DIPYRITE AND ASSOCIATED CONTACT MINERALS FROM THE FRANKLIN MOUNTAINS OF TEXAS[1]

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The mineral locality reported here is of interest because it contains a large supply of the scapolite mineral dipyrite in an unaltered condition and because the paragenesis of this mineral and associated contact metamorphic minerals is fairly plain. Incidentally the locality constitutes the first recorded occurrence of dipyrite in Texas though collections at the University of Texas contain specimens of scapolites said to be from Texas, but with localities only vaguely given.

The locality here described is on the east flank of the Franklin Mountains in the northwest corner of Section 36, Block 81, El Paso County, Texas, ten miles north and slightly east of the El Paso Post Office. The northwest corner of Section 36 is located on the north side of Fusselman Canyon and the contact minerals are found on the lower south and east slopes of the canyon wall. The locality is reached from the El Paso-Alamagordo highway running north past Fort Bliss. At a point on the road nearly opposite Fusselman Canyon a side road leads to the foot of the mountains near the north side of the canyon. The contact minerals are found a few hundred feet above the point where the road reaches the foot of the mountain and just below a United States Army artillery observation post established on the side of the mountain.

The Franklin Range is a narrow northwestward trending highland some 3,000 feet above flanking plains. The geologic column includes metamorphic and sedimentary formations from pre-Cambrian to Carboniferous age, consisting of quartzites, sandstones and limestones. Igneous rocks of at least three ages are also present. These include rhyolite porphyry, granite, syenite porphyry, andesite porphyry, and basic dikes. The structure is complex, but in general the entire series of rocks, both igneous and sedimentary, is sharply tilted to the westward and broken by numerous faults resulting in steep cliffs and escarpments on the

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east side of the mountains with excellent exposures of the rocks. The geology of the El Paso quadrangle has been described by Richardson[2] to whose report the reader is referred for further details of the general geology.

At the mineral locality a red granite is the most abundant rock, forming the base of the mountains and the north wall of Fusselman Canyon. The granite, according to Richardson, is post-Carboniferous in age and intrudes the sedimentary series of the region. Richardson, however, did not note contact metamorphic minerals which furnish additional evidence that the granite intruded the sedimentary rocks. The rock contains microperthite, acidic oligoclase, quartz and a little biotite and hornblende. A partial analysis is given below.[3]

SiO_2	73.76
CaO	0.81
K_2O	5.66
Na_2O	3.64

The contact of the granite with the sedimentary rocks is exposed on the north side of Fusselman Canyon. Quartzite and limestone are the intruded rocks and these dipping steeply westward have been sharply cut off along the strike by the granite. The contact is irregular, there being embayments in the limestone and in addition small isolated blocks of altered limestone are engulfed in granite. At the margin of areas of limestone nearly surrounded by granite, and in the engulfed blocks of limestone, dipyrite and other contact minerals are found.

The limestone in contact with the granite is gray, massive and dolomitic containing large quantities of chert and in some places is also arenaceous. The chert forms nearly continuous beds from a fraction of an inch to several inches in thickness. The limestone at a considerable distance from the granite has been changed to a medium grained marble containing scattered grains of olivine. Blocks of limestone a few feet long, engulfed in granite, have been changed to aggregates of metamorphic minerals and near the contact of the main mass of limestone a narrow zone of the same minerals is found. In the latter occurrence the development of silicate minerals is not confined to the original limits of the lime-

[2] Richardson, G. B., *Geol. Atlas of the U. S., El Paso Folio*, No. **166, 1909.**

[3] Richardson, G. B. *Op. cit.*, p. 7.

stone, but extends also into the margin of the granite. The metamorphism was somewhat irregular, apparently, being selective in nature. The zone found at the contact of granite and limestone where the alteration has been most profound is about 25 feet wide, but can be traced at this place less than 100 feet along the contact, due partly, to poor exposures. In other parts of the locality similar, but small exposures are found, but these will not be described in detail. In the main zone scapolite has been abundantly developed, even cherty layers of the limestone being replaced to some extent by the silicate. In the engulfed blocks of limestone a complete change to silicates occurred, but again selectively since some blocks are practically all garnet, while others are all diopside. In none of these isolated blocks of metamorphosed limestone is scapolite developed to any extent, it being confined to the zone at the contact of granite and the main mass of limestone. The formation of garnet and diopside extended to a greater distance from the granite than did the formation of scapolite, the latter being confined practically to the zone of 25 feet at the contact while the former are found, microscopically at least, in some cases 100 feet or more from the contact.

Veins and dikes are practically lacking at the border of the granite. One small dike a few inches wide cuts the sedimentary series. It is grayish white in color and consists of microperthite, microcline microperthite and orthoclase graphically intergrown with quartz. It is apparently the only representative of the pegmatite stage present. One fluorite lens or vein a few inches long was found cutting the mass of diopside rock. With the fluorite was some feldspar and calcite. The sedimentary series contains dikes of basic igneous rock older than the granite. In the metamorphism these were relatively unaffected, even less so than the chert layers of the limestone.

The minerals found at the locality are dipyrite, garnet, diopside, microperthite, microcline, fluorite, titanite, muscovite and olivine. Ore minerals are practically lacking only a few grains of pyrite being observed and these were found in the marble some distance from the actual contact.

Dipyrite is the principal mineral of the main metamorphic zone mentioned above. It occupies an area which represents original limestone and granite having to some extent at least replaced both. Where the scapolite penetrates granite, thin sections show that it crystallized contemporaneously with some of the granite minerals. Accompanying the scapolite are small amounts of garnet, diopside, calcite and microperthite. All of these are younger than the dipyrite and the feldspar is apparently a second generation mineral. It seems apparent that the dipyrite is more closely related to the granite in origin than such minerals as garnet and diopside. Probably the assimilation of limestone by the magma is involved to some extent. The scapolite not only replaced pure limestone, but the cherty layers as well.

The mineral is light grayish blue in color in fresh specimens and dirty gray on weathered surfaces. It occurs in roughly radiating groups and bundles of vertically striated, long bladed crystals without crystal faces. Individual blades or plates are as much as 10 inches in length. Optically the mineral is uniaxial negative with $\epsilon=1.543$, $\omega=1.553$; $\omega-\epsilon=0.010$. The cleavage is prismatic, excellent to perfect. A complete chemical analysis is not available but chemical and optical data at hand indicate the scapolite dipyrite corresponding to $Ma_{70}Me_{30}$ according to the definition of this mineral given by Winchell.[4]

Garnet next to scapolite is the most abundant mineral found at the locality. It replaces blocks of limestone to the exclusion of other silicates and is sparingly present in scapolite aggregates, replacing the latter. It has also to some extent replaced cherty layers of the limestone. In the scapolite masses the garnet occurs as small grains or masses sometimes with poorly developed crystal outlines. In the direct replacements of limestone, massive beds or bands of the mineral are found. These generally preserve the original bedding of the limestone, but also show banding apparently controlled by the crystal habit of garnet. A few poorly developed crystals are found showing the rhombic dodecahedron alone or combined with the tetragonal trisoctahedron. The mineral is brown in color and is probably grossularite.

Diopside occurs, as has already been indicated, associated with dipyrite and garnet and also alone where it has replaced isolated blocks of limestone. It occupies interstitial space in dipyrite aggregates and replaces this mineral. It also replaces garnet. At one point scapolite replacing a cherty layer of the limestone has been literally peppered with grains of diopside resulting in a very striking rock. It was one of the last minerals to form and is ac-

[4] Winchell, A. N., *Elements of Optical Mineralogy*, Pt. II, p. 346, 1927.

companied by feldspar. The diopside is monoclinic, biaxial positive. $Z \wedge C = 41°$. $\alpha = 1.680$, $\beta = 1.690$ and $\gamma = 1.705$; all $\pm$ .005; γ-α = .025 approximately. These data indicate a diopside relatively poor in iron.

Two generations of feldspar are thought to be present in this mineral assemblage. One is closely associated with dipyrite crystallizing contemporaneously with the earliest scapolite formed. The other belongs to the same general time as the diopside, replacing scapolite and the earlier feldspar. The earliest feldspar consists of microperthite and oligoclase and possibly microcline microperthite. The oligoclase is somewhat noticeable in amount. The later feldspar consists of microperthite and microcline with a virtual absence of oligoclase.

Olivine is found only in the marble either at a considerable distance from the contact or in closer areas of the rock which escaped extensive replacement by the other silicates. It occurs as minute grains in the marble constituting about five per cent of the mass. The resulting rock is much like the forsterite marble from Skye figured in many textbooks. The olivine is biaxial positive, with relatively low birefringence and is in the forsterite end of the forsterite-fayalite series.

Muscovite occurs to a very limited extent in the locality. An occasional flake is found in the scapolite specimens and it is probably related to the last part of the mineralization along with feldspar. In the marble some distance from the contact an occasional flake is seen in thin sections. Here the mineral is always in contact with olivine and often embayed by it.

Titanite is present in only small amounts but is related to the other silicates in origin. It occurs in the aggregates of silicate minerals being one of the last to form probably along with or just after diopside. Minute perfect crystals of the mineral were observed in thin sections associated with diopside and in a cavity in the garnet rock, this mineral along with diopside and feldspar was seen in grains 4 mm. in size.

Calcite occurs in the marble as a recrystallization product and as an interstitial material in the aggregates of silicate minerals. In the latter occurrence this mineral evidently took part in the mineralization and was the last mineral to form. It occupies open spaces between blades of scapolite and grains of the other silicates. It also to a limited extent is present as an alteration of diopside, and in this case is thought to be later than the interstitial calcite found in the silicate minerals. Much of the calcite is dark bluish gray in color. In size it varies from minute grains to veins and irregular masses an inch wide.

Fluorite in this assemblage of minerals is unrelated to the contact metamorphism. It occurs with calcite and feldspar in lenses a few inches long, cutting the metamorphosed sediments. The mineral is deep purple in color and is present in grains up to 1 cm. in size. It is to be ascribed to mineralizing agencies active later than the contact metamorphism and possibly of a pneumatolytic nature.

It is thought that the sequence of events in the formation of these metamorphic minerals was as is stated below. The relations of all of the minerals to each other cannot be stated but the major part of the sequence seems well established with the possible exception that overlap existed in the periods of crystallization.

1. Solidification of the granite the later stages of which were accompanied by the formation of dipyrite, since this mineral overlaps some of the minerals of the igneous rock. Apparently limestone was digested by the granite magma since the main scapolite zone definitely penetrates boundaries of both limestone and granite. The dipyrite is thus a mineral closely related in origin to igneous conditions rather than one formed by mobile solutions some distance from the igneous mass. With the final phase of crystallization of the granite scapolite replaced the limestone and even arenaceous beds so that dipyrite became the chief mineral of a zone about twenty-five feet wide.

2. Formation of garnet at the expense of scapolite and limestone. In general the area affected by this mineral is beyond the dipyrite, although throughout the latter small amounts of garnet occur replacing the dipyrite. The metamorphism of the various sedimentary beds was selective for there are blocks of garnet within the granite containing no scapolite as is the case also with blocks consisting chiefly of diopside

3. Replacement and filling of interstices of scapolite, garnet and sedimentary rocks by diopside, feldspar and titanite. This is shown in the scapolite zone proper and in rocks where only garnet and diopside of the silicates are found. The feldspar of this stage seems to be of a later generation.

4. Filling of available space by residual calcite.

5. Injection of the pegmatite dike and of the fluorite veins or lenses.

The place of olivine in this series is not known. It occurs in the marble. If it formed early in the sequence and was replaced by other silicates no remnants are left to give a hint of the event. Its presence may be due to selective action alone. The same statements are true of the mica accompanying the olivine.

The formation of this zone of silicate minerals involves the addition of soda for the formation of scapolite, of alumina for scapolite feldspar and garnet, of iron for the garnet and diopside, and possibly silica for all of the silicates, although there is an abundance of this material in the limestone. Potash was also added being present in the scapolite, feldspar and mica. The metamorphic zone is small and discontinuous but it furnishes a good illustration of this type of metamorphism. The dipyrite is of particular interest. It is a mineral known to be a primary constituent of certain rare igneous rocks and present in many contact metamorphic deposits. Here it marks the transition from granite to contact silicates, being partly pyrogenetic in its association and partly truly contact metamorphic. It may be that this mineral generally has such paragenetic relations.