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GEOLOGY OF THE VERA CRUZ MINE AND BRECCIA PIPE, LINCOLN COUNTY, NEW MEXICO

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Abstract—The Vera Cruz mine occurs in a hypabyssal breccia pipe that intrudes a sandstone and shale sequence in the Upper Cretaceous Mesaverde Group. The sedimentary rocks are gently domed by mid-Tertiary alkalic sills and the pluton which forms Vera Cruz Mountain. Near the intrusive contact, the shale and sandstone have been metamorphosed to hornfels and quartzite. Alignment of faults, alkalic intrusive rocks and dikes of the Capitan dike swarm suggest that a N20°E-trending structural zone exists. This zone is intersected by the east-west trend of the Capitan pluton and Jones Camp dike. The Vera Cruz breccia pipe formed at the intersection of local fault zones with trends similar to the regional structures. The breccia zone is 200 m long and up to 60 m wide on the surface. Distribution of breccia within the underground workings suggests the breccia zone widens with depth. Drill results suggest a southerly plunge to the mineralized portion of the pipe. Breccia fragments are angular to subrounded, clast supported and composed of highly altered fragments of sandstone, shale and intrusive rock. Much of the breccia zone is highly argillized with little pore space; however, the central mineralized portion is highly silicified and is more permeable. Gold mineralization occurs as fine grains in the upper, oxidized portion of the pipe. Gold values range up to 5.43 oz/ton from samples taken in the underground workings. The inclusion of altered intrusive fragments in the breccia together with the absence of crosscutting dikes and veins suggests that the formation of the breccia and subsequent mineralization were the latest hydrothermal-intrusive events in the Vera Cruz area.

INTRODUCTION

The Vera Cruz mine is located at the north end of the Nogal mining district in south-central Lincoln County, New Mexico, 18 km east of Carrizozo. Geology and mineralization of the Vera Cruz property are described in several reports, including Naramore (1907), Henderson (1908, 1909), Lindgren et al. (1910), Griswold (1959), Ryberg (1991) and unpublished company reports by F. C. Bowman (1938), C. F. Bauer (1974) and S. G. Zahony (1980).

MINING HISTORY AND PRODUCTION

Gold mineralization in the Vera Cruz area was probably discovered in the early 1880s, and the Vera Cruz claim was surveyed for patent in 1889. The Vera Cruz mine is first referenced in Mineral Resources of the United States for the period 1907–9 (Naramore, 1907; Henderson, 1908, 1909). These reports described the construction of a cyanide mill to process the ore after amalgamation had proved unsuccessful. L. C. Graton (Lindgren et al., 1910, p. 178) visited the mine in 1910 and reported that the workings consisted of a 700-ft tunnel and an open cut. He described the breccia zone as being 900 ft long and 120 ft wide. L. Vega, Sr. (personal comm., 1984), who worked as a miner at the Vera Cruz in 1914 and 1915, was again employed there in 1933 when the lower adit was being driven in an attempt to intersect the mineralized zone about 220 ft below the upper workings.

Production records are sparse or nonexistent. Griswold (1959, p. 51) estimated production at 50,000 tons based on the size of the workings. In 1938 F. C. Bowman mapped, sampled and prepared a report including ore reserve estimates for the Carrizozo Mining Company. Bowman's estimate of gold reserves is listed in Table 1.

The property lay idle until 1974 when GeoSurveys Inc. optioned the claims and carried out a limited magnetic and resistivity survey in the mine area. They concluded that the diameter of the breccia pipe increased with depth and drilled 12 vertical rotary holes the following year. Hole VC-2, located 16 ft south of the glory hole, encountered a 50-ft zone at a depth of 350 to 400 ft that averaged approximately 1% Cu. S. G. Zahony (unpubl. report for Armco, Inc., 1980) reported that microscopic examination of drill cuttings from this interval showed that the copper mineralization occurs as secondary chalcocite that coats abundant pyrite cubes. Hole VC-12, located 66 ft south of VC-2, intercepted a 10-ft zone from 330 to 340 ft deep that averaged 0.63 oz/ton Au. Shortly after the completion of the drilling program, GeoSurveys dropped the property.

S. G. Zahony (unpubl. report for Armco, Inc., 1980) discussed the results of geologic mapping, surface and underground sampling, and results encountered in two diamond-drill holes. Zahony noted the similarity to the Parsons breccia pipe, located 26 mi southwest (sec. 24, T9S, R11E), where deep drilling had encountered a 300-ft intercept that averaged 0.24% MoS_2.

TABLE 1. Vera Cruz mine ore reserve calculations by F. C. Bowman (unpubl. company report for Carrizozo Mining Company, 1938).

	Tons	Gold oz/ton
Assured ore	207,450	0.14
Probable ore	435,000	0.12
Possible ore	934,000	0.12

The first Armco drill hole on the Vera Cruz property was drilled to a depth of 1757 ft to test the root zone of the breccia pipe for molybdenum mineralization. Neither the root zone nor molybdenum mineralization were encountered. Instead, the drill hole penetrated 628 ft of faulted quartzite and hornfels cut by felsic and mafic dikes. At 628 ft the drill hole entered an aplitic quartz monzonite and stayed in the same rock type to the bottom of the hole. The second drill hole was angled to test the breccia zone below the underground workings. This hole intercepted a breccia zone in which a 50-ft intercept averaged 0.01 oz/ton Au. At this point Armco decided to drop the property.

A sampling program was undertaken by B & B Mining Company during August 1983 as a means of checking Bowman's 1938 results. A total of 122 samples with an average weight of 10 lbs were taken from the underground workings (Table 2). The samples were fire as-

TABLE 2. Average grade of gold in oz/ton from silicified vs. argillically altered portions of the Vera Cruz breccia pipe. Analytical results determined by fire assay.

ZONE	NUMBER OF SAMPLES	AVERAGE GRADE OZ/TON GOLD
ARGILLIC	64	0.005
SILICIFIED	58	0.146

sayed for gold and silver by Iron King Assay Office of Humboldt, Arizona. While assay values for individual sample intervals did not always match, the averaged assay results from this program closely matched Bowman's results in the stoped area below the glory hole. B & B Mining Company's assay results failed to duplicate Bowman's higher assay values along the haulageway away from the stoped area. Variations in sample values may be due to nugget effect as at least part of the gold occurs as visible grains in samples taken from the underground workings.

GEOLOGY

Regional setting

The Vera Cruz area is located at the intersection of two major crustal features that have influenced sedimentation and uplift since the Paleozoic (Thompson, 1991, p. 99). The Lincoln County porphyry belt (Kelley and Thompson, 1964, p. 114), which trends slightly east of north in the Vera Cruz area, is intersected by the east-west trend of the Capitan pluton and the Jones Camp dike (Fig. 1). Intrusive rocks of the Lincoln County porphyry belt are generally porphyritic and are monzonitic or syenitic in composition, whereas the Capitan pluton was described as a microgranite (Kelley and Thompson, 1964, p. 114).

Local geology

Stratigraphy

The Upper Cretaceous Mesaverde Group consists of white, gray, yellow and buff sandstone and gray shale (Griswold, 1959). In the Nogal-Capitan area, the Mesaverde Group consists of a lower sandstone unit, a middle shale unit and an upper sandstone unit with a total thickness of approximately 500 ft. In the Vera Cruz area, sandstone and shale units of the Mesaverde Group have been gently domed by the Vera Cruz laccolith. In the vicinity of the intrusion the sandstone and shale have been metamorphosed to quartzite and hornfels, respectively.

Intrusive rocks

The Vera Cruz laccolith is a fine-grained, hypabyssal, felsic intrusion. It was described by Griswold (1959) as an alaskite and by Thompson (1991) as a trachyte. Sample 4676, collected near the top of Vera Cruz Mountain, is fined grained and is composed primarily of alkali feldspar and quartz (Table 3). Using the classification of Streckeisen (1979), this sample plots in the rhyolite field near the intersection of fields for alkali rhyolite, rhyolite, quartz alkali trachyte and quartz trachyte. Chemically, Sample 4676 (Table 4) is slightly peraluminous, subalkalic, and plots on the boundary between trachyte and rhyolite (Fig. 2; Macdonald and Katsura, 1964; Le Bas et al., 1986).

The Vera Cruz intrusion is more silicic and less porphyritic than intrusive rocks in the Jicarilla Mountains (Ryberg, 1968; Segerstrom and Ryberg, 1974; McLemore et al., 1991, this volume). The texture and composition of the Vera Cruz intrusive rock may be more similar to the Capitan pluton than to porphyritic rocks found to the north along the Lincoln County porphyry belt.

Dikes observed on the surface in the Vera Cruz area are intermediate to mafic in composition and intrude both the Mesaverde sediments and the Vera Cruz laccolith. Sills are fine-grained felsic rocks, which megascopically appear to be similar in composition to the Vera Cruz laccolith. Dikes and sills noted by S. G. Zahony (unpubl. report for Armco, Inc., 1980) in drill hole VCD-1 range from rhyolitic to dioritic in composition. The trend of the dikes observed on the surface is N20°E, which corresponds to the orientation of the Capitan dike swarm described by Elston and Snider (1964, p. 140).

TABLE 3. Modal analysis of Sample 4676 from Vera Cruz intrusion.

Sample no.	4676 Fresh modal vol. %
Quartz	20
Orthoclase/Perthite	65
Plagioclase	12
Biotite	2
Magnetite	<1
Apatite	<1
Sphene	<1
Zircon	<1

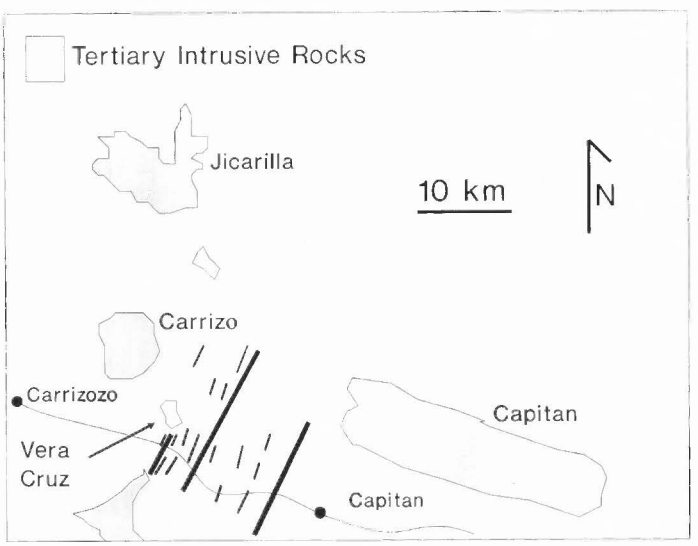

FIGURE 1. Location map and tectonic setting for the Vera Cruz area.

TABLE 4. Chemical analyses of samples taken from the Vera Cruz mine area. Sample 4676 is unaltered intrusive rock from the Vera Cruz laccolith. Sample 4677 is altered equivalent.

Sample no.	4676 Fresh	4677 Altered	Analytical Technique
SiO_2	69.50	86.20	D. C. Plasma
Al_2O_3	14.40	3.82	D. C. Plasma
Fe_2O_{3total}	2.14	2.09	D. C. Plasma
MnO	0.07	0.01	D. C. Plasma
MgO	0.34	0.27	D. C. Plasma
CaO	0.44	0.23	D. C. Plasma
Na_2O	4.32	0.20	D. C. Plasma
K_2O	5.65	1.27	D. C. Plasma
TiO_2	0.38	0.73	D. C. Plasma
P_2O_5	0.23	0.17	D. C. Plasma
LOI	0.77	2.44	Gravimetric
Total	98.24	97.43	
BaO	0.13	0.07	D. C. Plasma
Cr_2O_3	0.01	0.02	D. C. Plasma
S_{total}	0.03	0.12	Leco

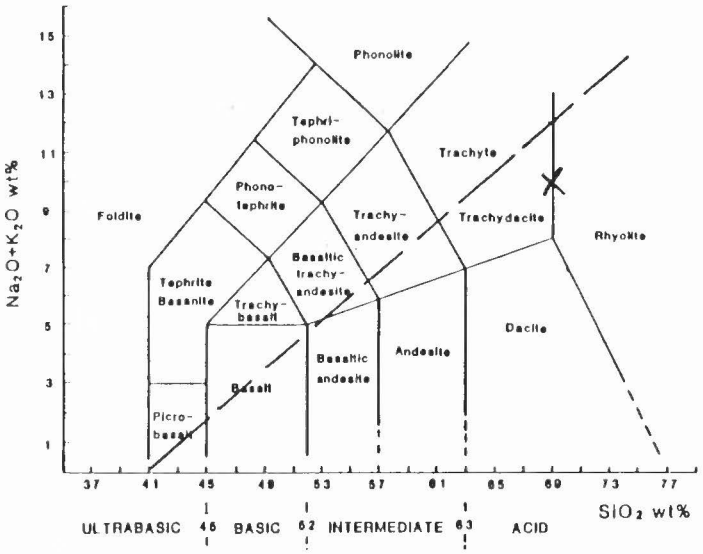

FIGURE 2. Alkali vs. SiO_2 diagram for Sample 4676 taken from the Vera Cruz laccolith. Classification scheme from Le Bas et al. (1986). Long dashed line is alkalic-subalkalic line from Macdonald and Katsura (1964).

Structure

In the Vera Cruz area, steeply dipping faults trending N20°E are intersected by a near-vertical fault that has an east-west strike. The Vera Cruz breccia pipe may have formed in a zone of weakness at the intersection of these faults.

Breccia pipe

The Vera Cruz breccia pipe (Fig. 3) is hosted in sediments of the Mesaverde Group near the south edge of the Vera Cruz laccolith. The east-west dimension is approximately 200 m and the zone is approximately 60 m wide near the east end. Distribution of breccia in the underground workings indicates that the zone widens with depth.

The contact between the breccia and the surrounding Mesaverde Formation is variable. Post-breccia faults bound the breccia zone on the south, in part of the underground workings, and along the east side of the glory hole. Elsewhere, there is a more gradual change as brecciation becomes less intense, evidence of rotation of fragments is less evident, and faulting is less intense and more widely spaced, until the transition to relatively undisturbed Mesaverde Group is complete.

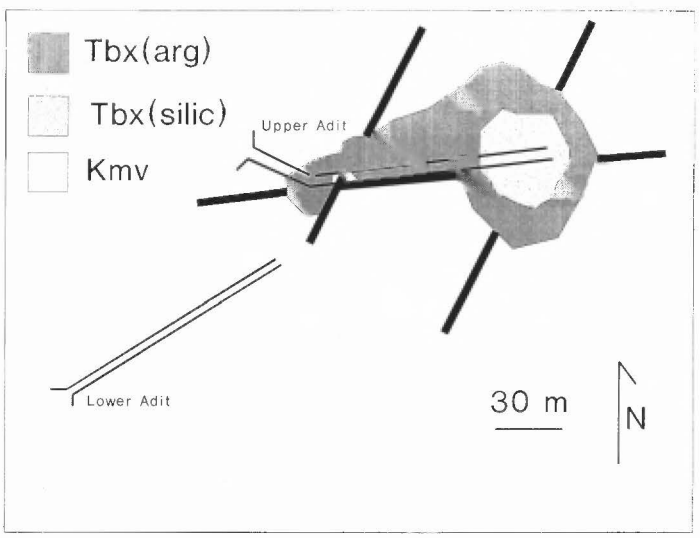

FIGURE 3. Geologic map of the Vera Cruz mine area illustrating the relationship between pre-breccia faults and the breccia pipe. Vera Cruz laccolith lies just north of map.

The breccia consists of angular to subrounded fragments of highly altered sandstone, shale, and both porphyritic and equigranular intrusive rock. Fragment size ranges from less than 1 mm to more than 1 m. Fragments are clast supported and much of the matrix probably consists of rock flour derived from the same rock found in the clasts.

The breccia has been intensely argillized and sericitized throughout. Much of the breccia zone appears to have little porosity or permeability. However, the central part of the breccia pipe is highly silicified, but apparently is more open and permeable than the rest of the breccia zone. In this area, the rock is friable and drusy quartz crystals line open spaces in the breccia.

MINERALIZATION

Results of a sampling program carried out for B & B Mining Co. (G. E. Ryberg, unpubl. report for B & B Mining Co., 1983) indicate that ore-grade gold mineralization is limited to the central, silicified portion of the breccia pipe. Gold concentrations range up to 5.43 oz/ton in the silicified zone, but are generally less than 0.01 oz/ton in the relatively unsilicified part of the breccia zone (Table 2). Limonite and hematite are abundant in the glory hole and in the underground stopes. Generally, areas with a higher concentration of iron oxide have higher gold values. Abundant pyrite casts suggest that much of the iron oxide is probably derived from pyrite, and that the pyrite was deposited at the time of the gold mineralization.

Drill results (S. G. Zahony, unpubl. report for Armco, Inc., 1980; J. W. Cole, personal comm., 1991) indicate that the mineralized zone plunges to the south. The same sources indicate that the sulfide zone begins at 350 ft and that the zone from 350 to 400 ft contains 1% copper. Results of recent drilling (Danielson, 1991) indicate that a zone of "massive to semi-massive sulphides" that is not part of the breccia pipe has been encountered in recent drilling. Assay results reported in this zone range up to 1.20 oz/ton Au for a 35-ft interval. The location of the "massive to semi-massive sulphide" zone is not given by Danielson, but any significant mineralization found beyond the limits of the breccia pipe could significantly affect the tonnage potential of the deposits.

CONCLUSIONS

Both the Vera Cruz intrusion and breccia pipe are located at or near the intersection of regional and local structures trending N20°E and east-west. The Vera Cruz laccolith is cut by dikes, but no dikes or veins cut the breccia pipe. The breccia pipe contains fragments of sandstone and shale, as well as fragments of porphyritic and equigranular intrusive rock. The inclusion of altered intrusive fragments in the breccia, together with the absence of crosscutting dikes and veins, suggests that formation of the breccia and subsequent mineralization were the latest hydrothermal-intrusive events in the Vera Cruz area.

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