



Cretaceous-early Tertiary history of the northern Pyramid Mountains, southwestern New Mexico

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CRETACEOUS-EARLY TERTIARY HISTORY OF THE NORTHERN PYRAMID MOUNTAINS, SOUTHWESTERN NEW MEXICO

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INTRODUCTION

The Pyramid Mountains are a north-trending range of Lower Cretaceous through middle Tertiary volcanic and plutonic rocks in the Basin and Range province of southwestern New Mexico southwest of Lordsburg. The Lordsburg and Pyramid mining districts produced about \$59,270,000 worth of copper, silver, lead and gold between 1870 and 1973 (Thorman and Drewes, 1978). A detailed geologic study of the Lordsburg district was made by Lasky (1938), and general study of the Lordsburg 15-minute quadrangle was made by Flege (1959). Clark (1970) described mineral zonation in the district.

The Cretaceous-early Tertiary history of the northern Pyramid Mountains, presented here, is based on new detailed mapping of the Gary and Lordsburg 7.5-minute quadrangles (fig. 1) by Thorman and Drewes (1978). Refinements and revisions to the previous geology are shown in Figure 1. Foremost among these revisions was the recognition of Lower(?) Cretaceous sandstone. The Upper Cretaceous basalt of Lasky (1938) is seen to consist of two units of Late Cretaceous and one of Paleocene age, all of andesite. The granodiorite stock is older, not younger as concluded by Lasky, than a unit of rhyolite intrusives. Mineralization of the district probably occurred about 55 to 57 m.y. ago.

The Pyramid Mountains lie within the area of Paleozoic carbonate-shelf deposition typical of southwestern New Mexico and southeastern Arizona, and about 40 km southwest of the west-northwest-trending Deming axis of post-Devonian age (Turner, 1962). Paleozoic rocks are not exposed in the Pyramid Mountains, although exotic blocks of Pennsylvanian limestone occur in Tertiary volcanic rocks of the central part of the range, and Pennsylvanian-Permian Horquilla Limestone underlies a low hill a few kilometers southwest of the range. Some aspects of the Paleozoic and Mesozoic history of the region are reviewed by Greenwood and others (1977).

ROCK UNITS

The Cretaceous and lower Tertiary rocks of the northern Pyramid Mountains are divided into Lower(?) Cretaceous sandstone and shale, Upper Cretaceous andesites, Paleocene acidic intrusive and andesitic extrusive rocks and Eocene latite(?) dikes. The Paleocene intrusive rocks include a granodiorite stock and rhyolitic plugs, breccia pipes and dikes. Quartz veins and mineral deposits postdate most of the intrusive activity. The rocks of Cretaceous to Eocene age are unconformably overlain by middle to upper Tertiary volcanic rocks, which are not discussed here but are shown as undifferentiated Tertiary volcanic rocks in Figure 1.

Lower(?) Cretaceous sandstone

A wedge of clastic rock underlies Upper Cretaceous andesitic rocks (67.3 m.y.) and is intruded by the Lordsburg stock (58.8 m.y.) in the southern part of the area. The rocks are light-brown, light-olive-gray or greenish-gray, fine-grained to gritty sandstone, siltstone, shale and quartzite in beds as much as 1.5 m thick. Most of the rocks are well indurated due to

thermal metamorphism. A few inclusions of laminated, epidote-bearing thermally metamorphosed shale and quartzite occur in the Lordsburg stock. An external mold of a fragment of a *Cardium* mollusc (N. F. Sohl, written commun., 1976) and other unidentifiable bivalve fragments were found in sandstone. Although these fossils are not diagnostic of the Lower Cretaceous, similar ones are common in the Lower Cretaceous of the Bisbee Formation to the southwest and the Mojado Formation to the southeast. The Lower(?) Cretaceous sandstone in the Brockman Hills (Thorman, 1977), 35 km to the southeast, and the Mojado Formation in the Big Hatchet Mountains (Zeller, 1965), 65 km to the south-southeast, represent the oldest unit exposed in the Pyramid Mountains.

Upper Cretaceous andesites

Andesites of Late Cretaceous age underlie much of the northern Pyramid Mountains and include flows, tuff breccias, flow breccias, bedded volcanoclastic rocks and intercalated rhyolitic units. These rocks have been divided into an older andesite of Shakespeare, and an unconformably overlying andesite of Gore Canyon (Thorman and Drewes, 1978).

Individual flows and breccias are as much as 50 m thick. The andesites are medium gray, dark gray, brownish gray and dark greenish gray in color, have a felted to pilotaxitic matrix, and contain 1-10 percent phenocrysts of andesine and clinopyroxene. Some andesites contain hornblende, olivine or biotite phenocrysts. The andesites of Shakespeare are typically pervasively and strongly propylitized, whereas the andesites of Gore Canyon are much less altered and have a fresher appearance.

Zircon from a flow in the andesites of Gore Canyon was dated as 67.3 ± 7.1 m.y. old by the fission track method (C. W. Naeser, written commun., 1978). The underlying andesites of Shakespeare are probably also Late Cretaceous in age.

The Upper Cretaceous andesites may be correlative to the Hidalgo Volcanics in the Little Hatchet Mountains, as suggested by Lasky (1947). Similar rocks also occur in the Brockman Hills (Thorman, 1977), in the central Peloncillo Mountains south of Steins Pass near the McGee mine (Gillerman, 1958; Drewes and Thorman, unpub. data, 1978) and in the northern Chiricahua Mountains (Drewes, unpub. data, 1978).

Paleocene intrusive rocks

This group includes, in order of emplacement, the Lordsburg granodiorite stock, aplite dikes and pods, and rhyolite vents and breccia pipes. The Lordsburg stock intrudes the Lower(?) Cretaceous sandstone and Upper Cretaceous andesites; it forms a partly concealed mass that is probably slightly elongate east-west, with an irregular upper surface. Its crescent-shaped outcrop pattern probably reflects an irregular top and the distribution of the capping host rock, rather than its planimetric outline. The granodiorite is a light-gray to light-brownish-gray porphyritic rock with a matrix of fine- to

medium-grained quartz, plagioclase, potassium feldspar, biotite, hornblende, magnetite, apatite, sphene, zircon and allanite: Phenocrysts of quartz, plagioclase and potassium feldspar are as much as 5 mm in diameter. Aplite dikes and pods as much as 1 km across cut the pluton but are not delineated on the geologic map (fig. 1).

Two K-Ar age dates on biotite have been obtained from the pluton. The older date, 58.8 ± 2.0 m.y. (R. F. Marvin, oral commun., 1977), is from an area of sparse alteration about 0.5 km from the southern edge of the body. The younger date, 56.5 ± 2.0 m.y. (P. E. Damon and W. Elston, oral commun., 1977), is from rock collected at the Eighty-Five mine dump on the northern margin of the body in an area of very strong mineralization and generally widespread alteration.

Rhyolite rocks intrude the Lordsburg stock and the andesite of Shakespeare along a 2- to 3-km-wide belt that trends west-northwesterly across the area. The intrusive rhyolite bodies compose irregular-shaped circular to elongate masses, some of which may have vented at the surface. Rocks in these bodies vary from nonbrecciated flow-banded rhyolite to megabrecciated rhyolite with subordinate inclusions of granodiorite and andesite. The breccia bodies, or breccia pipes, commonly intrude the nonbrecciated bodies. A few east-northeast-trending dikes of flow-banded rhyolite occur in the central part of the area.

The rhyolite is very light gray to greenish gray, aphanitic to porphyritic, with fine- to medium-grained quartz phenocrysts set in a silicified groundmass. Most of the coarsely brecciated masses are iron- or manganese-stained, altered and strongly silicified; they weather into prominent knobs.

Quartz veins and associated mineral deposits

Localization of quartz veins and silicified pods, and the ore deposition that formed the Lordsburg copper-silver-gold-lead deposits took place along east- and northeast-trending fault sets. Lasky (1938) noted several stages of silicification and mineralization within the veins that occur in Upper Cretaceous andesites, granodiorite and intrusive rhyolite bodies.

Paleocene andesite

Olivine andesite flows mapped by Thorman and Drewes (1978) as the andesite of Animas Road are medium gray to dark gray in color. The andesite contains phenocrysts of fine- to medium-grained plagioclase, clinopyroxene and olivine in a very fine grained groundmass of plagioclase, clinopyroxene, olivine and subordinate magnetite and zircon. A flow near the Lordsburg water tank has been dated as 54.9 ± 2.7 m.y. old by the fission track method on zircon (C. W. Naeser, written commun., 1977).

Eocene latite(?) dikes

The latite(?) porphyry dikes trend northeast and consist of fine- to medium-grained feldspar and, locally, biotite phenocrysts set in a very light gray groundmass. The feldspar phenocrysts and groundmass are typically saussuritized and sericitized. One dike has been dated as 52.7 ± 2.7 m.y. old by the fission track method on zircon (C. W. Naeser, written commun., 1977).

STRUCTURE

The dominant structural feature of the northern Pyramid Mountains is a conjugate fault system consisting of east-trending and northeast-trending sets that displace Cretaceous

and Paleocene rocks. The east-trending set includes two major faults that cross along the northern edge of the Lordsburg stock, cutting the Cretaceous andesites, granodiorite and intrusive rhyolite at Atwood Hill. The northeast-trending set occurs mainly between and south of the two major east-trending faults.

The fault pattern is strongly suggestive of strike-slip faulting. Lasky (1938, p. 23) notes that "The cross faults tend to bend eastward into the northern line of the eastward-trending faults and westward into the southern line ..." and that this geometry suggests right slip on the east-trending faults, with the cross faults being second-order structures that were dragged along and into the main structures. Slickensides on fault planes in both sets are nearly always horizontal or sub-horizontal, indicating an important component of strike-slip movement. Lasky (1938) noted 150 ft (46 m) of horizontal slip along a northeast-trending fault. On the other hand, the northeast-trending cross-fault set is oriented such that it could comprise a series of *en echelon* tension fractures.

Multiple strike-slip movement is postulated, with the east-trending structures having formed due to right slip along the north side of the Lordsburg stock, followed by several episodes of left slip along the same structures. The northeast-trending set formed initially as sympathetic strike-slip faults associated with east-west-oriented right slip; the horizontal slickensides in the fault planes and the deflected and warped ends of these faults into the east-west faults formed at this time. Subsequently, the northeast-trending faults became "tension gashes" in response to east-west left slip, opening several times as indicated by the multiple vein-filling and ore-depositing stages noted by Lasky (1938, p. 22 and 30).

Faulting occurred after emplacement of the rhyolite and before the late Paleocene andesite volcanism. The intrusion of the granodiorite and rhyolite apparently was not controlled by the conjugate fault system, but the later quartz veins and ore deposits show fault control. The late(?) porphyry dikes of early Eocene age trend northeasterly and may reflect a late reopening of that fault set.

The northern Pyramid Mountains lie in an east-west zone that has long been thought to have been the site of major strike-slip faulting that began in middle to late Precambrian time and has been intermittently active since that time. It is possible that a major structure occurs northeast of the Pyramid Mountains and that the location of the Lordsburg stock and of the conjugate fault system is related to such a structure. Similar faults and related features occur in the northern Chiricahua-Dos Cabezas mountains (Sabins, 1957; Drewes, 1978) and the Pinaleno Mountains (Swan, 1975).

Age of Mineralization

Major mineralization postdates the rhyolite intrusives and was coeval with opening of faults of the conjugate fault system. The younger of the two age dates from the Lordsburg stock, 56.5 m.y., probably dates the mineralization very closely. This date is based on K-Ar from biotite and is from the strongly mineralized northern margin of the stock along a large northeast-trending vein. Cooling of the stock and mineralization were probably approximately contemporaneous. This suggested age of mineralization is consistent with field relationships and the fission-track and K-Ar age dates.

Cretaceous-Early Tertiary Chronology

1. Deposition of Lower(?) Cretaceous sandstones.
2. Upper Cretaceous andesitic volcanism 67 m.y. ago.
3. Lordsburg granodiorite stock emplaced 59 m.y. ago into Lower(?) Cretaceous sandstone and Upper Cretaceous andesites. Possible initiation of conjugate fault system at this time.
4. Rhyolite and breccia pipes intrude into Upper Cretaceous andesites and the Lordsburg stock. Possible conjugate fault system activity.
5. Right slip along east-trending faults of conjugate fault system and subordinate related strike-slip movement along northeast-trending faults.
6. Left slip along east-trending faults and opening of northeast-trending faults as tension gashes, with major quartz vein filling and ore deposition about 56.5 m.y. ago.
7. Olivine andesite flows about 55 m.y. ago.
8. Lathe(?) porphyry dikes intruded along northeast-trending faults about 53 m.y. ago.

Guides for Mineral Exploration

Exploration for ore deposits in the area should perhaps be influenced by an analysis of the conjugate fault system. Mineralization was clearly localized along these structures. The eastern and western projections of this system into the adjacent basins are likely exploration target areas. Several intrusive rhyolite vents and pipes occur west of the range directly on trend with the major east-west faults and deserve consideration. Atwood Hill, a large rhyolite breccia body, was a major site of mineralization and is located in the east-west fault zone.

THORMAN and DREWES

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