Rocky Mountain region (abs.): Geological Society of America Abstracts with Programs, v. 9, no. 7, p. 1010.

Hutchinson, R. M., and Hedge, C. E. (1967) Precambrian basement rocks of the central Colorado Front Range and its 700-million-year history, *in* Geological Society of America, Rocky Mountain Section Field Trip 1, 20th Annual Meeting (Colorado) 1967: Colorado School of Mines.

Santos, E. S., Hall, R. B., and Weisner, R. C. (1975) Mineral resources of the San Pedro Wilderness and vicinity, Rio Arriba and Sandoval Counties, New Mexico: U.S. Geological Survey Bulletin 1385-C.

Silver, L. T., and Barker, Fred (1968) Geochronology of Precambrian rocks of the Needle Mountains, southwestern Colorado—Part 1, U-Pb zircon results (abs.): Geological Society of America Special Paper 115, p. 204–205.

Silver, L. T., and Anderson, C. A., Crittenden, M., and Robertson, J. M. (1977) Chronostratigraphic elements in the Precambrian rocks of the southwestern and far western United States (abs.): Geological Society of America Abstracts with Programs, v. 9, no. 7, p. 1176.

Silver, L. T., Bickford, M. E., Van Schmus, W. R., Anderson, J. L., Anderson, T. H., and Medaris, L. G., Jr. (1977) The 1.4–1.5 b.y. transcontinental anorogenic plutonic perforation of North America (abs.): Geological Society of America Abstracts with Programs, v. 9, no. 7, p. 1176–1177.

Snyder, G. L., and Hedge, C. E. (1978) Intrusive rocks northeast of Steamboat Springs, Park Range, Colorado: U.S. Geological Survey Professional Paper 1041.

Tweto, Ogden (1977) Nomenclature of Precambrian rocks in Colorado: U.S. Geological Survey Bulletin 1422-D.

Woodward, L. A., Gibson, G. G., and McLelland, D. (1976) Geology of Gallina quadrangle, Rio Arriba County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geological Map 39.

Woodward, L. A., McLelland, D., Anderson, J. B., and Kaufman, W. H. (1972) Geologic map of Cuba quadrangle, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geological Map 25.

Woodward, L. A., McLelland, D., and Husler, J. W. (1977) Precambrian rocks of the northern part of the Nacimiento uplift, New Mexico: New Mexico Geological Society 28th Guidebook, San Juan Basin III, p. 93–98.