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GEOLOGY AND ORE DEPOSITS OF RED RIVER AND TWINING DISTRICTS TAOS COUNTY, NEW MEXICO

A PRELIMINARY REPORT

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CHARLES F. PARK, JR. [1/] and

PHILIP F. McKINLAY [2/]

ABSTRACT

The Red River and Twining districts include the area bounded by meridians 105° 22' and 105° 30' W., and parallels 36° 35' and 36° 50' N., in the Sangre de Cristo Mountains, Taos County, New Mexico. (See Figs. 1 and 2.) Altitude ranges from 8,500 to 12,600 feet.

The rocks in the area range in age from pre-Cambrian to Tertiary. The oldest rocks are hornblende gneiss, quartz mica schist, quartzite, and amphibolite, all of pre-Cambrian age. The strike of the foliation in these metamorphic rocks is widely divergent, but averages N. 70° E., with the dips usually steeper than 60 degrees. A pinkish granite intrudes these metamorphic rocks.

In the vicinity of Gold Hill intensely folded talc schists, chlorite schists, quartz mica schists, and metamorphic gabbros crop out. Limestone

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2/ Geologist, New Mexico Bureau of Mines and Mineral Resources.

lenses which occasionally show bedding and fossil traces are associated with the schists. In this report these rocks are classified with the pre-Cambrian metamorphic rocks, but it is possible that they may be younger in age.

Interbedded limestones, shales, and grits in the southeastern part of the area contain fossils of Pennsylvanian age. These strata are the equivalents of parts of the Magdalena group of other areas in New Mexico. Thin-bedded limestones, shales, and grits that occur locally contain no fossils and their age is unknown.

Flows and intrusives thought to be of Tertiary age extend over most if the northern part of the area. Altered flows and tuffs, near the base of the Tertiary sequence, are intruded by discordant granodiorite bodies and by monzonite dikes and sills which occur in great abundance throughout the area. These intrusive rocks are thought to belong to one general period of intrusive activity. Rhyolite plugs and dikes intrude the granodiorite and crop out in all but the southernmost part of the area. A coarse-grained volcanic breccia, which contains fragments of andesite and pumice, overlies the granodiorite and monzonite, and grades upward into flows of dense glassy andesite which cap many of the ridges and mountain tops.

The region has been extensively folded and faulted, and has been intricately cut by dikes and other intrusive bodies.

Intensely altered rocks extend from the ridge west of Pioneer Creek, across the Red River, and along Bitter and Mallette Creeks into the Anchor and Midnight mining areas. In this altered some the metamorphic rocks, flows, and intrusive rocks are extensively sericitized, silicified, and

chloritized. The alteration is believed to have been caused by hot fluids which deposited silica and iron sulfides. Geologic contacts within the altered materials are usually difficult to recognize.

The remains of an old erosion surface or pediment are represented by the comparatively flat ridge tops and high-level gravel deposits at altitudes between 9,500 and 10,500 feet on many of the ridges. The higher peaks contain cirques and other evidence of glaciation.

Ore minerals occur in quartz veins and shear zones in the metamorphic rocks, in quartz veins and silicified breccia zones in the volcanic rocks, and in contact metamorphic zones on the margins of the granodiorite bodies. In the past, most of the prospecting and mining in the Red River and Twining districts was for gold and copper, but no extensive deposits have been discovered. The only active mine in the region at this time is the Questa molybdenum mine of the Molybdenum Corporation of America, which is located 6 miles west of the town of Red River.

Ore minerals seen or reported in the district are gold, molybdenite, galena, bornite, chalcocite, chalcopyrite, pyrite, hematite, magnetite, malachite, azurite, fluorite, and huebnerite. The ore deposits discovered so far are low-grade. Contact metamorphic deposits west and north of the area appear to be the most favorable areas to prospect.

INTRODUCTION

Recognizing the need for additional geologic mapping of New Mexico, the 18th session of the State Legislature appropriated annual funds to be used for basic geological surveys and reports. The funds were to be spent

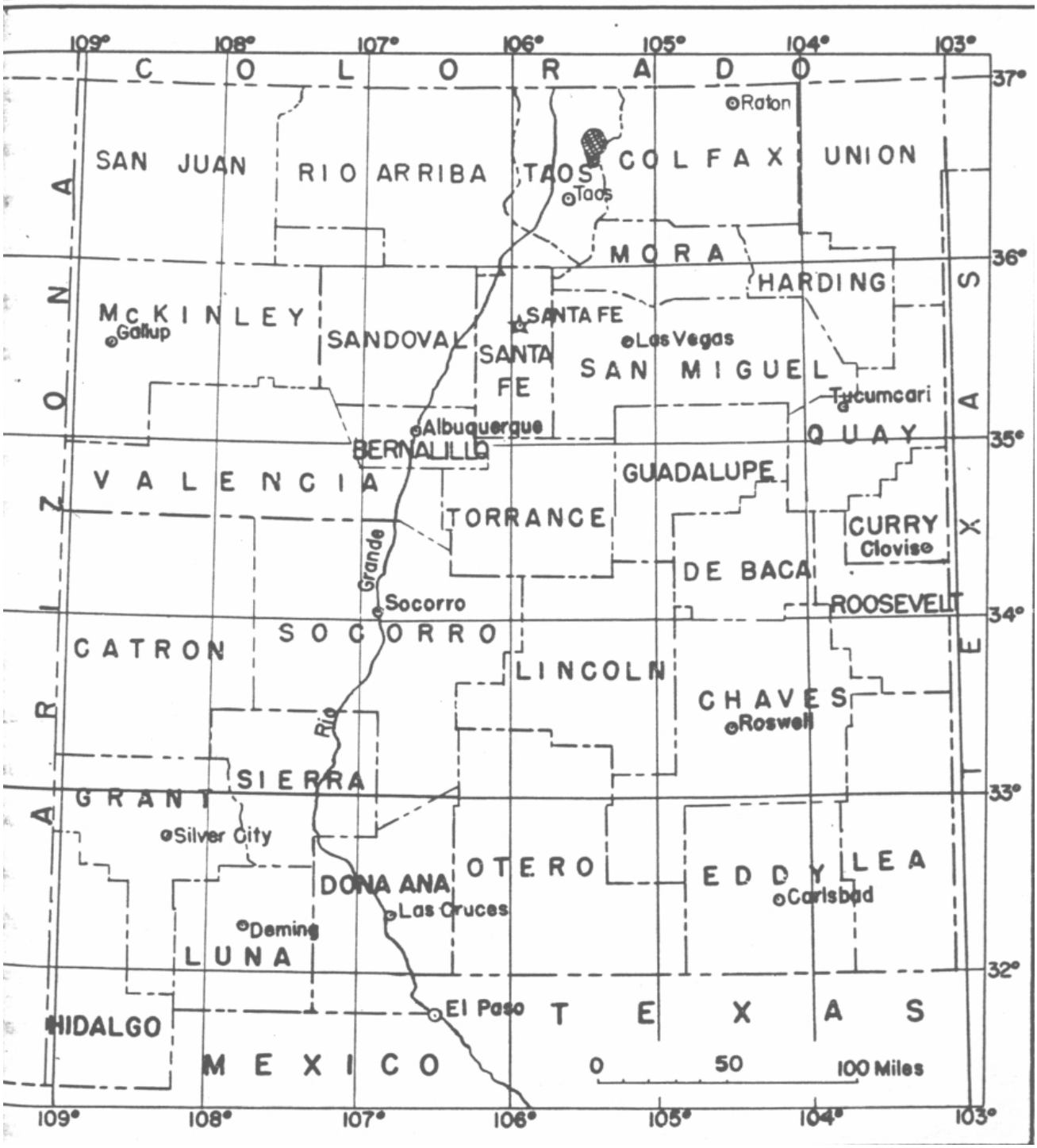


FIGURE 1. Index map of New Mexico showing location of Red River and Twining districts.

on cooperative projects between the New Mexico Bureau of Mines and Mineral Resources and the U. S. Geological Survey, provided such cooperation could be arranged.

The plan for the first project is to map the areas underlain by Tertiary volcanics and metamorphic rocks in the Sangre de Cristo Mountains south of the Colorado line. During the mapping special attention will be given to old mining districts and areas showing favorable ore indications, with progress reports being published after each season in the field. When the project is completed, a final report on the ore deposits of the Sangre de Cristo Mountains will be released.

This circular, the first of the series, is the result of an examination of the geology and ore deposits of the Red River and Twining districts, Taos County, New Mexico. The area was chosen first because of the extensive hydrothermal alteration of many of the rocks, and the widespread mineralization

During the summer of 1947, 58 days were spent in the field. The work started on the 27th of July and extended through the 24th of September. In addition to the detailed mapping of the Red River and Twining districts, several reconnaissance trips were made to other areas in the mountains. The purpose of these trips was to gain ideas on the general rock types and to help plan the work for the following years. Detailed mapping was done with the aid of aerial photographs at the scale of approximately 1:30,000. All prospects and mines encountered during the survey were examined, and maps were made of the very few accessible workings.

Previous geologic work in the Red River and Twining areas has been mainly reconnaissance. Lindgren and Graton briefly describe the ore deposits

in Geological Survey Professional Paper 68, 1910, "The Ore Deposits of New Mexico." Few reports on the area have been published, though the Questa molybdenum deposit [3/] and the Red River district [4/] have been described.

It is not possible to acknowledge by name all those who assisted in the compilation of this report. However, the writers wish to express their appreciation to C. B. Read, of the Geological Survey, for his cooperation while the field work was in progress, and to E. C. Anderson, Director of the Bureau, for his helpful supervision of the project. J. B. Carman, General Manager, Questa molybdenum mine, furnished information on the geology and ore deposits of the area. Messrs. Jack Brandenburg, Joe Cannard, G. D. and L. O. Kerschner, George L. Oldham, A. W. Phipps, and Bill Wilde, all of Red River, contributed information on mining operations in the districts and accompanied the writers to many of the prospects.

3/ Larsen, E. S., and Ross, C. S., The R and S molybdenum mine, Taos County, New Mexico: Econ. Geology, vol. 15, no. 7, pp. 567-573, November 1920.

Vanderwilt, J. W., Geology of the "Questa" molybdenite deposit, Taos County, N. Mex.: Colo. Sci. Soc. Proc., vol. 13, no. 11, pp. 599-643, 1938.

Vanderwilt, J. W., The occurrence and production of molybdenum: Colo. School of Mines Quarterly, vol. 37, no. 4, pp. 39-44, October 1942.

4/ Bush, F. V., Red River mining district, Taos Co., N. Mex.: Min. World, vol. 42, no. 12, pp. 541-543, March 1915.

Ellis, R. W., The Red River lobe of the Moreno glacier: N. Mex. Univ. Bull. 204, geol. ser., vol. 4, no. 3, 26 pp., November 1931.

PHYSICAL FEATURES

The area described in this report contains about 75 square miles, is enclosed by meridians 105°22’ and 105° 30’ W., and parallels 36° 35’ and 36° 50’ N. It lies in the heart of the Sangre de Cristo Mountains, Taos County, New Mexico, and includes the Red River and Twining mining districts (Fig. 2).

State Highway 38, a well-graded gravel road, crosses the area. It follows Red River Canyon and connects Questa and the town of Red River, a distance of approximately 13 miles. East of Red River, the highway follows the valley for 1 ½ miles before crossing the divide over Red River Pass to the Moreno Valley, where it continues to the town of Eagle Nest, 19 miles distant. Twining is reached by a graded road up Rio Hondo from Taos. All other roads in the districts are primitive and in many places ungraded and badly washed. The longest of the primitive roads extends from the bottom of the switchbacks east of Red River town, south 12 miles along Red River Valley, to an altitude of 10,000 feet on the West Fork of the river. This road, part of which is new, opened the area southeast of Gold Hill and greatly aided the mapping. Other roads extend up Bitter, Mallette, and Pioneer Creeks for distances of 3 to 5 miles. All of the area, not accessible by roads, may be reached by trails. From the town of Red River it is 55 miles to Colfax, where loading facilities of the Southern Pacific railroad are available.

The maximum relief in the area is about 4,000 feet. Wheeler Peak, 13,131 feet, which lies to the south of the area (Fig. 2), is the highest point in this section of the Sangre de Cristo Mountains. Gold Hill, with

altitude of 12,600 feet, and Frazer Mountain, with an altitude of 12,100 feet, lie on the western and southern boundaries of the area. The Red River ranges in altitude from 8,500 feet at the west boundary to 9,100 feet at the junction of the West and East Forks.

The annual precipitation is over 20 inches, and the months of maximum precipitation are July and August.[5/] The abundance of moisture promotes the growth of fir, aspen, and pine, and encourages the accumulation of organic material and rock decay, particularly on the more gentle slopes. Thus, over much of the district the rock outcrops are few in number and only an approximation of the contacts may be drawn.

Ground water level is fairly high throughout the region. It has in the past been a serious handicap to deep-mining operations. The control of ground water, especially where mines are near or below the stream gradient, may require the lowering of the water table in considerable areas.

Pleistocene glaciation has produced large cirques on the flanks of Gold Hill, Frazer Mountain, and Wheeler Peak, and to a lesser extent on other mountains in the region. Glaciers filled many of Red River's tributaries, and glacial ice may have extended down the Red River for several miles below its headwaters. The extent of the glacial effect was studied by Ray [6/] who found evidence of Wisconsin glaciation below the junction of the Middle Fork and East Fork at an elevation of about 9,100 feet. A prominent gravel

5/ Information from weather reports of the Dept. of Commerce, based on observations of Ethel E. Prunty, Red River.

6/ Ray, L. L., Glacial chronology of the southern Rocky Mountains: Geol. Soc. America Bull., vol. 51, no. 12, pt. 1, pp. 1851-1917, December 1940.

terrace along parts of the river is probably reworked outwash material from the glaciers. The present Red River is entrenched from 10 to 30 feet into these gravel deposits.

GEOLOGY

Only a short description of the rocks is included in this report as the microscopic examinations are not completed.

Metamorphic rocks

Pre-Cambrian rocks. -- Rocks of pre-Cambrian age crop out along the southern and eastern limits of the area. They consist of coarse hornblende gneiss, quartzite, amphibolite, and quartz mica schist. The trend of the foliation and compositional layering of these metamorphic rocks averages about N. 70° E., but ranges between N. 45° E. and N. 85° E. The dip of the foliation is usually steeper than 60 degrees, though in a few outcrops it is nearly horizontal.

A granite, probably of pre-Cambrian age, has intruded these older rocks and has been considerably metamorphosed and recrystallized. Locally it is gneissic and is spotted with salmon-colored orthoclase and white albite. A contact phase of granite with feldspar and quartz predominating fills cracks that cut the foliation, and locally replaces the schist or gneiss, making it difficult to distinguish the contact rock from the granite.

Hornblende gneiss trends about N. 30° E. across the southern part of the area from Frazer Mountain to a point near the Ditch Cabin. This gneiss is roughly foliated, and contains hornblende or biotite, as well as altered feldspar with muscovite or chlorite flakes commonly scattered throughout.

Much of the weathered gneiss shows small nodules, about 3 mm. in diameter, that are thought to be quartz or one of the metamorphic minerals.

Large outcrops of pre-Cambrian schist are found in the southern part of the area. The schist essentially contains the same minerals as the gneiss, namely hornblende with some feldspar, mica, and quartz.

Dark greenish amphibolite is abundant in the pre-Cambrian rock, occurring interbedded with the schist and gneiss. The rock is granular and consists of hornblende with some feldspar and quartz.

Quartzite crops out on Bitter Creek and on the headwaters of Bobcat Creek along with the gneiss. The quartzite occurs in massive layers, is colorless to dark pink, and contains flakes of muscovite.

In the vicinity of Gold Hill are sedimentary and igneous rocks of unknown age that have been highly folded and metamorphosed to chlorite schists, talc schists, quartz mica schists, and metamorphic gabbros. A few limestone lenses are associated with the schists and apparently grade into them. The foliation of these rocks is approximately parallel to that in the pre-Cambrian metamorphics.

Sedimentary rocks

Paleozoic rocks. -- Sedimentary rocks of Pennsylvanian age occur in the southeastern part of the region. They consist of bedded fossiliferous limestones, sandstones, and layers of grit or arkosic conglomerate. These rocks appear to be faulted against the pre-Cambrian rocks.

Rocks similar to the Paleozoic sediments appear near the mouth of Placer Creek, south of Bear Creek, in scattered outcrops on Goose Creek, and in small bodies in the granodiorite on Mallette and Bitter Creeks.

These strata contain a few questionable organic remains, and consist of thin-bedded limestone, dolomite, and quartz conglomerate. The beds are closely associated with the metamorphic rocks and in places may be folded in with the older rocks. Conglomerate on Bitter Creek contains pre-Cambrian fragments near its base and indicates an unconformity with the older rocks. Strikes of the beds range from N. 10° W. to N. 50° E., and dips are rather gentle, ranging from 10° to 40°.

Tertiary gravels. -- A high-level gravel forms the tops of many of the flat ridges at altitudes of 9,500 to 10,500 feet in the Red River and Twining districts. The gravel principally contains well-rounded boulders, cobbles, and pebbles of pre-Cambrian quartzites and schists, but pebbles and cobbles of Tertiary andesite are present. The gravel is thought to be of late Tertiary age.

The high-level gravels are described by Ellis, [7/] who studied them around the town of Red River and concluded that they represented till deposited by a glacier lobe which extended westward from a Moreno Valley glacier. Ray and Smith [8/] examined the Moreno Valley and decided that there was no evidence of a large glacier having occupied the valley.

Additional mapping shows that the gravels extend farther to the south and east than was previously realized, and could hardly have been deposited from a Moreno Valley glacier.

7/ Ellis, R. W., op. cit.

8/ Ray, L. L.., and Smith, J. F., Jr., Geology of the Moreno Valley, N. Mex.: Geol. Soc. America Bull., vol. 52, no. 2, pp. 177-210, February 1941.

Valley alluvium. -- Recent alluvium is confined to the valley floors, but the mapping includes both talus slopes adjacent to the valleys and glacier debris in the upper parts of the streams.

Igneous rocks

Pre-Cambrian granite. -- Pinkish granite, which consists essentially of pink and white feldspar and quartz with small amounts of biotite or hornblende, intrudes the pre-Cambrian metamorphic rocks. Much of the granite is gneissic with an elongation of the dark minerals. Alteration of the biotite to chlorite is common, but the feldspars are usually fairly fresh. A contact zone around the edges of the granite is a mile or more wide. Additional mapping to the west, south, and east is necessary before the extent of the granite mass is known exactly.

Pegmatite. -- Pegmatites that occur in the pre-Cambrian rocks may be related to the granite. These pegmatites contain pink orthoclase, a white feldspar, quartz, and muscovite. In general, they are small and irregular and probably have no commercial importance.

Green tuff. -- Rocks in this formation include a greenish to whitish tuff, an altered fine-grained diorite or andesite, and a gray andesite. These rock types can be mapped separately in some areas, but appear to grade into each other. The diorite and green tuff are chloritized and altered, but the gray andesite is relatively fresh and is probably the youngest. The gray andesite locally appears to grade into typical volcanic breccia.

The country rock of upper Bitter Creek is mainly green tuff, and older rocks were not recognized, though possibly some have been included.

Granodiorite. -- Granodiorite occurs around the town of Red River and extends for several miles west, north, and northeast of the town. Within this area only scattered outcrops of the invaded rocks, metamorphic rocks, Paleozoic sediments, and green tuff are recognized. The granodiorite contains pinkish orthoclase (?) and white plagioclase, possibly oligoclase, with small quartz crystals scattered throughout. The only dark mineral present is biotite which occurs as small well-developed phenocrysts, varying from about 2 to 5 percent. In places the rock is nearly all quartz and feldspar and is similar to the soda granite found at the Questa molybdenum mine.

Monzonite. -- A rock similar to the granodiorite, but as a rule containing more dark minerals, occurs throughout the district and has been mapped as monzonite. It occurs in small bodies as dikes, sills, or irregular plugs. A dike swarm south of Red River town trends about N. 30° E., but north and east of the town the trend swings to N. 20° W. In the field it was difficult to distinguish between the granodiorite and the monzonite, and actually the monzonite dikes may be a variation of the granodiorite intrusive. Intrusion of the two rocks probably occurred about the same period, although good examples of the granodiorite cut by monzonite dikes were seen. The monzonite cuts most of the rock formations in the districts.

Minerals occurring in the monzonite are orthoclase, plagioclase, biotite, and hornblende.

Monzonite porphyry. -- Long, narrow dikes of monzonite porphyry crop out in the northern part of the districts. These dikes cut the

metamorphic rocks and the granodiorite. One of the most impressive outcrops is about one mile up Placer Creek, and trends about N. 20° E. for more than 1 ½ miles to the slope just south of Red River town. North of the town is a badly altered dike that may be a continuation of the same porphyry, though this is uncertain. Several similar dikes occur in the region; a prominent one crosses the switchbacks on Red River Pass and extends across the lower part of Bobcat Creek. Rhyolite porphyry dikes that crop out in and near the granodiorite are possibly related to the monzonite porphyry as the phenocrysts are the same. The lighter color of the rhyolite porphyries is generally caused by alteration and leaching.

Minerals in the monzonite porphyry are orthoclase, quartz, and albite (?). Orthoclase occurs in crystals from 1 to 2 inches long, and small white crystals believed to be albite are characteristic. Quartz is in phenocrysts up to three-fourths of an inch in diameter. The quartz crystals are somewhat rounded, while the orthoclase and albite phenocrysts have sharp outlines. Small crystals of biotite and hornblende are seen in the fine-grained groundmass.

Rhyolite. -- A large body of rhyolite lies south and east of Relica Bill (Fig. 2). This rhyolite is probably an intrusive plug, although the contacts are in general obscure and there is no direct evidence other than its shape, a high rounded dome, to support such a conclusion. At Table Rock, to the west of the main mass, the contact between the rhyolite and the metamorphic rocks is a breccia. On a fresh surface the rhyolite has a white, sugary appearance and resembles quartzite. Small quartz and feldspar crystals are best seen on weathered surfaces.

In the northern part of the area the green tuff and granodiorite have been intruded by many dikes and bodies of rhyolite.

Volcanic breccia. -- Several different rock units are included in the volcanic breccia, but few of these units can be recognized throughout the district. A fine-grained purplish to reddish tuff containing numerous white inclusions is the lowest unit. Above this is a coarser-grained tuff which is usually greenish and contains small fragments of andesite. With these two basal tuffs are dense flows of purple hornblende andesite and gray andesite that grade upward into coarse purple breccia. This breccia is best seen on lower Goose Creek and in the nearby valley of the Red River. It is of pyroclastic origin and contains boulders and fragments as large as 3 feet in diameter. Nearly horizontal flows of dense glassy andesite top many of the ridges and are included in the breccia.

Only the tuff appears to be intruded by monzonite and monzonite porphyry dikes. The coarse breccia and andesite flows are not cut by the monzonite or the granodiorite; north of Goose Creek the breccia formation appears to rest on an older surface of monzonite.

Basalt dikes. -- Basalt dikes are found along the eastern border of the district, and occasionally elsewhere. They are dark and fine-grained with only a few phenocrysts large enough to be seen. They are common in areas of pre-Cambrian rocks. Those in the Tertiary volcanics are fresh and are probably the latest intrusive in the district.

Structure

The limited extent of the area examined during the field work makes it impractical to draw conclusions on the regional geology and

structure of the Sangre de Cristo Mountains. Publications numbers 1, 3, 4, 12, 13, 14, and 19 in the bibliography deal with the general geology and regional structure of the nearby Rocky Mountain area.

In this area compressional forces appear to be responsible for the major geologic structure. Several important fault zones were recognized, two of which are normal type, between younger rocks on the downthrown side and older rocks on the upthrown side. These normal fault zones contain numerous slivers, some of which are hundreds of feet wide and a mile or more long. They are possibly curved breaks around the borders of the downthrown Tertiary volcanic area.

Small faults and shear zones are abundant. They strike in almost any direction, though the majority trend between N. 30° E. and N. 50° E. Silicified veins, along which some movement has occurred, fall into two groups; one group trends between N. 10° W. and N. 10° E., and the other trends between N. 65° E. and S. 70° E.

The trend of the monzonite dikes is about N. 30° E. south of Red River town, but changes to N. 20° W. north and east of Red River. Their position and alignment suggest that the dike swarms are intruded along tension fractures developed on a large anticline.

Metamorphism has greatly obliterated original structures in the pre-Cambrian, though such structures appear in the metamorphic rocks near Gold Hill. The compositional layering, bedding where known, and schistosity in these metamorphic rocks trend in general N. 70° E. and are usually inclined about 60 degrees or more. In Long Canyon and the Gold Hill areas, the metamorphic rocks are compressed into tight isoclinal folds.

Folding in the younger rocks is difficult to interpret without further mapping. Paleozoic (?) sediments in the northern part of the area strike generally north, dip 25° E. along the eastern border and from 20° to 30° W. on the western boundary. This suggests that an open fold crosses the area with its axis striking approximately north.

Attitudes in the volcanic breccia are uncertain because of the massive nature of the deposit. The few dips within the volcanic breccia are of little value as they were probably formed on steep slopes or are due to slumping.

ORE DEPOSITS

General Statement

Mining in the Red River and Twining districts began around 1869 with prospecting for both placer and lode gold. From this period until the early 1900's the region was swarming with prospectors; most of the favorable areas were staked and worked extensively for gold and copper. Lead-silver prospects were described by early writers, but these deposits were of little consequence.

Several high-grade gold pockets were mined, but no large deposits were found. A combination of low-grade ore, ground-water flooding, and land disputes with the Sangre de Cristo Grant in the late 1800's forced many of the prospectors to abandon their workings. Since the turn of the century, little mining has been done, though efforts were made to operate the Independence, Caribel, Memphis, and Black Copper mines. As most of the workings are inaccessible, little first-hand underground

information was obtained. No mines are operating in the district at the present time, except the Questa molybdenum mine, which lies west of the area mapped.

Ore minerals are associated with quartz veins and shear zones in the metamorphic rocks, with silicified breccia zones in the Tertiary rocks, and with contact metamorphic deposits west of the mapped area.

Rock alteration

The area west of Pioneer and Bitter Creeks is underlain largely by intensively altered granodiorite and the border zones of this intrusive. The altered rocks continue westward beyond the mapped area and include the country rock of the Questa molybdenum mine and other prospects further to the west. The area is conspicuously marked by many large precipitous slides which are highly colored and are immediately noticed upon entering the region. During heavy rains these slides frequently wash across the roads and deposit muddy debris.

The colors of the altered rocks are predominantly light brown and creamy, though red, dark brown, and white rocks are present. The material consists essentially of sericite and fine-grained silica and, where unweathered, much of it is spotted with many tiny pyrite crystals. The alteration products have not been studied microscopically and it seems likely that clay minerals and other alteration products, such as alunite, may well be present. Numerous small stringers of quartz are widely scattered and many contain small amounts of pyrite, chalcopyrite, molybdenite, and fluorite.

The extensive alteration, which strongly resembles the alteration zones around many well known mining districts, is indicative of extensive hydrothermal activity. This evidence, coupled with the very widespread, though generally weak mineralization, furnishes the hopes for the districts in the future. It is always possible that orebodies of considerable size and value may be found in an area where hydrothermal activity is so extensive.

Deposits associated with metamorphic rocks

Deposits south of Gold Hill contain magnetite and specularite interbedded with quartzite, but the bodies are small and of little value.

Massive quartz veins and pegmatites believed to be related to the pre-Cambrian granite cut the metamorphics. They contain tourmaline, epidote, and pyrite, galena, chalcopyrite, and malachite in small quantities.

Quartz veins near Table Rock on the West Fork of the Red River are on the western contact of the rhyolite plug. A little galena, which carries about 18 ounces of silver per ton, [9/] occurs in the fractured quartz and a few copper stains are present.

Copper minerals are found in a large shear zone which trends N. 80° E. from the old Frazer camp at Twining across Bull of the Woods Mountain. Minerals recognized are bornite, chalcopyrite, chalcocite, malachite, and azurite.

9/ Assay by R. A. Matuszeski of the New Mexico Bureau of Mines and Mineral Resources.

Deposits in Tertiary rocks

In the northern part of the area the rocks are predominantly Tertiary volcanics and the ore deposits occur in quartz veins and fracture zones. Gold is the chief metal of the deposits, however, copper was sought in a few properties near Red River town. The ores are in pockets and are disseminated with pyrite throughout the fracture zones and country rock. Molybdenite and galena are found in small amounts in several prospects; at the Questa mine molybdenite is the ore mineral.

Contact metamorphic deposits

Contact metamorphic deposits occur west of the area mapped along the lower parts of the Rio Hondo, in the canyon east of the mouth of Columbine Creek, and north of Cabresto Creek. The deposits are in metamorphic rocks near granodiorite or granite. An interesting deposit of this type is the Hornet on Cabresto Creek. This deposit lies between quartzite and a granodiorite sill (?) where a zone of calcite, epidote, and garnet, with galena and sphalerite crops out. B. J. B. molybdenum, Horseshoe, and Nickel Plate are other promising prospects in the contact metamorphic zone.

Ore minerals

The following minerals were recognized during the field examination.

Mineral	Composition
Graphite	C
Gold	Au
Silver	Ag
Molybdenite	MoS_2

Mineral	Composition
Galena	PbS, often contains disseminated silver
Chalcocite	Cu_2S
Sphalerite	ZnS
Bornite	Cu_5FeS_4
Chalcopyrite	$CuFeS_2$
Pyrite	FeS_2, may contain gold
Hematite	Fe_2O_3
Fluorite	CaF_2
Magnetite	$FeO•Fe_2O_3$
Malachite	$CuCO_3•Cu(OH)_2$
Azurite	$2CuCO_3•Cu(OH)_2$
Huebnerite	$MnWO_4$

Gangue minerals

Mineral	Composition
Calcite	$CaCO_3$
Chlorite	$H_8(Mg,Fe)_5Al_2Si_3O_{18}$
Epidote	$HCa_2(Al,Fe)_3Si_3O_{13}$
Garnet, almandite (?) grossularite (?)	$Fe_3Al_2(SiO_4)_3$ $Ca_3Al_2(SiO_4)_3$
Limonite	$2Fe_2O_3•3H_2O$
Quartz	SiO_2
Sericite	$H_2KAl_3(SiO_4)_3$
Tourmaline	$H_9Al_3(B•OH)_2Si_4O_{19}$ Also H may be replaced by alkalies or Mg, Fe, Ca

PRODUCTION

Most of the prospecting in the Red River and Twining areas was done during the heyday of the mining around Elizabethtown, and any gold recovered was probably absorbed in the much larger production of the Elizabethtown district. A small amount of gold was obtained from the placer diggings on Placer Creek, and possibly a little from other workings. Some copper was also recovered from the old Frazer copper mine at Twining, though the amount is not known. In any case, the production has been very small.

ECONOMIC POSSIBILITIES

The fact that the Red River and Twining areas have been extensively prospected and have had several unsuccessful mining enterprises is a deterrent to development in the districts. The extensive hydrothermal alteration and the widespread mineralization are, however, encouraging signs. Most of the early-day prospecting was for gold in deposits related to the Tertiary rocks, especially to the monzonite. These deposits are lenticular or in small pockets and the chances of finding a large body of gold are unlikely.

Future prospecting in the districts possibly should be directed toward the discovery of fluorite, huebnerite, molybdenite, galena, and other minerals likely to have been passed over by the early gold seekers. The most favorable area for possible development of base metal deposits appears to be the contact zones around the granodiorite. No detailed examination has yet been made of this contact, although several favorable surface outcrops were seen along it.

PROSPECTS AND MINES

Mines and prospects in the southern part of area

Frazer copper prospect. -- The Frazer copper prospect is on a steep slope east of the old town of Twining, New Mexico. A description of the property is given by Lindgren, [10/] who visited the mine in 1904 (?). Considerable development work has been done, but the mine was not profitable and was closed about 1904. During 1942-1943 parts of the old workings were cleaned out by T. B. Everhart, but little additional work was done. All of the rather extensive tunnels and shafts are now caved, and it was impossible to examine the deposit underground, though surface exposures were good.

The country rock is pre-Cambrian amphibole and talc schist that is badly crumpled in a shear zone 200 feet wide. Foliation in the country rock is N. 80° E. approximately parallel to the trend of the shear zone. Copper minerals -- chalcopyrite, bornite, chalcocite, malachite, and azurite -- coat the shear planes and joints. Most of the copper minerals are concentrated in two 6-foot wide zones within the main shear belt. These mineralized zones are separated by 80 feet of very low-grade or barren schist. The mineral on the surface is low-grade and unless the deposit is more extensive or better in depth than on the surface, it could hardly be worked at a profit.

Highline copper prospect. -- The Highline copper prospect is immediately south of the crest of Bull of the Woods Mountain on the ridge between

10/ Lindgren, Waldemar, Graton, L. C., and Gordon, C. H., The ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, pp. 83-84, 1910.

Rio Hondo and the Middle Fork of Red River, and is on the eastward continuation of the Frazer copper shear zone. Owners are Joe Cannard of Red River and Elmer Burch of Taos, New Mexico. An old shaft on the ridge is about 25 feet deep and follows a mineralized zone 4 to 6 feet wide. The ore minerals are the same as those found at the Frazer copper prospect, however, copper carbonates are more abundant. On the east side of the ridge the mineralized zone is opened by a 30-foot adit and several small cuts.

No assays were made, but the ore appears to be too low-grade to be of commercial value unless a very large body is uncovered. The inaccessibility of the deposit is also a handicap.

MnO_2, Commonwealth, Iron Dyke, and Commodore Lode claims. -- All these claims, except the MnO_2 claim, are on the ridge between Gold Hill and Bull of the Woods Mountain, and are owned by Joe Cannard and Elmer Burch. The MnO_2 claim lies east of the West Fork. No recent work has been done, and all of the workings are caved and slumped. On the Commonwealth claim chalcopyrite, malachite, azurite, and specularite were found in small quartz nodules. On the MnO_2 claim a poorly mineralized zone of magnetite and quartzite, 20 feet wide, trends S. 60° W. at 57° N. A trace of manganese and considerable magnetite occur in a sample of the quartzitic rock from this claim. Specularite occurs on the Iron Dyke claim, and a few stains of copper oxides and flecks of sulfides are found on the dump of the Commodore Lode. All of these deposits are in the metamorphic rocks near Gold Hill. There has been no recorded production from these claims.

Silver Star claim. -- The Silver Star claim is about 300 feet south of Table Rock on the West Fork of the Red River. Several prospect holes expose narrow irregular quartz veins, though no development work has been done for many years. The upper of two old adits is now caved but the lower, on the Elizabethtown ditch, goes into the hill several hundred feet. It is said that $500 in silver were recovered from about 6 tons of ore shipped to Colorado from the upper adit. Three quartz veins, each less than one foot wide, are exposed in a 15-foot zone at the portal of the upper adit. The general trend of the veins is N. 85° W. and the dip is 20° N. Fine-grained galena, one assay of which indicated about 18 ounces of silver per ton, is associated with the quartz. Green copper carbonate and limonite are found in fractures in the quartz. The country rock consists of the metamorphic rocks found near Gold Hill.

Black Copper mine. -- The Black Copper mine is on the north side of Black Copper Canyon about 1,000 feet vertically below the Elizabethtown ditch. The mine is about 7 miles by road from the town of Red River. A five-stamp mill in poor condition is still standing. The workings consist of a shaft, a short upper adit which is open, and a lower adit trending S. 70° E. that is caved 177 feet from the portal. Another adit below and west of the above workings is flooded. The country rock is monzonite and altered basic dike rock in the lower adit, and gneissic pre-Cambrian granite in the upper adit. A shear zone, 1 to 3 feet wide, in the upper adit strikes S. 70° E. and stands nearly vertical. Quartz and pyrite are the principal minerals, and a little chalcocite is scattered throughout the quartz. The finding of a rich pocket of gold ore was reported by several people

who worked on the property, but no records have been found to substantiate this.

Mines and prospects on Bitter Creek

Memphis mine. -- The Memphis mine awned by the Kerschner Brothers of *Red River is on the east side of Bitter Creek Canyon, 5 miles from the town of Red River. A primitive road extends from Red River up Bitter Creek to within a mile of the mine. Development work was started in the early 1900's and continued sporadically through 1943. A good detailed report on the mine was made by J. B. Tenney in 191.O. Since then, additional work based on Tenney's recommendations has been completed. The average value of samples taken by Tenney are as follows:

Level number	Average value Gold and silver per ton
1	$19.78
2	5.00
3	5.00
4	7.96
Raise	16.56

Tenney estimated in 1940 that 5,300 tons of ore could be mined at a net profit of $5.50 per ton. A strong east-west vein which dips 60° S. has been opened by 4 adits at different levels. All of these adits are caved at the portals, but most of the work is concentrated on the lowest level. This level is said to be over 1400 feet long with two stopes above it and one raise 30 feet high. The country rock is a rhyolite dike. Considerable druzy quartz that appears to replace a breccia was found on the dumps.

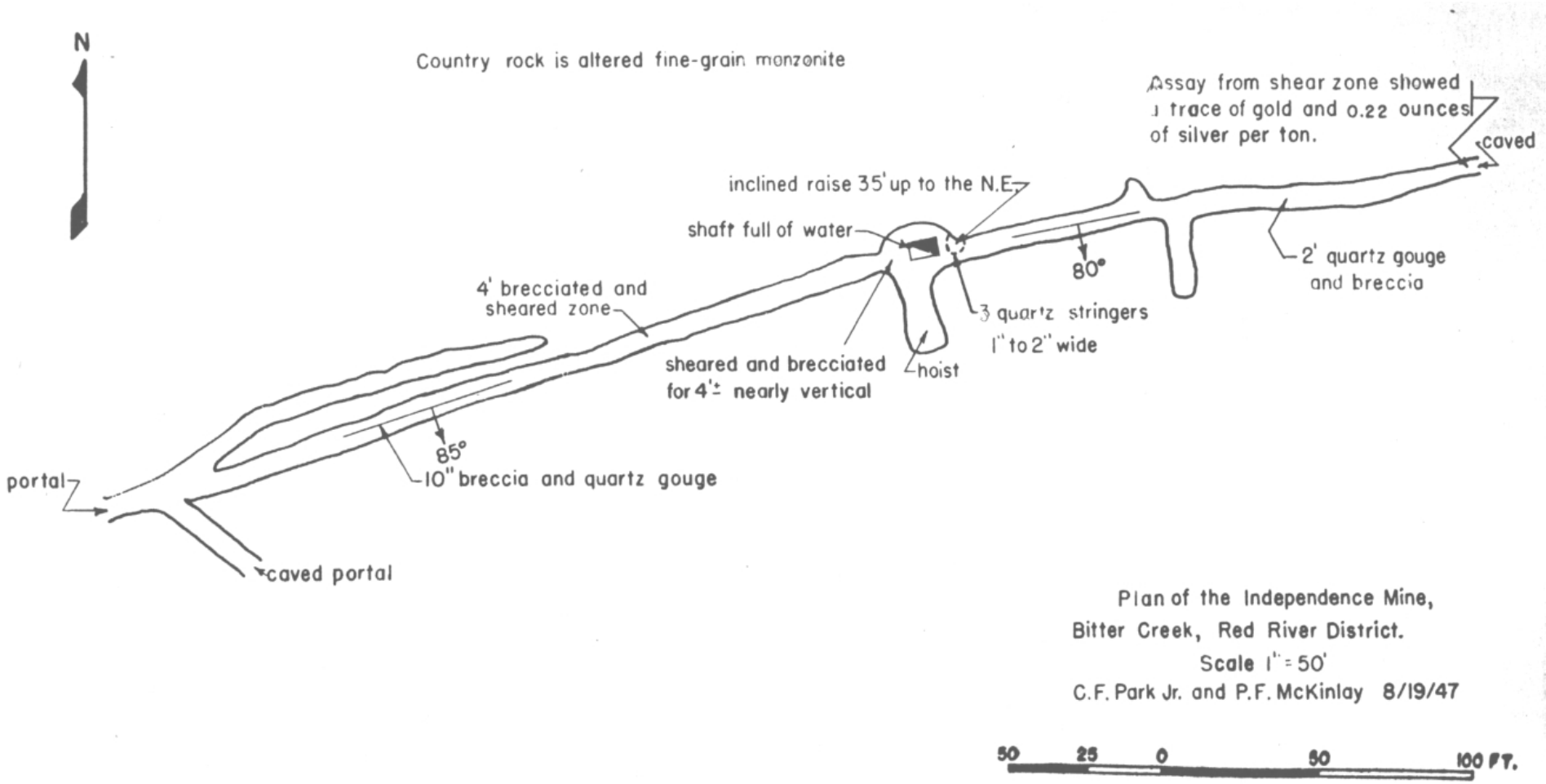

N
Country rock is altered fine-grain monzonite
Assay from shear zone showed a trace of gold and 0.22 ounces of silver per ton.
caved
inclined raise 35' up to the N.E.
shaft full of water
80°
2' quartz gouge and breccia
4' brecciated and sheared zone
3 quartz stringers 1" to 2" wide
sheared and brecciated for 4'± nearly vertical
hoist
85°
portal
10" breccia and quartz gouge
caved portal
Plan of the Independence Mine,
Bitter Creek, Red River District.
Scale 1" = 50'
C.F. Park Jr. and P.F. McKinlay 8/19/47
50 25 0 50 100 FT.

FIGURE 3

Independence mine. -- The Independence mine is in the Bitter Creek Canyon, 5 ½ miles up the creek from Red River and about half a mile above the Memphis mine. When the mine was working, the ore was hauled over a wagon road to Moreno Valley. Four miles of this old road nearest the mine are washed out and impassible. A report on the Independence mine, made by Graton [11/] in 1910, states that in 1905 ore was shipped that carried from $400 to $500 in gold per ton. The principal adit just east of Bitter Creek was accessible though badly caved at the portal. This adit is 420 feet long to cave, and a side drift near the portal is 100 feet long to face. (See Fig. 3.) A winze 250 feet from the portal is full of water. The main adit is on a sheared and silicified zone that trends N. 80° E. and dips about 85° S. Quartz lenses and stringers in this sheared zone range from 1 inch to 1 foot in width. Light gray gouge throughout the sheared zone is composed mainly of finely ground quartz. The monzonite country rock is sericitized and silicified along this shear zone.

Pyrite is found throughout the altered monzonite and occasionally in the quartz stringers. An assay of quartz taken from the shear zone shows a trace of gold and 0.22 ounces of silver per ton. [12/] Petzite, a gold telluride, was thought by Graton to have been one of the minerals in the high-grade ore, however, it was not found by the authors in their field work.

11/ Lindgren, Waldemar, Graton, L. C., and Gordon, C. H., op. cit.

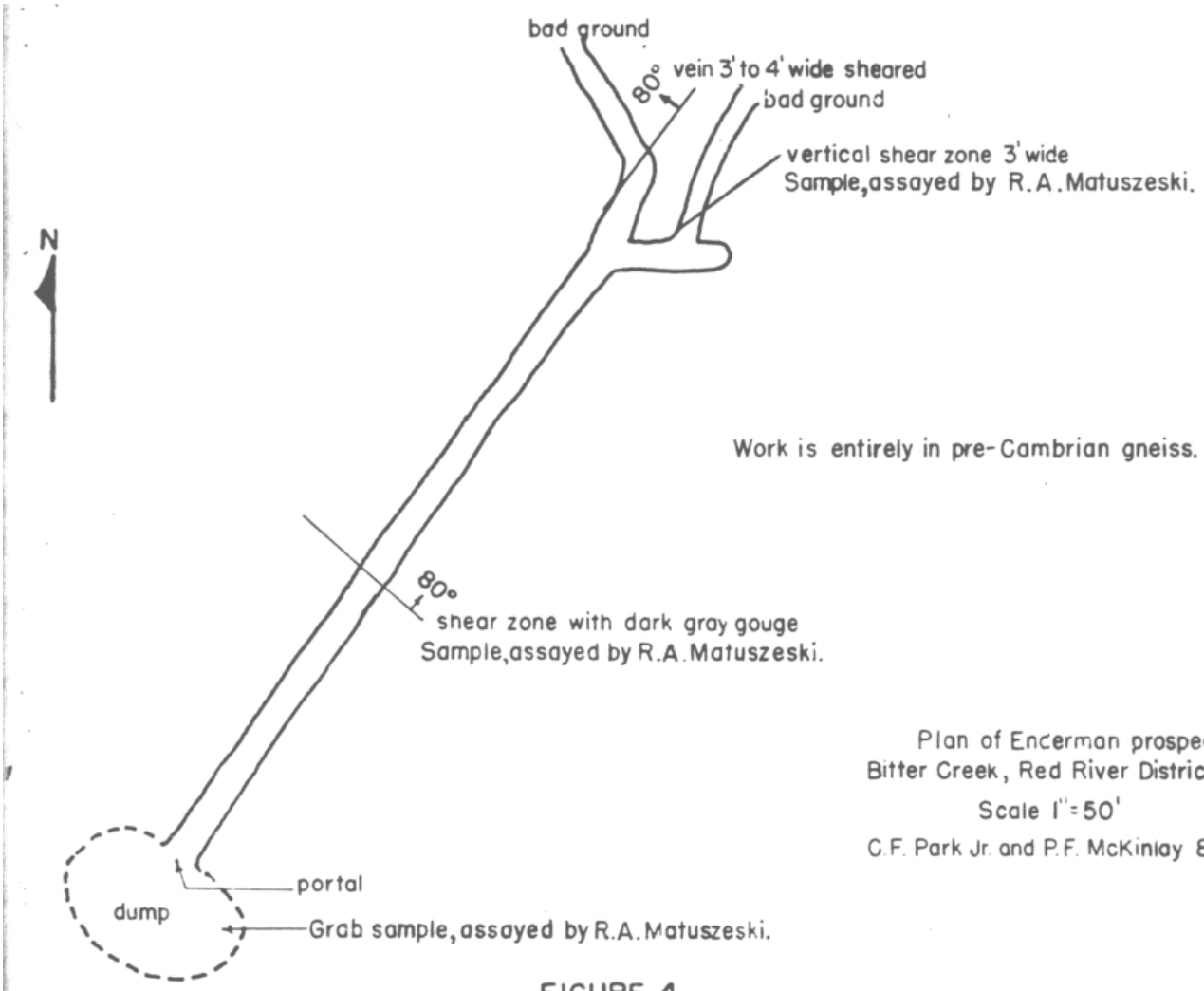
12/ Assay by R. A. Matuszeski of the New Mexico Bureau of Mines and Mineral Resources.

Enderman prospect. -- This prospect is on the west side of Bitter Creek at the end of the dirt road, 4 miles from Red River. The prospect adit is open and a map was made of the accessible workings. (See Fig. 4.) Pre-Cambrian gneiss is cut by several strong shears that contain considerable gouge. Samples analyzed by R. A. Matuszeski show a trace of silver and molybdenum but no ore in quantity.

Pete Deldosso prospect. -- This prospect owned by Pete Deldosso of Red River is about half a mile up Bitter Creek from the Independence mine. The workings consist of a 200-foot adit with several short crosscuts. These crosscuts follow along weak shear zones that trend between 30° N. and 60° E., and dip steeply to the southeast. A fine-grained sericitized and silicified monzonite is the country- rock. A little quartz occurs along the shear zones, but no ore minerals are present. (See Fig. 5.)

Big Five, Edison, Anchor, and Cashier mines. -- All of these mines are from 2 to 4 miles north of the Independence mine near the head of Bitter Creek. For years there has been no underground work on any of the proper-ties except the Edison, and all of them are caved. The country rock is altered greenish tuff and altered monzonite. The workings are on veins in shear and silicified zones. Jack Brandenburg, who worked in the Edison mine, reported that a rich gold streak, generally less than one foot wide, was worked for a short time but that a heavy flow of ground water forced the mine to close.

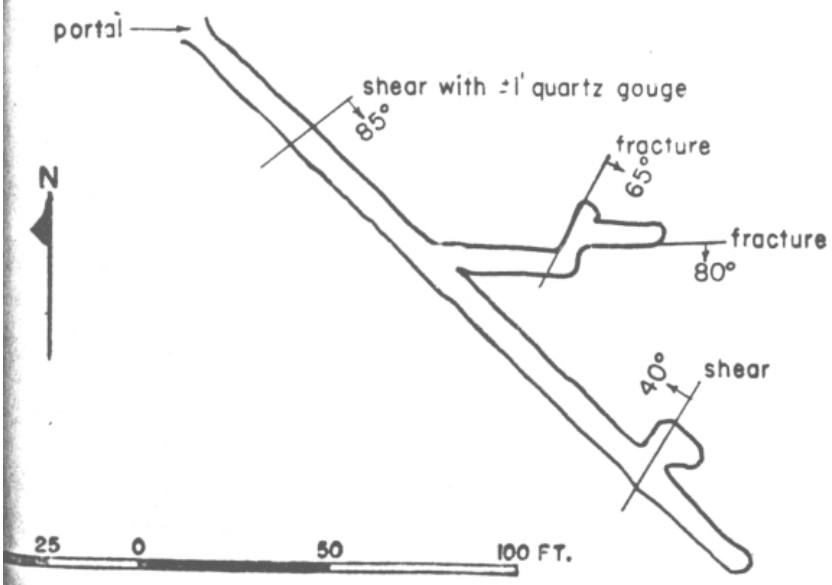
Midnight mine. -- This mine, operated during the late 1890's, is at the head of Bitter Creek. The inclined shaft is now caved. Material on the dump appears to be badly altered green tuff along with some mineralized



Plan of Encerman prospect,
Bitter Creek, Red River District.
Scale 1"=50'
C.F. Park Jr. and P.F. McKinlay 8/22/47

FIGURE 4

J.H.H.



Country rock is altered monzonite

Plan of Pete Deldosso
prospect, Red River District
Scale 1"=50'
C.F. Park Jr. and P.F. McKinlay 8/19/47

FIGURE 5

quartz. Very little information was available concerning the old workings. The lode was relocated on July 29, 1947, by M. A. Pratt.

Prospects on Placer Creek

Many prospects in the Placer Creek drainage have been abandoned for years. Most of the openings are caved and overgrown, and very little information is available. In general the workings follow broken and silicified zones in the monzonite, or are along the contacts of monzonite dikes and intruded rocks. Very little work has been done in the volcanic breccia, though at least two adits were driven in this formation.

Buffalo No. 1. -- The main Buffalo workings are 2 miles from the mouth of Placer Creek and are reached by a steep, badly washed wagon road from State Highway 38. The portal of the main adit is caved, but the size of the dump indicates a thousand or more feet of workings underground. Dump material is predominantly volcanic breccia with some altered monzonite and a small amount of silicified and pyritized breccia. From local reports, and judging from material on the dump, very little of the material was ore.

Buffalo No. 2. -- Buffalo No. 2 prospect is near the head of the north branch of Placer Creek. An adit on the property is open and extends S. 85° W. for 360 feet into the hill. (See Fig. 6.) The country rock in the mine is tuff belonging to the volcanic breccia formation. The adit was driven along a broken and silicified zone in the tuff; 50 feet from the portal, a small fault crosses the adit trending N. 40° E. Several minor shears trending north-south also cross the silicified zone. East of the portal a monzonite dike trending N. 30° E. crosses the canyon. Pyrite is scattered throughout the volcanic breccia and silicified zone, but ore minerals are lacking.

Buffalo No. 3. -- Buffalo No. 3 is on the divide between the heads of the two branches of Placer Creek. The portal to the edit is caved. Green tuff, volcanic breccia, and monzonite are on the dump, but very little mineralization was seen.

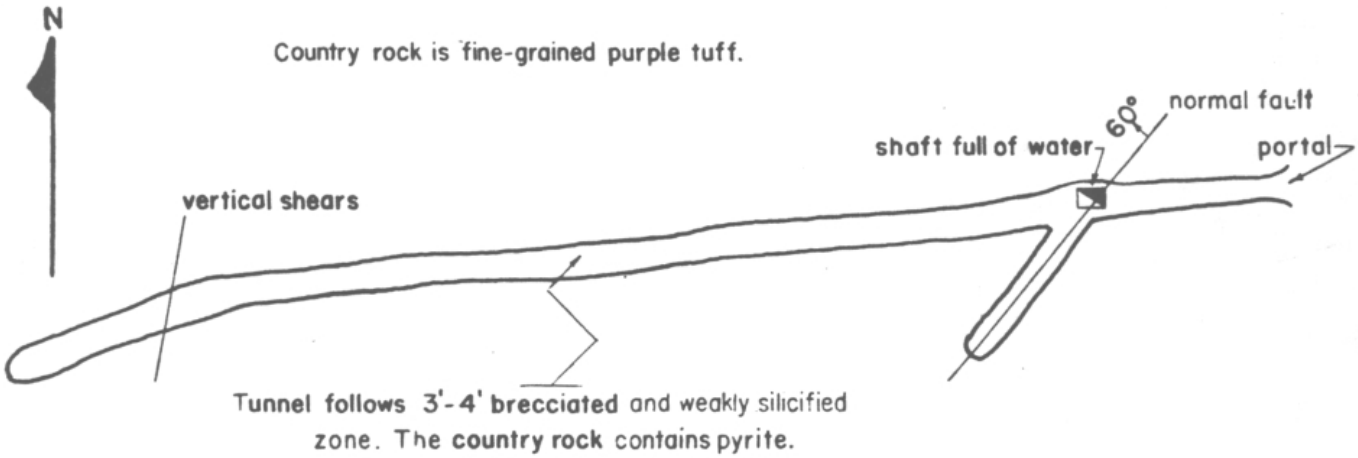
Prospects on Pioneer Creek

Along lower Pioneer Canyon are many old prospects, several of which have been recently reopened and timbered. These adits are in the granodiorite along sheared and silicified zones. Pyrite is common in the silicfied zones, but other sulfides are scarce. Molybdenite is reported [13/] but was not seen.

Silver Tip group. -- This group of prospects is in Pioneer Canyon approximately 2 miles south of Three Canyon Camp in Red River town. The owners are Mrs. L. M. Smith of Red River, C. Young of Leaque, Texas, and R. T. Keeling of Leona, Texas. The workings are extensive, though many of the adits are caved at the portals. The country rocks are limestone, grit, and conglomerate of Paleozoic (?) age that are intruded by many monzonite dikes. Along the contacts of the dikes slight metamorphism of the sediments was noticed. Limestone especially has been silicified and a little epidote was formed.

The main Silver Tip tunnel is caved, but the extensive dump contains monzonitic dike rock, metamorphosed limestone, and conglomerate. With the exception of pyrite, no ore minerals were observed on the dump. South of the portal sedimentary rocks strike north and dip 35° W. They are cut by a monzonite dike which strikes N. 20° E.

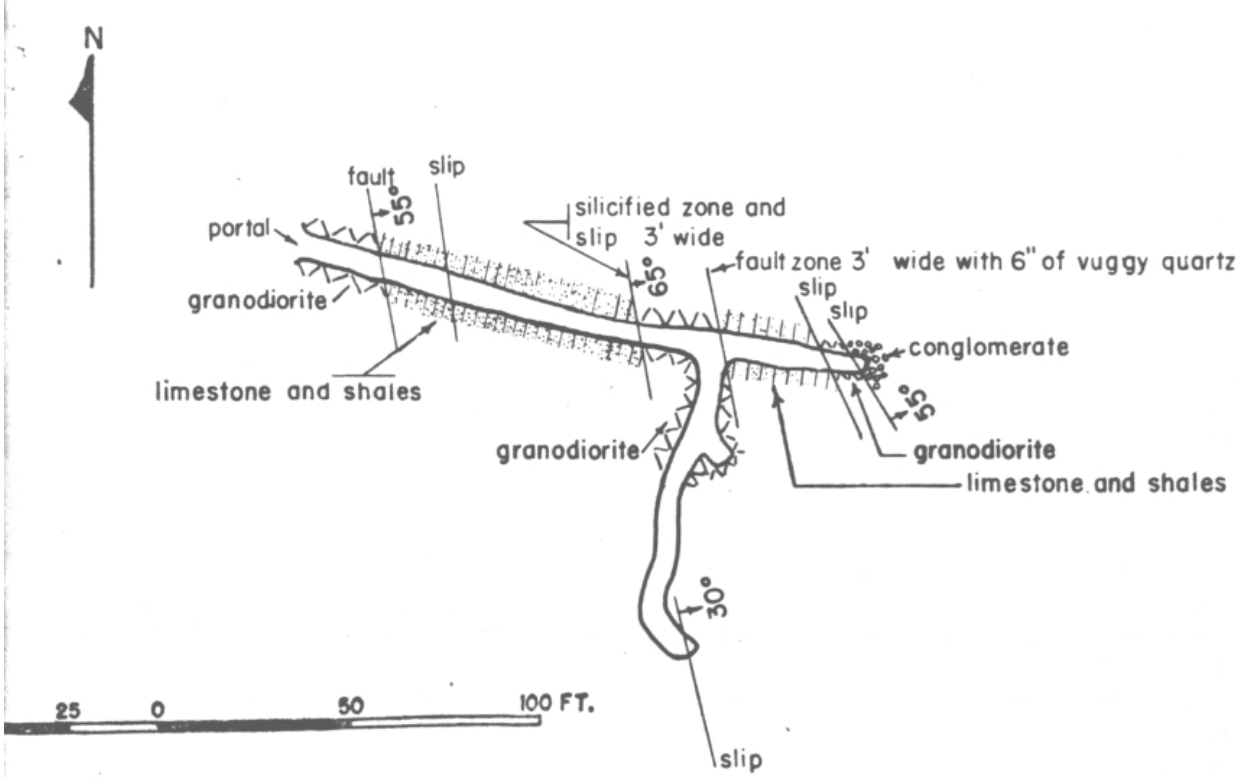
13/ Eng. and Min. Jour., News Item, p. 101, December 1947.



Plan of Buffalo No.2,
Placer Creek, Red River District.
Scale 1"=50'
C.F. Park Jr. and P.F. McKinlay 8/8/47

FIGURE 6

J.H.H.



Plan of prospect, just north of Midway Claims,
Pioneer Creek, Red River District.
Scale 1"=50'
C.F. Park Jr. and P.F. McKinlay 9/16/47

J.H.H.

An open prospect in the Silver Tip group lies near the property line just north of the Midway claims. The workings consist of an adit striking S. 80° E. for 200 feet, and a drift 120 feet from the portal that extends 100 feet to the south. The country rock is Paleozoic (?) limestones and shales cut by granodiorite dikes. A coarse conglomerate is found in the face of the east-west adit. Considerable movement has taken place on the contacts between the sediments and granodiorite. About 100 feet from the portal of the adit, a silicified zone 3 feet wide strikes N. 10° W. and dips 60° E. (See Fig. 7.)

Midway prospects. -- The Midway claims owned by Harry Moberg and brother of Red River, lie south of the Silver Tip claims on Pioneer Creek. The property is prospected by an adit said to include over 2,000 feet of workings. The adit is inaccessible, but rocks on the dump are metamorphic rocks and monzonite. The sedimentary rock is commonly silicified but ore minerals are scarce, though a few copper stains were seen. A short prospect adit on the southern part of the property starts in meta-morphic rock and ends in a monzonite dike. A slip contact between the two rocks trends N. 10° W. and dips 50° E.

Inferno (?) prospect. -- The caved adit of this prospect lies south of the Midway claims on the west side of Pioneer Creek. The pre-dominant rock on the large dump is monzonite with small amounts of sandstone ,and limestone. A little pyrite was seen.

Caribel mine. -- The Caribel mine is on the west side of Pioneer Creek, 4½ miles from Red River. The caved mine workings lie on the steep canyon slope and are connected by a switchback wagon road. Both fresh

and silicified monzonite, metamorphics, and red tuff were seen on the dumps, but no ore minerals were observed. A mill erected below the mine workings is still standing, though much of the equipment has been removed. A small tailings dump indicates that only a small amount of ore was put through the mill.

Miscellaneous properties

Tenderfoot Creek. -- Tenderfoot Creek is near the western edge of the mapped area (see Fig. 2) south of Red River and west of Pioneer Creek. Numerous prospects have been opened in the lower parts of this creek, but they are all caved or are inaccessible. The country rocks are metamorphosed Paleozoic (?) sediments and granodiorite. Most of the openings are on weakly silicified and pyritized zones. One prospect, half a mile up the creek, is reported to contain showings of lead and zinc. Pyrite is abundant but very little lead or zinc was found on the dump.

Jacks and Sixes prospect. -- This prospect is on a north branch of Bobcat Canyon, and is reached by a road and trail going northward from the top of Red River Pass. There are several cuts on the property, and a vein exposed in one cut near the top of the hill appears to trend east-west and dip steeply to the north. The upper adit, 135 feet long, is said to have exposed the vein, but it was caved and the vein could not be seen. A lower adit was driven in granodiorite about 190 feet in an effort to intersect the vein in depth. It is open, but is far short of intersecting the vein. Molybdenite is found on the dump of the upper adit, and patches of molybdenite are seen in the cut on top of the hill. The extent of the mineral is unknown.

Goose Creek. -- Lower Goose Creek is covered with a thick mantle of massive volcanic breccia, but little prospecting has been done. Metamorphic rocks are found in the upper part of the drainage and some prospecting has been undertaken. One adit, now inaccessible, has been driven for several hundred feet into a hard dense quartzite, as judged from the size of the dump. No information on any of these old workings has been obtained but, judging from the dumps, the mineralization is weak and valueless.

PLACER MINING

As in so many mining districts, the first work undertaken was the search for placer gold, and the streams were thoroughly combed. Most of the work was concentrated on Placer Creek and Bitter Creek, and apparently some placer production was obtained from these streams. Gold produced in this manner was probably taken to the nearby booming settlement of Elizabethtown, and no production has been recorded. Old diggings are extensive in the valleys of both Placer and Bitter Creeks, and apparently both of these streams were thoroughly worked. Placer Creek seems to have been idle for years, but some recent work has been done in Bitter Creek valley at the Big Five property and north of the Edison mine.

Some prospecting has also been done in the high-level Tertiary gravels. One shaft, in the top of the hill just west of Red River Pass, is said to have been sunk 135 feet deep without encountering bedrock. As far as it is known, the base of these gravels has not been thoroughly examined. Mineralization is considered to be earlier than the formation of the gravels, and the possibility of finding concentrations of gold in old channels cannot be completely dismissed.

BIBLIOGRAPHY

1. BURBANK, W. S., and GODDARD, E. N., Thrusting in Huerfano Park, Colo., and related problems of orogeny in the Sangre de Cristo Mountains: Geol. Soc. America Bull., vol. 48, no. 7, pp. 931-976, July 1937.

2. BUSH, F. V., Red River mining district, Taos Co., N. Mex.: Min. World, vol. 42, no. 12, pp. 541-543, March 1915.

3. BUTLER, B. S., Relation of the ore deposits of the southern Rocky Mountain region to the Colorado Plateau: Colo. Sci. Soc. Proc., vol. 12, pp. 23-36, 1929.

4. CABOT, E. C., Fault border of the Sangre de Cristo Mountains north of Santa Fe, N. Mex.: Jour. Geology, vol. 46, no. 1, pp. 88-105, January-February 1938.

5. CARMAN, J. B., Mining methods of the Molybdenum Corporation of America at Questa, N. Mex.: U. S. Bur. Mines Info. Circ. 6514, pp. 2-4, 1931.

6. ELLIS, R. W., The Red River lobe of the Moreno glacier: N. Mex. Univ. Bull. 204, geol. ser., vol. 4, no. 3, 26 pp., November 1931.

7. ELLIS, R. W., Glaciation in New Mexico: N. Hex. Univ. Bull. 276, geol. ser., vol. 5, no. 1, 31 pp., November 1935.

8. GRUNER, J. W., Geologic reconnaissance of the southern part of the Taos Range, New Mexico: Jour. Geology, vol. 28, no. 8, pp. 731-742, November-December 1920.

9. LARSEN, E. S., and ROSS, C. S., The R and S molybdenum mine, Taos County, New Mexico: Econ. Geology, vol. 15, no. 7, pp. 567-573, November 1920.

10. LASKY, S. G., and WOOTTON, T. P., The metal resources of New Mexico and their economic features: N. Mex. School of Mines, State Bur. Mines and Min. Res. Bull. 7, pp. 120-122, 1933.

11. LINDGREN, WALDEMAR, GRATON, L. C.., and GORDON, C. H., The ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, pp. 83-84, 1910.

12. LOVERING, T. S., Geologic history of the Front Range, Colo.: Colo. Sci. Soc. Proc., vol. 12, no. 4, pp. 59-111, 1929.

13. MELTON, F. A., The ancestral Rocky Mountains of Colorado and New Mexico: Jour. Geology, vol. 33, no. 1, pp. 84-89, January-February 1925.

14. NORTHROP, S. A., and others, Geologic maps of a part of the Las Vegas Basin and of the foothills of the Sangre de Cristo Mountains, San Miguel and Mora counties, New Mexico: U. S. Geol. Survey, Oil and Gas Investigations, Preliminary Map 54, 1946.

15. POWELL, W. C., Report on the investigation of the proposed dam sites on Red River, N. Mex.: N. Mex. State Engineer, 9th Bienn. Rept., pp. 91-96, 1930.

16. RAY, L. L., Glacial chronology of the southern Rocky Mountains: Geol. Soc. America Bull., vol. 51, no. 12, pt. 1, pp. 1851-1917, December 1940.

17. RAY, L. L., and SMITH, J. F., JR., Geology of the Moreno Valley, N. Mex: Geol. Soc. America Bull., vol. 52, no. 2, pp. 177-210, February 1941.

18. RAY, L. L., and SMITH, J. F., JR., Geology of the Cimarron Range, New Mexico: Geol. Soc. America Bull., vol. 54, no. 7, pp. 891-924, July 1943.

19. READ, C. B., and others, Geologic map and stratigraphic sections of Permian and Pennsylvanian rocks of parts of San Miguel, Santa Fe, Sandoval, Bernalillo, Torrance, and Valencia counties, north central New Mexico: U. S. Geol. Survey, Oil and Gas Investigations, Preliminary Map 21, 1944.

20. READ, C. B., and WOOD, G. H., Distribution and correlation of Pennsylvanian rocks in late Paleozoic sedimentary basins of northern New Mexico: Jour. Geology, vol. 55, no. 3, pt. 2, pp. 220-236, May 1947.

21. SUNDBERG, KARL, and NORDSTROM, ALLAN, Electrical prospecting for molybdenite at Questa, New Mexico: Am. Inst. Min. Met. Eng., Tech. Pub. no. 122, 13 pp., August 1928.

22. VANDERWILT, J. W., Geology of the “Questa“ molybdenite deposit, Taos County, N. Mex.: Colo. Sci. Soc. Proc., vol. 13, no. 11, pp. 599-643, 1938.

23. VANDERWILT, J. W., The occurrence and production of molybdenum: Colo. School of Mines Quarterly, vol. 37, no. 4, pp. 39-44, October 1942.

24. VAN DUST, E. C., and P. H., Notes on the geology of the western slope of the Sangre de Cristo Range in Costilla Co., Colo.: Colo. Sci. Soc. Proc. 5, November 1898.