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IGNEOUS ROCKS

Biotite Granite

The Sierrita mountains consist essentially of an intrusive granite core, which extends to the Helmet Peak area. The granite is flanked by a series of intensely metamorphosed sediments on the west and by slightly metamorphosed Paleozoic and Cretaceous rocks on the east.

On the western slope of the Sierrita mountain, Higdon¹ described the granite as intrusive into the sedimentary series. He mentions off-shoots of dioritic rocks in the limestone beds, presumably from the main granite mass. The limestone shows contact metamorphic minerals with "streaks of tremolite in radial fibrous aggregate associated with galens". Higdon described the granite as a soda granite with abundant microperthite, 15 percent quartz and the conspicuous absence of ferromagnesian minerals, except for sericite, which he thought was alteration of biotite.

In the Helmet Peak area, the granite is apparently intrusive into the Paleozoic and Cretaceous rocks. Evidence of intrusion into the Paleozoic sediments is present at the Mineral Hill sub-area where a tongue of granite is in contact with

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1. Higdon, C. E., Geol. and Ore Deposits of the Sunshine Area, Pima County, Arizona, Univ. of Arizona Library, Master's Thesis, 1933.
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the Bolsa quartzite and the Naco formation. Section E - E' shows the Bolsa quartzite dipping steeply into the granite. This part precludes the possibility of a normal sedimentary contact between the granite and the Bolsa quartzite, but rather suggests an intrusive contact. The intrusive metamorphism in the limestone and the apparent tilting of some of the beds of the Bolsa quartzite lend weight to the intrusive character of the granite. Eckel¹ mentioned that the granite was encountered at 600 feet by the mine workings in the Mineral Hill sub-area. Ransome² also mentioned this fact and added the possibility that the granite is a sill. A sill would mean the presence of sedimentary rocks below the granite. Eckel, however, believes that the coarse texture of the granite, the intensity of metamorphism of the sedimentary rocks and the large ore deposits associated with the intrusion are indicative of a larger intrusion rather than a sill. He implies that the granite encountered by the mine workings underground is the top of the stock itself and that the presence of sedimentary rocks below the present workings is improbable. He

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1. Eckel, E. B., op. cit., p. 15, 1930.

2. Ransome, F. L., Ore Deposits of Sierrita Mountains, Ariz., Contributions to Economic Geology, U. S. Geol. Survey Bull. 725, p. 421, 1921.
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added, however, that the question can only be settled by further exploration.

Unlike Ransome and Eckel, the writer was unable to visit the mine workings due to the presence of water and uncertain conditions underground. The writer can not, therefore, express his opinion as to the nature of the intrusive rock underground. He believes, however, that the main granite stock in this area is very close to the surface. The high intensity of contact metamorphism, as shown by the presence of high temperature minerals (garnet, molybdenite, magnetite, etc.) and the proximity of surface outcrops of the main granite stock to the area, support this view.

The mining men of the district informed the writer that the igneous rocks underground are interfingering with the limestone. This relation was not verified, but the presence of granitic and dioritic rocks on the dumps of some of the shafts indicates that granite was encountered.

In the San Xavier sub-area, the evidence for the intrusive nature of the granite is not conclusive. Intensive contact metamorphism of the limestone beds may well be due to the intrusion of the granite. A dike-like body along a fault on the northern side of a hill, east to the Twin Buttes road (see NE quadrant, Section 3), can be traced within a short distance to the main granite body and may connect with it. It separates a block of Escabrosa limestone from the rest of the limestone.

South of the San Xavier hills, a small body of granitic rock is exposed within the arkose formation (See boundary between Sections 10 and 11) and is apparently a part of the main stock. Some shafts within the White Arkose formation (Section 10) have encountered the granite within a few hundred feet from the surface, as shown by the presence of granitic rocks on the dumps.

The extensive mineralization and the high degree of wall-rock alteration of the volcanic rocks in the southwestern part of the area are probably due to the granitic intrusion. The contact of the granite and the volcanic rocks, as shown by underground workings at the Paymaster property, dips to the east. This granite was encountered by a shaft at about 300 feet from the surface. West of the Paymaster property, dips to the east. This granite was encountered by a shaft at about 300 feet from the surface. At property, the contact of the granite with the brecciated andesite is not clear. It is interesting to note, however, that aplite dikes and pegmatitic dikes are abundant near the contact of the granite and the breccia. In general, this type of dikes seems to be near the contact of an intrusive and the intruded rock.

The possibility of the presence of another type of granite (Pre-Cambrian?) within the area has not been overlooked. Numerous differences in color, texture, and composition of the granite have been observed, but the different types are gradational within the same mass and no separate type of granite was observed.

The granite is a coarse-grained, holocrystalline rock with abundant potash feldspars, albite, quartz and biotite as essential minerals. Some specimens show the marked predominance of potash feldspars and only subordinate sodic feldspars; others show more abundant sodic feldspars, sometimes exceeding the potash feldspars. The latter is almost on the boundary between quartz-monzonite and granite. Similar facies of differentiation within the granite had been reported by Ransome on the eastern

slope of the Sierrita mountains, near Magee's Ranch. He described one specimen as chiefly alkali feldspars and quartz with subordinate plagioclase and little biotite. Another specimen he examined from the same general locality showed more abundant plagioclase than the first specimen.

Biotite is the predominant ferro-magnesian mineral in all of the samples examined by Ransome, Eckel, Park and the writer. On the other side of the Sierrita mountains, Higdon observed the conspicuous absence of ferro-magnesian minerals in the granite, but he suggested the possibility of the sericite in the rock as alteration of biotite.

Detailed laboratory examination of a typical specimen taken from the north-east quadrant of Section 10 showed the following:

Megascopic: The rock is greenish-white to pinkish white in color. Large crystals of feldspar and quartz are surrounded by the groundmass. The ferro-magnesian mineral is mostly biotite, but it has apparently undergone some alteration. Magnetite and hematite are visible.

Microscopic: Essential Minerals:

| | <u>Per Cent</u> | <u>Size</u> |
|---|-----------------|----------------|
| Quartz | 15 | 0.5 to 10 mm. |
| Orthoclase | 20 | 0.5 to 10 mm. |
| Microperthite | 20 | 0.5 to 8 mm. |
| Albite (Ab ₉₀ An ₁₀) | 30 | 0.5 to 10 mm. |
| Biotite | 10 | 0.05 to 10 mm. |

Accessory Minerals:

- Magnetite = 1%
- Zircon = 1%
- Apatite = 1%

Alteration Minerals: Sericite, hematite and chlorite.

In thin-section, euhedral to anhedral grains of quartz, feldspar, and biotite predominate. The feldspars have undergone sericitization, either partially or completely. Biotite has undergone partial chloritization. Some pleochroic halos, probably surrounding inclusions of zircon, are included in biotite. Magnetite and apatite occur as small grains scattered through the section.

Granodiorite

The rock is in contact with the granite and a block of limestone on the northern spur of the Escabrosa limestone hill, west of the Twin Buttes road.

Megascopic: It is a dark-green to dark-gray rock with abundant quartz, plagioclase, orthoclase, biotite and subordinate epidote, sericite, and apatite.

Microscopic:

Essential Minerals:

| | | <u>Per Cent</u> | <u>Size</u> |
|---|---|-----------------|-----------------|
| Quartz | = | 40 | 0.05 to 0.2 mm. |
| Orthoclase | = | 10 | 0.1 to 0.3 mm. |
| Andesine (Ab ₆₄ An ₃₆) | = | 20 | 0.1 to 0.5 mm. |
| Biotite | = | 20 | 0.01 to 0.1 mm. |

Accessory Minerals:

| | | |
|---------|---|-----|
| Apatite | = | + 1 |
| Epidote | = | - 1 |

Alteration Minerals:

Limonite, sericite, and chlorite(?)

A considerable proportion of the area of the section consists of small irregular areas of quartz; much of the quartz was probably introduced by silicification. Some places in the section seem to suggest that the small grains which have been broken by later dynamic movement. The presence of this rock within a fault zone would probably support this suggestion. The biotite in the rock appears to be either a regenerated or introduced mineral which occupies the interstitial spaces between the earlier mineral grains. Some sericite are apparently pseudomorphic after biotite, although most of it is a product of the alteration of the feldspars. Direct alteration of the biotite to limonite is also present.

In general, the rock has suffered much metamorphism, but its original character was not completely lost.

Although microscopic and field evidence do not show the definite relation of the granodiorite to the granite, it seems a reasonable assumption that it is a slightly basic differentiate of the granite itself.

DIKE ROCKS

General Statement

Several dikes which are genetically related to the main intrusive granite occur in the area. Due to their small sizes, some were purposely omitted from the geologic map.

The dikes range from the acid type, the aplites and pegmatites, to the very basic variety, the lamprophyres. They vary in width from five to ten feet. Other dikes not exposed at the surface were reported to have been encountered by underground workings.

Aplite and Pegmatite Dikes

Aplite and pegmatite dikes occur mostly within the granite, near the contact with the intruded rocks. Analysis of a typical sample shows that the rock has 50 percent quartz and about 50 percent feldspar (microcline and orthoclase). A very little biotite is the only dark mineral.

The pegmatitic dikes in the Mineral Hill and west of the Paymaster group show graphic texture.

Lamprophyre Dikes

The lamprophyre dikes in the area occur as basic differentiate of the granite. A dike of this type, which is composed essentially of biotite and hornblende (minette), occurs in the Mineral Hill sub-area.

Diorite Dikes

Porphyritic diorite dikes were encountered by mine workings underground as shown by the presence of diorite on the mine dumps. Old mine reports mention the presence of such dikes underground. Small outcrops are also present within the Mineral Hill sub-area.

The rock is composed of hornblende, biotite, a little quartz, and plagioclase feldspars.

VOLCANIC ROCKS

Red Basalts

Red basalts crop out in the southern part of the area. Three main exposures, separated from each other by alluvium, were mapped; but they are apparently parts of a single flow connected under the thin alluvium cover.

The rock is composed of large phenocrysts of plagioclase feldspars (labradorite) in a red, glassy groundmass. The feldspars range in size from one-eighth of an inch to one inch. Gas cavities are very common indicating sub-aereal extrusion of the rock. Some of the gas cavities are either filled or partially filled with calcite thus forming an amygdaloidal texture.

Field evidence seems to indicate that the rocks were extruded along a

northeasterly extension of the fault fractures, which are mineralized in the vicinity of the Alpha group property. It is also interesting to note that the alignment of the three outcrops mapped is approximately parallel to the general trend of the fissures in the area.

The age of this formation is Post-Laramide (Late Tertiary?). Its extrusion along fractures in the Late Cretaceous arkose substantiates this contention. It may be as late as Quaternary or Recent.

Andesite Dikes

In the southern part of the area, a series of andesite dikes are intruded into the Cretaceous arkose. The dikes are ten to fifteen feet wide and vary from one hundred to seven hundred feet in length.

Petrographic examination of one sample showed the following:

Megascopic: The rock is light brown with a porphyritic texture. Large phenocrysts of feldspar and dark brown ferromagnesian minerals are visible in a light, grayish-brown groundmass.

Microscopic: The feldspar of the phenocrysts is fresh and shows very little alteration. Albite twinning and combined Carlsbad-Albite twinning are characteristic of the feldspar. Determination of the composition by extinction angles of faces normal to O10 showed that the feldspar is andesine ($Ab_{70}An_{30}$). Zoning is apparent in some feldspar crystals.

The groundmass consists of very minute crystals of andesine and a light brown glassy material. The size of the phenocrysts ranges from 0.5 mm. to 15 mm. maximum diameter.

Undifferentiated Basalts

A series of basaltic rocks occurs in the southeastern part of the area in sections 15 and 16. There are at least three types of basalt in the series, but due to the similarity of their field occurrence and composition, those rocks were mapped as a single unit. They differ from each other only in the color of their groundmass, which depends upon the amount of iron oxide.

Because of the inadequate field evidence, it is impossible to determine whether the basalts are intrusive or extrusive. The longer dimension of the outcrop is roughly aligned with the major structure in the vicinity.

Examination of the maroon-brown variety of basalt showed the following:

Megascopic: The rock has euhedral feldspar phenocrysts on a very fine, groundmass, which consists of minute euhedral crystals of maroon-brown groundmass. The feldspars are pinkish white to brownish in color.

Microscopic: Thin-section examination of the rock showed a very fine groundmass, which consists of minute euhedral crystals of feldspar and

a glassy material. The small crystals of feldspar in the groundmass show a more or less definite orientation along one direction. The glassy groundmass shows a flow structure along a similar direction.

The feldspar phenocrysts are highly altered and sericitized. Determination by the extinction angle method of sections normal to 010 shows that the feldspar is labradorite. Other phenocrysts with the outlines of olivine are almost completely altered to a brownish-pink mineral (iddingsite?). Secondary magnetite forms as border rims of olivine crystals. Limonite, hematite, and secondary carbonates are also present in the section.

Examination of the gray variety of basalt showed the following:

Megascopic: Rock has visible white feldspar phenocrysts in a brownish-gray groundmass.

Microscopic: The phenocrysts are mostly plagioclase feldspar, hornblende, and olivine. Their approximate size and proportion in the section are as follows:

Labradorite ($Ab_{46}An_{54}$) = 0.05 to 1.0 mm. = 15%

Olivine = 0.01 to 0.5 mm. = 10%

Hornblende = 0.01 to 0.3 mm. = 3%

The feldspar crystals are sericitized but the twinning is still distinct in most of them. The olivine crystals show alteration to secondary magnetite around the rims. The groundmass consists of minute crystals of feldspar and a glassy material which shows a typical flow structure. Secondary carbonates are present.

Green Andesite

A green andesite has a relatively wide areal distribution. The main mass occurs on the northern part of section 15 and extends to the southern part of section 10. Within the same mass the rock shows variation in texture which ranges from a decidedly porphyritic type to a fine-grained almost non-porphyritic variety.

Dike-like bodies of this rock occur within the Cretaceous series of the area. Small patches are also distributed in many places on the southern part of the area. The nature of these patches is not clear, but they seem to represent small necks or plugs which have reached the surface through some weak zones in earlier rocks.

The main mass has the character of a near-surface intrusive, which occupies a broad fault zone.

Thin sections of two representative varieties of the green andesite were examined. The porphyritic variety showed a high degree of hydrothermal alteration. Most of the phenocrysts are highly sericitized andesine. Some grains, however, still show the ghosts of albite twinnings and crystal outlines. Chlorite is abundant as the alteration product of ferromagnesian minerals. The groundmass is very fine-grained and almost glassy with small euhedral feldspar laths. Hematite is abundant, probably as the latest stage of alteration of the iron-bearing silicates.

The fine-grained variety is similar in composition to the porphyritic

variety. The thin-section shows minute crystals of euhedral andesine feldspars and the abundance of chlorite.

Since the rock intrudes the upper members of the Cretaceous series in the area, its age is very late Cretaceous or post-Cretaceous. Mineralization within the formation is rather extensive and the writer believes that it is related to the Laramide granite intrusion.

Gray Andesite

At the Paymaster property on the southwestern part of the area, a gray variety of andesite is in contact with the andesitic breccia (see page 70) and the Mill andesite. The nature of its occurrence is not clear, but the absence of flow structure and other criteria for sub-aerial deposition indicates that the rock is a shallow-depth intrusive.

The rock has a porphyritic texture with feldspar phenocrysts from one to four millimeters in diameter. Microscopic examination shows the presence of red iron oxide and a very high degree of hydrothermal alteration. Most of the feldspars were completely altered to sericite and kaolin, but the original crystallographic outline and albite twinning are still visible in some grains. Large crystals of red hematite, pseudomorphic after hornblende, are abundant in the section. Their size ranges from 0.02 to 0.5 millimeter. The gray-colored groundmass consists of very fine-grained crystals of feldspar and quartz. The quartz was probably introduced into the rock during later metamorphism.

The rock as a whole is greatly altered and has undergone a large amount of shearing and brecciation. Parts of the Paymaster veins are mineralizations along fractures within this formation.

Mill Andesite

A dark bluish-gray type of andesite occurs in contact with the Gray andesite and the andesitic breccia within the Paymaster group. The nature of its occurrence is very similar to the gray andesite.

The name Mill andesite is suggested by the writer for this formation, because of the presence of the old mill which was operated by the Olberg Exploration Co. of California in 1940, within the area of the formation.

The rock is porphyritic in texture with visible feldspar phenocrysts. A blue mineral is present in the rock, but it is difficult to identify without the aid of a petrographic microscope. The groundmass is dark-brown to dark-gray with shades of green. Hematite and magnetite are visible megascopically.

In thin-section, the rock shows a very intensive degree of hydrothermal alteration. The feldspars, which constitute about 20 percent of the rock, are the most predominant phenocrysts. They are almost completely sericitized and kaolinized. Serpentine constitutes about 30 percent of the section and is probably an alteration product of the ferromagnesian minerals. Secondary magnetite and hematite are also

abundant as alteration products of iron-bearing silicates. Secondary carbonates are present in the section, some of which suggest pseudomorphism after a mineral which looks very much like an olivine. The groundmass is fine-grained, but not glassy in texture. With the aid of a high power objective, the groundmass appears to be composed essentially of quartz and feldspar. The quartz was evidently introduced into the rock by hydrothermal solutions. No phenocrysts of quartz were observed.

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