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William G. Gustafson, D. G. Bryant, and T. L. Evans

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# GEOLOGY OF THE QUESTA MOLYBDENITE DEPOSIT, TAOS COUNTY, NEW MEXICO

By

William G. Gustafson, Donald G. Bryant, and Thomas L. Evans

Molybdenum Corporation of America

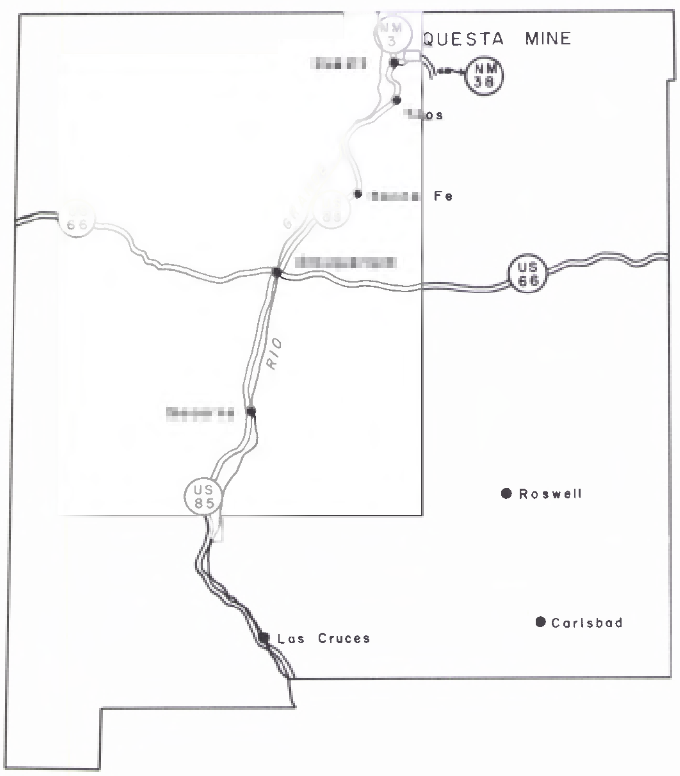
## INTRODUCTION

The Questa molybdenite deposit, on the west slope of the Taos Range in northern New Mexico, is in Sulfur Gulch, a side canyon of the Red River, at altitudes ranging from 7,900 to 10,000 feet. The Taos Range is part of the Sangre de Cristo Mountains, a north-trending uplift near the southern end of the Rocky Mountains. The range is underlain by Precambrian metamorphic rocks and a Tertiary complex of volcanics and intrusives.

Open-pit mining was started in 1964 and the first ore was sent to the present mill at the start of 1966. The current milling rate is in excess of 10,000 tpd.

## PREVIOUS INVESTIGATIONS

Early investigations of the Questa molybdenite deposit were made by Larsen and Ross (1920, p. 567-573), and Vanderwilt (1938, p. 599-643). These, and Schilling's (1956, 87 p.) early work, describe vein deposits mined by underground methods. More recently, Schilling (1965, p. 26-34) described the stockwork deposit now being mined.




Index Map of Questa Molybdenite Deposit.

Carpenter (1960, p. 79-86) published a report describing the events leading to formation of the deposits. Regional reconnaissance mapping was done by McKinlay (1956, 31 p.; 1957, 23 p.).

## PRECAMBRIAN ROCKS

Precambrian granite and granite gneiss crop out on the north side of Red River Canyon in the vicinity of the Questa deposit. The rocks are gray, medium to coarse grained, and contain quartz, orthoclase with minor biotite, and have foliated and non-foliated facies. The Precambrian granite is distinguishable from Tertiary granite by being gray rather than pink, and has coarser texture.

Scattered remnants of conglomerate, sandstone, and siltstone which occur directly above the granite and gneiss are included with the Precambrian of Figure 1. The age of these sediments is uncertain but is presumed to be either late Paleozoic or early Tertiary.

## TERTIARY ROCKS

### Andesite (Ta)

Andesite porphyry and andesite breccia are the oldest volcanic rocks in the area. Both andesites are characterized by phenocrysts of andesine, but the composition of the matrix is variable. The breccias are cemented by hematite, and contain epidote, apatite, and alunite in the matrix. The groundmass of porphyritic andesite consists of either fine-grained orthoclase and biotite, or glass fragments. The mafic content of andesites is remarkably low and consists of scattered phenocrysts of biotite. Andesites low in hematite or hydrothermal chlorite are often light gray in contrast to darker colors usually associated with andesites.

### Rhyolite (Tr)

Overlying the andesite is a sequence of rhyolite porphyry, tuff, and tuff breccia, which caps most of the ridges between the pit area and the west edge of the mountains. The rhyolite breccia, on the ridge west of the pit, consists of rhyolite porphyry fragments in a matrix of glass, and fine-grained quartz and orthoclase which is strongly flow-banded.

Farther west, in the area around Goat Hill (Fig. 1), the rhyolites are tuffs and tuff breccias which are characteristically fragmental, without flow-banding, and have a high clay-sericite content.

North and west of Goat Hill the rhyolites are flow-banded, dense welded tuffs containing abundant quartz phenocrysts.

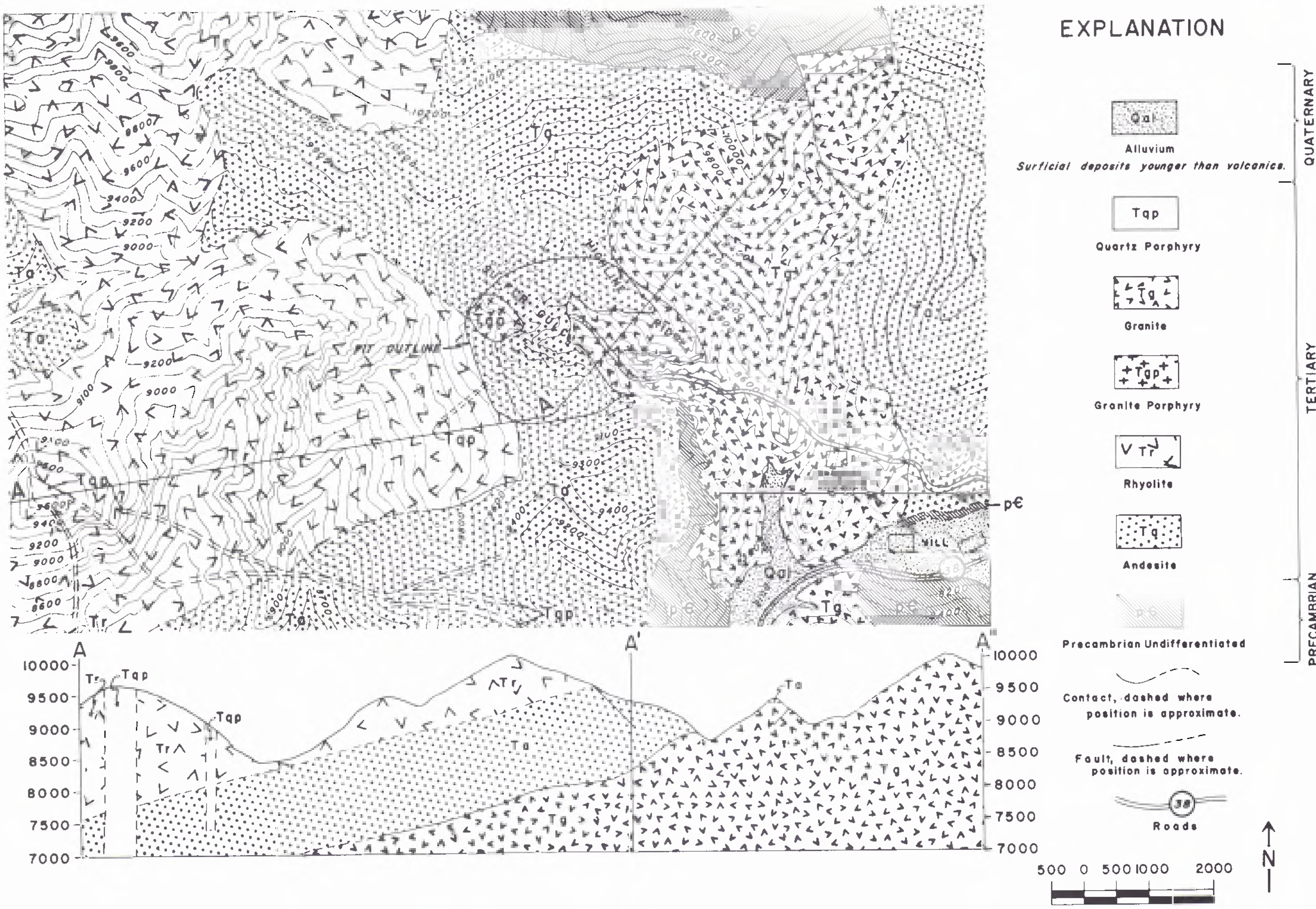



FIGURE 1
Geology of the Questa Molybdenite Deposit.

GRANITE PORPHYRY (TGP)

A granite porphyry plug at the west edge of the pit underlies the ridge between Sulfur and Iron Gulches. The plug is nearly oval in plan and is about 600 feet in diameter.

The granite porphyry is composed of quartz, orthoclase, and biotite phenocrysts up to ⅛ inch in diameter, set in a groundmass of quartz, orthoclase, and sericite. Hydrothermal alteration is pervasive and feldspars are altered to quartz and sericite. Previous sites of biotite are indicated by residual concentrations of quartz, sericite, and rutile. The entire plug is cut by numerous quartz veinlets, and shows pervasive silicification.

GRANITE (TG)

Several Tertiary granitic stocks are present in the Taos Range, but this paper is concerned with only one, the Sulfur Gulch stock (Fig. 1).

The stock intrudes Precambrian granite and granite gneiss, and Tertiary volcanics. The Questa molybdenite deposit is localized along the granite-andesite contact of the westward-plunging extension of the stock. Available infor mation indicates that dips are steep along the north anc south contacts.

The Sulfur Gulch stock is a mafic-deficient granite witl aplitic texture, and is usually referred to as "the aplite.' It consists of interlocking grains of quartz, orthoclase, anc albite in nearly equal proportions, with phenocrysts of bio tite and albite. Biotite constitutes less than one percen of the rock except in areas of molybdenum mineralization Decreases in the amount of albite in the matrix are fre quently compensated by an increase in albite phenocrysts

In the ore body, the intrusive has been subjected to re crystallization which has destroyed the original texture There has also been a reduction of albite, development o myrmekite and quartz veinlets, and enlargement of quart: grains.

QUARTZ PORPHYRY (TQP)

A plug and numerous dikes are designated as quart porphyry on Figure 1. These rocks consist of phenocryst of quartz and feldspar, ⅛ inch to ¼ inch in diameter, se


FIGURE 2
The Questa Open-Pit Mine, Spring of 1966
*(Photograph by Harold L. James; symbols are those used in Figure 1)*

in a finer grained silicic groundmass. The quartz porphyry plug (Fig. 1) is exposed at the top of Goat Hill. Numerous dikes extend radially outward from the plug. The remainder occur along the ridge between the pit and Goat Hill. Considerable variation in groundmass textures, not apparent in hand specimens, exists between these various quartz porphyry intrusions. Several have a relatively coarse-grained aplitic groundmass, while the groundmass textures of others is submicroscopic. Compositional variation is also significant. While most of the porphyries are granitic, a few are, in fact, quartz monzonite porphyry. Continued investigation will, it is hoped, provide a basis for a more suitable classification of these rocks.

### INTRUSIVE BRECCIA

Breccia dikes 5 to 20 feet wide intrude aplite on Highline Ridge, and aplite and andesite in the pit due east of the granite porphyry plug. The breccia is composed of rounded and angular fragments of aplite, quartz porphyry, and andesite in a fragmental matrix composed of quartz and granitic rocks. Distribution of breccia dikes is not well known and is not shown in Figure 1. The dike exposed in the pit is shown in Figure 2.

### ALLUVIUM (QAL)

Materials in this category shown in Figure 1 consist of stream sediments and mud flows of recent origin. These materials are usually coarse, poorly sorted, and in the case of mud flows, markedly angular because of the steep gradients and short transport.

## MINERAL DEPOSITS

### STRUCTURE

Both vein and stockwork molybdenite deposits have been found in and adjacent to the Sulfur Gulch stock. Quartz-molybdenite vein deposits south and east of the pit were mined, by underground methods, on a nearly continuous basis from 1919 to 1956 (Schilling, 1956, p. 6-8). These veins are in fractures paralleling the south-dipping aplite-andesite contact south of Sulfur Gulch. The veins are mostly quartz and molybdenite, with conspicuous amounts of fluorite, biotite, and calcite. Widths range from a few inches to nearly ten feet, and occur in both aplite and andesite, although ore shoots are usually in aplite. Vein boundaries are sharply defined, and wallrocks are nearly barren of mineralization. Schilling (1956, p. 42-66) has described these deposits in detail.

The source of current production is a molybdenite stockwork deposit. The ore body, as it is now known, occurs at the contact of the aplite and andesite and is centered about Sulfur Gulch (Fig. 1). Mineralization is in the myriad of fractures in aplite and andesite within a few hundred feet of the contact. In the pit this contact is irregular, trends northwest, dips southwest, and has been offset by numerous faults of small displacement. Stoped blocks and pendants of andesite occur in the intrusive, and aplite dikes a few inches to 10 feet wide intrude the andesite.

Neither through-going faults nor preferred orientation of mineralized fractures have been recognized. Sheeting parallel to the surface of the stock is usually prominent but not preferentially mineralized. The remaining fractures are short, discontinuous, without preferential orientation, and exhibit little or no offset. Veined fractures range from hairline cracks to fissures two feet wide. In places, the veins and veinlets are close enough and contain sufficient ore-grade mineralization to class the entire mass, wallrock and veins together, as ore, which justifies classification of the deposit as a stockwork.

## ALTERATION AND MINERALIZATION

Seventeen hydrothermal minerals, containing a minimum of fourteen introduced elements, have been identified in the molybdenite deposit. An additional three minerals, orthoclase, albite, and epidote, and two elements, sodium and calcium, are closely related to hydrothermal activity. Elements introduced via hydrothermal solutions are: K, Mg, Si, S, P, F, Fe, Mo, Pb, Zn, Ti, Mn, Cu, and W (?). Table 1 is a list of the hydrothermal minerals which contain these elements.

TABLE 1

HYDROTHERMAL MINERALS IN THE QUESTA MOLYBDENITE DEPOSIT

| | |
|---|---|
| Quartz | $SiO_2$ |
| Calcite | $CaCO_3$ |
| Rhodochrosite | $MnCO_3$ |
| Fluorite | $CaF_2$ |
| Biotite | $K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$ |
| Chlorite | $(Mg,Fe)_5(Al,Fe''')_2Si_3O_{10}(OH)_8$ |
| Sericite | $KAl_3Si_3O_{10}(OH)_2$ |
| Apatite | $Ca_5(F,Cl,OH)(PO_4)_3$ |
| Alunite | $KAl_3(OH)_6(SO_4)_2$ |
| Gypsum | $CaSO_4$ |
| Rutile | $TiO_2$ |
| Pyrite | $FeS_2$ |
| Molybdenite | $MoS_2$ |
| Galena | PbS |
| Chalcopyrite | $CuFeS_2$ |
| Huebnerite (?) | $MnWO_4$ |
| Sphalerite | ZnS |

Quartz, biotite, chlorite, sericite, alunite, apatite, and rutile are the principal minerals involved in the alteration of wallrocks. Substantial differences in the final composition of aplite and andesite are characteristic. Silicification of aplite is marked by veinlets, enlargement of pre-existing quartz, and generation of new quartz grains. Alunite and sericite are the other principal alteration products. Hydrothermal biotite, with associated apatite, rutile, and huebnerite (?), plays a minor role in alteration of aplite, and there is little increase in mafic content. Alteration of andesite is characterized by suites dominated by chlorite (penninite) and/or quartz and dark-brown hydrothermal biotite. Chlorite, and minor sericite and alunite occur adjacent to the ore deposit. In and near the deposit andesite is replaced, almost completely, by a granular aggregate of quartz and biotite with lesser amounts of pyrite, rutile, and apatite. Rutile and apatite are invariably associated with the biotite. Apatite occurs as small euhedral crystals near biotite; rutile occurs as bead-like droplets near biotite, and as reticulated networks of prismatic crystals in the biotite. A mineral tentatively identified as huebnerite (?) is also commonly associated with the hydrothermal biotite. Pyrite is distributed as small individual grains along numerous, hair-line fractures.

Veins and veinlets in the molybdenite deposit are composed of various combinations of quartz, fluorite, carbonates, biotite, chlorite, gypsum, and sulfides. Quartz is the principal vein mineral and extends well beyond the limits of economic mineralization. Gypsum veinlets are extensively developed in andesite and, although numerous and widespread, seldom attain thicknesses greater than ¼ inch. Calcite commonly occurs in veins which are predominantly fluorite. Pyrite is disseminated in all types of veins, and occurs as large euhedral crystals in veins devoid of other minerals. Molybdenite is exceedingly indiscriminate and occurs in veins and veinlets of all kinds and sizes. The intense fracturing of the deposit has resulted in some dissemination of hydrothermal minerals. Granular disseminations of pyrite, biotite, molybdenite, and huebnerite (?) are extensive. Locally, galena and sphalerite occur as disseminations in quartz veins.

Supergene modification of the molybdenite deposit is restricted to a relatively thin zone. Kaolinization of plagioclase, partial destruction of pyrite to limonite, and conversion of part of the molybdenite to ferrimolybdite are the major effects. It should be stressed that weathering of the deposit is a minor feature and plays not at all the role it does in so many porphyry copper deposits of the Southwest.

The altered areas devoid of vegetation that are conspicuous along Red River Canyon are caused by weathering. Mixtures of clay, limonite, and quartz occur at the surface of these areas. Directly beneath these materials is a zone of intense silicification and minor, disseminated pyrite. Beneath this zone are pyritized volcanics, usually andesite. It is believed that alteration is caused by generation of sulfuric acid from pyrite, which in turn is responsible for decomposition of rock minerals to clay and quartz. The final alteration products are those seen at the surface; silicification below the surface is caused by deposition of residual silica from downward-moving, supergene solutions.

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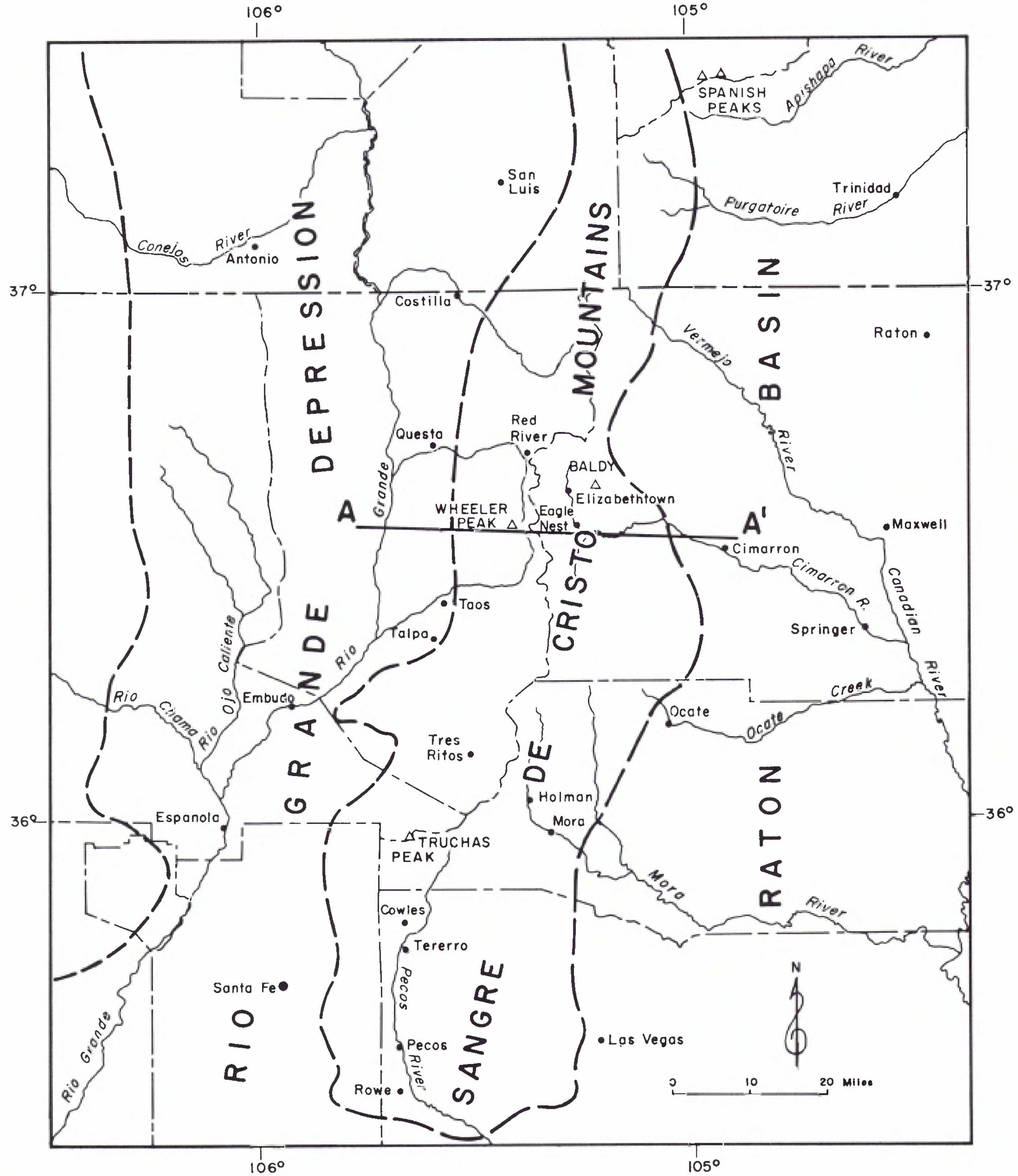


FIGURE 1

Physiographic features of north-central New Mexico and south-central Colorado.