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STRATIGRAPHY AND MINERALIZATION OF HELL CANYON GREENSTONE BELT (PRECAMBRIAN), NEW MEXICO

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INTRODUCTION

Precambrian greenstone belts long have been known to be associated with gold deposits, and in fact, most of the world's largest primary gold deposits are associated closely with greenstone belts (Anhaeusser and others, 1969). Other metals and minerals also are associated commonly with greenstone, including silver, chrome, nickel, asbestos, talc and magnesite. In view of the recent mining of gold near Hell Canyon (Woodward and others, 1978), a detailed investigation of this greenstone belt was undertaken, with emphasis on stratigraphy, petrology and mineralization.

Mapping for this project was at a scale of 1:8,000. Parchman mapped the northern half of the belt and performed some of the whole-rock chemical analyses for specimens from that area. Edwards mapped the southern half of the belt. Atomic absorption spectrophotometric analyses and some of the whole-rock analyses were performed by Husler. Stratigraphic sections were measured by Parchman and Woodward, and Edwards and Woodward in the northern and southern parts of the belt, respectively. The mineralization was studied by Woodward and this report written by him.

Previous work includes reconnaissance mapping by Reiche (1949) at 1:63,360 scale and generalized discussion of some of the rock units. Maps by Myers and McKay (1970, 1971) at 1:24,000 scale are similar to Reiche's map, but more generalized. A detailed description of the Milagros mine in the Hell Canyon district was presented by Woodward and others (1978).

GEOLOGIC SETTING

The Manzano Mountains form an eastward-tilted fault block that developed in late Cenozoic time on the east side of the Rio Grande rift (Kelley, 1977). Precambrian rocks are exposed along the western base of the mountains and are overlain unconformably by Paleozoic strata that cap the range. The western margin of the Precambrian exposure is terminated by normal faults that mark the eastern limit of the Albuquerque basin, a graben filled with several thousand meters of upper Cenozoic sediments (Woodward and others, 1975).

In the Manzano Mountains (fig. 1), the rocks of the greenstone complex are exposed mainly in an isoclinal, southwest-plunging anticline that is cut by northeasterly and northwesterly trending high-angle faults (fig. 2). In the southwestern part of the greenstone exposures near the intrusive contact with the Ojito quartz monzonite stock, there are east-trending folds in the greenstone.

The greenstone and related rocks, including metagabbro, metadiabase and metadiorite, underwent regional synkinematic metamorphism of greenschist facies. These rocks later were contact-metamorphosed adjacent to silicic dikes and other intrusions (not shown on fig. 2) with the grade of metamorphism locally reaching the hornblende-hornfels facies.

ROCK UNITS

In addition to greenstone and metatuff in the Hell Canyon area, there are three metasedimentary units informally designated units 1, 2 and 3. In ascending order, the stratigraphic sequence consists of: unit 1, consisting of 580 m of phyllite and quartzite with the base not exposed; a greenstone unit that probably is about 1,500 m thick; unit 2 which consists of at least 500 m of phyllite and quartzite, but locally is missing along an erosional unconformity near Hell Canyon; the Lacorocah Metatuff that ranges from a wedge-edge to 630 m thick; and unit 3, approximately 2,900 m of phyllite. The stratigraphic relations of these units are shown diagrammatically in Figure 3.

Precambrian rocks of the Ladron Mountains (Condie, 1976), Los Piflos Mountains (Stark and Dapples, 1946), south Manzano Mountains (Stark, 1956), north Manzano Mountains (Reiche, 1949), and southern Sangre de Cristo Mountains (Miller and others, 1963) include metamorphosed clastic sediments overlain by bimodal (rhyolitic and basaltic) metavolcanic rocks. The base of the metaclastic sequence is exposed only in the north Manzano Mountains, where metatuff and greenstone underlie the metasedimentary rocks of units 2 and 3. Thus, the oldest Precambrian rocks of the region appear to be exposed only in the north Manzano Mountains.

Figure 1. Index map.

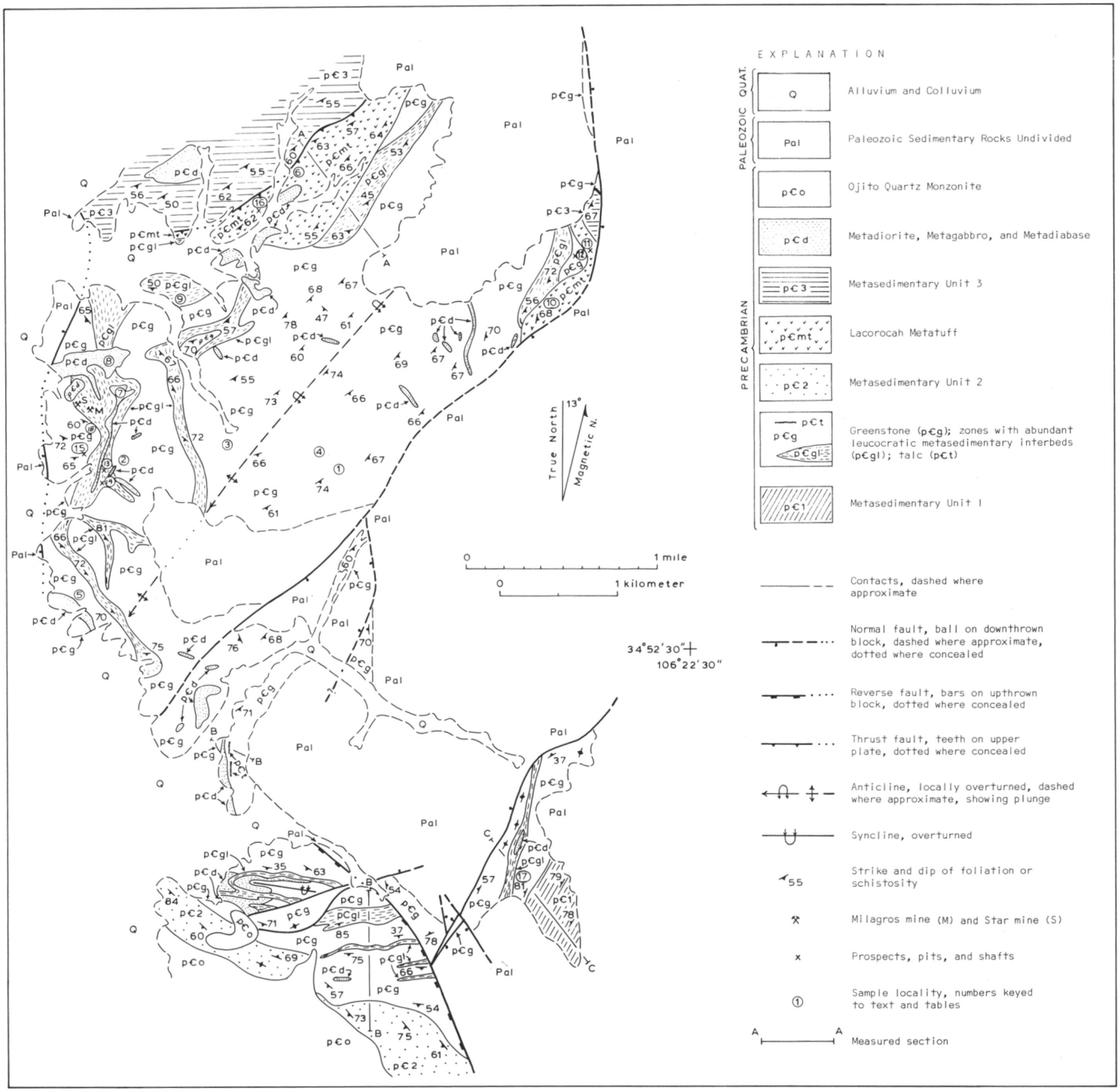

Figure 2. Generalized geologic map of Hell Canyon greenstone belt.

There are no radiometric dates on Precambrian rocks of the Manzano Mountains, but they generally have been considered to be Proterozoic. A gneissic rock from the southern Sandia Mountains was dated at 1,600 ± 60 m.y. using a Rb-Sr whole-rock isochron (Brookins, 1974). The stratigraphic relation of this gneiss to the rocks of this report is not known.

Unit 1

This unit is overlain by greenstone and its base is not seen. The exposed part of the unit is 580 m thick and mostly consists of phyllite and subordinate gritty, schistose metaquartzite with minor interbedded greenstone near the top.

Phyllites are light green, whitish and brownish gray with well developed schistosity parallel to compositional layering. They are composed of (in volume percent) clasts of silt-size subrounded to subangular quartz (25-40%) and sodic plagioclase (7-10%) in a matrix of well aligned sericite, chlorite and green biotite. In some beds, epidote and clinozoisite make up 30% of the matrix. Very small porphyroblasts of chlorite and green biotite occur sparingly in most of these rocks. Traces of pyrite, hematite and clastic tourmaline are present.

Brownish-gray, weakly schistose metaquartzites are poorly sorted and contain rounded to well rounded clasts up to 2.5 mm across. The rock consists of monocrystalline and poly-

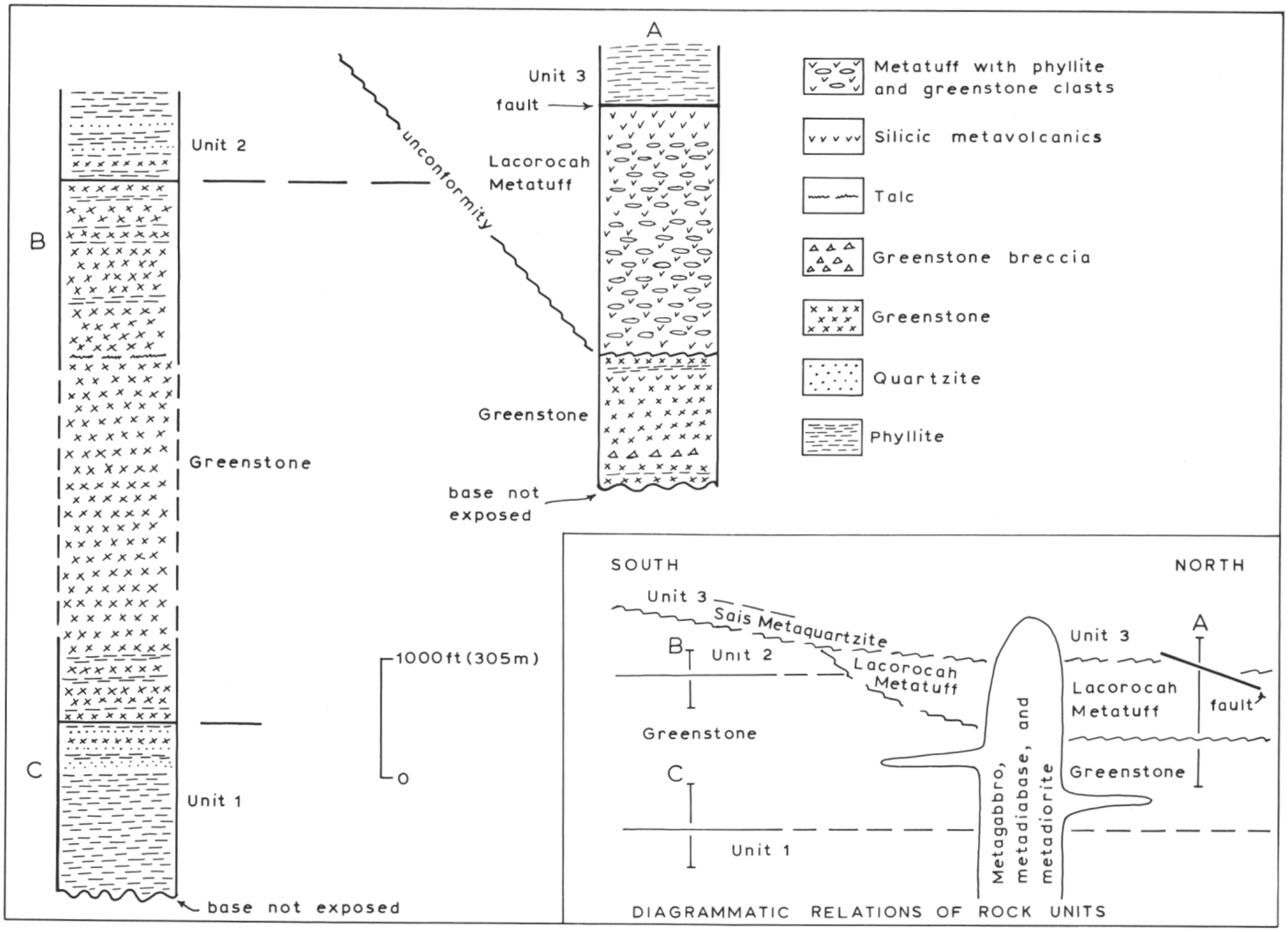

Figure 3. Columnar sections from Hell Canyon greenstone belt, with diagrammatic north-south sketch showing inferred stratigraphic relations of greenstone and associated rocks (inset). Letters show positions of columnar sections.

crystalline quartz (65-75%), sodic plagioclase (about 10%), sericite (15-20%), and accessory alkali feldspar, muscovite, chlorite and green biotite with traces of opaque minerals, tourmaline, apatite and zircon.

Near the top of this unit are two interbeds of weakly schistose greenstone, each about 1.5 m thick, that are composed of very fine-grained green hornblende (30%), chlorite (25%), sodic plagioclase (20%) and epidote (20%), with minor quartz and white mica. Their contacts parallel the compositional layering and schistosity of the metasedimentary rocks.

Seven graded beds, each 2.3 to 2.5 m thick, are present in the upper part of the unit. They fine toward the greenstone contact, grading from medium- and coarse-grained sand to silt- and clay-size particles. They are interpreted as fining-upward sequences indicating that the top of unit 1 is the contact with the greenstone. This contact is gradational and is placed where greenstone becomes the dominant lithology.

Parent rocks of the phyllites were shale, silty or sandy shale, and calcareous shale. Metaquartzite was derived from poorly sorted, argillaceous quartzose sandstone and the greenstone from mafic volcanic rocks.

This unit was not recognized by previous workers (Reiche, 1949; Myers and McKay, 1970), nor did they recognize the base of the greenstone.

Greenstone

This unit is estimated to be about 1,500 m thick. The basal 500 m and the upper 300 m are well exposed and in good stratigraphic order, but structural complexity and cover by younger strata make it difficult to obtain a precise measurement of the middle part of the greenstone sequence. The dominant lithology is massive, fine-grained greenstone (albite-epidote-actinol ite-hornblende hornfels) with subordinate greenstone breccia, chlorite phyllite, quartz-mica phyllite, argillite, metasiltstone, leucocratic metavolcanic rocks, and minor talc. Interbedded metasediments occur mainly in the lower and upper parts of the unit (fig. 3). The base and top of the unit are transitional with metasedimentary units 1 and 2, respectively, except where an unconformity has cut through metasedimentary unit 2 into the greenstone. At the latter locality, Lacorocah Metatuff rests unconformably on greenstone.

Massive greenstone consists of actinolite-hornblende (10-60%) in patchy intergrowths that are partly chloritized and biotitized, epidote or clinozoisite (5-35%), albite (5-40%) that is sericitized and saussuritized, and chlorite (10-30%). Minor sericite, opaque minerals, sphene and quartz commonly are present. In some of the greenstone, there is weak to strong schistosity marked by aligned chlorite, epidote and amphibole. Monolithologic greenstone breccia consists of angular massive greenstone clasts mostly 3-5 cm or rarely 20 cm across in a slightly finer-grained matrix; clasts and matrix have the same composition. The greenstones are all dark green on fresh surfaces and weather tan to brown. They mostly form slopes with fair to good exposures.

In the southern part of the greenstone exposure, there are occurrences of talc (fig. 2) in lenses 5-8 cm thick in two zones about 1 m thick each. The talc lenses are foliated and are enclosed by schistose greenstone. The zones are intermittently continuous for about 250 m along strike and are parallel with the greenstone except locally for about 0.5 m where the contact is sharply discordant. The lenses are composed of very fine-grained lepidoblastic talc (92%), actinolitic hornblende (6%) and opaque minerals (2%). The talc is interpreted to have been derived from ultramafic segregations within basaltic sills.

Chlorite phyllite, present throughout the unit as minor interbeds but more abundant in the upper part, consists mostly of fine-grained chlorite moderately aligned in the schistosity, with subordinate albite and epidote, and minor calcite, quartz and opaque minerals.

Metasedimentary interbeds include phyllite, argillite, metasiltstone and intraformational conglomerate. Phyllites and argillites are mostly light gray to tan and are composed of very fine-grained white mica with subordinate quartz, chlorite and feldspar. Minor epidote, metamorphic biotite and opaque minerals are commonly present, and in some specimens, epidote is a major accessory mineral. Except for argillite, these rocks have schistosity, mostly parallel to compositional layering. The intraformational conglomerate consists of elongate pebbles of light-colored phyllite and metavolcanic rocks in a phyllite matrix.

Leucocratic metavolcanic rocks that are interbedded with greenstone and metasedimentary rocks in the upper part of the unit are dacitic, and consist of blastoporphyritic sodic plagioclase and chloritized biotite in a matrix of extremely fine-grained sodic plagioclase, biotite, epidote, white mica, calcite and opaque minerals. A chemical analysis of one of these rocks (Table 1, no. 5) is similar to Nockolds' (1954) average dacite + dacite-obsidian.

Chemical analyses of massive greenstone (Table 1, nos. 1-4) are similar to Nockolds' (1954) average normal tholeiitic basalt. No relict pillows or amygdules were noted, but it seems likely that the massive greenstone, brecciated greenstone and foliated greenstone all were derived from tholeiitic parent rocks. Chlorite phyllite also appears to have formed by intense penetrative deformation of mafic volcanic rocks. The parent rocks of the metasediments were shale, siltstone and intraformational mudstone conglomerate.

Unit 2

This unit overlies and is transitional with the greenstone through an interval of about 200 m where metasedimentary rocks and greenstone are interbedded. The contact is placed at the base of where metasediments become the dominant lithology. Locally, two greenstone beds about 5 and 9 m thick occur approximately 100 m above the base of the metasedimentary unit. The top of unit 2 is an unconformity that cuts stratigraphically lower to the north where this unit is missing (fig. 3). To the south of the area of this report, the Sais Metaquartzite rests unconformably on unit 2 (Reiche, 1949, p. 1190). The maximum stratigraphic thickness of unit 2 cannot be determined, as the upper part is intruded by the Ojito stock (fig. 2). The lower 500 m are present between the greenstone and the Ojito stock.

Light-gray to bluish- and greenish-gray, fine- to medium-grained metaquartzite and subordinate muscovite and chlorite phyllite with minor greenstone make up the lower part of unit 2. Most metaquartzites are schistose and impure, containing clasts of quartz (40-50%), feldspar (up to 30%) and subordinate muscovite and chloritized biotite. Interstitial sericite, epidote, chlorite and green biotite appear to be metamorphic. Phyllites are composed of well aligned chlorite and muscovite with accessory silt-size quartz and feldspar. The metaquartzites were derived from argillaceous and calcareous, arkosic sandstone, and the phyllites from shale and mudstone. The greenstone interbeds are interpreted to have formed from basalt flows.

Lacorocah Metatuff

The Lacorocah Metatuff was named by Reiche (1949, p. 1188) for exposures along Hell Canyon where it rests unconformably on greenstone. Reiche considered the metatuff to be a member of the greenstone complex; however, we consider the metatuff to be a separate formation because of its distinc- tive lithology and stratigraphic relations. Maximum thickness of the metatuff is about 630 m in a measured section (fig. 3) where the top is a fault. Displacement along this fault is not known, but it is likely that the lower part of the overlying metasedimentary unit 3 has been eliminated tectonically. The metatuff thins southward and is absent at the southern end of the greenstone belt, probably as a result of having been de- posited in a topographic low.

Reiche (1949, p. 1187) considered the metatuff to be andesitic, but examination of 11 thin sections shows that the metatuff is mostly dacite and rhyodacite with only minor andesite. The metatuff is gray to light-greenish gray and contains abundant platy lithic fragments of phyllite, schist, greenstone and hematitic quartz 5 to 30 cm across (fig. 4). Most of the unit contains lithic fragments, with some beds made up of 60% inclusions, but near the top of the formation there are fewer lithic inclusions. The matrix around the fragments consists of blastoporphyritic sodic plagioclase (about 35%) and quartz (10-15%) up to 1.5 mm in diameter in a groundmass of extremely fine-grained sericite, sodic plagioclase and epidote, with minor chlorite and opaque minerals. Plagioclase ranges from albite to oligoclase. A minor variety of the metatuff is green and the matrix is composed mostly of saussuritized albite with minor sericite, epidote and opaque minerals; the parent rock was probably andesite.

The metatuff is moderately to strongly schistose with well aligned sericite and tiny elongate lenses of quartz and feldspar in the matrix. Larger grains of quartz and feldspar are partly porphyroclastic, being sheared, pulled apart and partly ground into mortar along the plane of schistosity. This schistosity is largely cataclastic and appears to be parallel to and superimposed on original primary igneous flow structure.

A chemical analysis of the metatuff (Table 1, no. 6) is similar to Nockolds' (1954) average rhyodacite + rhyodacite-obsidian, although the silica and lime are slightly higher and magnesia is slightly lower in this average. The metatuff is interpreted to have been a crystal-rich tuff containing abundant lithic fragments.

TABLE 1. Chemical analyses and molecular (modified CIPW) norms of Hell Canyon greenstone and related rocks. Numbered localities are shown on Figure 2. Analyses by Parchman indicated by * and analyses by Husler indicated by †

	Massive Greenstone				Metadacite	Metatuff	Metadiorite	Metamonzonite
	1*	2*	3*	4*	5*	6†	7†	8†
SiO_2	49.84	47.51	49.10	47.97	62.15	61.21	47.99	50.76
Al_2O_3	14.96	12.94	14.35	13.67	17.08	16.90	13.95	9.73
Fe_2O_3	3.91	3.49	5.55	2.64	2.70	7.61	5.03	2.69
FeO	7.47	10.12	8.35	10.11	1.77	0.34	9.42	5.59
MgO	5.50	6.40	5.33	7.60	1.49	3.45	6.03	15.65
CaO	11.32	10.49	7.17	9.22	4.45	0.90	10.08	5.65
Na_2O	2.60	2.33	3.22	2.83	3.67	3.78	1.74	1.33
K_2O	0.12	0.13	0.11	0.08	2.31	2.07	0.088	3.17
H_2O+	1.91	2.81	4.05	2.94	3.22	2.70	3.14	4.23
H_2O-	0.24	0.20	0.18	0.22	0.12	0.12	0.19	0.22
TiO_2	1.14	1.44	1.03	1.18	0.62	0.26	1.30	0.50
P_2O_5	0.09	0.10	0.07	0.08	0.23	0.082	0.104	0.183
MnO	0.17	0.26	0.21	0.26	0.07	0.112	0.232	0.155
SrO	0.01	0.01	0.01	0.01	0.06	0.021	0.014	0.025
TOTAL	99.28	98.23	98.73	98.81	99.94	99.56	99.31	99.88
Total Fe (as Fe_2O_3)	12.22	14.75	14.84	13.89	4.67	7.99	15.50	8.90
L.O.I.	1.10	1.75	3.22	1.83	3.11	2.67	2.12	3.01
FeO after L.O.I.	0.31	0.78	0.96	0.24	0.79	0.02	0.23	0.10
Q	3.65	1.24	4.84	0.0	20.01	23.59	6.15	0.0
Or	0.74	0.82	0.70	0.50	14.22	12.75	0.57	19.15
Ab	24.41	22.43	31.15	26.77	34.34	35.38	16.76	12.21
An	30.11	26.24	26.27	25.67	21.61	4.17	32.18	11.47
Co	0.0	0.0	0.0	0.0	1.07	7.94	0.0	0.0
Di	22.42	23.12	9.28	17.60	0.0	0.0	16.65	12.84
Hy	12.53	19.87	19.79	18.94	4.40	9.93	19.88	28.74
Ol	0.0	0.0	0.0	5.72	0.0	0.0	0.0	11.62
Mt	4.27	3.91	6.25	2.91	2.94	0.53	5.64	2.88
Il	1.66	2.15	1.55	1.73	0.90	0.38	1.94	0.71
He	0.0	0.0	0.0	0.0	0.0	5.18	0.0	0.0
Ap	0.20	0.22	0.16	0.18	0.50	0.17	0.22	0.38
Thornton-Tuttle normative differentiation index	28.80	24.49	36.70	27.26	68.57	71.71	23.49	31.36

Unit 3

This unit consists of tan, light-gray and light-green phyllites that are in fault contact with the Lacorocah Metatuff. The fault is about parallel to compositional layering and foliation in the metatuff and the metasediments, but probably has tectonically cut out some of the basal part of unit 3. Reiche (1949) estimated the thickness of this unit to be about 2,900 m. Reiche (1949), p. 1188) tentatively correlated this unit with the rocks we have mapped as unit 2, but noted that the unit might actually be stratigraphically higher than our unit 2.

The phyllites are composed of moderately to well aligned, extremely fine-grained sericite and chlorite with angular clasts of quartz and feldspar. The parent rocks were probably shale, mudstone and siltstone.

Metagabbro, Metadiabase and Metadiorite

These rocks occur as sills, dikes and small, irregularly shaped plutons that were intruded into the greenstone, metatuff and metasedimentary rocks prior to regional metamorphism. Greenschist-facies metamorphism resulted in changes in their

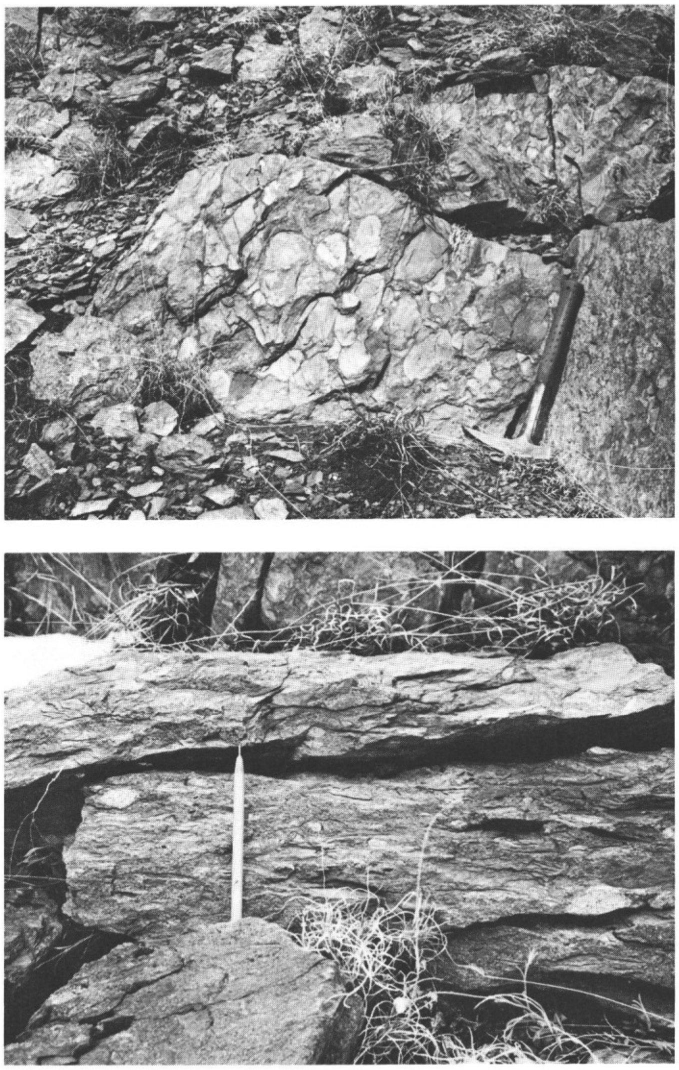

Figure 4. Lacorocah Metatuff with abundant lithic fragments exposed along plane of schistosity (above) and in cross section (below).

mineral assemblages, but locally discordant contacts, and relict minerals and textures indicate their intrusive origin.

Metagabbros range from massive to moderately foliated, with crystals 0.5 to 2.0 mm in diameter of actinolite and (or) hornblende (40-60%) after pyroxene, biotite (15-20%) after amphibole, chlorite (about 5%), sericitized and saussuritized sodic plagioclase (10-25%), anorthoclase (0-5%), and traces of quartz, sericite, sphene, apatite and opaque minerals. Calcite occurs locally as replacement of plagioclase.

Metadiabase has about the same mineral composition as the metagabbro but is finer-grained (0.5-1.0 mm) and has relict subophitic texture. Metadiorite consists of hornblende and subordinate actinolite (10-35%), saussuritized sodic plagioclase (35-55%), chlorite (2-20%), epidote (8-20%) mostly after plagioclase, with minor opaque minerals, quartz, sphene, apatite and rarely myrmekite. The normative minerals of a typical metadiorite (Table 1, no. 7) indicate that the rock could be classified as diorite based on the amount of mafic minerals present or gabbro using the anorthite content of the plagioclase.

A rock similar in mineral composition to the metagabbros has a chemical composition and norm (Table 1, no. 8) like that of a mafic monzonite or possibly a shonkinite.

MINERALIZATION

Greenstone is the host rock for gold, silver and copper deposits of the Hell Canyon mining district (Mardirosian, 1977). Northrop (1959) and File and Northrop (1966) included this district with the Tijeras Canyon district, the main part of which is about 22 km north of Hell Canyon. The principal mines and prospects are shown on Figure 2.

The vast majority of the recorded production from the Hell Canyon district is from the Milagros deposit and the adjacent Star claim, now held jointly with the Milagros. Reiche (1949, p. 1207) reported that the Milagros claim was patented in 1876, and in the 1880's and early 1900's produced 1,000 to 1,500 tons (910 to 1,370 M.T., respectively) of ore that yielded $5 per ton in gold. Shortly after 1910, the adjacent Star shaft produced 9 carloads of ore that averaged $10 per ton in gold and 9 to 28% copper. During 1975 and early 1976, the Milagros deposit was operated as an open-pit mine, and the gold was recovered by leaching an open heap with cyanide solution (Chisholm, 1975), with production of 2,348 ounces (6.7 x 104 gm) of gold and 3,333 ounces (9.4 x 104 gm) of silver having a total value of $338,604.00 (Woodward and others, 1978).

At the Milagros deposit, native gold occurs in a lenticular quartz vein emplaced along a shear zone striking northeast and dipping steeply to the northwest in the greenstone. The vein consists of microcrystalline brownish-red, white and tan quartz. The brownish-red quartz contains disseminated hematite and appears to have formed before the white and tan varieties as it is brecciated and infilled with white and tan quartz. Some of the white quartz has a sinter-like appearance. It seems likely that the Milagros vein is Precambrian, as the overlying Paleozoic strata in the vicinity are barren of quartz veins.

The native gold occurs as microscopic specks and as thin films along fractures in the vein. Seven atomic absorption spectrophotometric analyses of material from the vein indicate 0.023 to 0.145 ounce of gold and 0.13 to 1.23 ounces of silver per ton (0.7, 4.5, 4.0 and 38 gm/M.T., respectively) (Table 2). The silver-bearing mineral or minerals were not determined.

Iron-oxide staining, particularly near voids, and thin films of malachite, azurite and chrysocolla along fractures indicate that iron- and copper-bearing sulfides may be present in the vein below the zone of oxidation. Copper carbonates are also present as thin films along fractures in the greenstone immedi-

TABLE 2. Atomic Absorption Spectrophotometric Analyses of Vein Material from the Milagros Deposit, Hell Canyon District, New Mexico.

	Au oz/ton	Ag oz/ton	Cu ppm
Ocherous quartz	0.023	0.13	810
Brecciated red quartz	0.065	0.42	64
Dense brown quartz	0.138	1.23	520
Sintery tan quartz	0.145	0.66	604
Dense reddish quartz	0.024	0.22	328
Sintery white quartz	0.089	0.15	18
Dense reddish quartz	0.110	0.57	26

ately south ot the Milagros deposit. Native copper is a minor constituent in the vein.

The evidence suggests that the Milagros vein is of Precambrian age and that it was emplaced in a shear zone by hydrothermal replacement of greenstone with brownish-red microcrystalline quartz forming first, followed by brecciation and infilling by white and tan microcrystalline quartz. The ultimate source of the gold is not known, but it may have been derived by hydrothermal leaching of sheared greenstone.

Our analytical methods (atomic absorption spectrophotometry) are sensitive only for concentrations of gold greater than 68 ppb (0.002 oz/ton (0.06 gm/M.T.)); therefore, we detected only highly anomalous amounts of gold, as the average abundance in greenstone is probably below 5 ppb (Tilling and others, 1973). Our methods are not sensitive enough to determine average gold abundances in nonmineralized rocks. The limit for detectable silver is 680 ppb (0.02 oz/ton (0.6 gm/M.T.)).

Copper content in rocks that are not megascopically mineralized is as follows: 9-29 ppm for metatuff and other silicic metavolcanics; 7-19 ppm for metasedimentary rocks intercalated in greenstone; 66-75 ppm for metadiorite; 9-40 ppm for metagabbro; and 56-84 for greenstone.

Gold, silver and copper content for prospects and veins other than the Milagros are summarized in Table 3. Mineralization appears to be strongest in shear zones in the greenstone and in quartz veins emplaced in the shear zones. We favor a hydrothermal origin for the mineralization, with possible leaching of metals from the greenstone and deposition by ascending solutions.

Exploration in the area should be guided by detailed mapping of shear zones in the greenstone. A detailed study of the directions of sediment transport immediately above the unconformity at the base of the Paleozoic in combination with geochemical analyses might provided additional exploration targets for mineral deposits in the greenstone concealed beneath the Paleozoic strata.

TABLE 3. Atomic Absorption Spectrophotometric Analyses of Veins and Prospects, Hell Canyon Greenstone Belt, New Mexico. Numbered Localities are shown on Figure 2. Elements not detected indicated by n.d.

Locality	Description	Au oz/ton	Ag oz/ton	Cu ppm
9	quartz vein	n.d.	n.d.	15
10	quartz vein	n.d.	n.d.	8
10	quartz vein	n.d.	n.d.	5
11	quartz vein	n.d.	n.d.	15
12	sheared greenstone	0.24	0.12	404
12	sheared greenstone	0.009	0.04	416
13	quartz vein	n.d.	n.d.	15
13	quartz vein	n.d.	n.d.	5
14	sheared greenstone	n.d.	n.d.	218
14	sheared greenstone	0.02	0.09	516
15	quartz vein	n.d.	n.d.	22
15	quartz vein	0.063	0.09	72
16	quartz vein	n.d.	n.d.	6
16	quartz vein	n.d.	n.d.	9
17	greenstone	n.d.	0.035	540
18	quartz vein	0.46	0.80	n.d.

ACKNOWLEDGMENTS

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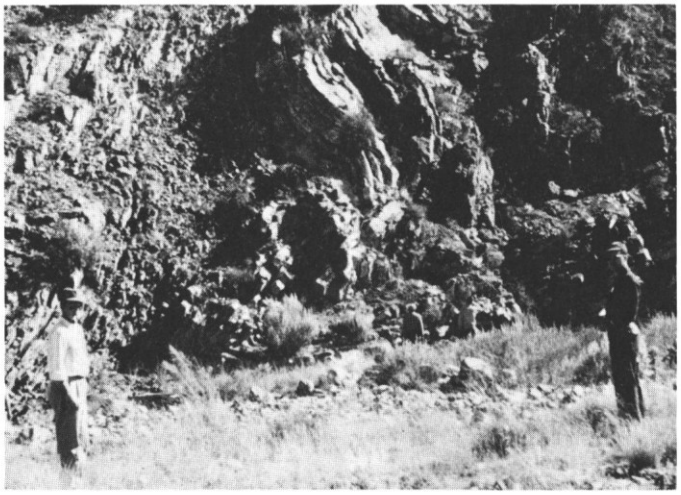
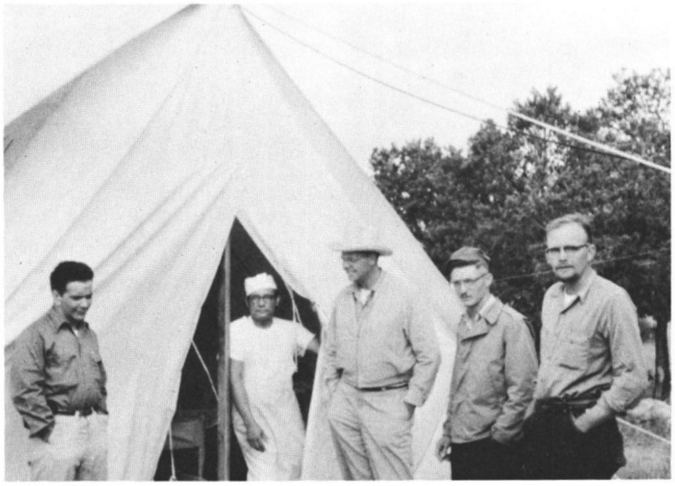
George Verville, Stanolind paleontologist, and Enos J. Strawn, Ray Blakely, Robin Lyons and Jim Momper, all Stanolind geologists, November 1955.—E. J. Strawn.



Ray Blakely and Jim Momper, Stanolind, at a contorted fault zone on east side of San Andres Mountains, November 1955.—E. J. Strawn.

THE LATE HOLOCENE



Hector Ugalde, Pemex geologist working for Fuels Branch on exchange program; Tony, camp cook; Ed Beaumont, camp instructor now consultant in Albuquerque; Paul — , USGS student geologist from Denver; Bob Harbour who was staying at the camp while working on the geologic map of New Mexico. USGS field geology training camp, Jicarilla Mountains near Ancho, New Mexico, August 1955. Photo taken by Philip Hayes, with a Kodak Pony 35. Phil is now retired from USGS and is a free-lance writer/photographer in Denver. Ed Beaumont relates an interesting story about a 7-foot long rattlesnake being dropped into his lap by Ray Becker.

Doug Kinney, Rocky Mountain Supervisor, Fuels Branch, USGS, Denver; Bob Harbour; Phil Hayes; and Charlie Read, Albuquerque Office Supervisor, Fuels Branch.—Phil Hayes