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CONTACT METAMORPHISM IN THE TRES HERMANAS MOUNTAINS, LUNA COUNTY, NEW MEXICO

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INTRODUCTION

The Tres Hermanas Mountains are located about twenty-five miles south of Deming, and consist of a group of 4900- to 5800-foot peaks occupying an area of about thirty-eight square miles. The three most prominent peaks, from which the mountains derive their name, lie about three miles west of New Mexico State Highway 11 about six miles north of Columbus. The mountains are made up of a series of Tertiary volcanics and intrusives which overlie or intrude Paleozoic sedimentary rocks, principally limestone and dolostone.

The general features of the area were first described by Lindgren (1909) and Darton (1916). Early mining in the area was from small fissure veins of silver, lead, and gold ores. Subsequently, zinc was mined from veins and replacement bodies at the north end of the mountains. The principal ore mineral was willemite with minor zincite, hemimorphite, smithsonite, and hydrozincite (Wade, 1913), suggesting that the original mineralized zone was metamorphosed prior to the extensive development of an oxidized zone. In recent years mining has been restricted to quarrying of banded calcite onyx at the southeast end of the area and to the removal of small amounts of fluorescent aragonite from a cave on the South Peak. Small amounts of lavender spurrite rock also appear to have been quarried on the lower slopes of South Peak.

The upper Paleozoic rocks of the area were described by Bogart (1953). The most extensive work in the area was done by Robert Balk over the period 1952-1955, but resulted in no published data at the time of death. His geologic map of the area, field notes, and thin sections were most graciously made available by Christina L. Balk and A. J. Thompson at the time this study was made in •1958. Robert Balk's map was published posthumously in 1961. The principal geologic features of the area, as described by Balk (1952-1955, 1961) and modified after the stratigraphic work of Bogart (1955) are, in brief summary, as follows: The Hueco Limestone and Magdalena Formation exposed in the north and northeast and the Fusselman Dolomite exposed in the north and west were overlain and intruded by an early or middle Tertiary series of volcanics consisting principally of andesites and minor quartz latites. This was followed by the intrusion of a quartz monzonite stock, accompanied by extensive contact metamorphism of the intruded limestones and dolostones. A subsequent quartz latite series developed, followed by rhyolite and latite dikes which cut all of the older igneous rocks. The quartz monzonite is exposed in the central and northeastern part of the area where it makes up the main mass of the three principal peaks. The volcanic rocks are exposed north and southwest of the quartz monzonite. Late Tertiary to Pleistocene rhyolite tuffs are exposed in the southwestern part of the area. The youngest igneous rocks are Pleistocene olivine basalt flows also exposed in the southwest.

Homme (1958) studied the metamorphic rocks of the South Peak as a part of his Master of Science work at The University of New Mexico. This work was never published, and constitutes the basis of this paper. Figure 1 is a geologic map of the South Peak of the Tres Hermanas as prepared by Homme and slightly simplified for this paper. In this area lower Hueco and/or upper Magdalena beds are intruded by the main mass of the quartz monzonite stock and separated into several blocks by three apophyses and dike-like extensions of that mass. The northernmost of these dike-like bodies trends northwest. The sedimentary rocks east of it dip 40-55° to the southeast, but the narrow body of sediments between it and the main mass of quartz monzonite displays dips from 15-50° to the southwest. Southward, two additional apophyses separate the sedimentary rocks into two bodies dipping gently to the west and steeply to the southwest respectively. Everywhere along the contact the limestones are metamorphosed to calc-silicate hornfels and medium- to coarse-grained marble with intercalated garnetized bands. Despite this extensive metamorphism, poorly preserved, large gastropods are still recognizable. A small area of unusual contact metamorphic rocks at the east side of the northwest-trending apophysis was studied in great detail.

CONTACT ROCKS AND THEIR PARAGENESIS

On the lower slopes of South Peak, when viewed from the east, a light colored, nearly white outcrop can be seen at an elevation of about 4800 feet. This distinctive appearance is caused by the caliche-like weathering product of the spurrite-bearing zone of contact rocks. This area is designated on Figure 1, and mapped in detail in Figure 2. The wide variety of contact metamorphosed rocks exposed in this small area are here described in their approximate order of formation. We recognize at least three distinct stages of metamorphism, but these are not always clearly defined. In all probability the stages are gradational and represent a relatively short time span.

Stage I involves essentially thermal metamorphism of the limestones as a result of the emplacement of the quartz monzonite stock. The resultant metamorphic rocks are of three types. 1) A calc-silicate hornfels derived from argil-

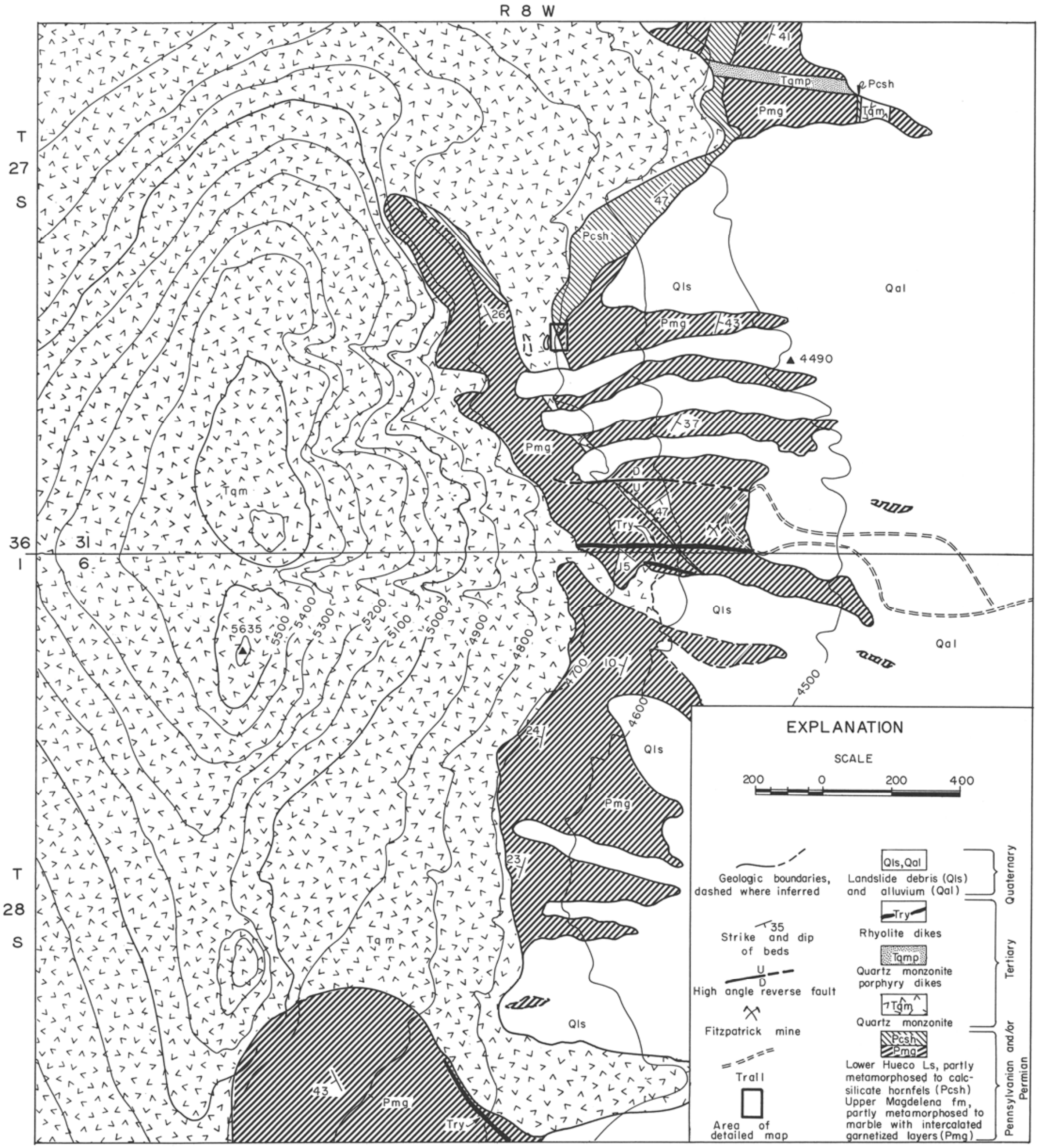

FIGURE 1.
Geologic map of the east flank of South Peak, Tres Hermanas Mountains (*after* Homme, 1958).

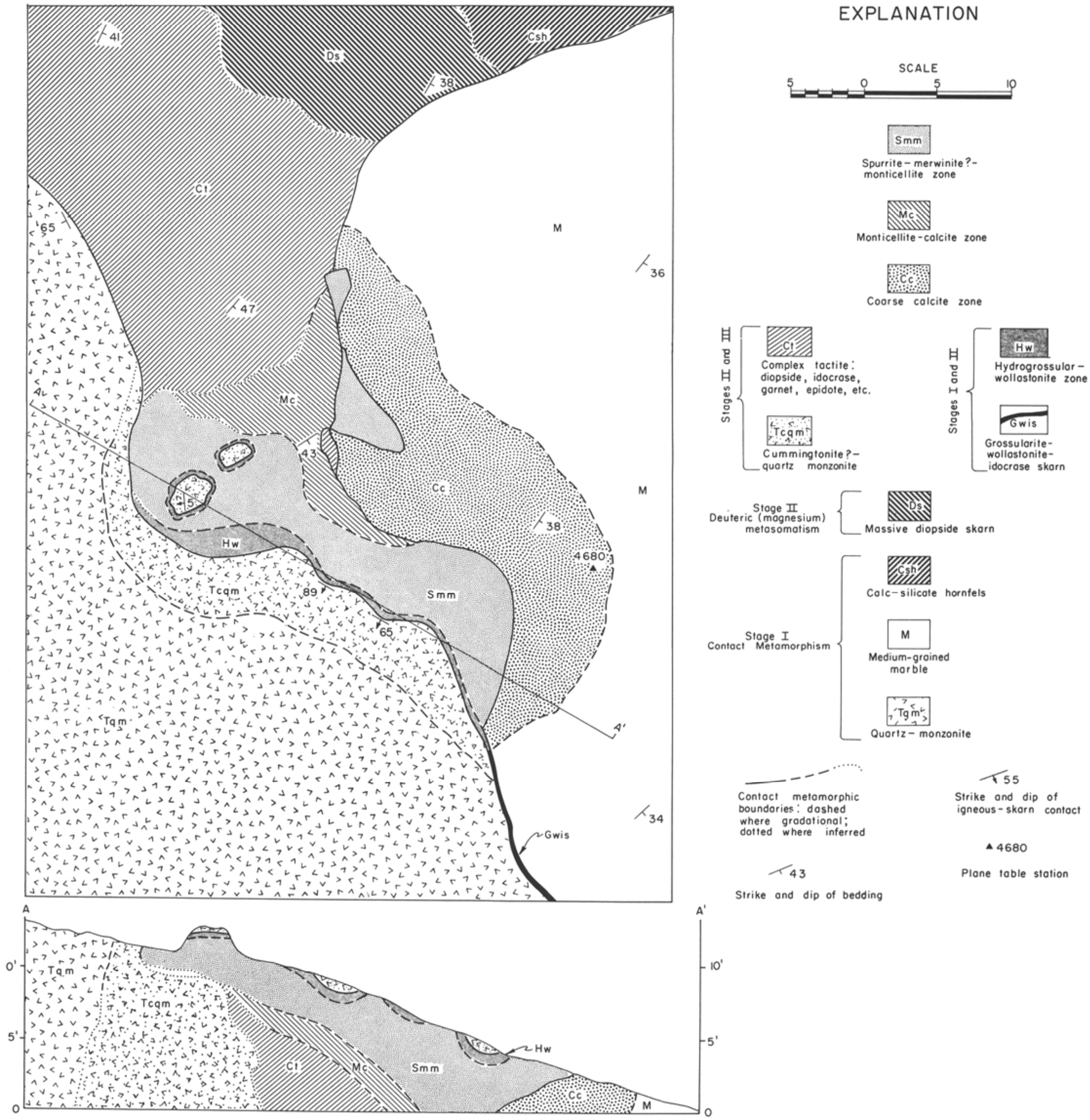

FIGURE 2.
Detailed geology of spurrite skarn lens, South Peak, Tres Hermanas Mountains (*after* Homme, 1958).

laceous limestones and shales which crop out extensively on the north and northeast flank of the mountains. This hornfels consists of microcrystalline quartz, garnet, epidote, diopside and some idocrase. 2) Medium- to fine-grained marble derived from relatively pure limestones which overlie the parent rock of the hornfels. 3) Grossularite-wollastonite skarn derived from impure layers in the original limestone. A garnet-wollastonite-idocrase skarn was formed along the very sharp igneous-sedimentary contact, and may have involved the slight addition of igneous-derived material.

This initial stage was followed by the local emplacement of fine-grained quartz monzonite along the original igneous-sedimentary contact. The pyroxene content of this rock is significantly higher than that found in the stock proper (8 percent as opposed to about 2 percent); this pyroxene was subsequently altered to cummingtonite. The contact between this igneous rock and the stock is generally very sharp, as is the contact with the metamorphic rocks. A body of metamorphosed limestone is almost engulfed by this intrusive, so that a lens several feet thick is overlain by igneous rock. Stage II, which is closely linked to the emplacement of the cummingtonite-quartz monzonite, clearly involves the introduction of magnesium into the previously formed metamorphic rocks. The calc-silicate hornfels is changed to a fine-grained, greenish to tan diopside skarn, and monticellite ($CaMgSiO_4$) begins to appear in the marble near the contact. The absence of significant dolomite from the parent sedimentary rocks was established by partial chemical analyses of the unmetamorphosed limestone.

Stage III is gradational with Stage II, probably involves continuing magnesium metasomatism, and represents the maximum temperatures attained in the system. In the lower part of the marble lens, a medium-grained monticellite-calcite skarn developed. This skarn forms a slab several feet thick near the bottom of the lens. It is made up of 40-60 percent monticellite, the balance being predominantly gray to bluish calcite, resulting in an overall honey-yellow to tan color. This rock represents the pyroxene hornfels facies of contact metamorphism. The balance of the lens between the overlying monzonite and the monticellite-calcite skarn was converted into a spurrite ($Ca_5(SiO_4)_2CO_3$)-monticellite-merwinite ($Ca_3Mg(SiO_4)_2$) skarn. This spurrite rock is generally of a pale lavender color whose intensity is directly proportional to the spurrite content, which may be as great as 85 percent. Other essential minerals in this zone are monticellite (up to 30 percent), blue calcite (up to 15 percent), and an unknown mineral, designated X (up to 15 percent). According to Bowen (1940), spurrite should appear at temperatures on the order of 1000°C at pressures of 400 atmospheres. At lower pressures (100 atmospheres) spurrite may appear at temperatures as low as 700°C (Bowen, 1940; Tilley, 1951). The final stage of metamorphism in this area appears to have involved rapidly circulating gases and solutions which suggests a relatively open system and relatively low temperatures for the formation of spurrite which is characteristic of the sanidinite facies of contact metamorphism.

A final surge of metamorphic activity introduced considerable water, silica, potash, and soda into the system. At the lower contact this produced a complex tactite containing as much as 90 percent feldspar, principally orthoclase. At the upper contact (cross-section, Fig. 2) this tactite does not appear. Here a band several inches thick of a hydrogrossular-wollastonite skarn was formed. It forms a very sharp contact with the igneous rock, but is gradational into the spurrite skarn. At this stage or at the end of Stage III the marble of the lens east of the skarn zone recrystallized to form a coarse-grained, blue, calcite marble.

This rather unusual assemblage of minerals has been observed only at this outcrop. The distinctive caliche-like weathering crust which forms on the spurrite skarn should make it easily recognizable in the field, but no additional outcrops of this type were noted. However, it is not unlikely that similar bodies have been removed by erosion or still lie unexposed. The total original volume of the spurrite-bearing lens is estimated at no more than 200 cubic feet.

MINERALOGY

The minerals which formed at the several stages of metamorphism are as follows:

Stage I—Grossularite, wollastonite, diopside, calcite, epidote, quartz.

Stage II—Diopside, pyrite, magnetite, and possibly cummingtonite.

Stage III—Spurrite, monticellite, merwinite, unknown X, calcite, magnetite, diopside, idocrase, scapolite, grossularite, hydrogrossular, orthoclase, oligoclase, cordierite, zoisite, sphene, etc.

Alteration products—Prehnite, antigorite, epidote, chlorite, saussurite, unknown Y.

Spurrite—This mineral was first described by Wright (1908) from Velardena, Durango, Mexico. It was later described from several other localities: Crestmore, California (Foshag, 1920); Scawt Hill, Antrim, Ireland (Tilley, 1929); Tokatoka, North Auckland, New Zealand (Mason, 1957). The spurrite from the Tres Hermanas Mountains was first identified by A. H. Koschman of the New Mexico Bureau of Mines and Mineral Resources (Talmage and Wooton, 1937). Of particular interest in this occurrence is the unusual twinning of the spurrite. Crystals of spurrite seen in thin section may be as much as three or four millimeters in diameter. They are almost invariably twinned on (001), the well known and most common polysynthetic twinning of this mineral. In some instances a second twin type occurs which, in combination with the (001) twinning, results in cyclic twins. This twinning is on the plane (205) and is not polysynthetic. These cyclic twins often show zoning which is visible in cross-polarized light. With the aid of precession X-ray photographs, the growth planes as well as the twin planes may be indexed. The growth planes (001), (100), (201), (201), and (207) were observed (Fig. 3).

Unknown X—This mineral occurs as a fine-grained constituent of the spurrite-monticellite-merwinite skarn. It characteristically displays low birefringence and polysynthetic twinning. The following optical properties were ob-

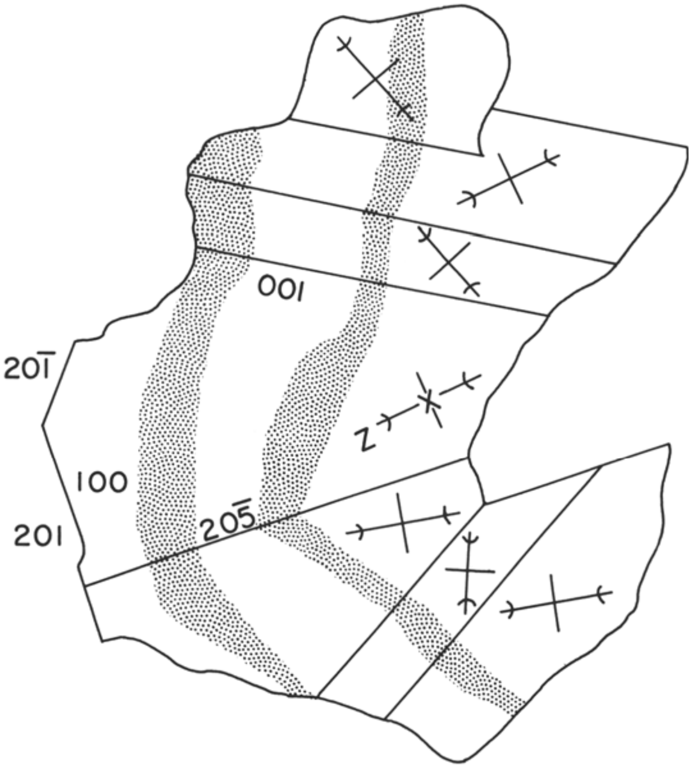

FIGURE 3.

Spurrite crystal showing twinning on (001), polysynthetic, and (20$\bar{5}$), cyclic. Shaded area depicts zoning. Miller indices refer to crystal faces, growth planes, or twin planes.

served: optically positive with a moderate to large optic angle; N_x = 1.648, N_y = 1.650, N_z = 1.657.

Unknown Y — This unidentified mineral occurs as an alteration product of spurrite at the western end of the lens. It is extremely fine grained, partly opaque in thin-section, and has a wavy extinction. No further properties were determined.

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