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Douglas G. Brookins and Arun Majumdar

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THE SANDIA GRANITE: SINGLE OR MULTIPLE PLUTONS?

DOUGLAS G. BROOKINS
Department of Geology
University of New Mexico
Albuquerque, New Mexico 87131

and

ARUN MAJUMDAR
Department of Geology
Louisiana State University
Baton Rouge, Louisiana 70803

INTRODUCTION

The petrology and field relations of the Sandia granite have been studied by a number of workers (Lodewick, 1960; Green and Callender, 1973; Kelley and Northrop, 1975; Enz and others, 1979; Berkley and Callender, 1979; Condie and Budding, 1979). The Sandia granite is a gray to pink, medium- to coarse-grained, porphyritic rock. It consists mainly of distinctive microcline, quartz, oligoclase, and biotite. Accessory minerals are sphene, magnetite, apatite, hornblende, muscovite, tourmaline, and pyrite. The average modal analysis for the granite is 35 percent quartz, 15 percent microcline, 35 percent plagioclase, 10 percent biotite, and 5 percent microperthite (Kelley and Northrop, 1975). The overall composition of the granite is from quartz monzonite to granodiorite, although there is pronounced local variation.

The northern contact of the Sandia granite with adjacent metamorphic rocks of the Juan Tabo series is rather sharp, and a distinct metamorphic aureole occurs near the granite boundary (Green and Callender, 1973). The southern contact of the granite with the Cibola gneiss is in part gradational, with microcline megacrysts of the pluton decreasing in size over a few meters from granite into the gneiss (Condie and Budding, 1979; Connolly, this guidebook). Lodewick (1960) relates this change to peripheral alkali metasomatism. Elsewhere, such as in Tijeras Canyon, there are unmistakable intrusive contacts of the granite into the Cibola gneiss (Taggart and Brookins, 1975; Connolly, 1982 and this guidebook). Further, Lodewick (1960) has reported sillimanite in the contact zone of the Cibola gneiss which may have formed due to contact metamorphism during intrusion by the Sandia granite. Berkley and Callender (1979) cite differences in the nature of the contacts (sharp versus gradational) of the Sandia granite with intruded rocks as evidence for granite emplacement in several discrete pulses, and they note that the granite has been emplaced as dikes and sills where the country rocks show dilation effects.

The Sandia granite is a product of magmatic crystallization as documented by the studies of Enz and others (1979) who show that the quartz-microcline-oligoclase-biotite granites plot near the hypothetical minimum on the normative quartz-albite-orthoclase ternary. They further propose that the main body of granite crystallized in a relatively water-undersaturated condition, in accordance with the experimental evidence of Maaloe and Wyllie (1975).

Orbicular granites are known from several sites within the Sandia granite (see Affholter and Lambert, this guidebook). Thompson and Giles (1974) have suggested that the La Luz trail site orbicular granite is a product of metasomatism, but Enz and others (1979) provide evidence for an igneous origin. In the Juan Tabo picnic area, another occurrence of orbicular granite is composed essentially of alternating rings of quartzo-feldspathic material; whereas, the La Luz site occurrence is characterized by alternating rings of mafic minerals with quartzo-feldspathic minerals. Affholter (1979) and Affholter and Lambert (this guidebook) have reported on quartzo-feldspathic orbicular granite from the southern part of the Sandia Mountains which is very much like the Juan Tabo occurrence.

The radiometric age of the Sandia granite is 1.44 ± 0.04 b.y. (billions of years) and is based on samples from widespread locations throughout the Sandia granite exposures. There appears to have been a mild (?) thermal event which affected the Sandia granite at about 1.35 b.y. to 1.375 b.y. (Brookins and others, 1975; Brookins and Majumdar, 1982). This event was sufficient to cause "Ar (* = radiogenic) loss from biotites and some "^{87}Sr loss from biotites as well. Muscovites from the metamorphic rocks and from pegmatites in the Rincon area yield K-Ar dates of about 1.375 b.y., slightly older than the reset biotites of 1.35 b.y. Sphene also yields a fission track date of 1.4 b.y. (in Naeser, 1971) which may be due to the same thermal event. Brookins (this guidebook) discusses this problem in more detail.

THE TWO-PLUTON HYPOTHESIS

Condie and Budding (1979) have recently proposed that the Sandia granite can be divided into two major plutons, a north and a south block with the contact in/or very close to Pino Canyon (see maps by Condie and Budding, 1979; Kelley and Northrop, 1975). Their interpretation of a two-pluton origin for the Sandia granite is based on nine samples, four from the northern block and five from the southern block, which they analyzed for major and minor elements. In addition, petrographic studies were carried out on all samples.

Many of the arguments by these authors seemed to us to be inconclusive or at least debatable. To test their hypothesis, we have analyzed samples from north and south of Pino Canyon, and we have compiled published data from other sources. The available data are presented in Table 1 for major elements and in Table 2 for trace elements. Standard analytical methods were employed by all investigators, but there are some aspects of these methods worth mentioning. The major element data of Condie and Budding (1979) were by x-ray fluorescence; hence, iron is reported as total Fe_2O_3. For the other data (by Enz and others, 1979; Affholter, 1979; and Brookins and Majumdar, this guidebook) gravimetry, atomic absorption spectrophotometry, and colorimetric methods were used. The trace element data by Condie and Budding (1979) and Brookins and Majumdar (this guidebook) were by neutron activation analysis, although some Rb and Sr data were by standard isotope dilution techniques (Brookins and Majumdar, 1982).

According to Condie and Budding (1979), the northern Sandia pluton is more alkali-rich, less mafic, and contains more Rb and REE (rare earth elements). Inspection of the data in Tables 1 and 2 show that the samples from north of Pino Canyon reported by Enz and others (1979), Affholter (1980), and our new data (columns 3, 4 of Table 1) only in part support Condie and Budding's (1979) hypothesis. The northern samples do consistently show slightly higher TiO_2 and SiO_2 and less MgO and CaO. However, Na_2O, which varies considerably, is slightly higher in southern versus northern samples for columns 3 and 4 (Table

Table 1. Chemical analyses of the Sandia granite, New Mexico.

Oxide	1	2	3	4	5	6
SiO_2	69.2	66.3	65.2	63.65	69.4	66.6
TiO_2	0.76	1.03	1.07	1.18	0.79	1.05
Al_2O_3	13.7	13.9	13.74	13.56	13.9	14.3
Fe_2O_3	4.81	6.85	2.42	2.98	2.29	2.30
FeO	—	—	4.23	4.75	3.10	3.10
MgO	1.00	1.33	1.34	1.62	0.95	1.24
CaO	2.75	3.73	3.14	3.74	2.29	3.21
Na_2O	3.29	3.11	2.94	3.07	3.34	3.06
K_2O	3.99	3.25	4.31	3.42	3.71	4.02
H_2O (+)	—	—	0.85	0.94	0.73	0.81
H_2O (−)	—	—	0.12	0.06	0.06	0.06
P_2O_5	—	—	0.33	0.40	0.30	0.30
MnO	—	—	0.115	0.13	0.11	0.11
SrO	0.024	0.023	0.022	0.024	0.025	0.026
	99.5	99.5	99.78	99.54	100.99	100.18

Notes: Column 1: average of 4 samples of north Sandia pluton (Condie and Budding, 1979); column 2: average of 5 samples of south Sandia pluton (Condie and Budding, 1979); column 3: average of 4 samples from north of Pino Canyon, Sandia granite (Majumdar, unpublished data); column 4: average of 4 samples from south of Pino Canyon, Sandia granite (Majumdar, unpublished data); column 5: average of 6 samples from north of Pino Canyon, Sandia granite (Enz and others, 1979); column 6: average of two samples from south of Pino Canyon, Sandia granite (Enz and others, 1979; Affholter, 1979).

*Table 2. Comparison of some trace elements from "north" and "south" Sandia granite.**

	North Area		South Area	
Element (ppm)	1	2	3	4
Cr	9	—	10	—
Co	11	14	18	16
Rb	192	176	150	145
Sr	241	197	228	216
Zr	364	—	365	—
Ba	840	—	790	960
Cs	8.3	—	7.6	—
La	62	55	49	57
Ce	140	108	118	113
Sm	13	9	11	10
Eu	3.1	2.4	2.9	2.4
Tb	2.3	—	1.9	—
Yb	4.9	6.3	4.1	6.2
Lu	0.79	—	0.64	—
Th	—	11.8	—	10.7
Hf	—	8.0	—	9.1
Sc	—	20.6	—	19.5
K/Rb	173	232	180	243
Rb/Sr	0.8	0.89	0.66	0.67
La/Yb	13	8.7	12	9.2

Notes: (*) The words north and south refer to samples from north and south of Pino Canyon in the Sandia Mountains, which is the proposed contact between the two major plutons of the Sandia granite of Condie and Budding (1979). Data in columns 1 and 3 are from Condie and Budding (1979); data in columns 2 and 4 are from A. Majumdar and D. G. Brookins.

1) and K,0 is higher in southern samples than in northern samples for columns 5 and 6 (Table 1). Further, Condie and Budding (1979) indicate an apparent difference of more than 2 weight percent total Fe (as Fe_2O_3) between north and south samples. Our data (columns 3, 4 of Table 1) show a smaller difference, and the iron content of samples reported by Enz and others (1979) and Affholter (1980) in columns 5 and 6 of Table 1 show no difference. The data for MnO and SrO for columns 3-6 (Table 1) also show no apparent difference although our data do suggest that the samples from north of Pino Canyon are slightly more Rb rich.

REE data and other trace-element data are given in Table 2, and our data are plotted in Figure 1. The data of Condie and Budding (1979) and our data are in good agreement, especially since different samples were used by both sets of investigators. Basically, we see no real difference between the REE contents or distributions between north and south samples. In fact our southern samples are more REE rich than those from the north, which is the opposite of the interpretation by Condie and Budding (1979). However, data are sparse and could be influenced by a few more analyses. The REE abundances for the two groups are so close as to preclude any definitive statement concerning real differences between the groups.

Another aspect of the Condie and Budding (1979) two-pluton hypothesis deserves mention. They argue that the north Sandia pluton was emplaced at a higher temperature than the south pluton based on possibly greater contact metamorphic effects on the intruded rocks. Yet, this is contradictory to their statements (Condie and Budding, 1979, p. 47) in which a formation temperature for granodiorites of 750°C to 800°C is given relative to 700°C for quartz monzonite, and the northern pluton is more quartz monzonitic than the grandioritic southern block.

CONCLUSION

Chemical variations within large bodies of granitic rock are common, and mineralogic and chemical changes within any large pluton are often the rule rather than the exception. The data for the Sandia granite shown in Tables 1 and 2 do not support any separate-magma sources for samples from north and south of Pino Canyon. In fact, in view of the data in Tables 1 and 2 and the REE distribution curves in Figure 1, it is reasonable to argue that the data support the Sandia granite being a single pluton. The data further suggest that any "one versus two" pluton hypothesis probably cannot be supported by chemical studies. Detailed mapping could resolve the single or multi-pluton conflict.

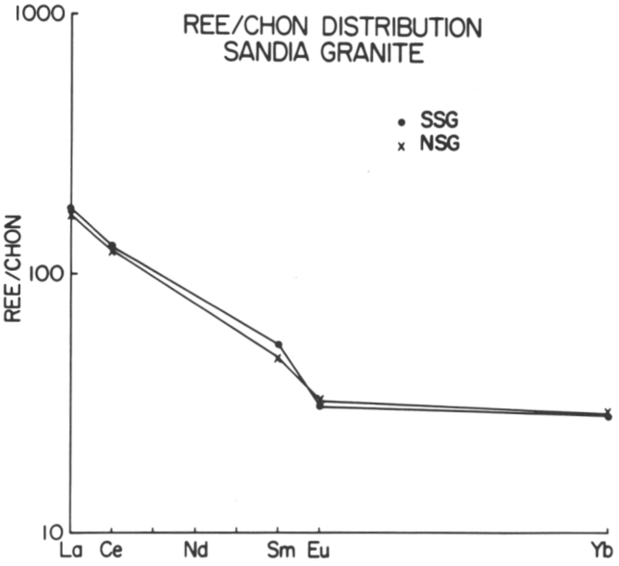

Figure 1. Rare earth element distribution in selected samples of the Sandia granite.

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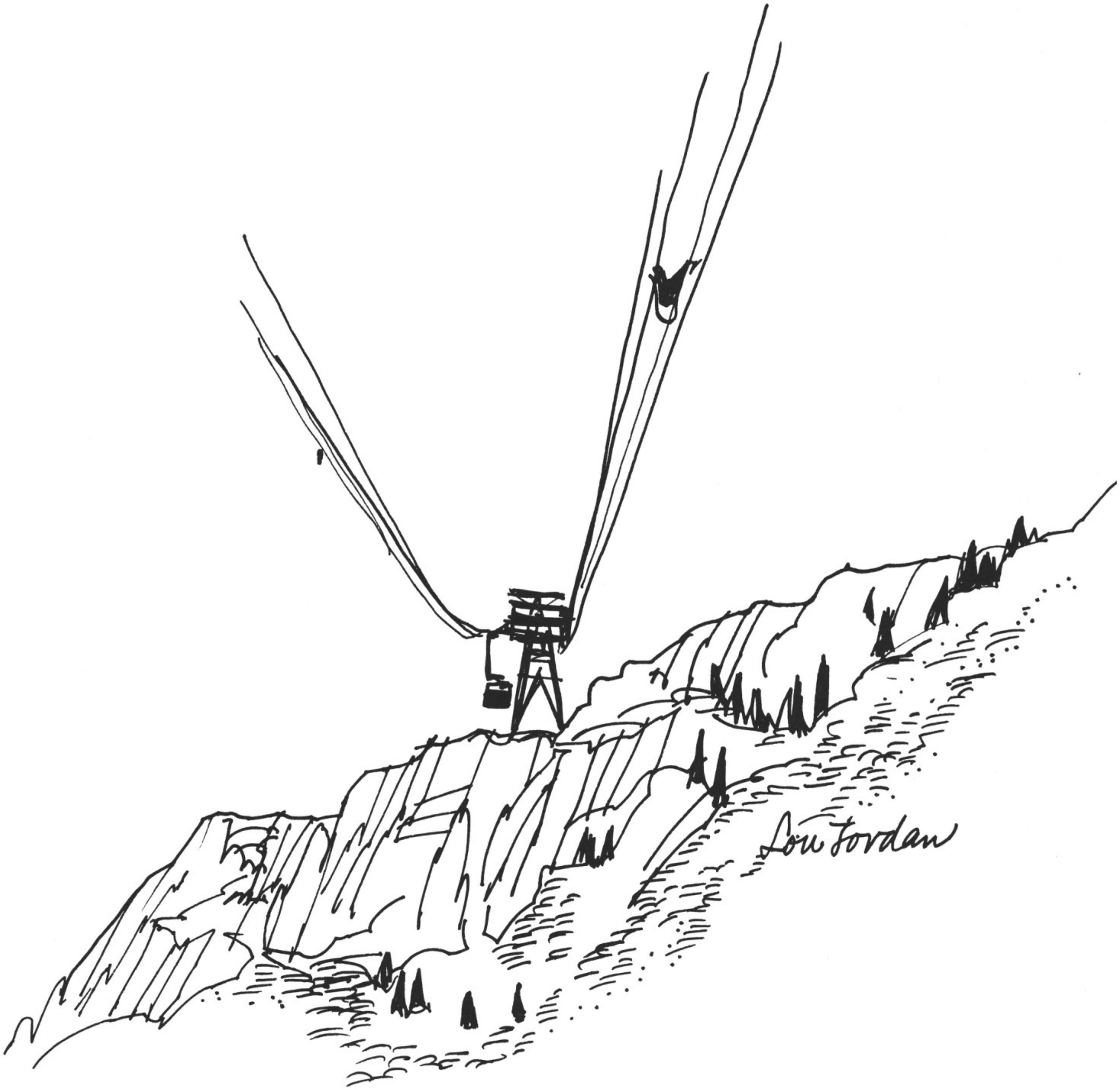
Fold in Precambrian quartzites, Manzano Mountains (P. Bauer photo).



Lou Jordan