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MISCELLANEOUS FIELD STUDIES
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PAMPHLET

MINERAL RESOURCE POTENTIAL OF THE COLUMBINE-HONDO WILDERNESS STUDY AREA, TAOS COUNTY, NEW MEXICO

By

Steve Ludington, U. S. Geological Survey,
John P. Briggs, U. S. Bureau of Mines,
and
James M. Robertson, New Mexico Bureau of Mines and Mineral Resources

STUDIES RELATED TO WILDERNESS

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and the Joint Conference Report on Senate Bill 4, 88th Congress, the U. S. Geological Survey and the U. S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System, and some of them are currently being studied. The act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. The act directs that the results of such surveys are to be made available to the public and be submitted to the President and the Congress. This report discusses the results of a mineral survey of the Columbine-Hondo Wilderness Study Area in the Carson National Forest, Taos County, N. Mex. The Columbine-Hondo Wilderness Study Area was established by Public Law 96-550, December 19, 1980; it was earlier classified as a further planning area (B3032) during the Second Roadless Area Review and Evaluation (RARE II), by the U. S. Forest Service, January 1979.

MINERAL RESOURCE POTENTIAL SUMMARY STATEMENT

Two areas, one adjacent to, and one within the Columbine-Hondo Wilderness Study Area, have high potential for the occurrence of stockwork molybdenum deposits. These areas are bordered by regions of moderate potential for stockwork molybdenum deposits that include parts of the study area.

Two regions within the study area have moderate potential for massive sulfide deposits.

Two small areas, one within, and one partially within the study area, have moderate potential for small, low-grade gold- and silver-bearing epithermal vein deposits.

LOCATION AND ACCESS

The Columbine-Hondo Wilderness Study Area (fig. 1), in north-central New Mexico, covers about 46,000 acres (186 km^2) of the Carson National Forest in Taos County.

The area extends from the mountain front on the east side of the Rio Grande Valley to the crest of the Sangre de Cristo Mountains, though the highest peaks are in the central part of the study area, west of the range crest. The area is drained on the south by the Rio Hondo and its tributaries and on the north and east by the Red River and its tributaries. Elevation ranges from 12,711 ft (3,874 m) on Gold Hill to about 7,800 ft (2,380 m) at the point where the Rio Hondo emerges from the mountains. Access is via New Mexico Highway 38 up the Red River on the north and New Mexico Highway 150 up the Rio Hondo on the south, both paved. A U. S. Forest Service road skirts the eastern margin of the area, and several U. S. Forest Service roads provide access to the western margin from New Mexico Highway 3.

GEOLOGIC SETTING

The study area lies in the Sangre de Cristo Mountains, an uplifted block, which is bounded on the west by a series of structural depressions that make up the Rio Grande rift. On the east, the area is separated from the high plains by several lower uplands and mountain blocks. Present relief and topography is due largely to Neogene and post-Neogene uplift.

In the study area, the range is composed primarily of Precambrian rocks, partly mantled by mid-Tertiary volcanic rocks. Both the Precambrian rocks and the Tertiary volcanic rocks are intruded by rocks of Tertiary age that exhibit a wide range of compositions.

The Precambrian rocks are of volcanic, sedimentary, and intrusive origin, and of medium to high metamorphic grade. They are believed to be of Proterozoic X age (1.7 to 1.8 billion years), though no radiometric ages are available.

Along an approximately 5-mi (8-km) wide, northeast-trending zone, centered approximately on the Rio Hondo, some of the metamorphic rocks exhibit

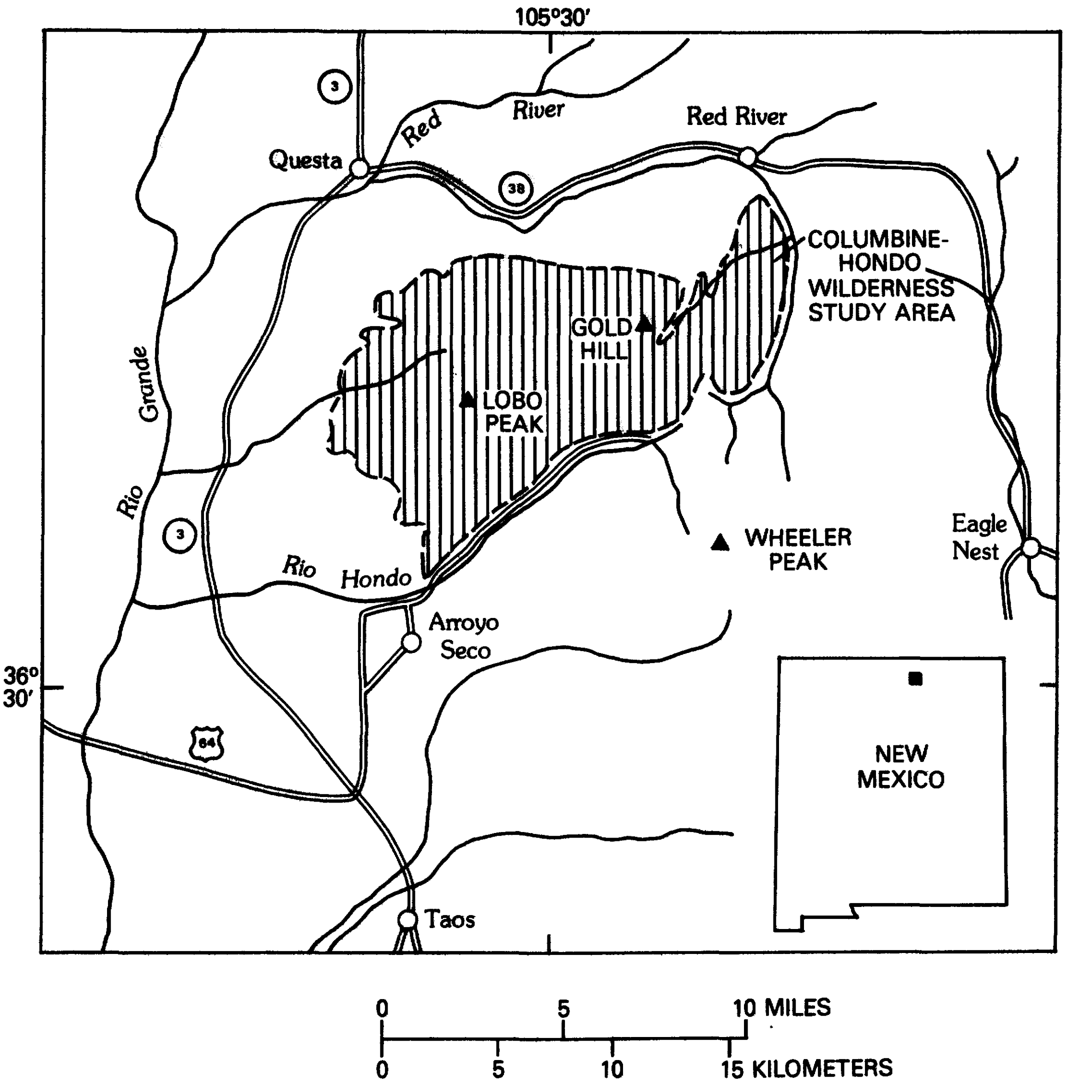


Figure 1. -- Index map showing location of the Columbine-Hondo Wilderness Study Area.

retrograde greenschist facies assemblages and cataclastic textures. These features may be related to the Jemez zone of crustal weakness of Precambrian ancestry, which has been an important control of late Cenozoic plutonism and tectonism (Lipman and Mehnert, 1979).

The Tertiary igneous rocks include parts of the Latir volcanic field and intrusive rocks associated with the Latir field (Lipman, 1981). Rocks of the Latir field include basalt to quartz latite lava flows, overlain by a welded ash-flow sheet of rhyolite erupted during the collapse of the Questa caldera. A few rhyolite flows overlie the ash-flow tuff.

Within the study area, only a few volcanic rocks are preserved. Perhaps one third of the study area is underlain by Tertiary intrusive rocks related to the Latir field; they range in composition from basalt to rhyolite and form plutons, dikes, and sills. The major features are the Columbine-Hondo pluton, composite in detail, but predominantly quartz monzonite, and a large, predominantly rhyolitic dike swarm.

MINES, MINING DISTRICTS, AND MINERALIZED AREAS

Introduction

The Columbine-Hondo Wilderness Study Area and vicinity have been the site of considerable mining activity. Placer mining in the region dates from 1866 and lode mining from 1867. Only in the 1890's, when prospecting and mining efforts focused on gold and silver lode deposits, did the mining camps at Red River, Twining, and Amizette flourish. By 1905, the boom had died, although short-lived periods of renewed activity occurred about 1910, 1920, and 1930 (Schilling, 1960).

Most of the mining activity took place in the northeast part and around the northeast perimeter of the study area. Production was recorded principally from placer deposits along Red River and Rio Hondo and from the Caribel, Jayhawk, and Silver King mines (Schilling, 1960; U. S. Bureau of Mines, unpub. production records). Despite the extensive development, value of production probably did not exceed $20,000 between 1900 and 1930.

Current significant mining activities include a large molybdenum mine (Questa; fig. 4) north of the study area, which has been in continuous production since 1922. In addition, several mining companies have conducted exploration programs over the last few years, both for molybdenum and for base- and precious-metals, principally in the southwest part of the study area.

The Columbine-Hondo Wilderness Study Area encompasses the northern half of the Rio Hondo mining district and the southern half of the Red River mining district (fig. 2).

The earliest claims in the area probably predate the 1872 mining law. Of 1,080 unpatented mining claims (1,030 lode and 50 placer) in or near the area, 360 have been filed with the U. S. Bureau of Land Management in compliance with Federal recording requirements. These 360 claims are located in two tracts in the NW 1/4 of T. 28 N., R. 13 E., and in sections 7, 8, 16, 17, and 18 of T. 27 N., R. 13 E (Briggs, 1982). Most of the 37 patented claims in the area were patented between 1897 and 1922.

For the purpose of discussion of existing mineral deposits and prospects, the area has been subdivided into 10 mineralized locales (fig. 2). Further details, and the analytical data from the U. S. Bureau of Mines are found in Briggs (1982).

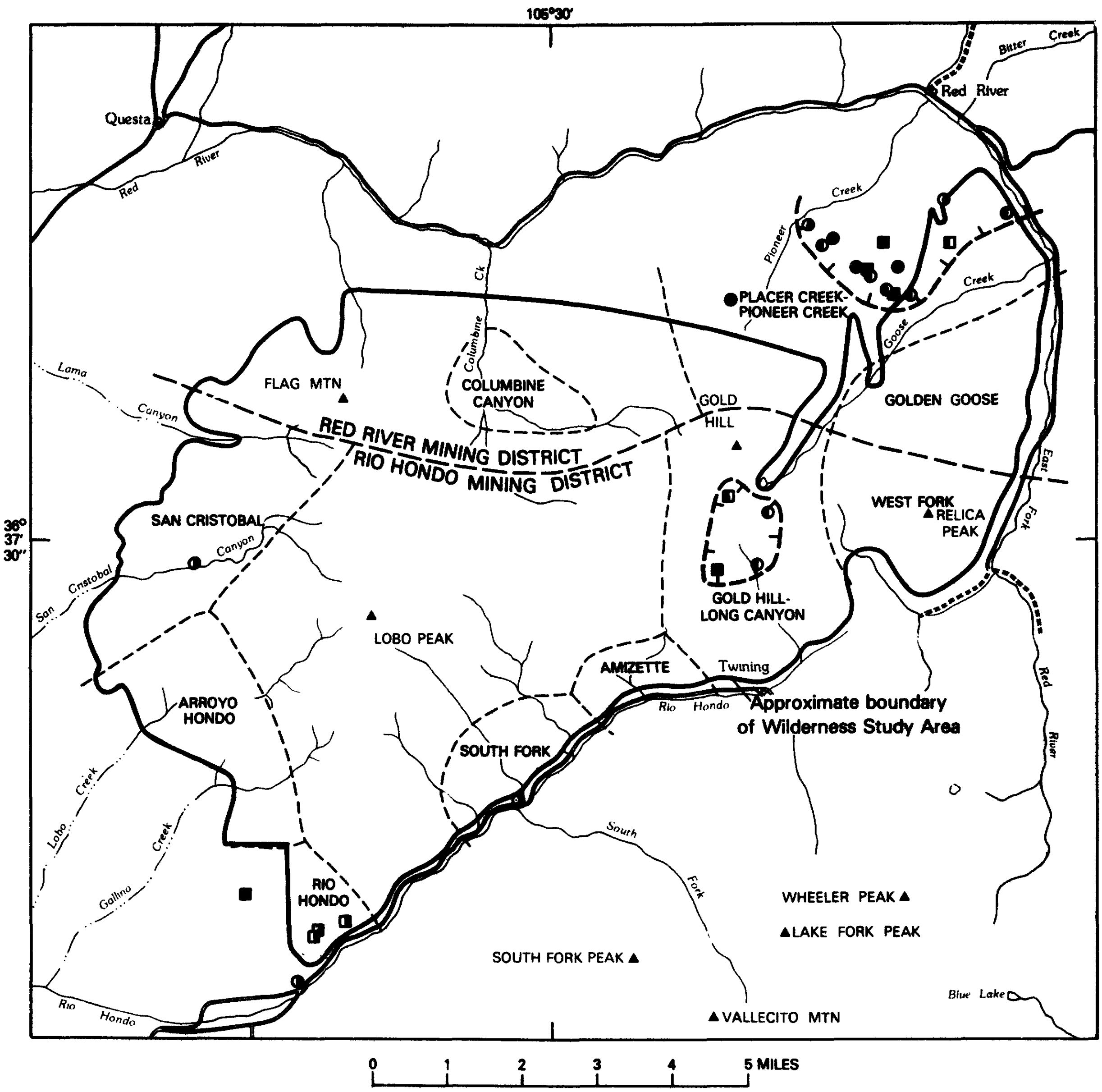
Rio Hondo Mining District

The Rio Hondo district contains seven mineralized locales (fig. 2); they are, clockwise from the northeast:

1. West Fork—Workings in the West Fork locale explore quartz-pyrite veins in Precambrian quartzites and amphibole and mica schists. Gold and silver were detected in two dump samples collected in this area.
2. Gold Hill-Long Canyon—Three types of mineralized structures are present in the Gold Hill-Long Canyon locale. Most workings explore precious-metal bearing quartz veins and pods in Precambrian rocks. A caved adit on Gold Hill appears to be driven on a northeast-trending shear zone which contains base-metal sulfides with gold and silver. Lenses of magnetite in quartz-biotite schist and diabase were explored in a 300 ft (91 m) adit. Assay results from chip samples taken in this area show that small amounts of gold and silver are present in some workings.
3. Amizette—The Amizette workings explored quartz veins along contacts between Tertiary quartz monzonite and Precambrian amphibolite. Assay results show trace amounts of gold, as much as 0.4 oz/ton (14 g/t) silver, and up to 0.39 percent copper in samples taken from this area.
4. South Fork—Workings in the South Fork locale explore narrow silver-, copper-, and gold-bearing shear zones trending N. 60° W. that mark the contact between Tertiary quartz monzonite and Precambrian amphibolite. Assay results from several chip samples show small amounts of gold and silver.
5. Rio Hondo—An east-trending shear zone extends into the southern tip of the study area. Small amounts of gold, silver, and copper are contained in chip and channel samples from this area.
6. Arroyo Hondo—The Arroyo Hondo locale encompasses the Gallina Creek and Lobo Creek drainages. Silver, copper, and trace amounts of gold are present in the mineralized area.
7. San Cristobal—The principal working in the San Cristobal locale is the Iowa lode (Briggs, 1982). An inclined shaft follows a 1 to 6 ft (0.3 to 2 m) thick shear zone in quartzite. Sample assays indicate the presence of silver, copper, and minor gold.

Red River Mining District

Production from the Red River mining district between 1897 and 1922 amounted to 2,539 tons (2,303 t) of ore containing 262 oz (8,150 g) of gold (U. S. Bureau of Mines, unpub. production records). Average grade was 0.1 oz/ton (3.43 g/t) of gold and 2.15 oz/ton (73.7 g/t) of silver. Schilling (1960) reports additional production from the area, but the data are not specific. Principal producing mines were the Jayhawk (1895-1930), Caribel (1910-1922), and the Silver King or Buffalo (about 1905-1935) (U. S. Bureau of Mines, unpub. production records; Clark and Read, 1972; Briggs, 1982).



EXPLANATION

SAMPLE LOCALITIES--Right half of symbol filled indicates Ag >1 oz/ton (34.3 g/metric ton); left half of symbol filled indicates Au >0.1 oz/ton (3.4 g/metric ton)

● Grab or dump sample

■ Chip or channel sample

——— BOUNDARY OF WILDERNESS STUDY AREA

— — BOUNDARY OF MINING DISTRICT

---- BOUNDARY OF MINERALIZED LOCALE

⊥— BOUNDARY OF AREA HAVING MODERATE POTENTIAL FOR PRECIOUS-METAL VEIN DEPOSITS

Figure 2.--Map showing areas having potential for precious-metal vein deposits.

The Red River mining district contains three mineralized locales (fig. 2), clockwise from the west:

1. Columbine Canyon—In Columbine Canyon there is a 485 ft (148 m) adit driven in Precambrian quartz monzonite along the east bank of Columbine Creek. The quartz monzonite is cut by felsic to latitic dikes and by numerous fault zones that contain abundant pyrite. Minor amounts of silver were detected in several samples from the adit.
2. Placer Creek-Pioneer Creek—The Placer Creek and Pioneer Creek drainages have more mining development than any of the other mineralized locales, but only the Jayhawk and Great Western adits were accessible. Workings are along fissure veins or brecciated zones in argillized andesite porphyry and latite porphyry. Samples from this locale contain as much as 2 oz/ton (68.6 g/t) silver and as much as 0.4 oz/ton (13.7 g/t) gold. Most of the high assay values are from samples taken outside the study area.
3. Golden Goose—Prospect pits in the Golden Goose locale explore pyrite- and limonite-bearing quartz veins in argillized Tertiary volcanic rocks. Adits follow east-trending fracture systems in Precambrian metamorphic rocks. Samples assayed as high as 0.02 oz/ton (0.7 g/t) gold and 0.9 oz/ton (31 g/t) silver, along with trace amounts of base metals.

Placer mining

Placer mining occurred in both the Red River and Rio Hondo districts, but was less extensive than hardrock mining operations. Stream and terrace gravels were worked for gold that was probably derived from the fissure vein deposits in the area. Gold was detected in 15 of 25 panned concentrate samples collected in and near the study area.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

Introduction

Mineral resource potential is a measure of favorability for presence of a particular type of mineral deposit and is estimated by comparing the known geologic factors in an area with the geologic factors known or assumed to be associated with that type of deposit. Thus, a high potential indicates that the area shares many geologic characteristics with an occurrence model for a particular type of mineral deposit. This model may be explicit or implicit, simple or complex, analytic or intuitive (based on experience and expertise).

In this study, the potential for five types of mineral deposits was evaluated. Most deposit types were implicitly eliminated from consideration because the study area shares few diagnostic criteria with occurrence models. A summary of the evaluation is presented in figure 3.

Stockwork molybdenum deposits

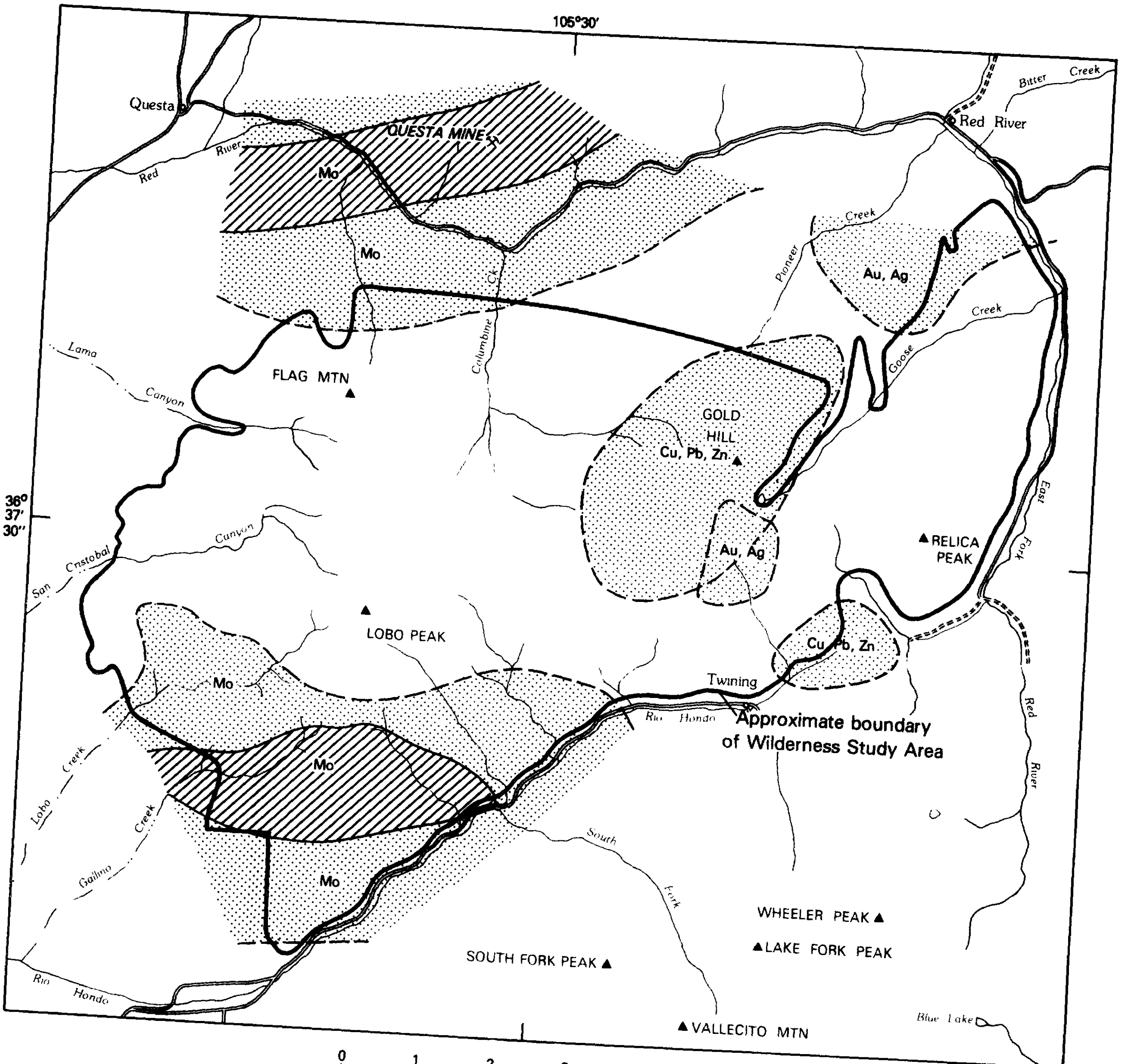
A group of important stockwork molybdenum deposits closely associated with post caldera granite and aplite plutons is found immediately north of the study area. These deposits, (referred to as the Red River deposits in this report), include the Sulfur Gulch deposit (mined 1922 to the present), the Goat Hill deposit (mining scheduled to begin in 1983), and the Log Cabin deposit (not scheduled for mining at present), are in an east-northeast trending belt that is approximately parallel to the Red River and to the southern margin of the Tertiary Questa caldera. Mineralization is widespread from north of the town of Red River west to the mountain front; the deposits shown in figure 4 are those which have been extensively explored by drilling and(or) have been mined. The belt containing the Red River deposits has high mineral resource potential for stockwork molybdenite deposits, though none of the area of high potential is inside the study area.

Recently, a number of occurrence models for stockwork molybdenum deposits have been published (Mutschler and others, 1981; Westra and Keith, 1981; White and others, 1981; Ludington, 1982). The Red River deposits do not correspond exactly to any of these models, yet they are very similar, and were considered in the formulation of all four published models. For the purpose of evaluation of the mineral potential of the Columbine-Hondo Wilderness Study Area, it is unneccessary to consider the published occurrence models in detail; the nearby Red River and South Fork Peak deposits themselves serve as particularly appropriate models. Some features of the study area that conform to the occurrence models are the presence of multiple intrusive episodes of silicic, hypabyssal rocks, indicated by cross-cutting relations between and among dikes and plutons. These intrusive events closely follow the end of subduction-related igneous activity and the beginning of extensional tectonics in the southern Rocky Mountains; this is the tectonic setting of all known granite molybdenite systems in the western United States.

In the southern Sangre de Cristo Mountains, all the deposits, including the mineralization at South Fork Peak (Ludington, 1981), are found in and above the apical portions of evolved, post-caldera granites and rhyolites. The higher grade mineralization is often found in mafic- to intermediate-composition volcanic wall rocks that include Miocene andesite along the Red River and Precambrian amphibolite and biotite-amphibole gneiss in the South Fork Peak area.

Within and adjacent to the study area, two areas have these characteristics. One is an east-northeast trending belt, south of and contiguous to the belt of known mineralization and high potential along the Red River (fig. 4). This area has moderate potential; it contains additional plutons and dikes of granite and rhyolite and is known to contain sporadic low-grade molybdenite mineralization. It is unlikely that major ore bodies are present in this area of moderate potential, but there is probably additional concealed low-grade mineralization. Elongate gravity, audio-magnetotelluric, and magnetic lows also help delineate the areas of high and moderate potential along the Red River (Cordell and others, in press; Moss, in press).

The swarm of northwest-trending rhyolite dikes and small plutons in the southwest part of the study area is probably the surface expression of a granite pluton at depth. Gravity, audio-magnetotelluric, and magnetic features define an east-west trough in this area that is similar to, though less well-developed than the one along the Red River (Cordell and others, in press; Moss, in press). Scattered stream-sediment anomalies (Ludington and others, in press) for Mo, La,

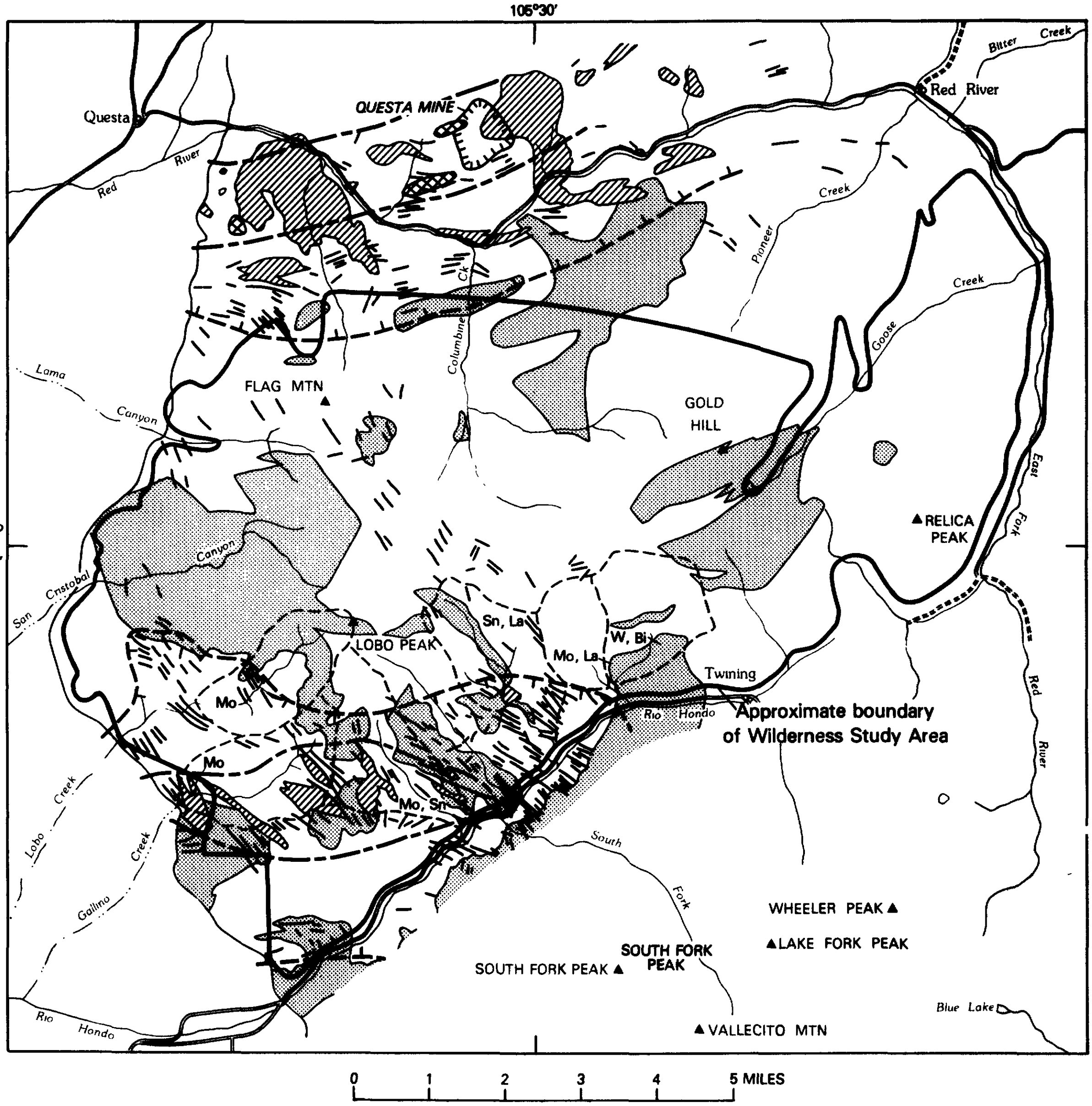


EXPLANATION

AREA HAVING MODERATE POTENTIAL FOR GOLD (Au) AND SILVER (Ag), COPPER-LEAD-ZINC (Cu-Pb-Zn), AND STOCKWORK MOLYBDENUM (Mo) DEPOSITS

AREA HAVING HIGH POTENTIAL FOR STOCKWORK MOLYBDENUM (Mo) DEPOSITS

Figure 3.--Map showing mineral resource potential of the Columbine-Hondo Wilderness Study Area.



EXPLANATION

EXISTING OPEN PIT FROM WHICH MOLYBDENITE HAS BEEN MINED

RED RIVER MOLYBDENITE DEPOSITS

POST-CALDERA GRANITE AND RHYOLITE DIKES

PRECAMBRIAN AMPHIBOLITE

BOUNDARY OF WILDERNESS STUDY AREA

BOUNDARY OF AREA HAVING HIGH POTENTIAL FOR STOCKWORK MOLYBDENUM DEPOSITS AND (OR) HAVING KNOWN MOLYBDENITE MINERALIZATION

BOUNDARY OF AREA HAVING MODERATE POTENTIAL FOR STOCKWORK MOLYBDENUM DEPOSITS

DRAINAGE BASINS ANOMALOUS IN ELEMENTS INDICATIVE OF BURIED STOCKWORK MOLYBDENUM DEPOSITS--Element symbols are indicated

Figure 4.--Map showing areas having potential for stockwork molybdenum deposits.

Sn, W, and Bi (molybdenum, lanthanum, tin, tungsten, and bismuth) suggest the presence of concealed mineralization, and the postulated granitic pluton could be its source. The majority of wall rocks in this area are Precambrian amphibolite. We assign high potential to the intensely intruded area near Gallina Peak because it is most likely to overlie the apex of the postulated pluton, and assign moderate potential to the rest of the swarm of rhyolitic intrusions (fig. 4).

Precious- and base-metal vein deposits

The Red River and nearby mining districts were the site of much mining and prospecting activity in the latter part of the nineteenth century and the early part of the twentieth century. Most of the gold and silver mines and prospects are in a hydrothermal vein system in the Tertiary intrusive and extrusive quartz latite south of the town of Red River, though substantial prospecting of veins also occurred near the settlements of Twining and Amizette along the Rio Hondo, and in several areas on the mountain front in the western part of the study area. This activity had two significant aspects; production of metal was rare, and promotion was profuse. Analyses of mineralized rock, taken mostly from dumps, generally lack significant gold or silver concentrations (Briggs, 1982). Base-metal content of the veins is also low, and geochemical stream-sediment studies (Ludington and others, in press) did not indicate any areas having unexplained precious- or base- metal anomalies.

Thus, despite substantial historic prospecting activity, the area has, in general, low potential for precious- and base-metal vein deposits. Two areas, one near the Jayhawk mine (Briggs, 1982), which did have some production, and one in the Gold Hill-Long Canyon locale, are assigned a moderate potential for small, relatively low-grade precious-metal-bearing deposits (fig. 2). This potential is assigned mostly on the basis of high concentrations of gold and silver in samples taken for this study.

Though several samples from the Rio Hondo locale have high silver concentrations, gold concentrations are low, and the veins appear to be small and discontinuous. These veins, like the veins at Amizette, are related to the margins of the Columbine-Hondo pluton and do not appear to be part of a large hydrothermal system.

The placer gold deposits in the area probably constitute a minor, low-grade resource.

Massive sulfide deposits

Volcanogenic massive sulfide deposits consist of stratiform accumulations of sulfide minerals formed on or near the sea floor by precipitation from hydrothermal brines. The enclosing strata are mainly volcanic, either mafic or felsic. Ores typically contain more than 60 percent sulfide minerals, mostly pyrite and(or) pyrrhotite, along with variable amounts of sphalerite, chalcopyrite, and galena. These deposits can be divided into two distinct groups, a Cu-Zn (copper-zinc) group and a Zn-Pb-Cu (zinc-lead-copper) group (Franklin and others, 1981).

The Precambrian massive sulfide deposits of north-central New Mexico appear to belong to the Zn-Pb-Cu group (Robertson and Moench, 1979; Riesmeyer and Robertson, 1979; Moench and Robertson, 1980). These deposits in the Pecos greenstone belt, 50 mi (80 km) south of the study area, are associated with felsic, mainly fragmental, volcanic rocks that probably represent local felsic eruptive centers. Layered to massive ferruginous chert is commonly associated with mineralization. Adjacent to the massive sulfide bodies, the felsic volcanic rocks are altered to mixtures of quartz-sericite and(or) quartz-chlorite-biotite-tremolite. Silicification is locally significant (Riesmeyer, 1978).

Precambrian metavolcanic and meta-volcaniclastic rocks in the study area are similar in age and lithology to those of the Pecos greenstone belt. Accordingly, the massive sulfide potential has been evaluated in terms of similarities to known occurrences and favorable settings in the southern Sangre de Cristo Mountains.

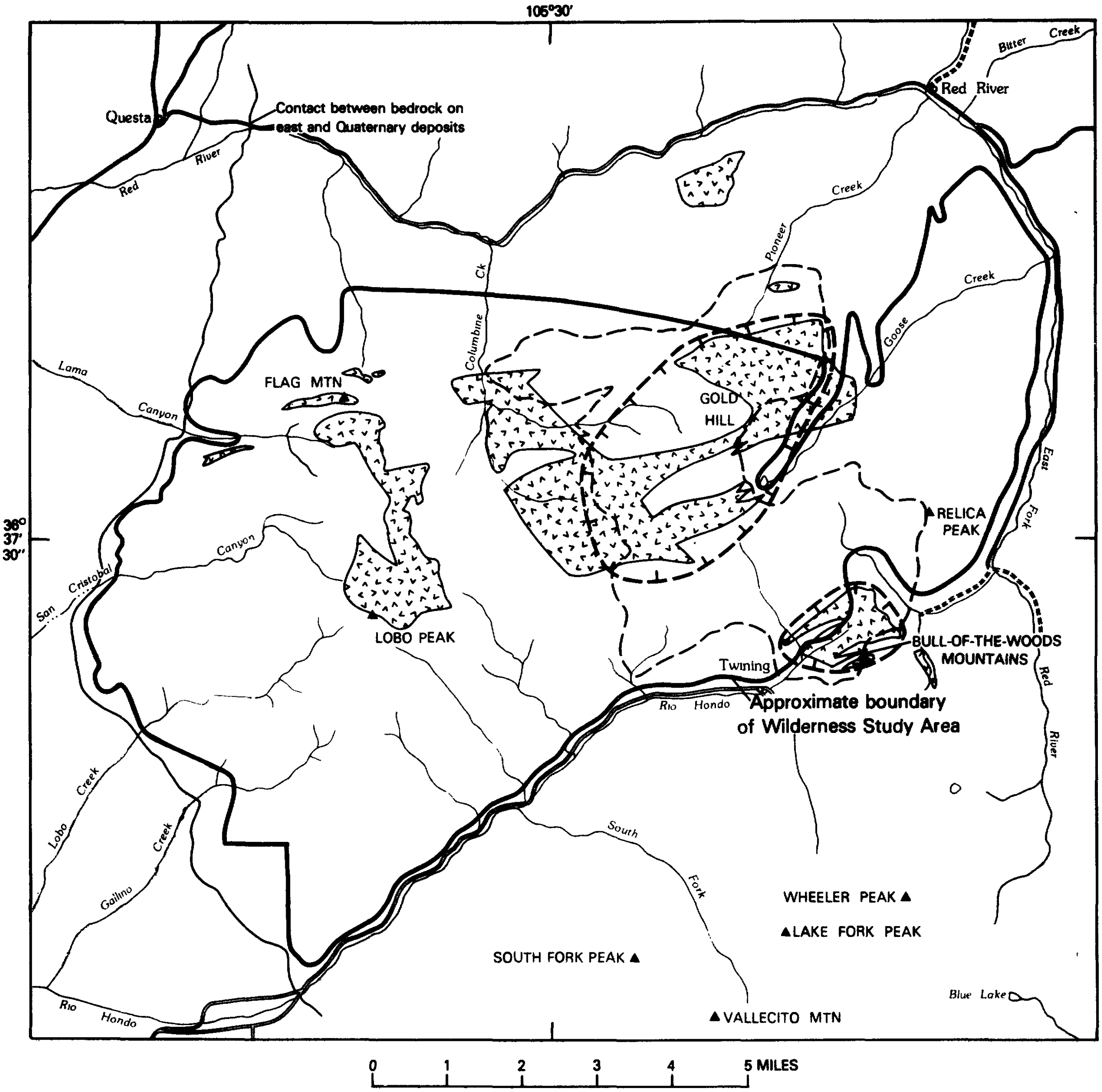
Precambrian, felsic metavolcanic rocks are widespread in the north-central part of the study area. Similar felsic rocks crop out in a relatively small area to the southeast, near Bull-of-the-Woods Mountain (fig. 5), where they are interleaved with quartz-sericite phyllites of possible volcanic derivation.

Fragmental felsic volcanic rocks are exposed in only one limited area on the south side of the Red River canyon. These rocks display a crude stratification, both on the macroscopic and microscopic scale, which suggests that they may have been, at least in part, reworked prior to lithification. They show no sign of significant alteration and contain no visible sulfides.

Silica-rich horizons, with or without iron oxides, are rare in the Precambrian felsic volcanic terranes. The Bull-of-the-Woods Mountain area to the southeast contains several crudely to finely banded ferruginous silica-rich horizons, but they do not contain visible sulfides. A single large, lens-shaped body of chert that crops out across the top of the ridge east of Long Canyon contains neither iron oxides nor sulfides of any kind.

The Bull-of-the-Woods Mountain area contains a number of workings and prospects that follow quartz-chalcopyrite-pyrite pods and stringers enclosed in Precambrian phyllites. A sedimentary and(or) volcaniclastic origin for most of the rocks on Bull-of-the-Woods Mountain is suggested, though the quartz-sericite phyllites that host the copper mineralization exhibit little convincing evidence for a volcanic origin except for some scattered quartz "eyes" which may be either phenocrysts or quartz pebbles. The sedimentary aspect of the rocks, the lack of obvious alteration in the phyllites, and the lack of any zinc or lead associated with the copper all suggest that the mineralization does not conform to the classic model of a Zn-Pb-Cu volcanogenic massive sulfide deposit.

Boron metasomatism is associated with massive sulfide deposits in many parts of the world (Slack, 1982), and a boron anomaly was noted in the geochemical study of this area (Ludington and others, in press). The anomaly is probably the result of weathering of a number of tourmaline-bearing quartz veins in the vicinity of Gold Hill. The drainage basins associated with anomalous concentrations of boron, as well as the distribution of probable felsic metavolcanic rocks are plotted on figure 5.



EXPLANATION

FELSIC METAVOLCANIC AND METAVOLCANICLASTIC ROCKS	APPROXIMATE BOUNDARY OF WILDERNESS STUDY AREA
DRAINAGE BASINS ANOMALOUS IN BORON IN THE HEAVY NONMAGNETIC FRACTION OF STREAM-SEDIMENT SAMPLES	BOUNDARY OF AREA HAVING MODERATE POTENTIAL FOR MASSIVE-SULFIDE DEPOSITS

Figure 5.--Map showing areas having potential for massive-sulfide deposits.

Felsic metavolcanic and metavolcaniclastic rocks occupy much of the central part of the study area and are associated with boron anomalies in the heavy nonmagnetic fraction of stream-sediment samples. The two areas where these two features coincide (fig. 5.) have been assigned a moderate potential for volcanogenic massive sulfide deposits. Features that characterize high-potential areas in the southern Sangre de Cristo Mountains, such as the combination of coarse fragmental textures, Fe-Mg (iron-magnesium) alteration, visible sulfides, and adjacent cherty iron-rich horizons have not been found in the area and no prospects display typical Pb-Zn-Cu mineralization.

Near Gallina Creek, in the southwest part of the study area, disseminated sulfides in mafic Precambrian metamorphic rock are reminiscent of massive sulfide deposits. The sulfide assemblage is rich in sphalerite. However, the area is only a few hundred meters in largest dimension, and is surrounded by Tertiary rhyolite porphyry. There are no obvious felsic metavolcanic rocks nearby, and this area has low potential for massive sulfide deposits.

Porphyry copper deposits

Both the main portion of the Columbine-Hondo quartz-monzonite pluton and the group of quartz-latite intrusions south of the town of Red River are generally of the appropriate composition to be the source of porphyry copper deposits. The wall rocks, especially south of Red River, where they are cogenetic volcanics, are also permissible for such deposits. Schilling (1960) describes copper mineralization near the town of Red River, near the north margin of the quartz latite, and we have observed some small chalcopyrite-bearing veins near the margins of the Columbine-Hondo pluton. The small size and limited extent of the veins, the Tertiary age of these rocks, and especially the lack of widespread phyllic alteration associated with the intermediate-composition rocks, all suggest that the potential for porphyry copper deposits is low.

Fluorspar

Fluorite is commonly present in molybdenite-bearing veins in the Red River deposits and elsewhere. They probably constitute a low-grade fluorspar resource.

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