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PRECAMBRIAN METAMORPHISM IN THE PLACITAS-JUAN TABO AREA, NORTHWESTERN SANDIA MOUNTAINS, NEW MEXICO

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INTRODUCTION

Precambrian rocks of the northwestern Sandia Mountains consist of a thick metasedimentary sequence which has been intruded by plutonic rocks of "granitic" composition. Metamorphic recrystallization occurred in two major episodes, a regional greenschist event and subsequent hornblende-hornfels contact metamorphism associated with regional plutonism. This paper summarizes the geology of a part of this Precambrian sequence and outlines the environment of metamorphism and metamorphic history of the area. The lack of modern, detailed studies on Precambrian rocks of the Sandia Mountains, coupled with extensive Phanerozoic cover and complex Cenozoic structures, prevented regional correlation with other nearby Precambrian rocks. However, recent work by Grambling, Robertson and Moench, and Condie (all, this guidebook), Condie and Budding (1979), Callender and others (1976), among others, suggests that the Precambrian events described here may be related to a broad zone of regional metamorphism, volcanism and plutonism about 1500 million years old.

Previous Work

The region was mapped first in reconnaissance fashion by Hayes (1951), who mainly focused on rocks of the Juan Tabo basin about 5 km south of the Placitas-Juan Tabo area. Fitzsimmons (1961) and Kelley and Northrop (1975) summarized the Precambrian geology of the Sandia Mountains. Kelley and Northrop (1975) suggested the name Rincon metamorphics for metamorphic rocks of the northwestern Sandia Mountains. This terminology is used here. Green and Callender (1973) delineated the geometry of the hornblende-hornfels contact metamorphic aureole; Berkley and others (1976) outlined the metamorphic history of the area.

Geologic Setting

The location and general geology of the Placitas-Juan Tabo area are shown in Figure 1. The western face of the Sandia Mountains forms the eastern margin of the Albuquerque basin of the Rio Grande rift (Kelley, 1977; Woodward and others, 1975). Precambrian rocks are exposed along the northwestern foothills of the Sandia Mountains, mainly in a prominent northeasterly trending spur, Rincon Ridge. Rincon Ridge is bounded on the west by the Rincon fault, which marks the eastern edge of the rift (Kelley and Northrop, 1975), and on the east locally by an eastward-dipping normal fault, the Piedra Lisa fault, which offsets Precambrian rocks in the southwestern part of the area (fig. 1). Other normal faults, mainly Tertiary in age, have deformed the northern part of the area; the more important faults are shown in Figure 1. The Rincon metamorphics are overlain by Phanerozoic sediments to the north and bordered by Precambrian plutonic rocks on the south and east.

PRECAMBRIAN ROCKS

Rincon Metamorphics

Metamorphic rocks in the Placitas-Juan Tabo area consist of a tightly folded sequence of pelitic phyllite, schist and gneiss, quartzofeldspathic gneiss, calc-silicate beds and amphibolite lenses. These units generally have a northeasterly strike and an easterly dip (fig. 1). Phyllite and gneiss are more abundant in the north, whereas schist and schistose gneiss predominate to the south. Bulk chemistry of examples of the various rock types are given in Table 1.

Metapelitic rocks include chlorite-muscovite phyllite, muscovite-biotite schist, generally with andalusite porphyroblasts, muscovite-biotite-andalusite gneiss and biotite-sillimanite gneiss. Quartzofeldspathic rocks are mainly microcline gneiss, thinly bedded metagraywacke and rare, discontinuous quartzite. Pebble conglomerate and relict cross-bedding are found locally in quartzite beds. Calc-silicate rocks, mainly diopside-calcite-quartz (± grossularite ± hornblende) granulite, are interbedded with pelitic and quartzofeldspathic rocks in the northern part of the area. Thinly bedded, quartz-rich amphibolite is intercalated with the calc-silicate rocks. Thinly laminated chlorite schist, greenstone and amphibolite layers, generally containing less modal quartz than mafic layers in calc-silicate beds, are exposed locally throughout the Rincon metamorphics. Chlorite schist, and amphibolite layers and lenses crop out in schist and gneiss, whereas greenstone generally is restricted to small boudinaged pods in phyllite.

Field relations and bulk chemistry of the Rincon metamorphics suggest that they represent a metamorphosed sequence of predominantly clastic sedimentary rocks. Foliation, bedding and lithologic contacts are generally parallel throughout the area, although subsequent thermal effects have altered this relationship near the Sandia granite. Relict cross-bedding, metaconglomerate lenses, interfingering lithologic contacts and remnant clastic texture in metagraywacke and quartzite imply sedimentary protoliths for the schist and gneiss units. Calc-silicate rocks probably represent siliceous limestones or dolomites; the discontinuous nature of many of these beds may reflect changes in stratigraphic thickness along strike. Quartz-bearing amphibolites intercalated with calc-silicate rocks commonly contain alternating laminae of aluminous silicate and calcareous assemblages. These amphibolites may have formed from a reaction of pelitic and calcareous material in interlayered calcareous shales or mudstones (Orville, 1969). More mafic chlorite schist, greenstone and amphibolite lithologies, which are generally conformable to regional bedding, may represent metamorphosed mafic tuffs, flows or sills. Estimates of stratigraphic thickness are complicated by folding and young faulting, but range from 1000 m to over 2000 m (Hayes, 1951).

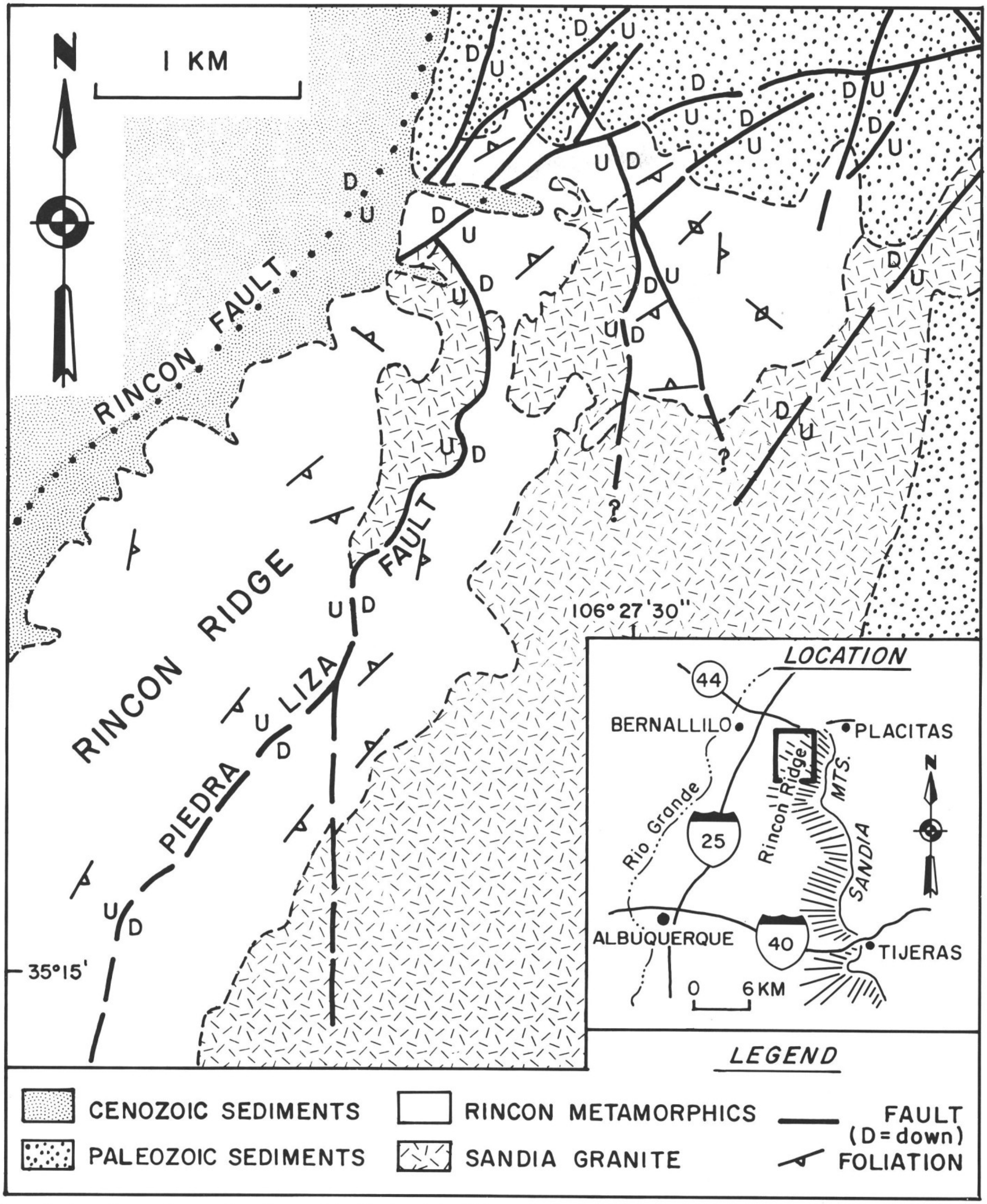

Figure 1. Location and general geology of the Placitas-Juan Tabo area. Faults in Paleozoic rocks in part from Kelley and Northrop (1975).

Table 1. Whole-rock, major element chemistry of selected igneous and metamorphic rocks from the Placitas-Juan Tabo area. J. Husler, analyst. Values below 100 percent may reflect presence of B, Ba, S, F_2 or Cl_2, which were not analyzed.

	chlorite-muscovite schist	muscovite-andalusite-biotite-cordierite schist	sillimanite-biotite-**andalusite** gneiss	muscovite-sillimanite-biotite gneiss	biotite-sillimanite-Kspar gneiss	hornblende amphibolite	Sandia granite—border phase	Sandia granite
Index	PLC-64	NM-22	NM-6	PLC-60	PLC 3-508	NM-17	PLC 3-507	PLC 3-506
SiO_2	59.81	41.52	61.81	60.21	56.16	47.96	65.57	74.19
Al_2O_3	19.92	36.00	23.02	22.90	20.50	12.25	13.80	12.80
TiO_2	0.53	0.92	0.82	0.75	0.95	0.54	0.86	0.39
Fe_2O_3	4.06	6.42	0.64	3.22	5.88	3.98	4.40	2.93
FeO	2.69	3.31	6.92	4.57	4.38	6.95	3.33	1.61
MgO	1.82	0.92	1.33	1.36	1.64	12.70	1.07	0.20
MnO	0.11	0.11	0.05	0.08	0.212	0.26	0.098	0.044
CaO	2.0[illegible]	0.51	0.30	0.24	0.84	11.60	2.82	2.72
Na_2O	2.88	1.60	0.66	0.74	1.60	0.64	3.94	3.57
K_2O	2.77	5.10	2.95	3.57	4.83	0.68	2.48	1.10
SrO	0.027	0.013	0.010	0.008	0.015	0.012	0.023	0.020
P_2O_5	0.09	0.15	0.09	0.11	0.06	0.20	0.01	0.05
$H_2O(+)$	2.61	3.04	1.12	1.76	2.28	1.91	0.84	0.47
$H_2O(-)$	0.04	0.04	0.04	0.09	0.14	0.06	0.15	0.14
Total	99.44	99.65	99.76	99.61	99.49	99.74	99.39	100.23

Sandia Granite

The Sandia "granite" pluton borders the Placitas-Juan Tabo area to the east and is in intrusive contact with Rincon metamorphics except along faults. In the Placitas-Juan Tabo area, the "granite" commonly contains abundant plagioclase and probably is better termed quartz monzonite. Local usage, however, has thoroughly established the term "granite" for this body (Kelley and Northrop, 1975), and therefore, Sandia granite will be used in this paper. Although consisting of several separate intrusive phases with distinct textures, the Sandia granite is generally coarse-grained and contains large pink or gray microcline phenocrysts in a matrix of quartz, microcline, plagioclase, biotite and local muscovite. Table 1 gives an example of the bulk chemistry of the Sandia granite in this area; Enz and others (1979) presented additional chemical analyses of the Sandia granite.

A border phase of the granite, found only near contacts with metamorphic rock, is generally finer-grained, contains smaller pink microcline phenocrysts locally rimmed by white microcline or albite, commonly has a higher modal plagioclase/potassium-feldspar ratio than other granitic species in the area, and contains hornblende in addition to biotite as a mafic phase. Various pegmatite and aplite veins, dikes, sills and lenses intrude the Rincon metamorphics or crop out in the granite. The larger and more extensive of the intrusive bodies apparently have their source in the Sandia granite. The granite contact parallels major structural trends of the country rocks (fig. 1), and its emplacement probably was controlled by previously existing or penecontemporaneous structures. According to Taggart and Brookins (1975), the Sandia granite is 1,504 ± 15 m.y. old.

The intrusive nature of the Sandia granite has been questioned (Fitzsimmons, 1961), and indeed, the contact is gradational in some parts of the Sandia Mountains, especially in Tijeras Canyon, southeast of the present study area. In the Placitas-Juan Tabo area, however, the contact is generally intrusive, as suggested by the following observations: (1) the granite injects country rock as dikes and sills, some of which show dilation effects; (2) contacts are invariably sharp, although metasomatic contamination of country rock is locally common; (3) numerous inclusions of country rock are found in the granite, particularly near contacts; (4) contact breccia zones are found in which competent blocks of Rincon metamorphics have been rotated as much as 90° relative to adjacent blocks and intruded by mobilized, fluid country rock; and (5) the granite locally displays chilled contacts. These observations, coupled with the development of a contact metamorphic aureole with concentric metamorphic zones paralleling the granite contact (Green and Callender, 1973; this paper), imply an igneous origin for the Sandia granite in this area.

METAMORPHISM

Metamorphic Zones

Three distinct metamorphic zones roughly parallel the contact with the Sandia granite in the Placitas-Juan Tabo area. They are: chlorite zone, biotite-andalusite zone and sillimanite zone (fig. 2). The two higher-grade zones are defined by the

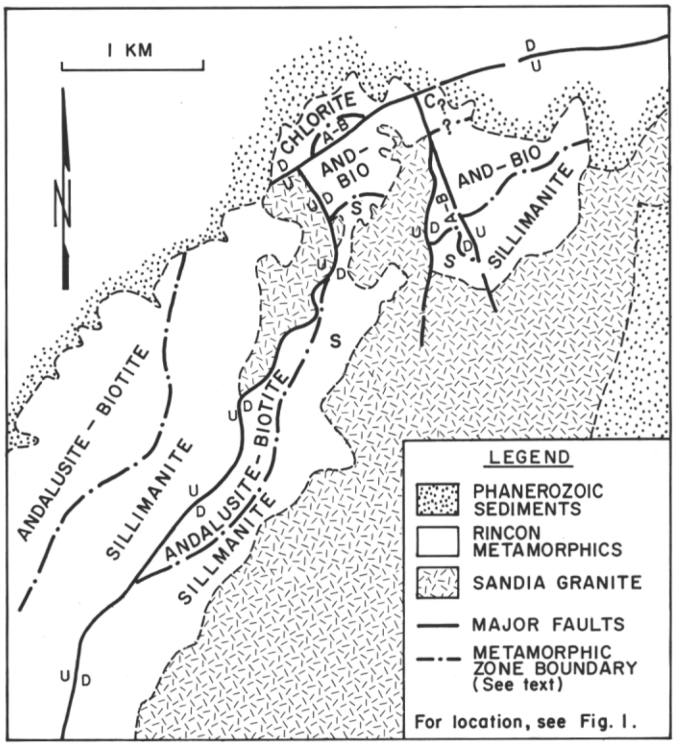

Figure 2. Metamorphic zones in the Placitas-Juan Tabo area. See text for discussion.

presence of the stable Al2S105 polymorph in the respective zone.

The chlorite zone consists of rocks metamorphosed to the middle greenschist facies and probably represents the original state of the country rock prior to contact metamorphism. As discussed below, textural relations and the superposition of a second foliation associated with thermal metamorphism support this hypothesis. Prograde reactions that form biotite and andalusite mark the transition from the chlorite zone to the biotite-andalusite zone and delineate the first appearance of the hornblende-hornfels facies. Andalusite grains in the biotite-andalusite zone lack reaction coronas and display stable textural configurations, including sharp, relatively straight grain boundaries. Biotite, muscovite, plagioclase, quartz, ilmenite, titanomagnetite and magnetite are present in most rocks of the biotite-andalusite zone in addition to andalusite. Fibrolitic sillimanite may occur in minute amounts in rocks near the sillimanite zone.

In rocks of appropriate composition, the transition from the biotite-andalusite zone to the sillimanite zone is characterized by assemblages in which andalusite and sillimanite occur as mutually stable phases. These rocks occur on or near the boundary of the sillimanite zone as plotted in Figure 2. Because andalusite and sillimanite commonly contain about one weight-percent FeO, according to microprobe analyses, and because sillimanite is generally fibrolitic in the transition zone, this zone probably is not an andalusite-sillimanite univariant surface. Instead, the transition zone undoubtedly represents a pressure-temperature-composition volume in which a number of stepped or "cyclic" (Carmichael, 1969) reactions took place.

Metapelitic rocks in the sillimanite zone contain similar mineral assemblages to the biotite-andalusite zone but differ in the almost ubiquitous presence of abundant sillimanite, generally fibrolite. Andalusite is found in most aluminous metapelitic rocks of the sillimanite zone. However, its unstable (or metastable) state is apparent from the presence of reaction coronas, usually consisting of muscovite, potassium feldspar, plagioclase or combinations of these phases. Sillimanite rarely is intergrown with andalusite porphyroblasts; instead, it is associated with biotite, quartz, cordierite, or less commonly, muscovite. Potassium feldspar makes its first significant appearance in sillimanite-zone metapelites, although it is not always present.

Textural changes in grade mimic the mineralogic variations described above. Phyllites of the chlorite zone grade into mica schists and micaceous gneisses in the biotite-andalusite zone. Metapelitic rocks at the boundary between the biotite-andalusite and sillimanite zones are commonly highly micaceous schists, with modal muscovite greater than biotite. Gneisses are the rule in the sillimanite zone, and near the granite contact, most metapelitites are dark, quartzofeldspathic, biotite-sillimanite gneisses or granulites. Muscovite persists to the granite contact, but modal muscovite-biotite generally is diminished greatly relative to more distant rocks. Potassium feldspar porphyroblasts give a spotty appearance to gneisses near the granite. Mineral assemblages and textures for each zone are given in Figure 3.

Temporal Development of Metamorphic Zones

Three major metamorphic events have been recognized in the Rincon metamorphics. The first event was regional metamorphism, whereas the latter two events correspond to the onset and culmination of contact metamorphism and are viewed as a continuum which was not separated by a significant time break. Figure 4 summarizes the critical microtextures and mineral parageneses for the three metamorphic events. This figure is schematic; not all rocks in a particular metamorphic zone show precisely the same temporal patterns. Also shown on the figure are interpretative cross sections of

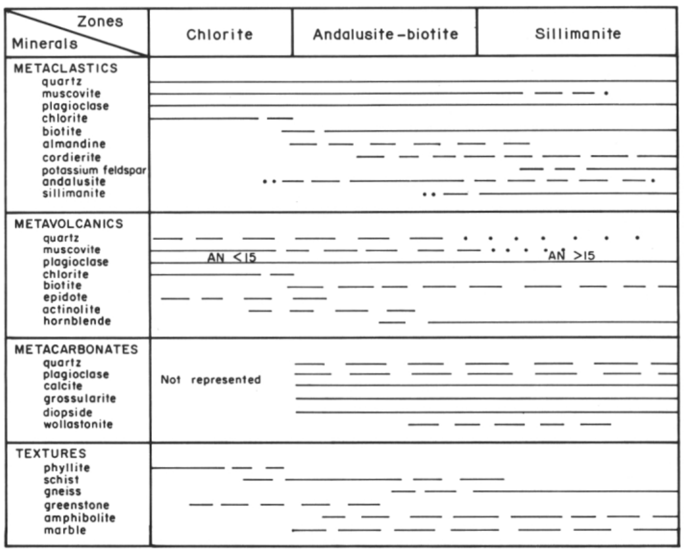

Figure 3. Schematic mineral parageneses for the Rincon metamorphics of the Placitas-Juan Tabo area. Solid line, present as a major phase; dashed line, commonly present as a minor phase; dotted line, rarely present in small amounts as an accessory phase. Plagioclase composition given for metavolcanics.

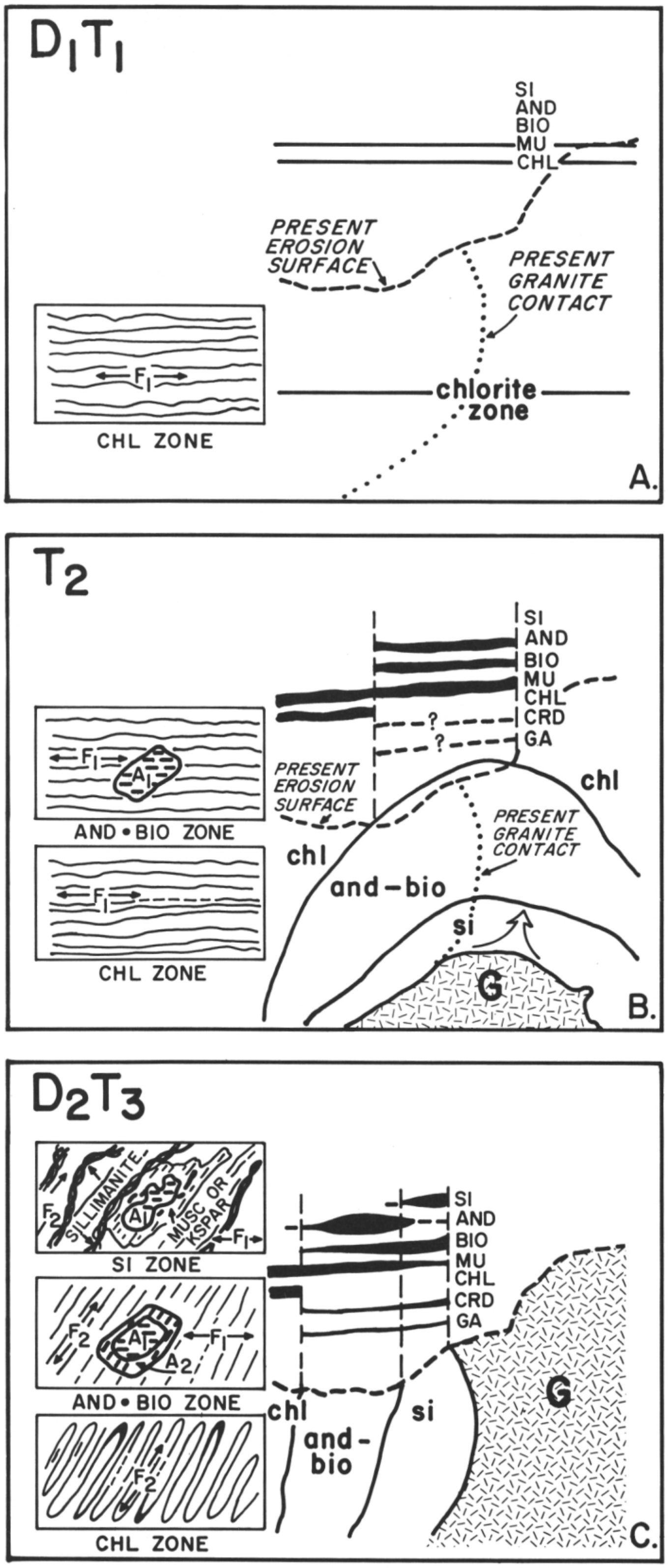

Figure 4. Temporal development of metamorphism in the Placitas-Juan Tabo area. A is oldest, C is youngest. Critical textural information schematically shown on left. Diagnostic mineral assemblages for pelitic rocks are located above interpretative cross sections on right. Si, sillimanite; And, andalusite; Bio, biotite; Mu, muscovite; Chl, chlorite; Crd, cordierite; Ga, garnet. See text for discussion.

the geologic and dynamothermal environment, which ultimately resulted in granitic intrusion at the present stratigraphic level. The events in Figure 4 are described briefly below.

First tectonic (D,), first thermal (T1) period

Metamorphic rocks in the Sandia and Manzano mountains of central New Mexico generally contain mineral assemblages characteristic of the middle greenschist to lower amphibolite facies (Fitzsimmons, 1961; Reiche, 1949; Stark, 1956; Stark and Dapples, 1946; Woodward and others, this guidebook). These rocks are commonly well-foliated phyllites and schists, mafic greenstones, quartzites, and other low- to medium-grade rocks. These regionally metamorphosed rocks are of approximately equal grade everywhere, and their textures broadly suggest one major period of syntectonic metamorphic recrystallization. The rocks of the chlorite zone in the Placitas-Juan Tabo area probably were metamorphosed regionally during this period, and initial metamorphic foliation (F1) was developed in the Rincon metamorphics (fig. 4a).

Second thermal (T2) period

A local, rather large increase in heat flow is recorded for an area corresponding to the present outer limits of the biotite-andalusite zone and extending over the present outcrop area of the Sandia granite in the Placitas-Juan Tabo area (fig. 2). During this thermal event, first-generation andalusite (A1) was superimposed on F1, as suggested by closely spaced, undisturbed inclusion trains in the cores of most andalusite porphyroblasts (fig. 4b). The area of A1 development approximately parallels the granite contact and is shown by the northeast trend of the boundary of the biotite-andalusite zone (fig. 2). Crystallization of biotite from earlier chlorite-bearing assemblages apparently took place at this time, since biotite, as well as muscovite, quartz and oxide phases, is observed as oriented inclusions in A1. Incipient growth of garnet may have occurred during T2, although this is texturally difficult to document. It is probable that the Sandia granite pluton resided at some level below its present stratigraphic position during T2. Certainly, the thermal regime involved in the generation of granitic magma and contact metamorphism was present, but no appreciable change in the regional strain environment was recorded.

Second tectonic (D2), third thermal (T3) period

The culmination of thermal metamorphism and granite plutonism is represented by a distinct change in metamorphic textures in the Placitas-Juan Tabo area (fig. 4c). The mineralogical effects of thermal metamorphism in the chlorite zone are not well developed, but many chlorite-muscovite phyllites contain tabular, chlorite-muscovite pseudomorphs of a porphyroblast phase, probably incipient andalusite. These porphyroblasts may have formed as a result of contact effects. Texturally, the evidence is clearer. Most phyllites in the area are true phyllonites and possess a strongly developed, secondary slip-cleavage (F2), which has overprinted earlier foliation (F1).

In the biotite-andalusite zone, many rocks contain a later generation of andalusite (A2) which nucleated on Al. A2 grew episodically at different localities as F2 developed. In some areas, A2 appears to have grown simultaneously with development of the new F2 strain environment, yielding curved ("snowball") inclusion trains in A2, whereas in other places, growth of A2 appears to have taken place after the development of F2. The latter case is shown particularly well by parallel helicitic inclusions in the cores of andalusite porphyroblasts which are oblique to F2, whereas inclusions in the rims parallel F2. In these rocks, the boundary between core and rim in andalusite is generally sharp.

Rocks in the sillimanite zone also show growth of A2 porphyroblasts, especially in the vicinity of the boundary between the biotite-andalusite and sillimanite zones. In this zone, however, growth of A2 apparently was inhibited as pressure-temperature conditions approached the stability field of sillimanite, the sillimanite zone presumably migrating upward and outward as granitic magma rose higher in the stratigraphic sequence. For example, early muscovite or potassium feldspar rims on A2 grains are replaced partially by biotite + sillimanite or cordierite + sillimanite assemblages. Alteration of andalusite to muscovite is more common away from the granite contact than close to it where potassium feldspar (or potassium feldspar + muscovite) rims are more common. Potassium feldspar may have formed preferentially relative to muscovite near the contact because of dehydration associated with higher temperatures near the granite or because of relatively dry conditions (cf. Enz and others, 1979).

F2 appears to have formed prior to or concurrently with the culmination of thermal metamorphism and granitic intrusion. Fibrolitic sillimanite is generally "disharmonious" (Vernon and Flood, 1977) to F2 crystal growth, suggesting post-F2 crystallization of fibrolite. Lath-like, "bladed" sillimanite parallels or crosscuts F2. Syn- or posttectonic crystallization of sillimanite also is suggested by epitaxial growth of sillimanite on F2 micas, which largely is responsible for growth of sillimanite parallel to F2.

Quartzofeldspathic "sweatout" veins, and aplite dikes and sills are found near the Sandia granite. The "sweatout" veins contain relatively more feldspar in the sillimanite zone than in the other zones of the Placitas-Juan Tabo area. These veins crosscut previously existing and somewhat more deformed (F2) quartzose veins in biotite-sillimanite gneiss near the granite contact. Since higher feldspar content in such veins can be related to increased metamorphic grade (Vidale, 1973), this relationship suggests late-stage, post-F2 vein development at higher temperatures, perhaps related to the culmination of granitic intrusion. In addition, selvages of fibrolite are associated with aplite bodies which intrude both sillimanite- and biotite-andalusite-zone rocks and crosscut or parallel F2. This relationship suggests that the physical environment of granite intrusion was also that of sillimanite formation, and that aplite intrusion took place after the development of F2.

Retrograde metamorphism

The last metamorphic episode recorded in rocks of the Placitas-Juan Tabo area is a minor retrograde event mainly characterized by chlorite-sericite alteration and oxidation. The degree of alteration during this event is quite variable, with rocks commonly displaying different amounts of retrograde alteration in a single outcrop. Retrograde metamorphism may be related to a water-enriched magmatic event during the late stages of the emplacement of the Sandia granite (cf. Enz and others, 1979). Retrograde metamorphism may have affected the K-Ar geochronology of the metamorphic suite, since a preliminary K-Ar age of the Rincon metamorphics yields an age of 1,376 ± 29 m.y. (Brookins and Shafiqullah, 1975).

Conditions of Metamorphism

Mineral assemblages in metapelitic and calc-silicate rocks of the Placitas-Juan Tabo area (fig. 3) suggest that the Rincon metamorphics were formed in the greenschist and hornblende-hornfels facies of Turner (1968). Regionally metamorphosed rocks of the chlorite zone underwent greenschist metamorphism, but rocks of the biotite-andalusite and sillimanite zones recrystallized in the hornblende-hornfels facies. Sillimanite-zone assemblages containing quartz-microcline-sillimanite-cordierite (-± andalusite ± muscovite) may be transitional to the pyroxene-hornfels facies. Detailed discussion of mineral chemistry and phase relationships which delineate a specific pressure-temperature environment for metamorphism of the Rincon metamorphics is beyond the scope of this paper. A summary is given below and in Figure 5.

The presence of andalusite and the absence of kyanite in aluminous metapelites limit total (load) pressure during formation of the contact aureole to less than 3.7 Kb, using the Al2Si05 triple-point of Holdaway (1971), which is probably the closest approximation to natural conditions (Grambling, 1979; Holdaway, 1971, 1978). Muscovite has reacted to form potassium feldspar and sillimanite near the granite contact (Green and Callender, 1973); this reaction must have taken place under a total pressure of more than 2 Kb (Kerrick, 1972). Depending on the partial pressure of H20 during ther-

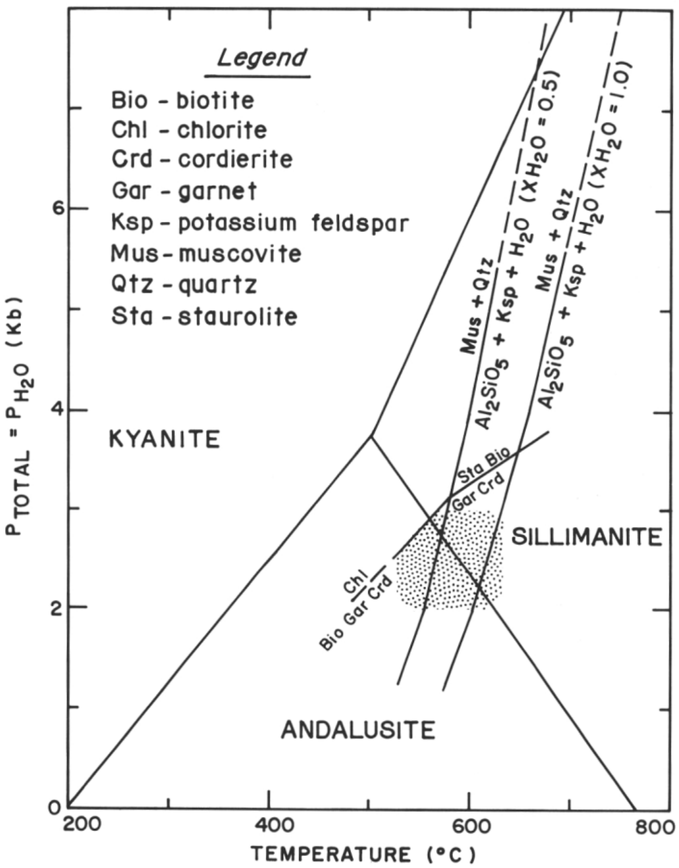

Figure 5. Petrogenetic grid showing approximate P-T environment for metamorphic rocks of the Placitas-Juan Tabo area (stippled). Al_2SiO_5 equilibrium curves from Holdaway (1971). Muscovite-quartz curves from Kerrick (1972). Cordierite stability from Thompson (1976).

mal metamorphism, temperatures for this reaction range from 550 to 650°C (Kerrick, 1972).

Cordierite is abundant in many rocks of the biotite-andalusite and sillimanite zones, but almandine is rare and staurolite is absent. This suggests a relatively low pressure regime (Chin- ner, 1959; Hensen, 1971; Thompson, 1976), although the bulk composition of the protolith is an important factor in deter- mining the relative abundance of these phases. Locally, cor- dierite coexists with biotite and highly resorbed almandine; textural relations suggest that cordierite has formed from almandine. Microprobe analyses of coexisting biotite, cor- dierite and almandine indicate that these phases are relatively iron-rich, suggesting that this assemblage formed at lower pres- sures and temperatures than more magnesium-rich systems, which are constrained better experimentally (Hess, 1969; Mueller and Saxena, 1977; Richardson, 1968; Thompson, 1976). Using the petrogenetic grid of Hess (1969), as modified by Thompson (1976), the absence of staurolite and presence of iron-rich biotite-cordierite-almandine (+ quartz + Al2S105) assemblages in metapelites of the Rincon metamorphics sug- gest a temperature domain of 525-630°C and total pressure of between 2 and 3 Kb. Assemblages in calc-silicate rocks, which contain diopside, grossularite and wollastonite but not tremo- lite, imply temperatures in the range of 560-600°C at pressures of 2 to 3 Kb, and relatively low partial pressure of CO2 (Wink- ler, 1976).

Figure 5 depicts the approximate pressure and temperature regime of contact metamorphism in the Rincon metamorphics. The culmination of metamorphism during plutonism yielded the highest temperatures. Low load pressures, corresponding to depths of about 10 km, are suggested by abundant andalusite and cordierite, and the absence of staurolite. Temperatures were in the range of 500-600°C. Regional grcenschist metamorphism probably took place at similar depths but lower tem peratu res.

SUMMARY

The Rincon metamorphics in the Placitas-Juan Tabo area represent a dominantly clastic sedimentary sequence at least 1 km thick of pelitic shale, siltstone, arkosic and argillaceous sandstone, minor quartz sandstone and graywacke, interbedded sandy limestone or dolomite, and tuff. This sedimentary sequence was deformed intensely and metamorphosed regionally to the greenschist facies prior to 1,500 m.y. B.P. Subsequent thermal activity associated with regional plutonism caused prograde recrystallization of the Rincon metamorphics in a broad zone, culminating in intrusion of the Sandia granite and associated contact metamorphism of the hornblende-hornfels facies. Mineral assemblages in the contact aureole imply a relatively shallow depth of intrusion for the Sandia granite (less than 10 km). The well defined, narrow contact zone suggests a temperature gradient across the aureole which is typical of plutons of the shallow mesozone (Buddington, 1959). Temperatures during thermal metamorphism ranged from about 500 to 650°C, whereas temperatures of regional metamorphism were probably somewhat lower. The presence of a well defined contact aureole, in addition to concomitant intrusive features, such as dikes and sills, confirms a magmatic origin for the Sandia granite in this area. This is in contrast to the gradational, metasomatic contact encountered elsewhere and suggests, along with structural and metamorphic evidence, that granite emplacement may have occurred as several discrete pulses rather than a single event.

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