

# Geology and Geochemistry of the Cortez Gold Deposit, Nevada<sup>1</sup>

JOHN D. WELLS, LEE R. STOISER, AND JAMES E. ELLIOTT

## Abstract

Gold has been discovered recently at Cortez, Nevada, about 45 miles southwest of Carlin in carbonate rocks in a window of the Roberts Mountains thrust. The host rock consists of laminated to thin-bedded dark- to light-gray, silty dolomitic limestone and calcareous dolomitic siltstone in the upper part of the Silurian Roberts Mountains Limestone. These rocks contain sparse pyrite cubes and aggregates and some organic carbon. The rocks have been faulted and folded repeatedly during their complex geologic history. The gold is disseminated in a large zone where the rocks have been fractured and bleached and the pyrite oxidized. During oxidation the iron was redistributed, giving the rock a color ranging from light gray to dark red. The alteration zone envelops a 34-m.y.-old intrusive body of biotite-quartz-sanidine porphyry, which is also altered. No genetic relationship between the mineralization and the intrusive body is known. Silicification, iron-oxide staining, decalcification and, in extreme cases, dedolomitization generally accompanied the gold metallization, although any one of these phases of hydrothermal alteration may have been well developed without introduction of significant amounts of gold. Some clay alteration occurred in the igneous rock but none in the ore body. The gold is in micron-sized particles of native gold. Gold is mostly with silica between original silt grains and to a lesser extent in quartz-filled microfractures and hematite-goethite pseudomorphs after pyrite.

The gold was discovered during the examination of an arsenic-antimony-tungsten-mercury geochemical anomaly known in the area. Other gold deposits in north-central Nevada are associated with such anomalies.

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## Introduction

THE gold geochemical anomaly reported at Cortez, Nevada, in 1966 by the U. S. Geological Survey (Erickson and others, 1966) has been developed into an exploitable gold deposit. After intensive exploration by drilling, surface sampling, and geologic mapping, initially supervised by Lee Stoiser, a joint venture group announced, in a press release dated March 8, 1968, "... a presently measured ore reserve of approximately 3.4 million tons con-

<sup>1</sup> Publication authorized by the Director, U. S. Geological Survey.

taining 0.29 ounce of gold per ton. The deposit will be mined by open pit methods and processed through a mill of 1500 tons per day capacity." The Cortez joint venture group consists of American Exploration & Mining Co., The Bunker Hill Company, Vernon F. Taylor, Jr., and Webb Resources, Inc.

The purpose of this paper is to describe the geologic setting, mineralogy, and geochemistry of the Cortez disseminated gold deposit as now known. Some tentative conclusions may require modification as the extent of the deposit and the geologic and geochemical relations become more fully known.

*Acknowledgments.*—Geologists and chemists of the U. S. Geological Survey in addition to the authors contributed to this study. Robert P. Moragne and Robert D. Lupe were field assistants, Gordon H. Van Sickle and David J. Grimes gave guidance on chemical and spectrographic analysis, and Ralph L. Erickson gave us the advantage of his experience and judgment pertaining to geochemical exploration in general and to geochemistry at Cortez in particular. William C. Cheesman, Dennis Reith, and John J. Oberbillig of the American Exploration & Mining Co., conducted sampling, well logging, and geologic mapping and supervised the exploratory drilling on a day-to-day basis, thereby accumulating valuable data that were contributed to this paper.

### Geologic Setting of the Cortez Gold Deposit

The Cortez gold deposit is in altered Roberts Mountains Limestone of Silurian age exposed in a window (Cortez window) of the Roberts Mountains thrust near the south end of the Cortez Range in north-central Nevada about 65 miles southwest of Elko and about 55 miles south of the Carlin gold mine (Figs. 1, 2). Mining started in the Cortez district in 1863 (Emmons, 1910; Lincoln, 1923) and about \$14 million worth of ore has been produced.

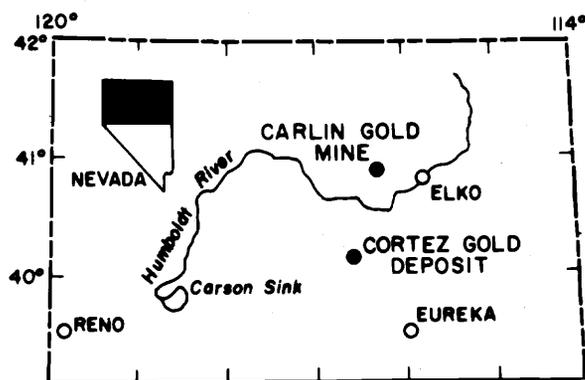


FIG. 1. Map showing the location of the Cortez gold deposit.

The early mining was for silver in veins and manto deposits in the Cambrian Hamburg Dolomite at the old Cortez silver mine (near center of Fig. 2). Silver-lead-zinc-copper-gold veins have been mined in the Wenban Limestone of Devonian age and in quartz monzonite of Jurassic age in the Mill Canyon area. Prospects for copper, zinc, and mercury are present in the upper-plate rocks nearby. The district has been relatively inactive since World War II.

The Gold Acres mine, where gold was mined from the Roberts Mountains thrust zone, is about 8 miles northwest of the Cortez gold deposit. About 7 miles to the east, gold occurs at the Buckhorn mine along a fault zone in Pliocene andesitic basalt flows.

The geology of the Cortez quadrangle is described by Gilluly and Masursky (1965) and the part of their geologic quadrangle map showing the Cortez mining district is reproduced here with some modification and simplification (Fig. 2). Only those rock units pertinent to the geologic setting of the gold deposit are discussed in this report. These are the Roberts Mountains Limestone and the Wenban Limestone exposed in the Cortez window, the Mill Canyon quartz monzonite stock east of the gold deposit, the Caetano Tuff and associated biotite-quartz-sanidine porphyry dikes and sills, the basaltic andesite flows, the rhyolite plug and flows of Horse Canyon. The basalt and rhyolite crop out just east of the area shown in Figure 2.

The Roberts Mountains Limestone, described by Gilluly and Masursky (1965, p. 25–29) is a laminated, black, silty graptolite-bearing limestone about 1,000 feet thick. The upper part is a thinly laminated, dark-gray to light-gray dolomitic siltstone, calcareous siltstone, and silty limestone (Fig. 3) that contain some carbon and locally show scour graded beddings, and crossbedding. Pyrite cubes and aggregates of cubes less than 6 mm across occur throughout the unit and show no genetic relationship to igneous bodies or mineralized areas. Generally the most abundant pyrite is in the coarser-grained silty layers. The pyrite cubes are euhedral and much larger than the silt grains, indicating that they were not introduced into the rock as detritus, and are likely diagenetic. The favorableness of the lower-plate carbonate rocks in general and the Roberts Mountains Limestone in particular for the occurrence of low-grade gold deposits in north-central Nevada has been noted in many recent publications (Roberts, 1960, 1966; Roberts and others, 1967; Hardie, 1966; Stewart and McKee, 1968; Erickson and others, 1961, 1966; Erickson, Masursky, and others, 1964).

The Wenban Limestone, described by Gilluly and Masursky (1965, p. 29–38), is massive to thin-bedded argillaceous, bioclastic, gray limestone that

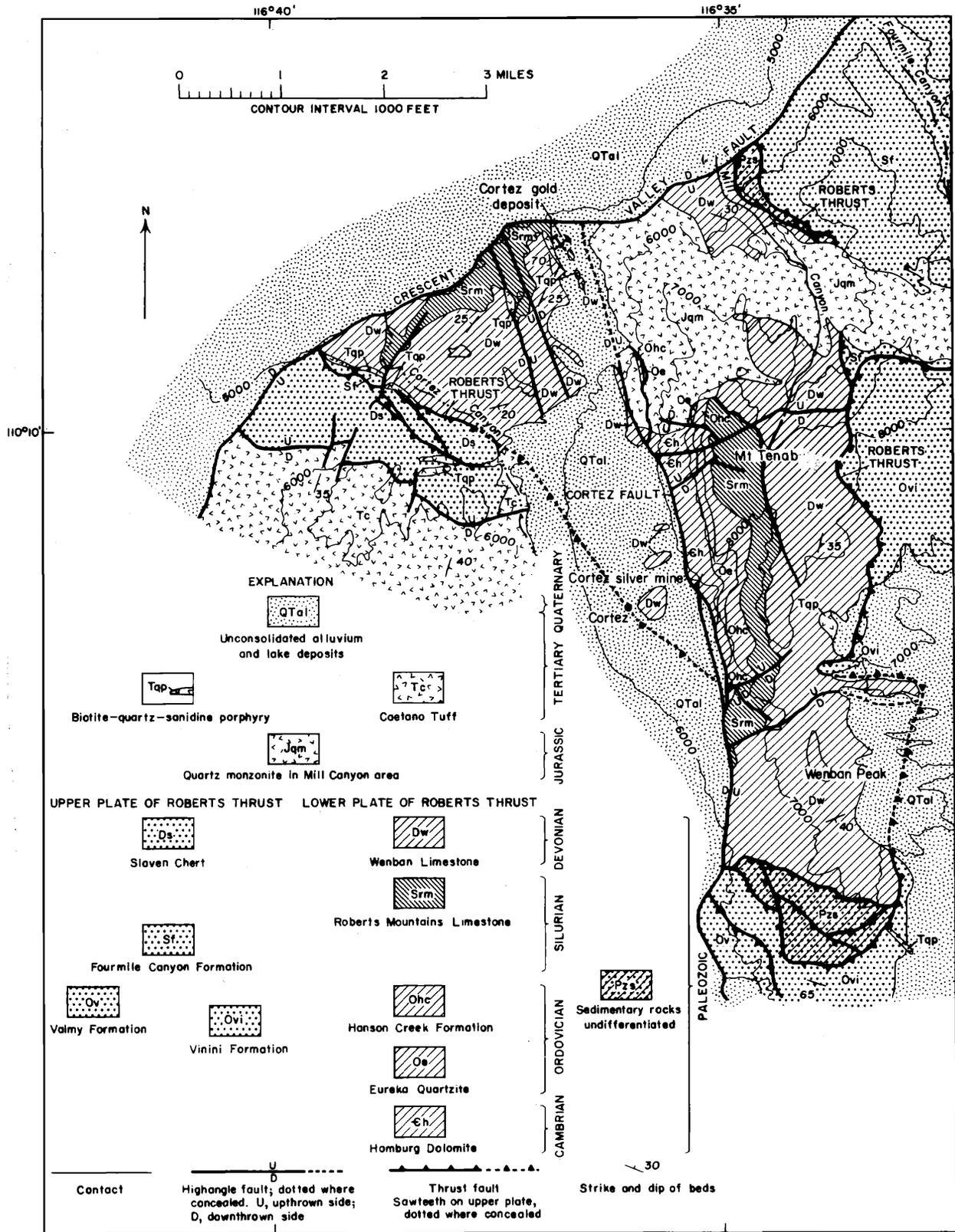


FIG. 2. Generalized geologic map of the Cortez district, modified from Gilluly and Masursky (1965).

is exposed through a thickness of about 2,900 feet. The lower part of the Wenban Limestone, 100 to 200 feet thick, is laminated to thin-bedded limestone, much like the Roberts Mountains Limestone, interbedded with medium-bedded and bioclastic limestone.

The contact between the Devonian Wenban Limestone and the Silurian Roberts Mountains Limestone is placed by Gilluly and Masursky (1965, p. 33) at the base of the lowest bioclastic limestone above the thin-bedded gray pyritic graptolite-bearing Roberts Mountains Limestone. Although they report that at Cortez and nearby mountain ranges the formations appear to be conformable, this is not true everywhere in north-central Nevada. At the Carlin mine (Hardie, 1966, p. 77) an unconformity appears to exist between the Roberts Mountains Limestone and an overlying limestone.

The Roberts Mountains thrust is the most prominent fault in the district. It is shown in Figure 2 separating the upper-plate siliceous rocks from the lower-plate carbonate rocks. A projection of the thrust would place it well above the Cortez gold deposit. Numerous small high-angle faults are present in the area but only the major ones—the Cortez fault with an offset of about 3,000 feet and the Crescent Valley fault with some 10,000 feet of offset—are shown (Fig. 2). The Crescent Valley fault offsets gravels in the valley and is undoubtedly still active. The significance of the Roberts Mountains thrust fault and the high-angle faults, particularly in the lower plate, as sites for the localization of ore deposits in north-central Nevada has been discussed by several authors (Roberts, 1960, 1966; Roberts and others, 1967; Hardie, 1966; Stewart and McKee, 1968; Erickson and others, 1961, 1966; Erickson, Masursky, and others, 1964).

Folding in the area has formed many anticlines and synclines but no regional pattern is known to exist. Near the Cortez gold deposit are many complex minor folds but the beds dip generally to the east or north.

Four periods of igneous activity are recognized by Gilluly and Masursky (1965). The earliest was the intrusion in Late Jurassic time of a quartz monzonite stock in Mill Canyon immediately to the east and possibly underlying the gold mine area (Fig. 2). Low-grade contact metamorphism occurred around the intrusive. The next igneous event was deposition of the Oligocene (?) Caetano welded tuff south of the Cortez window and intrusion of small bodies of biotite-quartz-sanidine porphyry, one of which is enveloped by the gold deposit (Fig. 2). Isotopic ages of the Caetano Tuff and the biotite-quartz-sanidine porphyry dikes are the same, 34 m.y. (J. D. Obradovich, written communication, 1967). These ages are in close agreement with the age of

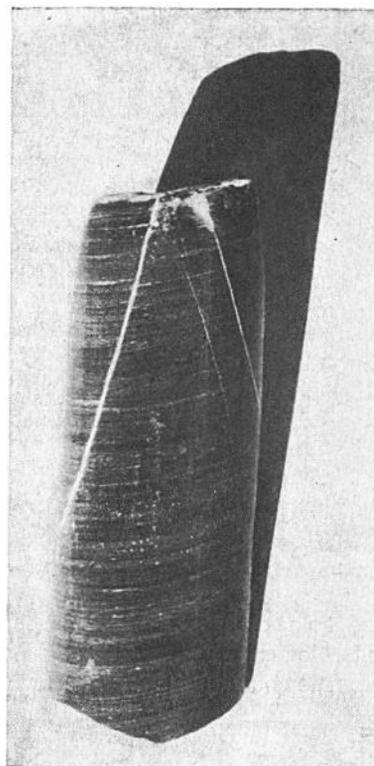


FIG. 3. Fresh dark-gray Roberts Mountains Limestone showing typical laminations and pyrite cubes (small bright specks on laminations).

31.5 m.y. for the Caetano Tuff reported by Gilluly and Masursky (1965, p. 78).

Basaltic andesite flows and associated dolerite dikes and younger rhyolite plugs, and flows northeast and east of the mapped area constitute the third and fourth periods of igneous activity. Both of these periods occurred in the Pliocene.

## Cortez Gold Deposit

### Discovery

The Cortez district has been one of several outdoor laboratories for research by the U. S. Geological Survey in geochemical exploration methods since 1959 (Erickson and others, 1961, 1966; Erickson, Masursky, and others, 1964). One result of this work was the discovery of anomalous amounts of arsenic, antimony, and tungsten in jasperoid and fracture fillings in the Wenban and Roberts Mountains Limestones (Erickson, Masursky, and others, 1964). About the same time the association of mercury, arsenic, antimony, and tungsten with gold in several mines such as Getchell, Bootstrap, Carlin and Gold Acres was recognized (Erickson, Maranzino, and others, 1964: *Engineering and Mining Journal*, 1966, p. 200). The recognition of this association prompted additional determinations for



FIG. 4. Discovery outcrop at Cortez showing the high-grade red breccia zone.

mercury and gold at Cortez after commencement of the U. S. Geological Survey's Heavy Metals program. Anomalous amounts of mercury (up to a few parts per million) and gold in amounts up to 14 parts per million (34 ppm = 1 oz/ton) in surface samples and up to 8 ppm in heavy mineral concentrates from drill cuttings were found in a new area along the mountain front northwest of the old silver mines. After it was determined that anomalous amounts of arsenic, antimony, tungsten, mercury, and gold were present in the new deposit at Cortez, 238 new rock samples were collected and analyzed for gold. Of these, 38 contained more than 0.3 ppm

Au, 5 contained between 34 and 102 ppm, and 2 contained more than 102 ppm. With the publication of this information (Erickson and others, 1966) the American Exploration & Mining Co., who had claims over the ground, started exploration with extensive surface sampling, core and rotary drilling, and geologic mapping that developed the discovery into the Cortez gold deposit.

The discovery outcrop of altered silty carbonate rock in the Roberts Mountains Limestone (Figs. 4 and 5) is red to gray. A fault breccia exposed in the outcrop contains more than 3 oz of gold per ton and is deep red. The altered rock is notably un-

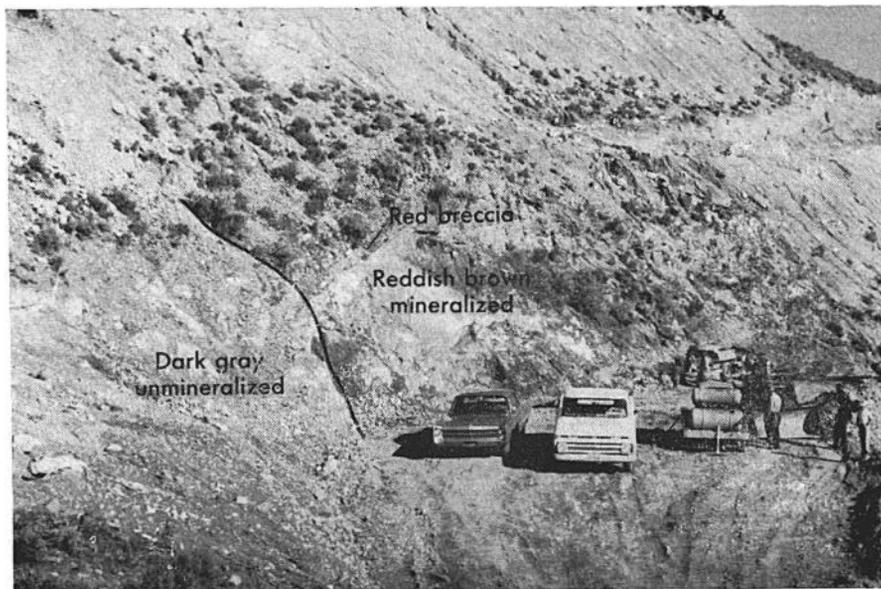


FIG. 5. Discovery outcrop after some development, showing the high-grade red breccia, reddish-brown mineralized rock and dark-gray unmineralized rock.

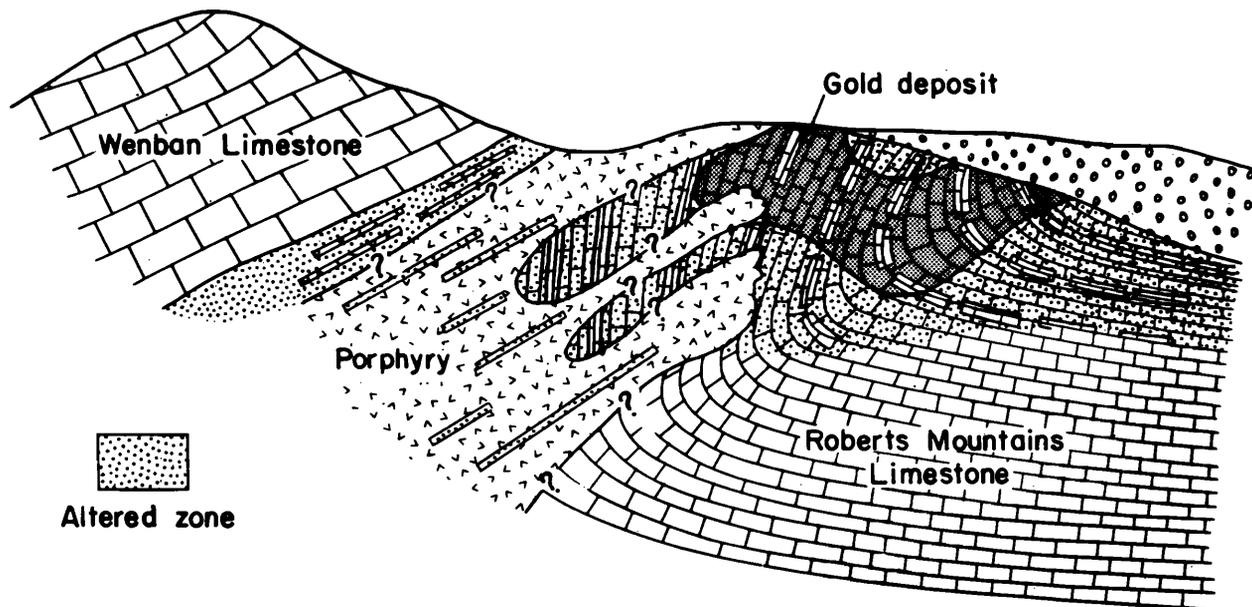


FIG. 6. Idealized cross section through the Cortez gold deposit from west to east showing rock units, gold deposit, alteration zone (the lower extent of which is unknown), and overlying gravels.

impressive in the field because it commonly weathers a reddish color, and similar deep-red unmineralized outcrops are common in this area. Undoubtedly many prospectors have panned the drainages without success because the gold is so fine grained that it cannot be recovered by panning.

#### *Position and Form*

The Cortez gold deposit is located where altered Roberts Mountains Limestone was faulted, brecciated, and folded along the margin of a Tertiary biotite-quartz-sanidine porphyry intrusive. Considerable crenulation of bedding, strong drag-folding, jointing, and cracking of the siltstone took place in this zone. The gold deposit clearly cuts across the bedding along the intruded front of a thick, sill-like mass of the porphyry (Fig. 6). Farther away from the intrusive, the deposit occupies only certain altered beds. Post-mineralization faults disrupt the ore zone and the Crescent Valley fault apparently offsets it.

#### *Alteration*

The normally dark-gray laminated siltstone beds (Fig. 3) of the Roberts Mountains Limestone have been variably leached and bleached by hydrothermal solutions over a very large area. The more calcareous Wenban Limestone was only slightly affected by the solutions, because most of the calcareous and carbonaceous material remain. These solutions were introduced after the emplacement of the porphyry sill, which itself has been bleached and altered to clay.

Hydrothermal bleaching, leaching, and oxidation were most intense in the highly fractured limestones. Alteration changed pyrite to iron oxide and mobilized minor amounts of the iron. The interface between fresh, dark-gray, unaltered rock and bleached rocks that are light gray to reddish gray is very sharp; on the bleached side there is a decrease of carbon and carbonate content and an increase in porosity (Fig. 7). The increase of porosity aided widespread introduction and emplacement of late chalcedonic silica, or jasperoid, resulting in the formation of a semi-brittle rock ranging in color from predominantly



FIG. 7. Gold-bearing bleached Roberts Mountains Limestone (light-gray area) separated from barren rock (black) by a white calcite-filled fracture.

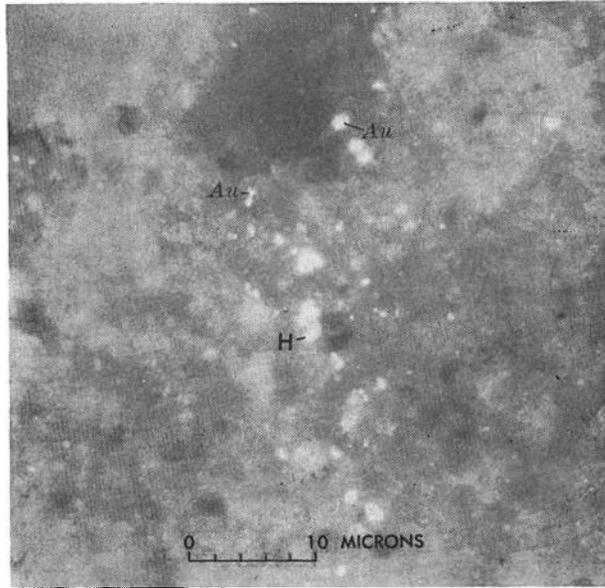


FIG. 8. Photomicrograph of gold particles (Au) with hematite (H) scattered through Fe oxide-stained silica between silt grains ( $\times 1,000$ ). The larger gold particle labeled is 1 micron across. The larger grains, one of which is labeled, are hematite.

light gray with some grayish brown to red brown. The grayish-brown variety breaks with a characteristic conchoidal fracture. The silica also cements or coats rock fragments.

Along breccia zones surface waters have removed part of the iron oxide from the pseudomorphs after pyrite and dispersed it through the altered light-gray to reddish-gray rock to give it colors that are predominantly brick red but vary to purple and yellow brown. Late post-ore coarse-grained white calcite

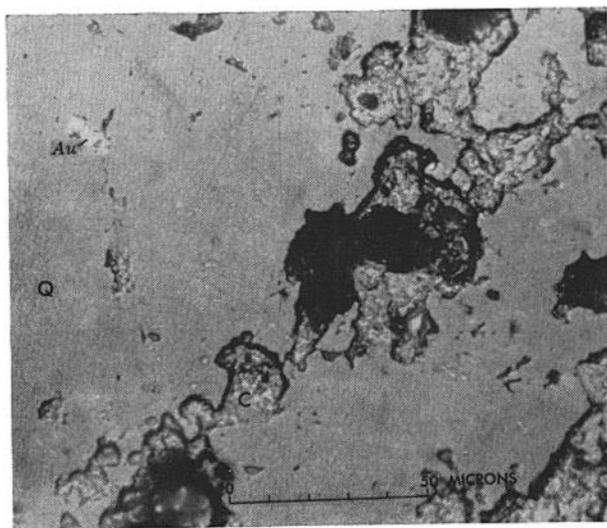


FIG. 9. Photomicrograph of gold (Au) in quartz veinlet (Q) with calcite (C) ( $\times 325$ ). The gold particle is about 8 microns across.

fills fractures and cements tectonic breccia within the silicified sedimentary rocks.

The silicified siltstone beds of the Roberts Mountains Limestone contain most of the gold, but not all silicified rocks are gold bearing, and relatively un-silicified rocks may contain significant values. The altered intrusive contains only trace amounts of gold except along its contact with altered siltstone, where values are higher. Fingers and lenses of silicified rock in the Wenban Limestone may contain minor amounts of gold.

#### Mineralization

The gold is in micron- to submicron-sized particles. Particles as large as 10 microns (0.010 mm) and as small as 0.5 micron have been observed in polished sections. Rarely, grains up to 0.1 mm have been seen. Laboratory studies by Gordon Van Sickle of the U. S. Geological Survey, in which gold particles were released by hydrofluoric acid leaching, show that measurable amounts of particulate gold pass 0.1 micron filter paper.

The gold occurs as: 1) clusters of particles between silt grains in siltstone (none was found in the original silt grains) (Fig. 8); 2) scattered grains in quartz veinlets (Fig. 9); and 3) individual grains in hematite-goethite pseudomorphs after pyrite (Fig. 10).

#### Geochemistry

In order to determine the chemistry of the original rocks, partial chemical analyses were made of samples of unmineralized Roberts Mountains Limestone and

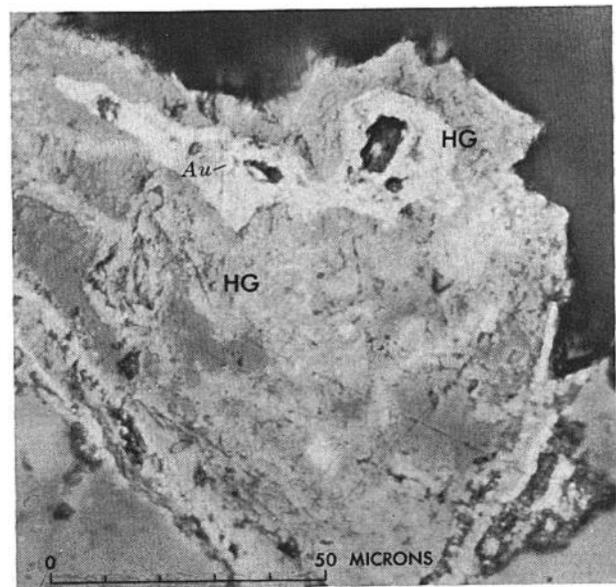


FIG. 10. Photomicrograph of gold particle (Au) in a hematite-goethite (HG) pseudomorph after pyrite ( $\times 400$ ). The gold particle is about 4 microns across.

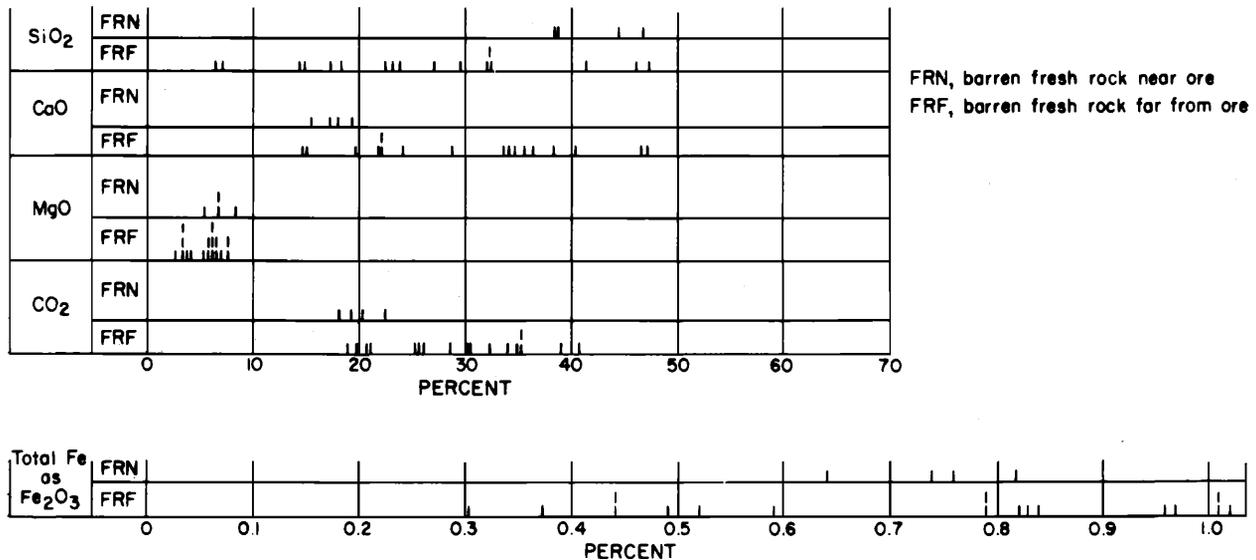


FIG. 11. Diagram showing the weight percent of SiO<sub>2</sub>, CaO, MgO, CO<sub>2</sub> and total Fe as Fe<sub>2</sub>O<sub>3</sub> in barren fresh rock adjacent to gold ore (FRN) and barren fresh rock far from ore (FRF). Analyses by G. T. Burrow, Johnnie Gardner, Wayne Mountjoy, and H. H. Lipp, U. S. Geological Survey.

lower part of the Wenban Limestone. These samples were collected south of Cortez, approximately 5 miles from the gold deposit. Another suite of unmineralized rock was collected near the gold deposit. The results of these analyses are shown in Figure 11. The wide range in composition of the rocks south of Cortez reflects the variable lithology of the rocks described earlier. The rocks with the most silica and magnesia and least lime are from the upper silty interval of the Roberts Mountains Limestone. The rocks collected near the deposit are from the upper part of the Roberts Mountains Limestone and are essentially the same composition as the corresponding rocks south of Cortez. The mineralized interval does not represent an unusual lithology in the Roberts Mountains Limestone although the rocks are relatively rich in silica and magnesia, poor in carbon dioxide and lime, and normal in iron.

Organic carbon is present throughout the Wenban and Roberts Mountains Limestones, but no correlation between variations in carbon content and the gold deposit was noted. Analyses by I. C. Frost of 12 samples show that the organic carbon content of the fresh Roberts Mountains Limestone and Wenban Limestone ranges from below detection limits (less than 0.05) to 0.25 weight percent. Gilluly and Masursky (1965, p. 26) report as much as 3 percent organic carbon from the Roberts Mountains Limestone. Five gold-bearing samples range from below detection limits (less than 0.05) to 0.08 percent organic carbon.

Analyses of unoxidized pyrite separated from barren unaltered Roberts Mountains Limestone (Table

1) show a wide range of metal content. Most of the samples were collected within a few thousand feet of gold-mineralized rock. Four samples were taken from south of Cortez, well away from mineralized rock. The samples were small, and therefore the possible analytical error was large and no duplicate determinations could be made to check values that appeared erratic. No significant difference is apparent between the metal content of the pyrite near the deposit and that distant from the deposit for any of the elements shown, based on this limited amount of information. The median values shown may be considered approximately representative of the entire suite of samples. The pyrite is probably the locus of most of these metals detected in the unaltered whole rock samples.

Estimates of the quantity of pyrite and in turn the quantity of gold in the Roberts Mountains Limestone can be calculated from the data in Figure 11 and Table 1. Virtually all of the iron in the unaltered host rock is in the pyrite. Calculations of original pyrite from the total iron content give values ranging from 0.45 to 1.80 percent pyrite with a median value of 1.19 percent. This median value is probably somewhat high because most of the samples were taken from pyrite-rich zones of the formation. A reasonable approximation of the pyrite content of the Roberts Mountains Limestone is about 1.0 percent. The gold content of the pyrite shown in Table 1 is 0.6 ppm; therefore, the gold content of the whole rock is about 0.006 ppm.

Chemical analyses of a suite of samples collected from an exploratory drift at 1-foot intervals along

Table 1.--Metal content of fresh pyrite separated from the Roberts Mountains Limestone

Element	Number of samples	Median (ppm)	Minimum (ppm)	Maximum (ppm)
Au	19	0.6	<0.02	38
Hg	11	0.5	0.19	>6
As	21	500	<500	1500
W	21	<50	<50	100
Ag	21	1	<1	100
Pb	21	70	<10	500
Cu	21	150	20	1000
Ni	21	300	100	1000
Co	21	200	50	1000
Cr	21	15	5	20
Sb	21	<200	<200	10,000

Analysts (U.S. Geological Survey):

J. M. Motooka, W. L. Campbell, R. L. Miller, H. D. King, E. L. Mosier,  
G. H. VanSickle, and S. M. Rickard

a single bed and across the contact of barren and ore-grade rock (Fig. 12) show a significant increase in silica (27 to 46 percent) and a decrease in lime

(26 to 18 percent) and carbon dioxide (29 to 22 percent). The lime and CO<sub>2</sub> contents of ore-grade rock are probably about 14 percent and 17 percent, respectively, because late barren calcite was contained in microfractures in the analyzed ore samples. Magnesia, alumina, and soda-plus-potash show small decreases. The total iron content shows little change and this suggests that the oxidized iron in ore was derived from original pyrite.

The gold content of fresh and slightly altered rocks is very low (less than 0.04 ppm) but the content increases sharply to a maximum of 46 ppm in the highly altered rock (Figs. 13, 14)—an enrichment factor of 1,200 over barren rocks. Rocks in the ore zone are particularly enriched in arsenic (up to 45 times) and mercury (up to 35 times) in relation to their concentration in adjacent barren rocks. Antimony and tungsten are enriched to a lesser degree (7 and 4 times, respectively). Although the copper and nickel values are very low, being less than the crustal abundance (Krauskopf, 1967) for these metals, they show some apparent enrichment. Barium and strontium show apparent depletion and probably are removed with lime and CO<sub>2</sub>. Lead, zinc and silver contents are low and show no significant change from barren rocks to gold-bearing rocks.

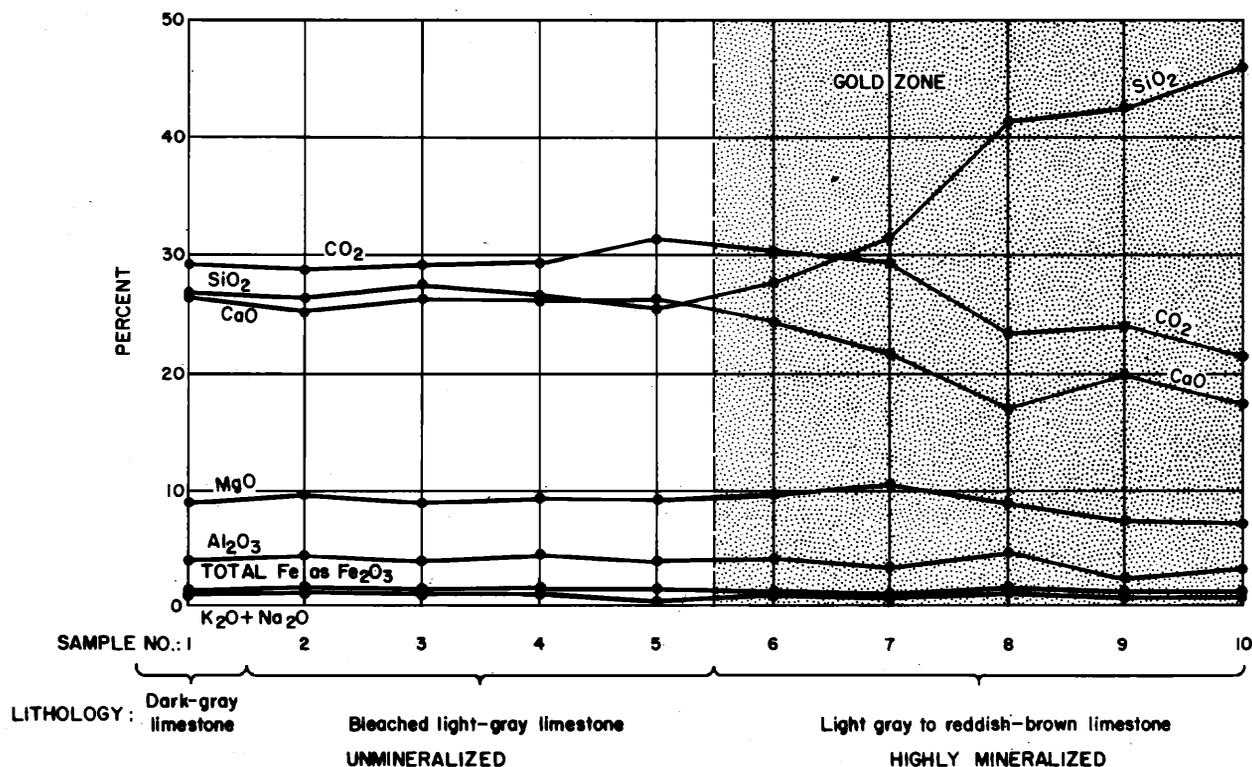


FIG. 12. Diagram showing variation in chemical composition of samples taken at 1-foot intervals along a bed from fresh unmineralized rock to highly mineralized rock. Analyses by Paul Elmore, Lowell Artis, S. D. Botts, G. W. Chloe, J. L. Glenn, James Kelsey, and H. Smith, U. S. Geological Survey.

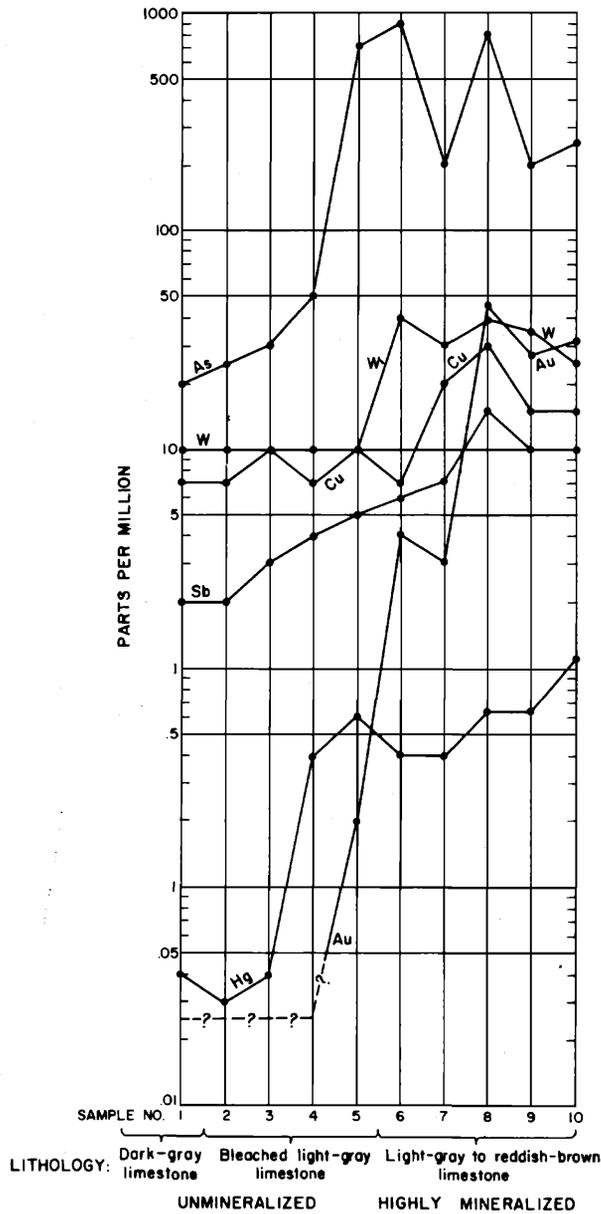


FIG. 13. Diagram showing variation in metal content of samples taken at 1-foot intervals along a bed from fresh unmineralized rock to highly mineralized rock. Queried dotted line indicates values below limit of sensitivity. Analyses by J. L. Finley, E. J. Fennelly, J. G. Frisken, J. A. Thomas, and Claude Huffman, U. S. Geological Survey.

Thus the elements that show most significant enrichment in the gold deposit and in relation to their crustal abundance are arsenic, mercury, antimony, and tungsten. These results support the reconnaissance geochemical results reported earlier (Erickson, Masursky, and others, 1964; Erickson and others, 1966).

The organic carbon in this suite of samples ranges from 0.4 percent in the fresh unmineralized to 0.04

percent in the oxidized mineralized rock (Fig. 14). In detail the variation in carbon content shows a close inverse relationship to the variation in the content of metals introduced during mineralization. The carbon seems to have been removed as the metals were deposited.

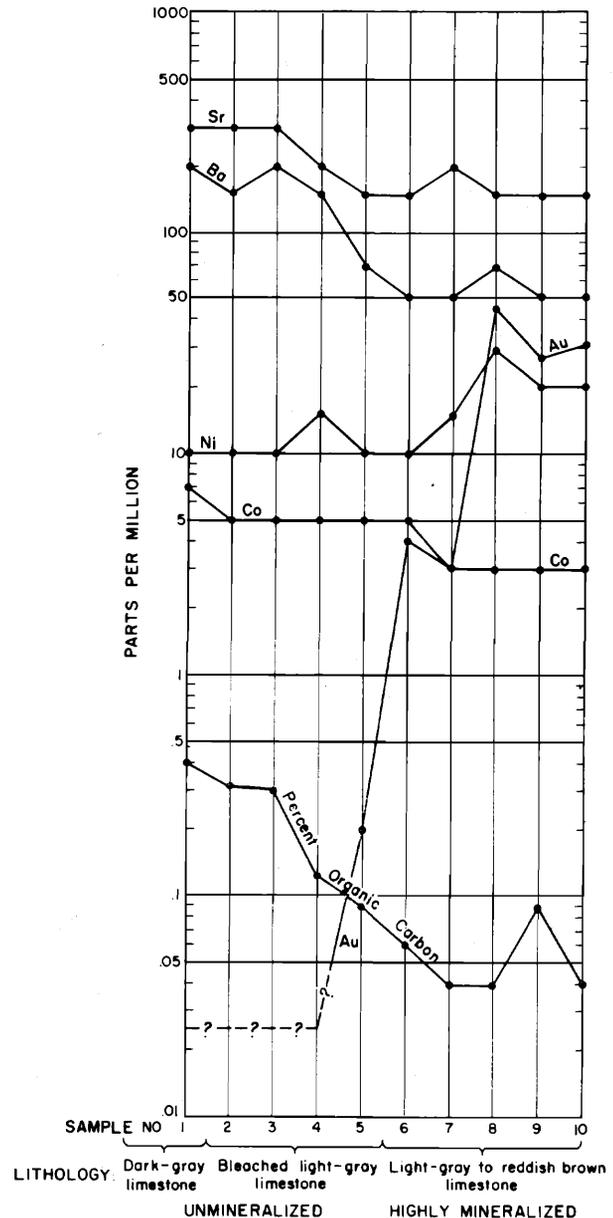


FIG. 14. Diagram showing variation in metal content of samples taken at 1-foot intervals along a bed from fresh unmineralized rock to highly mineralized rock. Queried dotted line indicates values below limit of sensitivity. Metal content shown as parts per million and organic carbon content shown as percent. Analyses by J. L. Finley, E. J. Fennelly, J. G. Frisken, J. A. Thomas, and Claude Huffman, U. S. Geological Survey.

### *Interpretations*

The ore controls at Cortez are difficult to determine at this time but certain interpretations can be made. The deposit is enveloped by a zone of hydrothermal alteration characterized by leaching and oxidation of pyrite and carbon in and near a zone of faulting, folding, and fracturing. The host rock is the upper part of the Roberts Mountains Limestone, a silty limestone and calcareous siltstone that is dolomitic and pyritic and contains carbon. Rocks of this stratigraphic interval and lithologic character are widespread in this area of the state but not mineralized everywhere and all altered rock does not contain ore.

At the Carlin gold mine 60 miles north of Cortez some gold occurs in unoxidized, carbonaceous, pyrite-bearing siltstone beds of the Roberts Mountains Limestone (Hardie, 1966). Hardie states (p. 80) that "the absence of carbon and pyrite from the major portion of the body is probably the result of oxidation." By contrast, gold has not been detected (except in pyrite separates described earlier) to date in unoxidized siltstone in the Cortez deposit. Bleached rock, encountered hundreds of feet below the deposit or laterally away from it, may be overlain by unaltered siltstone. This bleaching is believed to be the result of wide-ranging hydrothermal solutions, and not the effects of supergene alteration, which later affected the Cortez deposit. In the Cortez deposit carbon appears to have been removed during the hydrothermal phase and not during the more recent period of near-surface weathering.

The role of organic carbon in ore deposition at Cortez cannot as yet be determined. Carbon-bearing rocks are widespread but no ore is known in dark-gray unoxidized rocks, some organic carbon has been removed from the rocks in the ore zone. The carbonaceous Wenban Limestone immediately overlies the deposit but is barren; high carbon content, then, is not the dominant lithologic factor although it may be a contributor as is possibly the dolomite, silt content and/or pyrite in the host rock.

The presence of the hydrothermally altered zone and the addition of gold, mercury, arsenic, antimony, tungsten, copper, and nickel to the Roberts Mountains Limestone show that the metals in the Cortez gold deposit were likely carried by hydrothermal solutions from one of the igneous bodies nearby. It is difficult at this time to identify the igneous source rock. The deposit is possibly contemporaneous with and genetically related to the 34-m.y.-old biotite-quartz-sanidine porphyry at the deposit. It is also possibly younger and could be associated with rhyolite at Horse Creek and the gold mineralization at the Buckhorn mine, both of which are younger than the Pliocene andesitic basalt. The deposit, however,

appears to be older than the Crescent Valley fault.

The gold concentrated in this deposit is possibly at least in part derived from the auriferous pyrite found in the fresh host rock. If all of the gold had been leached by hydrothermal solutions from the surrounding rock, about 1,700 times as much rock as is present in the deposit would have been needed to be leached to produce the ore deposit with an average grade of 10 ppm (0.29 oz/ton).

### **Summary**

The Cortez gold deposit consists of minute disseminated particles of gold in a brecciated, faulted and folded, pyritic, dolomitic, silty, laminated limestone in the upper part of the Roberts Mountains Limestone in the same stratigraphic interval as at Carlin. The deposit post-dates an enveloped 34-m.y.-old biotite-quartz-sanidine porphyry sill and occurs where the rocks have been leached, bleached, oxidized, and silicified from an original dark-gray to various shade of brown and red, and light gray.

Small amounts of mercury, arsenic, antimony, and tungsten—metals normally found in hydrothermal veins—are associated with the gold. The gold occurs in micron- to submicron-sized particles in clusters in silica that replaces the original calcite and dolomite cement between silt grains.

Organic carbon appears to be present in only small amounts in both the mineralized rock and the fresh barren unaltered rock, and its distribution appears to be unrelated to the deposit. No clay alteration has been found in the limestone or mineralized area; clays are present in the oxidized biotite-quartz-sanidine porphyry.

The U. S. Geological Survey is currently engaged in an isotopic dating program on the igneous rocks; data also are being gathered on lead isotopes of igneous rocks, host rocks, and ores in an effort to trace geologic events in the area. A program to determine the distribution of sulfur, oxygen, and carbon isotopes relative to the mineralized rock is just starting. This research and more detailed study of the deposit and its environs should provide more definite answers on the origin and geologic setting of this important deposit.

J.D.W. AND J.E.E., U. S. GEOLOGICAL SURVEY,  
DENVER, COLO.,

L.R.S., AMERICAN EXPLORATION AND MINING CO.,  
SAN FRANCISCO, CALIF.,

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