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RADIOMETRIC AGE DETERMINATIONS FROM THE SANDIA GRANITE, NEW MEXICO: SUMMARY AND INTERPRETATION

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Radiometric age determinations from the Sandia granite, New Mexico have been cited by numerous authors. The earliest dates are the K-Ar and Rb-Sr biotite age determinations reported by Aldrich and others (1957) and by Aldrich and others (1958) although the precise location of the granite sample from which the biotite was extracted is not given. Tilton and others (1962), Steiger and Wasserburg (1966), and Wasserburg and Steiger (1967) have reported U, Th-Pb dates from zircons and sphenes and diffusion dates from zircons. Tilton and others (1962) worked on the same material as did Aldrich and others (1957) while Steiger and Wasserburg (1966) worked on material from a single block of Sandia granite collected from Tijeras Canyon 12.5 miles east of Albuquerque. In 1965 Wasserburg presented preliminary data (Wasserburg and others, 1965) for Rb-Sr studies of the Sandia granite. While never published in full detail parts have been presented by Wasserburg and Steiger (1967) and Steiger and Wasserburg (1969). Finally, two fission track age determinations by Poupeau (1969) are cited by Naeser (1971); again, there is no knowledge of exact sample location.

All of the above cited references are of importance in deciphering the geologic history of the Sandia Mountains and this work represents an effort to synthesize the data and attempt a reasonable interpretation.

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Constants used are: K-Ar ages: $\lambda_\epsilon = 0.585 \times 10^{-10}$/yr, $\lambda_\beta = 4.72 \times 10^{-10}$/yr, $K^{40}/K_{total} = 1.22 \times 10^{-4}$ g/g. Rb-Sr ages: $\lambda_{Rb^{87}} = 1.39 \times 10^{-11}$/yr. U, Th-Pb ages: $\lambda_{U^{238}} = 1.537 \times 10^{-10}$/yr., $\lambda_{U^{235}} = 9.72 \times 10^{-10}$/yr., $\lambda_{Th^{232}} = 4.99 \times 10^{-11}$/yr., $U^{238}/U^{235} = 137.8$. Diffusion dates of Wasserburg and Steiger (1967): D = diffusion coefficient, D_o = constant, $D_1 t$ = coefficient proportional with time (see discussion in Steiger and Wasserburg, 1966). Corrections for common Pb given with age data (this report). No data available for fission track dates of Poupeau (1969).

DISCUSSION

One of the main problems associated with attempting to draw definitive conclusions from the preceding data is due to the small amount of Sandia granite represented by the analytical work. Over two hundred square miles of granite are exposed on the western side of the Sandia Mountains and several different mineralogical assemblages are noted. Much of the outcrop material is either too poorly exposed or too weathered for adequate collecting yet it is unfortunate that the analytical data (nos. 1-16) are for samples taken from only two or possibly three locations. The Tijeras Canyon samples (NM5; nos. 2, 5-12, 14) occur close to granite gneiss and are cut by pegmatite and aplite. It is possible that the granite in Tijeras Canyon may have been subjected to a different post-formational history than other parts of the granite. This, if true, might account for the subtle metamorphism which has apparently affected the granite in Tijeras Canyon (e.g. discordant Pb dates and excess Sr^{87} in minerals). It is not known if more, or all (?), of the Sandia granite has been similarly affected or not; the sampling is too inadequate to tell.

The Pb^{207}-Pb^{206} dates average 1470±20 m.y. The U, Th-Pb dates are discordant, however, and the zircons and sphenes have been disturbed since original formation. Steiger and Wasserburg (1966) propose that if an episodic loss of radiogenic Pb occurred 1470 m.y. ago then, depending on the model and the material analyzed, upper intersections with the concordia curve yield ages of original formation ranging from 1490 to 1640 m.y. with a mean of about 1535 m.y. The uncertainties are such that an even older age of original crystallization is possible. A further consequence of this episodic model is that a "last event" of about 60 m.y. is obtained. Steiger and Wasserburg (1966) suggest that this may reflect the time of uplift during the Laramide Orogeny.

The K-Ar date on biotite is 1300 m.y.; this date may be low (e.g. relative to other dates reported here) due to normal diffusion of radiogenic Ar^{40} from the mica structure, to a possible slightly later crystallization of the biotite, or to incipient metamorphism. It is impossible to distinguish between these possibilities at present.

The Rb-Sr data are even more difficult to interpret. Muscovite from aplite cutting Tijeras Canyon samples (NM-5) yields a date of 1470 m.y. (Steiger and Wasserburg, 1969). This date must be considered as a minimum as aplites commonly represent the last part of a granite to crystallize and this aplite cuts the remainder of the Sample NM-5. That this muscovite date is older than the possible whole rock isochron for several aliquots of five whole rocks (1.41 b.y.; see Wasserburg and Steiger, 1967; Fig. 1) is probably due to the uncertainties of the whole rocks behavior during incipient metamorphism. Several minerals from these whole rocks are greatly enriched in radiogenic Sr^{87} thus arguing for peturbance of the systems and, more important, the spread in Rb^{87}/Sr^{86} ratios for the whole rock is only from 1.6 to 2.5 (with all but one sample falling in an even narrower range of 2.1 to 2.5) which is inadequate for any whole-rock isochron solution to the problem of age of formation. Data from samples with different mineralogies and from several sites well removed from Tijeras Canyon should allow a greater range in Rb/Sr to be found as well as to rule out the uncertainties introduced in Tijeras Canyon by the presence of the granite gneiss. The manuscript "in preparation" by Wasserburg and others (see Wasserburg and Steiger, 1967; Ref. 10 note) based on material presented orally (Wasserburg and others, 1965) has not been published. It is possible that samples from sites other than in Tijeras Canyon may be included in the final manuscript as W. E. Elston (personal communication, 1973) has reported that he conducted a field trip for Wasserburg to several locations in the Sandias. The writer has not received further information concerning this matter.

The fission track dates of Poupeau (1969; cited by Naeser, 1971) do shed some light on the degree of incipient metamorphism that can have affected the Sandia granite, presumably in Tijeras Canyon. The apatite date of 50 m.y. is significantly lower than the sphene date of 1400 m.y. This is not surprising in that apatite fission tracks are annealed at very low temperatures (175°C for 1 m.y. for 100 percent track loss) relative to sphene (420°C for 1 m.y. for 100 percent track loss) according to Naeser and Faul (1969). The apatite date (No. 17) is thus interpreted as heating associated with uplift during the Laramide Orogeny. At the same time, the uplift must have been relatively rapid (geologic sense) and at a relatively low temperature as the sphene date is 1400 m.y., not far below the 1470 m.y. Pb^{207}/Pb^{206} and 1480 m.y. Rb^{87}-Sr^{87} (muscovite) dates cited earlier. That the sphene date is older than the biotite date of 1300 m.y. also suggests that radiogenic Ar^{40} loss from the biotite may well have been due primarily to combined normal diffusion coupled with slight heating (the last being at a temperature well under 400°C).

The following conclusions can be reached for the Sandia Granite: (1) A minimum age of formation of the granite is given as 1470 to 1480 m.y. (2) The granite was probably uplifted during the Laramide Orogeny 50 to 60 m.y. ago. (3) Mineral (and whole rock?) systems reflect weak metamorphism, probably thermal, as reflected in discordant U,Th-Pb dates and Sr isotopic discordancy for some minerals. Finally, it should be mentioned that new research is planned for Sandia granite and associated Precambrian rocks. (Brookins, 1973).

SAMPLE DESCRIPTIONS

1. Aldrich and others (1958) — K-Ar — (biotite) 1300 m.y.
No. 18, Table 9 — Rb-Sr — (biotite) 1340 m.y.
"This white granite is exposed on the lower part of the Sandia Escarpment northeast of Albuquerque. It is composed of sericitized plagioclase, biotite, apatite, rather large grains of sphene, and a little chlorite and magnetite.": Collected by: L. T. Aldrich. Carnegie Inst. Washington: dated by: Carnegie Inst. Wash.

2. Wasserburg and Steiger (1967) — Rb-Sr — (whole rock isochron) 1410 m.y.
No. NM-5
Sandia granite (35°03′50″N, 106°28′00″W, Bernalillo Co., NM). Possible isochron constructed through array of unlabelled whole rocks (Rb^{87}/Sr^{86} spread 1.6 - 2.5) and mineral data; all samples from single block of granite (NM-5). Some minerals (apatite, epidote, sphene) anomalously enriched in Sr^{87}. Collected by: G. J. Wasserburg, Calif. Inst. Tech.; dated by: G. J. Wasserburg, D. G. Towell, R. H. Steiger, Calif. Inst. Tech. (Wasserburg and others, 1965).

3. Steiger and Wasserburg (1969) — Rb-Sr — (muscovite) 1470 m.y.
Fig. 2
Aplite cutting Sandia granite (NM-5 of Wasserburg and others, 1965; Steiger and Wasserburg, 1966) (35°03′50″N, 106°28′00″W, Bernalillo Co., NM). Isochron (Fig. 2) weighted by muscovite separate (Rb^{87}/Sr^{86} = 940; Sr^{87}/Sr^{86} = 20.017; initial Sr^{87}/Sr^{86} = 0.704).

4. Tilton and others (1962) — U^{238}-Pb^{206} (zircon) 1120 m.y.; U^{235}-Pb^{207} (zircon) 1250 m.y.; Th^{232}-Pb^{208} (zircon) 1290 m.y.; Pb^{207}-Pb^{206} (zircon) 1475 m.y.

Zircon separate from same granite (A-26) collected by Aldrich and others (1958; see sample no. 1, this report). "Zircon clear hyacinth, euhedral, zoned, dark inclusions, some cores, length/breadth = 2.5." Pb^{206}/Pb^{204} = 17.0, Pb^{207}/Pb^{204} = 15.50, Pb^{208}/Pb^{204} = 36.5. Dated by: G. R. Tilton and others, Carnegie Inst. Wash.

5. Steiger and Wasserburg (1966), No. NM5A-B1, Table 2 — U^{238}-Pb^{206} (zircon) 1290±15 m.y.; U^{235}-Pb^{207} (zircon) 1360±15 m.y.; Th^{232}-Pb^{208} (zircon) 1295±15 m.y.; Pb^{207}-Pb^{206} (zircon) 1470±20 m.y.

Sandia Mountain granite (35°03′50″N, 106°28′00″W, Tijeras Canyon, Bernalillo Co., NM). Single block of granite (NM-5) split into two parts (A and B); granite consists of quartz, K-feldspar (microcline), plagioclase, biotite, muscovite, zircon, magnetite, apatite, epidote, sphene (Wasserburg and Steiger, 1967). NM-5 cut by pegmatite (?) and aplite. Zircon +325 mesh, nonmagmatic. Pb^{206}/Pb^{204} = 16.9, Pb^{207}/Pb^{204} = 15.50, Pb^{208}/Pb^{204} = 36.50. Collected by: R. H. Steiger, G. J. Wasserburg; Calif. Inst. Tech.; dated by: R. H. Steiger, G. J. Wasserburg; Calif. Inst. Tech.

6. Steiger and Wasserburg (1966), No. NM5A-B2, Table 2 — U^{238}-Pb^{206} (zircon) 935±15 m.y.; U^{235}-Pb^{207} (zircon) 1105±10 m.y.; Th^{232}-Pb^{208} (zircon) 865±20 m.y.; Pb^{207}-Pb^{206} (zircon) 1460±20 m.y.

See No. 5 for sample location and description. NM5A-B2 is +325 mesh, magnetic fraction of zircon separated from Sandia granite.

7. Steiger and Wasserburg (1966), No. NM5-B-1, Table 2 — U^{238}-Pb^{206} (zircon) 1100±15 m.y.; U^{235}-Pb^{207} (zircon) 1215±10 m.y.; Pb^{207}-Pb^{206} (zircon) 1430±20 m.y.

See No. 5 for sample location and description. NM5B-1 is -120 + 150 mesh fraction of zircon separated from Sandia granite.

8. Steiger and Wasserburg (1966), No. NM5B-2, Table 2. — U^{238}-Pb^{206} (zircon) 1110±15 m.y.; U^{235}-Pb^{207} (zircon) 1235±10 m.y.; Pb^{207}-Pb^{206} (zircon) 1460±20 m.y.

See No. 5 for sample location and description. NM5B-2 is -150 +200 mesh fraction of zircon separated from Sandia granite.

9. Steiger and Wasserburg (1966), No. NM5B-3, Table 2 — U^{238}-Pb^{206} (zircon) 1170±15 m.y.; U^{235}-Pb^{207} (zircon) 1275±10 m.y.; Th^{232}-Pb^{208} (zircon) 1125±25 m.y.; Pb^{207}-Pb^{206} (zircon) 1455±20 m.y.

See No. 5 for sample location and description. NM5B-3 is -150 +230 mesh fraction of zircon separated from Sandia granite.

10. Steiger and Wasserburg (1966), No. NM5B-4, Table 2 — U^{238}-Pb^{206} (zircon) 1130±15 m.y.; U^{235}-Pb^{207} (zircon) 1250±10 m.y.; Th^{232}-Pb^{208} (zircon) 1065±20 m.y.; Pb^{207}-Pb^{206} (zircon) 1455±20 m.y.

See No. 5 for sample location and description. NM5B-4 is -230 mesh fraction of zircon separated from Sandia granite.

11. Tilton and Grunenfelder (1968), No. NM5A-B1, Table 2 — U^{238}-Pb^{206} (sphene) 1460 m.y.; U^{235}-Pb^{207} (sphene) 1462 m.y.; Pb^{207}-Pb^{206} (sphene) 1470 m.y.

See Nos. 5 & 6 for sample location and description. Pb^{206}/Pb^{204} = 16.25, Pb^{207}/Pb^{204} = 15.51, Pb^{208}/Pb^{204} = 35.73. Collected by: R. H. Steiger, G. J. Wasserburg, Calif. Inst. Tech.; dated by: G. R. Tilton, M. H. Grunenfelder; Univ. Calif., Santa Barbara.

12. Tilton and Grunenfelder (1968) No. NM5A-B2, Table 2

	U^{238}-Pb^{206}	(sphene) 1450 m.y.
	U^{235}-Pb^{207}	(sphene) 1456 m.y.
	Pb^{207}-Pb^{206}	(sphene) 1480 m.y.

See Nos. 5 & 6 for sample location and description. Collected by: R. H. Steiger, G. J. Wasserburg; Calif. Inst. Tech., dated by: G. R. Tilton, M. H. Grunenfelder, Univ. Calif., Santa Barbara.

13. Tilton and Grunenfelder (1968) No. A-26

	U^{238}-Pb^{206}	(sphene) 1440 m.y.
	U^{235}-Pb^{207}	(sphene) 1460 m.y.
	Pb^{207}-Pb^{206}	(sphene) 1490 m.y.

See No. 1 for approximate sample location and sample description. Collected by: L. T. Aldrich and others, Carnegie Inst. Wash.; dated by: G. R. Tilton, M. H. Grunenfelder; Univ. Calif., Santa Barbara.

14. Wasserburg and Steiger (1967) Table 1

	Diffusion ages	
Sample	$D = D_o$	$D(t) = D_1 t$
(zircon, NM5A-B1)	1510 m.y.	1500 m.y.
(zircon, NM5A-B2)	1640 m.y.	1580 m.y.
(zircon, NM5B-1)	1530 m.y.	1490 m.y.
(zircon, NM5B-2)	1560 m.y.	1530 m.y.
(zircon, NM5B-3)	1530 m.y.	1510 m.y.
(zircon, NM5B-4)	1540 m.y.	1520 m.y.

See Nos. 5-10 for sample description and locations. Collected by: R. H. Steiger, G. J. Wasserburg; dated by: G. J. Wasserburg, R. H. Steiger.

15. Poupeau (1969) See also Naeser, 1971, p. 4980) — Fission Track — (sphene) 1400 m.y.
Location: Sandia Mountains, N.M.; sphene concentrate. Dated by: G. Poupeau

16. Poupeau (1969) See also Naeser, 1971, p. 4980) — Fission Track — (apatite) 50 m.y.
Location: Sandia Mountains, N.M.: apatite concentrate. Dated by: G. Poupeau.

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