



Precambrian geology and metals potential of the Twining-Gold Hill area, Taos Range, New Mexico

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PRECAMBRIAN GEOLOGY AND METALS POTENTIAL OF THE TWINING-GOLD HILL AREA, TAOS RANGE, NEW MEXICO

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INTRODUCTION

Early Proterozoic supracrustal and intrusive rocks crop out in the northern Sangre de Cristo Mountains from east of the town of Taos to north of the New Mexico/Colorado state line. Recent studies of this terrane in the Taos Range segment of the Sangre de Cristo Mountains refine previously published information on the area. This paper presents an overview of the Precambrian supracrustal geology of the southern Taos Range, describes in detail the geology of a small area north of Twining, and discusses the region's potential for deposits of volcanogenic metals.

Reed (this guidebook) outlines the Precambrian geology of the entire range, based on recent U.S. Geological Survey mapping (Reed and others, 1983). McCrink (1982) mapped portions of the Gold Hill and Wheeler Peak areas and conducted a geochemical study of the rocks (Condie and McCrink, 1982).

GEOLOGY

Overview

The Proterozoic supracrustal section of northern New Mexico comprises two major lithologic units: (1) a suite of mafic and felsic metavolcanic rocks with intercalated volcanoclastic and epiclastic metasedimentary rocks, and (2) a metasedimentary sequence dominated by quartzite, but also containing metamorphosed conglomerate, shale, arkose, and rare felsic tuff. In the areas of Picuris and Truchas Peaks to the south, these sequences are the Vadito Group and the Ortega Group, respectively (Montgomery, 1963; Long, 1976; Robertson and Moench, 1979). The Vadito Group is the older of the two, although locally it structurally overlies Ortega Group quartzite (Grambling and Coddling, 1982; Holcombe and Callender, 1982). Felsic volcanic rocks from the southern Taos Range yield U—Pb zircon ages of 1,750 m.y. (Bowring and others, 1984).

In the Taos Range, metavolcanic rocks dominate the supracrustal assemblage exposed between the Taos Pueblo and Red River, while a quartzite and mica-schist sequence constitutes most of the supracrustal outcrop north of Red River (Reed, this guidebook). Proterozoic gabbroid to granitic plutons, and Tertiary granitic stocks and volcanic rocks related to the Questa caldera, intrude and cover older rocks throughout the range (Reed and others, 1983). Numerous high-angle faults further define the outcrop distribution of supracrustal sequences.

The most extensive exposure of metavolcanic and associated metasedimentary rocks in the area lies in the southern part of the Taos Range, between Gold Hill and Wheeler Peak (Fig. 1). A 2.5 by 3.5 km portion of this sequence, situated east and north of Twining between Gold Hill and Bull-of-the-Woods Mountain, is the focus of this study. The area was reconnaissance-mapped at scales of 1:24,000 and 1:12,000, and locally mapped in detail at a scale of 1:6,000. Geologic control is good to fair in places, but is lacking in others owing to thick soil and forest cover.

Textures and primary structures are surprisingly well preserved in metavolcanic and metasedimentary rocks, in spite of amphibolite-facies metamorphism and intense deformation (Reed, this guidebook, and McCrink, 1982). These textures allow the determination of protoliths in most cases, and rocks are named accordingly in the descriptions and discussion which follow. The prefix "meta" is omitted. Reference to megascopic metamorphic appearance is made in descriptive sections of

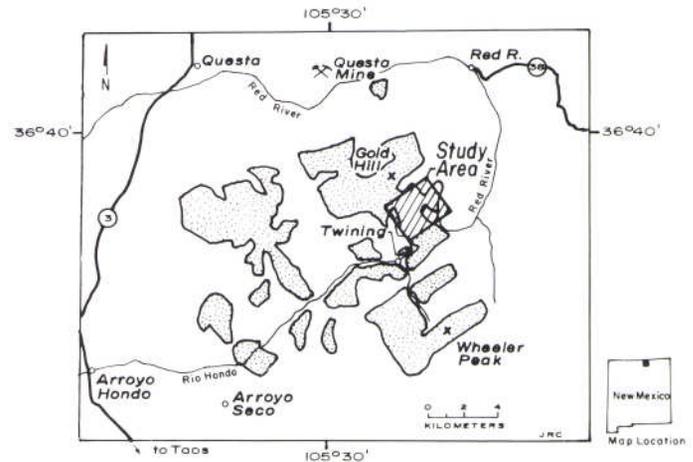


FIGURE 1. Index map showing Precambrian supracrustal rocks (stippled) in the southern Taos Range and the area discussed in this paper (outlined).

this report. Primary structures also allow the determination of an apparent stratigraphy; the following section describes rocks of the immediate study area on that basis, from oldest to youngest.

Rock Types

Basaltic Flows and Tuff

A mafic volcanic sequence composed of basaltic flows, tuff, and tuff breccia crops out from Gold Hill Ridge east to the headwaters basin of the Red River (Fig. 2). The sequence is 1,000 m thick on Gold Hill Ridge. Basalt flows occur on the margins of the mafic sequence, and thin flows are interbedded with tuff in the middle portions. Individual flows are 5-30 m thick where flow margins can be discerned. Flow rock is fine-grained, mostly massive, with poorly developed schistosity, and commonly is vesicular or amygdaloidal. Flow breccia is preserved at one locality and in a few places along the east wall of Long Canyon there are faint suggestions of small pillows. Deformation makes this interpretation tenuous.

Basaltic tuff and tuff breccia make up the middle two-thirds of the mafic sequence. Lithic fragments and broken plagioclase phenocrysts in a foliated, fine-grained, dark-green groundmass characterize the tuff; fragments and phenocrysts constitute 0.5-15% of the rock (fig. 4 in Reed, this guidebook). Thin sections reveal a groundmass of green to blue-green hornblende needles mixed with calcite and minor epidote and biotite. Plagioclase phenocrysts are altered to albite and calcite. The tuff contains rare subhedral to euhedral hornblende phenocrysts partially altered to chlorite. Groundmass hornblende is largely unaltered. Basaltic-tuff breccia is best exposed at the 11,800-ft-contour level along Gold Hill Ridge. At this locality a fine-grained, probably ash-rich basaltic groundmass contains up to 40% lapilli- and block-sized clasts of amygdaloidal basalt. The breccia is monolithologic overall, but contains accidental fragments of fine-grained felsite and coarse-grained granitic rock. Basaltic clasts are flattened in the plane of layering and clast shapes, and edge textures indicate that many were viscous

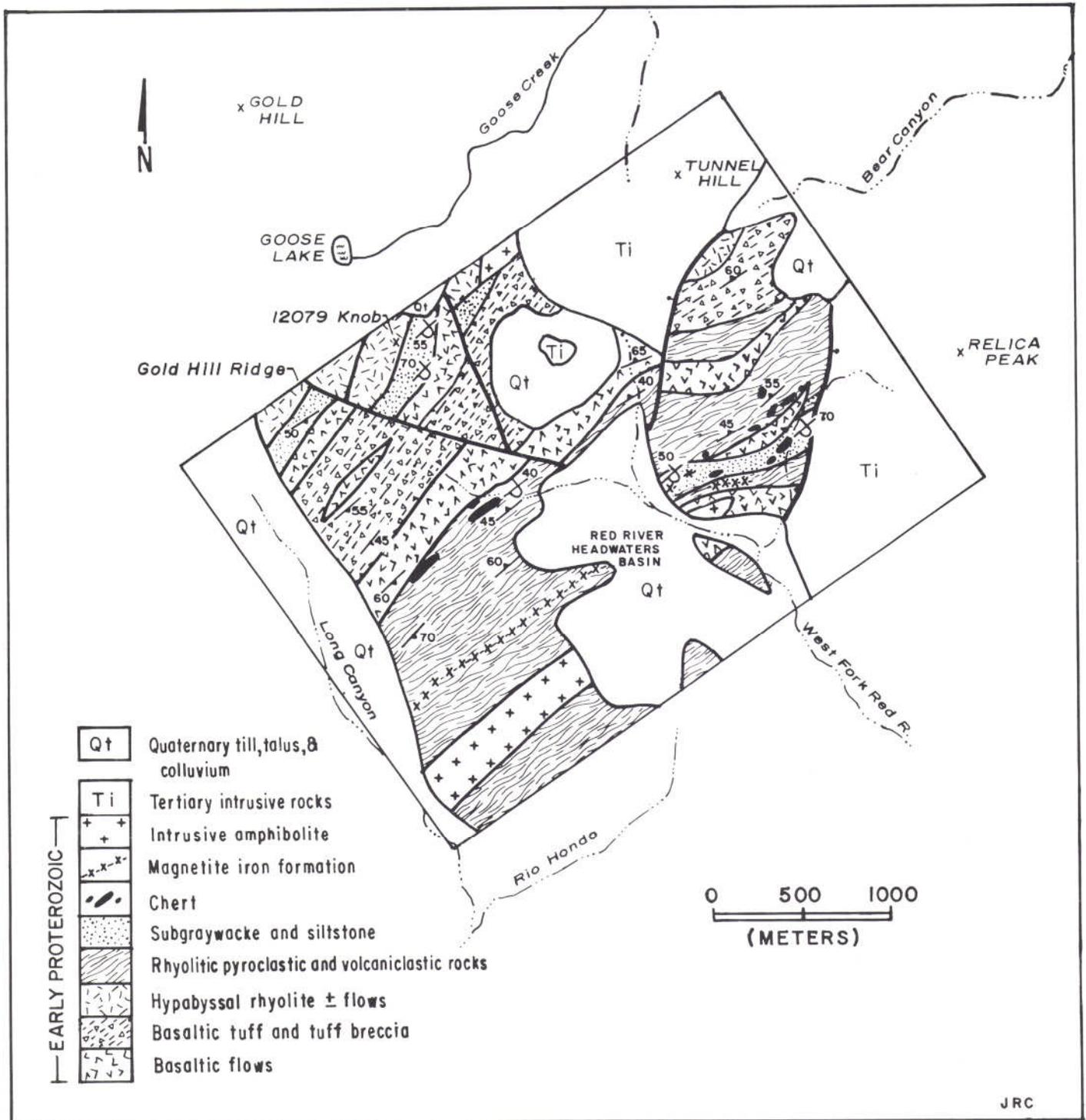


FIGURE 2. Simplified geologic map of a portion of the Gold Hill to Bull-of-the-Woods section.

when incorporated into the groundmass. The tuff breccia is more than 100 m thick. Outcrops display large-scale grading from clast-rich to clast-poor layers. These textures and features suggest that this rock originated as an agglomerate.

Rhyolitic Tuff

Fine-grained felsic tuff and volcanoclastic sedimentary rocks crop out south of the basaltic sequence. The felsic section is more than 1,000 m thick and contains crystal-lapilli tuff, lithic-lapilli tuff, very fine-grained, ash-rich tuff, and reworked tuff. Poorly to well foliated quartz-sericite phyllite and schist are the dominant lithologies in the section. Individual layers contain up to 10% potassium feldspar and/or quartz phenocrysts, 15% lithic lapilli, and 25% lapilli-sized fragments of unknown protolith. These latter fragments are mineralogically identical to the groundmass and may be pumice. Some individual tuff layers are graded over a few tens of meters from lithic-rich bottoms to ash-rich tops. Where observed, the contacts between fine-grained tops and lithic- or lapilli-bearing bottoms of overlying tuff units are sharp. Mafic and felsic dikes and sills intrude the tuff section.

Massive Rhyodacite

Massive rhyodacite crops out along Gold Hill Ridge west of Goose Lake, around the head of Long Canyon, and locally within the rhyolitic tuff section. This rock is gray to pink, mostly massive, and weakly foliated to nonfoliated. The rock contains 1-20% potassium feldspar and plagioclase phenocrysts in an aphanitic sericite—quartz groundmass. Phenocrysts are euhedral to subhedral and 1-4 mm in size. Subrounded quartz phenocrysts comprise up to 20% of the phenocryst population, but are rare to absent in many of these rocks. This rock type probably originated as hypabyssal sills and dikes, as evidenced by its massive character and mostly unbroken phenocrysts. Some of this rock possibly formed as flows.

Sedimentary Rocks

A 100-m-thick subgraywacke section occurs in the headwaters basin of the West Fork of the Red River. These sedimentary rocks are metamorphosed to biotite—quartz schist, chlorite—quartz schist, minor chlorite schist, and minor sandstone. Muscovite is present in most rock types. Garnet and calcite occur in some, and the rocks contain a trace to 10% magnetite and pyrite. Mappable rock units are 1-4 m thick; layering within these units is a few centimeters thick.

One hundred meters of laminated to thin-bedded siltstone and very fine-grained quartz sandstone and graywacke underlie the basaltic section along and east of Gold Hill Ridge. The rocks contain three distinct grain-size fractions, most in separate laminae. Grading is evident in a few layers; small-scale trough crossbedding is present at a single locality along Gold Hill Ridge. Centimeters-thick layers of magnetite, magnetite and quartz, epidote, and epidote and calcite are interbedded with the elastic rocks.

Chert and Iron Formation

Chert and iron formation occurs at a number of localities in the Gold Hill area (Fig. 2). Rhyolitic tuff and subgraywacke host chert along Gold Hill Ridge and in the headwaters basin of the Red River. The chert is massive and cryptocrystalline, and forms pods and lenses 3-10 m thick and up to 100 m long. The chert contains a trace to 8% disseminated and fracture-bound pyrite and most chert outcrops are iron-stained. A large chert body crops out at the 11,600-ft level on, and east of, Gold Hill Ridge. This chert occurs as discontinuous lenses for over 600 m of strike length; individual lenses are as much as 70 m thick. The chert is white to light gray and has a fragmental texture, with angular to subrounded fragments ranging in size from pebbles to cobbles. The fragmental texture occurs along the south side of the lenses, the presumed stratigraphic top of the unit; the northern, basal parts of the lenses are massive. I interpret this fragmental rock as a syngenetic breccia. Fine-grained, disseminated tourmaline is an accessory mineral in the chert. Waxy, pale-green sericite, identified by x-ray occurs in clots and veins.

Oxide-facies iron formation, composed of massive magnetite or magnetite and quartz, occurs in both the rhyolitic tuff and sedimentary sections. Most iron-formation layers are 1-8 m thick and continuous for a few tens of meters along strike. Bedding in the iron formation varies from thin and continuous, with sharp bedding contacts, to massive and structureless. The largest iron formation extends in outcrop and float for 1,500 m, from the bottom of Long Canyon across Gold Hill Ridge and to the steep slope above the Red River. This unit is more than 30 m thick and produces a strong high on the regional aeromagnetic map (USGS Open-file Report 82-952).

Sulfide-facies iron formation, stratabound stringers of fine-grained pyrite in a cryptocrystalline siliceous groundmass, is present at two localities within rhyolitic tuff. Pyrite constitutes up to 25% of the rock in selected hand samples. Overall, the 3-5 m thick sulfide-bearing layers contain 5-15% pyrite. Chlorite, garnet, magnetite, and tourmaline are accessory minerals. Locally, this rock contains small lithic fragments with the same mineralogical makeup as the groundmass.

Structure and Pseudostratigraphy

Primary Structures

Primary sedimentary structures are preserved in a few places in the area and all indicate that stratigraphic tops are to the south. Observed features include small-scale crossbedding in sandy layers north of the basalt on Gold Hill Ridge, graded bedding in sedimentary rocks south of Goose Lake and in the headwaters basin of the Red River, outcrop-scale grading in lithic-lapilli rhyolite tuff in the eastern part of the area, and the position of a stockwork feeder zone on the north side of chert lenses west of Relica Peak (discussed below). These data agree with facing directions reported by Reed (this guidebook) from other localities in the range, but disagree with data reported by McCrink (1982). Overall, the data indicate stratigraphically younger rocks to the south, with felsic tuff overlying the mafic sequence. However, transposition of asymmetric folds can produce the same apparent results (see Callender, 1983, p. 143).

Pseudostratigraphy

In terranes where transposition is recognized, the regional map distribution of rock units defines a pseudostratigraphy (Callender, 1983). Transposition is clearly evident on a small scale in the Gold Hill area (this report) and to the south near Wheeler Peak (Callender, 1983, fig. 3). Map-scale folds were not identified in this or previous studies in the area (McCrink, 1982), though intense polyphase deformation is characteristic of the range (Norman and Nielsen, 1982).

In recognition of the structural complexities, map-scale lithologic layering may no longer reflect the primary stratigraphic succession. On the other hand, a major lithologic unit, such as the thick basalt sequence, probably behaved coherently during strain. While transposition has altered the details of bedding and stratigraphic relationships within some rock types, the pseudostratigraphic order of the major rock units may not differ significantly from the original, truly stratigraphic sequence.

Folding and Transposition

The Proterozoic rocks in the Taos Range are intensely and multiply deformed, a characteristic common to Proterozoic rocks throughout northern New Mexico (Callender, 1983). Layering in the rocks south of Gold Hill is defined by bedding and parallel to subparallel foliation. Layering strikes northeast and dips are moderate to steep. Layering east of Gold Hill Ridge is overturned to the north, based on the primary structures cited above (Fig. 2). The map patterns of major rock units parallel the northeast trend of outcrop-scale layering.

Evidence of isoclinal folding and bedding transposition is well preserved in sedimentary sequences in the headwaters of the Red River and near the 12,079-ft knob south of Goose Lake. Rocks at these localities display isoclinal-fold noses from a few centimeters to 0.5 m across. The noses are often isolated from one or both fold limbs. Near the 12,079-ft knob, centimeters-thick epidote + calcite layers are spec-

tacularly boudinaged. Mafic and felsic volcanic rocks do not show the small-scale effects of the intense deformation as clearly as the sedimentary rocks do, although fold noses, cleavage, and attenuated bedding are locally evident.

Alteration

Mapping identified several modes of moderate to intense sericitic and silicic alteration associated with chert lenses and iron formation. Stockworks, stringers, and veins of quartz, accompanied by pervasive silicification, underlie chert lenses in the eastern part of the area. Silicification is present for 150 m on the north or down-section side of the lenses and textures, and field relationships argue convincingly that the zone of silicification is a feeder structure for exhalative chert.

Sericitic alteration is more widespread. White mica replacing chlorite in felsic tuff and mafic rocks, muscovite and sericite along fractures, massive muscovite schist in shear zones, and waxy-green sericite in chert lenses are manifestations of this alteration type. An envelope of sericitic alteration surrounds the silicified zone described above. Restricted zones of intense sericitic alteration occur stratigraphically beneath chert and iron formation east of Gold Hill Ridge. Sericite schist at these latter localities contains up to 30% disseminated tourmaline.

Widespread chloritic alteration is not evident in the area. Where developed, it is spotty and weak. Mafic rocks locally exhibit carbonate alteration.

DISCUSSION

Geologic Synthesis

The supracrustal succession from Gold Hill to Bull-of-the-Woods is a sequence of submarine, felsic, dominantly pyroclastic rocks with interlayered basaltic flows and tuff and minor epiclastic sedimentary rocks. Because the range exposes only remnants of the supracrustal succession, the mafic/felsic ratio of the regional terrane cannot be ascertained. The apparent base of the sequence south of Gold Hill is massive rhyodacite, which originated in part as hypabyssal intrusions

and possibly in part as flows. Siltstone and fine-grained graywacke with interbedded magnetite iron formation overlie the rhyodacite and reflect a period of volcanic quiescence. This period of sedimentation was followed by explosive submarine mafic volcanism manifested by basaltic flows, tuff, and tuff breccia or agglomerate. Clast size in the agglomerate implies relative proximity to a vent.

A thick section of rhyolitic tuff and reworked tuff caps the basaltic rocks. Much of this pyroclastic sequence was probably deposited as debris and slump flows off the flanks of underwater volcanic edifices. Data from well-studied submarine volcanic complexes indicate that this is a common, if not universal, feature in the subaqueous volcanic environment (Fiske, 1963; Fiske and Matsuda, 1964). Outcrop-scale grading of lithic fragments and ash, and interbedded iron formation and sedimentary rocks are further evidence of a subaqueous environment. Along the eastern edge of the area, sedimentary rocks followed by additional rhyolite and basalt cap the felsic-tuff section.

Regional Potential for Deposits of Volcanogenic Metals

The submarine mafic and felsic volcanic rocks in the southern Taos Range constitute a permissive geologic environment for deposits of volcanogenic metals. Several lines of evidence indicate that the seafloor hydrothermal-processes requisite for the formation of volcanogenic deposits operated in the Precambrian section between Gold Hill and Bull-of-the-Woods. These include the pyrite-bearing chert lenses and adjacent feeder zone in the eastern part of the area, chert and syngenetic chert breccia on Gold Hill Ridge, exhalative-type iron formation at multiple locations in the section, two occurrences of exhalative stratabound pyrite, and associated stratabound tourmaline—a common mineral constituent of volcanogenic systems (Slack, 1982). The hydrothermal systems which gave rise to these specific features were iron-rich but sulfur and base-metal poor (oxide-facies iron formation), or were relatively cool and lacking in all metals (chert). The

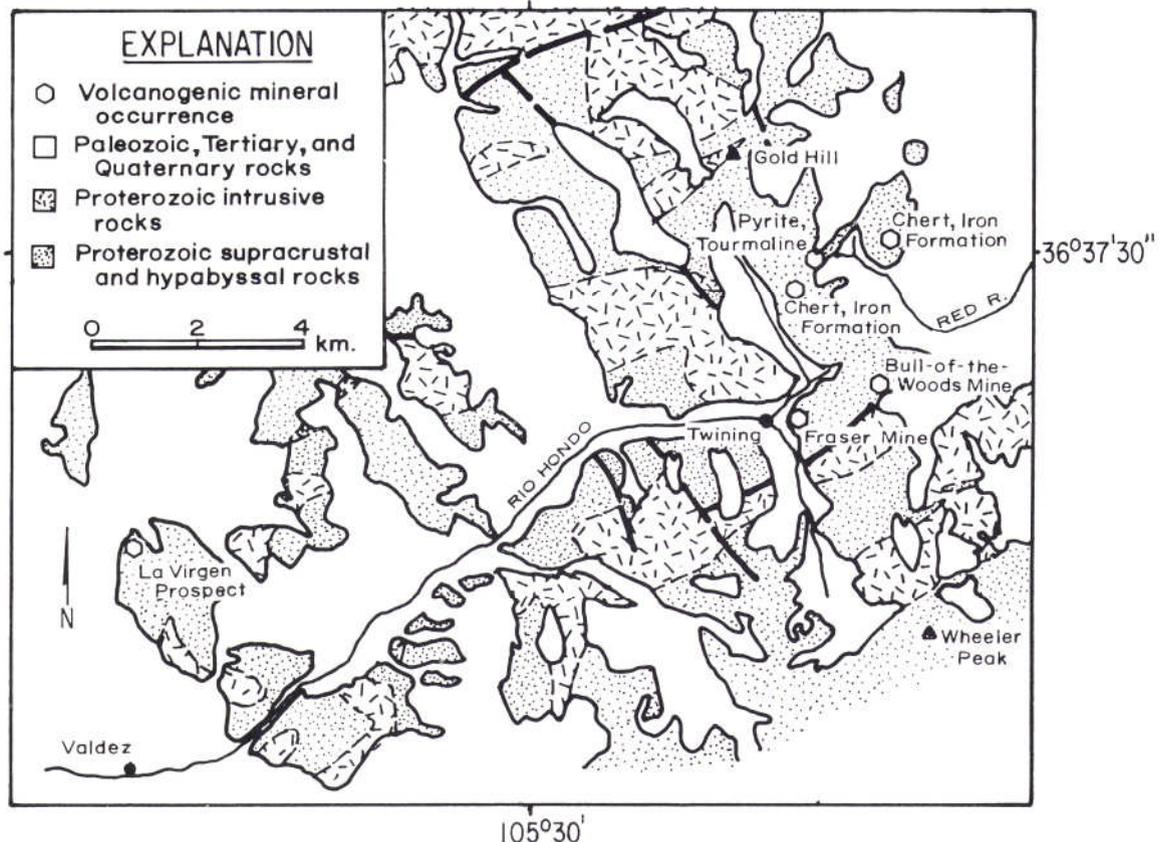


FIGURE 3. Volcanogenic mineral occurrences in the southern Taos Range, New Mexico. Geology generalized from Reed and others (1983).

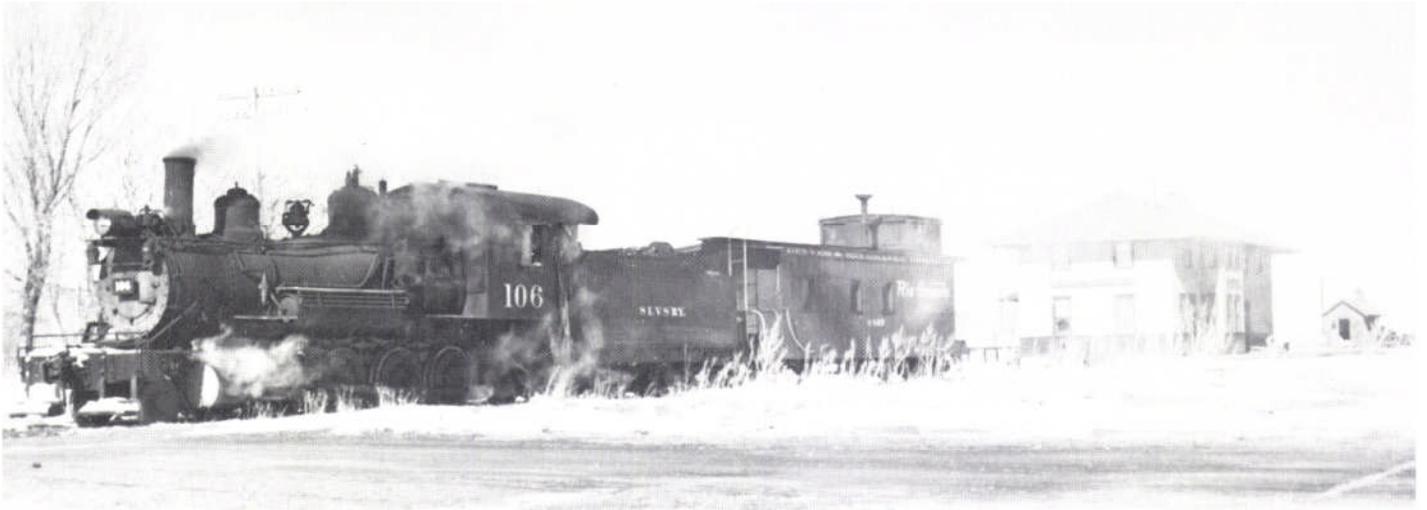
chert, iron formations, local sedimentary component of the section, and lack of extensive felsic flows and flow/dome complexes reflect a distal volcanogenic setting for the Gold Hill area (Hutchinson and others, 1971).

At least two other volcanogenic-type mineral occurrences are known in the southern Taos Range (Fig. 3). Magnetite iron formation and pyritic chert crop out in the vicinity of the Fraser mine east of Twining (Noranda reconnaissance, 1982). These are associated with sheared rhyolitic rocks and chlorite, sericite, and talc schists which are part of a larger sheared and mineralized zone extending from Twining to Bullof-the-Woods Mountain (Fulp and Woodward, 1981). Mines and prospects in this zone pursue copper sulfides and secondary copper minerals. The iron formation and chert are exhalative in origin; a volcanogenic origin for the copper is equivocal (Ludington and others, 1983, p. 8). North of the mouth of Hondo Canyon, the La Virgen Prospect exposes a small body of massive sphalerite with subordinate pyrite, chalcopyrite, and galena (J. Loghry, oral comm. 1983). Biotite schist and chloritesericite schist host the sulfides. Boulders of pegmatitic amphibolite are present in dump material. The Precambrian host rocks are invaded and largely destroyed by the Tertiary Rio Hondo quartz monzonite, but the morphology of the sulfide body and the mineralogy of the immediate host rocks imply a volcanogenic origin for the occurrence.

These volcanogenic-type mineral shows attest to good geologic potential for massive sulfide deposits in the Precambrian terrane of the Taos Range. The Taos Range supracrustal rocks are in many respects similar to other Precambrian terranes in southern Colorado and northern New Mexico which host volcanogenic deposits and prospects (Fulp and Woodward, 1981; Riesmeyer and Robertson, 1979; Sheridan and Raymond, 1977). Known occurrences in these areas contain both base and precious metals. However, the lack of kilometer-scale continuity of exposure of potential host rocks and the area's present and projected land status decrease the exploration appeal of the Taos area Precambrian terrane.

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The San Luis Valley Southern No. 106 heads south at San Acacio in 1955, probably to pick up a load of scoria at Mesita. This locomotive was retired soon afterward, and now reposes in the Colorado Railroad Museum (photo by Bob Richardson).