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GEOLOGY AND MINERAL RESOURCES IN THE MACHO MINING DISTRICT, SIERRA COUNTY, NEW MEXICO

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Abstract—The Macho mining district is southwest of the Lake Valley mining district in the eastern foothills of the Mimbres Mountains and was discovered about 1879. Volcanic-epithermal veins along faults in the Tertiary Macho Andesite strike north-south to N40°E and are steeply dipping to the west. Production from these veins amounted to 61 oz Au, 20,000 oz Ag, 679,000 lbs Pb, and 11,000 lbs Zn from 1879 to 1977. Grades of ore shipments ranged from 5 to 23.7 oz/short ton (0.1-0.7 g/mt) Ag and 3 to 50% Pb with minor amounts of Au (<0.16 oz/short ton or 0.005 g/mt), Zn (5-11%), Cu (0.02-0.3%), and V (<10%). In addition, collected samples from this district contained 136-1,086 ppm As, 3-41 ppm Mo, 1-233 ppm Cd, and 5-64 ppm Bi. Drilling in 1983 by Nicor Minerals Ventures, Inc. indicated that mineralized zones occur in the Fusselman Dolomite 1,097-1,128 m below the volcanic-epithermal veins. Additional mineral potential is probably present in the district, but more drilling is required along strike of the veins and within the mineralized structures to better evaluate the mineral resource potential.

INTRODUCTION

The Macho mining district (DIS201, New Mexico Mines Database, McLemore et al., 2005a, b) is a small mining district southwest of the Lake Valley mining district (DIS200), in the eastern foothills of the Mimbres Mountains (Fig. 1). The Macho district was discovered about 1879 and is estimated to have yielded 61 oz Au, 20,000 oz Ag, 679,000 lbs Pb, and 11,000 lbs Zn in production from 1879 to 1977 from volcanic-epithermal vein deposits (Table 1). Most of the production came from the Old Dude and Anniversary mines (Table 2). Carbonate-hosted Pb-Zn replacement deposits have been found by drilling beneath the volcanic-epithermal veins by Nicor Mineral Ventures, Inc, in 1983. In 1995, the U.S. Bureau of Mines released a report with chemical analyses of samples collected from the district during an evaluation of the U.S. Bureau of Land Management's Caballo Resource Area (Korzeb et al., 1995). The U.S. Geological Survey (USGS) with this author examined the area again in the late 1990s, and a CD-ROM of data was published (Green and O'Neill, 1998), but the collective data was never interpreted because of time constraints. Since the 1990s investigations, the price of gold and silver have dramatically increased, resulting in re-examination of gold and silver mining districts throughout New Mexico for their mineral resource potential. The purposes of this paper are to 1) summarize the geology, geochemistry, and mineral production of the district, 2) discuss the age and formation of these deposits, 3) evaluate previously collected data (Korzeb et al., 1995; Green and O'Neill, 1998), and 4) comment on the future economic potential of mineral deposits in the district.

This work is part of ongoing studies of mineral deposits in New Mexico and includes updates and revisions of prior work by North and McLemore (1986, 1988), McLemore (1996, 2001) and Green and O'Neill (1998). Published and unpublished data on existing mines and mills within the Macho mining district were inventoried and compiled in the New Mexico Mines Database (McLemore et al., 2005a, b). A geologic map was compiled in ARCMAP@ using U.S. Geological Survey topographic maps as the map base and by modifying Jicha (1954) from field reconnaissance by the author (Fig. 2). Samples were collected, analyzed, and compared with published data (Table 3; Korzeb et al., 1995). Igneous rock lithologies were identified on the basis of mineralogy and chemistry as defined by LeMaitre (1989). Names of types of mineral deposits (i.e. volcanic-epithermal veins and carbonate-hosted Pb-Zn replacement deposits) are from Cox and Singer (1986), North and McLemore (1986), McLemore and Lueth (1996), and McLemore (1996, 2001). Mineralized areas were examined, mapped, and sampled in 1996 and 2011. Samples were analyzed using Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES) and Instrumental Neutron Activa-

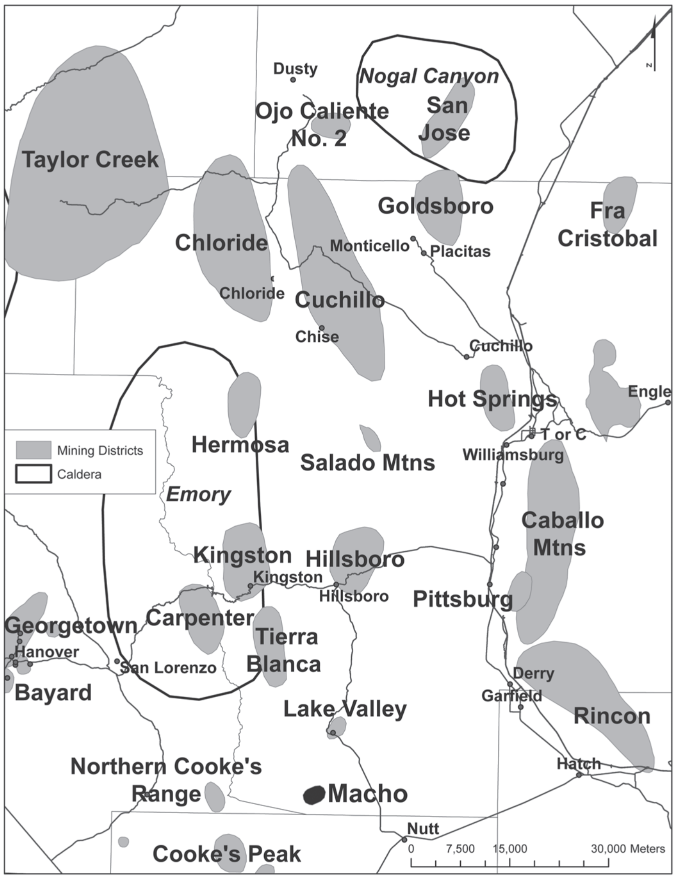

FIGURE 1. Location of the Macho mining district.

TABLE 1. Estimated and reported production from the Macho mining district, Sierra County (from Harley, 1934; Jicha, 1954; NMBGMR file data). * estimated production.

Year	Tons	Au (oz)	Ag (oz)	Pb (lbs)	Zn (lbs)
1879–1904*	1,000	20.0	5,000	60,000	—
1918	8	0.4	101	3,232	—
1919	20	0.4	474	11,040	1,824
1919	22	0.7	493	11,792	3,840
1921	8	0.4	154	4,960	3,300
1926	537	16.1	2,578	73,032	—
1927	95	17	1,377.5	240,000	—
1928	1,051	22	15,765	249,796	—
1977	16	2.6	504	15,808	1,664
TOTAL 1879–1977*	2,757	79.6	26,446.5	669,660	10,628

tion Analysis (INAA) by the USGS (Table 3). Mineral production is in Table 1. Mining and production records are generally poor, particularly for the earliest times, and many early records are conflicting. These production figures are the best data available and were obtained from published and unpublished sources (NMBGMR file data). However, production figures are subject to change as new data are obtained. Any resource or reserve data presented here are historical and are provided for information purposes only, and do not conform to Canadian National Instrument NI 43-101 requirements.

MINING HISTORY AND PRODUCTION

Prospectors discovered the volcanic-epithermal veins in the Macho mining district about 1879, probably attracted to the area by the nearby rich Lake Valley silver deposits. Prior to 1907, small mining companies constructed the shafts and produced some ore (Table 1). In 1907, the Dude Mining Co., later reorganized as the Good Luck Mining Co., operated the mines. The Roper Mining Co. purchased and operated the mines in 1917 and closed in 1921 because of financial difficulties. Small mining companies, including the Hanover Bessemer Iron and Copper Co., shipped some ore in 1926-1928, but the mine soon closed in 1929. During and after the most productive mining years, 1879-1928, much of the surrounding area was settled by homesteaders. Today, much of the surface is privately owned, but the subsurface mineral rights are under federal ownership. During World War II, an unsuccessful attempt was made to dewater the shafts.

Various exploration companies examined the area over the next 60 years. In 1977, the U.S. Mining and Milling Corp. sent a small shipment of ore to the El Paso smelter (Table 1). Nicor Mineral Ventures, Inc. drilled two drill holes in 1983 (Fig. 2) and in 1997, Toque de Oro, Inc. drilled a third drill hole. The mines were reclaimed by the New Mexico Abandoned Mine Lands Program in 1995. Standard Silver Corp. acquired the properties about 2008 and reorganized as the Texas Rare Earth Resources about 2009 (Texas Rare Earth Resources, 2011).

TABLE 2. Mines and prospects in the Macho mining district, Sierra County (from Harley, 1934; Jicha, 1954; and field reconnaissance, 12/15/95). Mine Id Number is from the New Mexico Mines Database (McLemore et al., 2005a, b).

Mine Id Number	Mine Name (Alias)	Location	Latitude, longitude (decimal degrees)	Commodities produced (commodities present, not produced)	Development	Years of Production
NMSI0468	Anniversary (Good Luck, Mable A, Dude)	SW20 19S 7W	32.634185, 107.589523	Ag, Pb, Zn, Au (As, Bi, Sb, V)	500 ft shaft	1879-1977
NMSI0469	Bulldog	SW20 19S 7W	32.636594, 107.58765	Ag, Pb, Zn, Au	200 ft shaft, pits	1879-1928
NMSI0470	Old Dude (Independence, Selma, Good Luck, Hudson)	NW29 19S 7W	32.635118, 107.58923	Ag, Pb, Zn, Au (V, Cu)	300 ft shaft	1879-1977
NMSI0471	unknown (north of Old Dude)	20 19S 7W	32.635956, 107.59026	(Ag, Pb, Zn, Au)	trench	none
NMSI0476	unknown	SW20 19S 7W	32.636012, 107.58746	Ag, Pb, Zn, Au	trench, pits	1879-1928
NMSI0475	unknown	SW20 19S 7W	32.637527, 107.58739	Ag, Pb, Zn, Au	pits, 100 ft shaft	1879-1928
NMSI0472	unknown	20 19S 7W	32.637452, 107.58933	(Ag, Pb, Zn)	pits, trenches	none
NMSI0474	unknown	20 19S 7W	32.636697, 107.59098	(Ag, Pb, Zn)	pits, trenches	none
NMSI0477	unknown	20 19S 7W	32.635601, 107.58916	(Ag, Pb, Zn, Au)	trench	none
NMSI0478	unknown-Greg Hills	NC31 19S 7W	32.619637, 107.59928	(Ag, Cu)	25-30 ft shaft, shaft, pits	none
NMSI0473	unknown	16, 21, 19S 7W	32.649291, 107.67408	(Au, Ag, Cu)	Adit, shaft	none

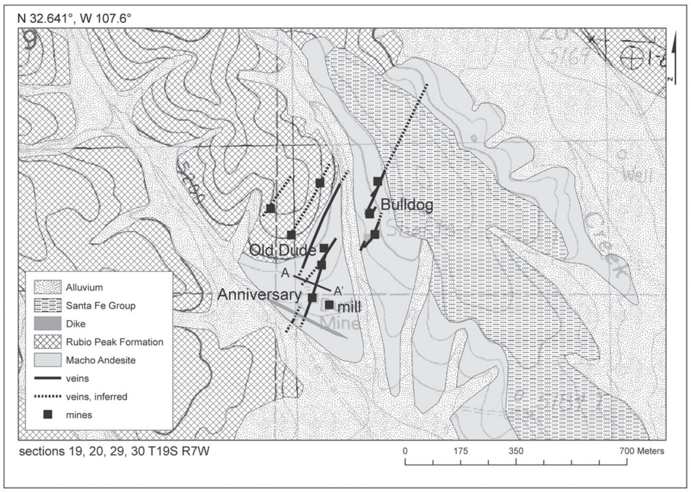

FIGURE 2. Geologic map of the Macho mining district showing mine workings and mineralized areas (modified by the author from Jicha, 1954 using the Lake Valley topographic map as a base). Line A-A' is cross section shown in Figure 3. The veins are along faults.

The Anniversary two-compartment shaft is 160 m deep with a sump level below the 500- ft (152 m) level (Figs. 2, 3). The Dude shaft is at least 61 m with five levels of more than 396 m of underground workings. Harley (1934) may have erroneously reported the depth as 91 m. Two additional shafts accessed separate veins northeast of the Anniversary vein and are 46 m and 91-122 m deep. Most of the shafts are flooded; the depth to water table is estimated at approximately 3-18 m.

GEOLOGIC SETTING

The Macho mining district lies southeast of the Black Range (Fig. 1), and is dominated by Tertiary volcanic rocks typical of the Mogollon-Datil volcanic field. The Mogollon-Datil volcanic field is part of a late Eocene-Oligocene volcanic province that extends from west-central New Mexico southward into Chihuahua, Mexico (McIntosh et al., 1991, 1992a, b; Chapin et al., 2004). Approximately 25 high- and low-silica rhyolite ignimbrites (ash-flow tuffs) were erupted and emplaced throughout the Mogollon-Datil volcanic field; source calderas have been identified for many of the ignimbrites (McIntosh et al., 1992a, b; Chapin et al., 2004).

In the Black Range area, Eocene intermediate volcanism (36-40 Ma) was followed by Eocene to Oligocene basaltic to andesitic and silicic volcanism (24-36 Ma). The Emory caldera is one of the largest calderas forming the Mogollon-Datil volcanic field and is an elongate north- to northeast-trending structure (Fig. 1). The caldera was formed by the eruption of the Kneeling Nun Tuff (34.9 Ma; McIntosh et al., 1991) and eruption of rhyolite domes and intrusions of the Mimbres Peak Formation (34.5 Ma; McIntosh et al., 1991). Subsequent faulting, hydrothermal alteration, and volcanism have offset, altered, and covered portions of the ignimbrites. The Macho mining district is the southernmost mining district in a mineralized belt in western Sierra County consisting of the Lake Valley, Hillsboro, Hot Springs, and Cuchillo mining districts that surround the Emory caldera (Fig. 1; Lovering and Heyl, 1989). Many of the mineralized structures

TABLE 3. Chemical analyses of samples from the Macho mining district, Sierra County. Au, Ag, Zn, As, Sb, and Hg were analyzed by INAA and Cu and Pb were analyzed by ICP. Analyses of sample numbers 303, 304, 305, 306, and 307 are from Korzeb et al. (1995). na—not analyzed. Complete data set with sample location is in Appendix 1.

Field No.	Location	Sample Description	Au ppb	Ag ppm	Cu ppm	Pb ppm	Zn ppm	As ppm	Sb ppm	Hg ppm
Macho 1	Anniversary	select dump	2,460	150	153	45,003	23,000	820	1,000	2.8
Macho 3	Anniversary	select dump	118	14	48	14,713	3,400	240	55	0.4
303	Anniversary	3.5 ft chip	130	22	45	7,148	2,700	173	142	na
304	Anniversary	grab	1,560	140	120	>10,000	7,900	1,340	490	na
305	Anniversary	grab	2,860	<5	293	>10,000	6,900	1,150	1,090	na
306	Anniversary	grab	1,940	>300	832	>10,000	19,000	418	462	na
307	Anniversary	grab	1,580	>300	651	>10,000	>30,000	457	737	na
Macho5	Anniversary	slag from dump	29	<5	117	52	<50	5.1	6.1	<1
Macho6	Anniversary	dump select	2,200	170	204	34,592	3,710	190	210	<1
Macho7	Dude	chip of altered andesite	25	<5	40	2,499	2,800	120	53	<1
Macho8	Dude	select of veinlet	15	<5	178	13,666	7,700	230	45	<1
Macho9	North of Dude	dump select	416	130	250	34,765	11,100	350	350	<1
Macho10	North of Dude	3 ft chip	170	42	41	6,795	3,880	170	140	<1
Macho11	North of Dude	2 ft chip of vein	893	160	351	35,702	12,600	660	660	<1
Macho12	North of Dude	dump select	1,500	98	78	23,234	6,240	600	250	4
Macho13	North of Dude	dump select	2,470	38	144	8,336	3,390	140	260	<1
Macho14	North of Dude	dump select	290	<5	31	1,603	3,490	150	69	<1
Macho15	Anniversary	dump select	2,570	280	170	37,282	5,650	250	310	<1
Macho16	Gregg Hills	dump grab	2,230	240	1,831	6,201	739	380	340	4
Macho17	Gregg Hills	dump select	600	93	747	4,022	1,130	360	410	<1

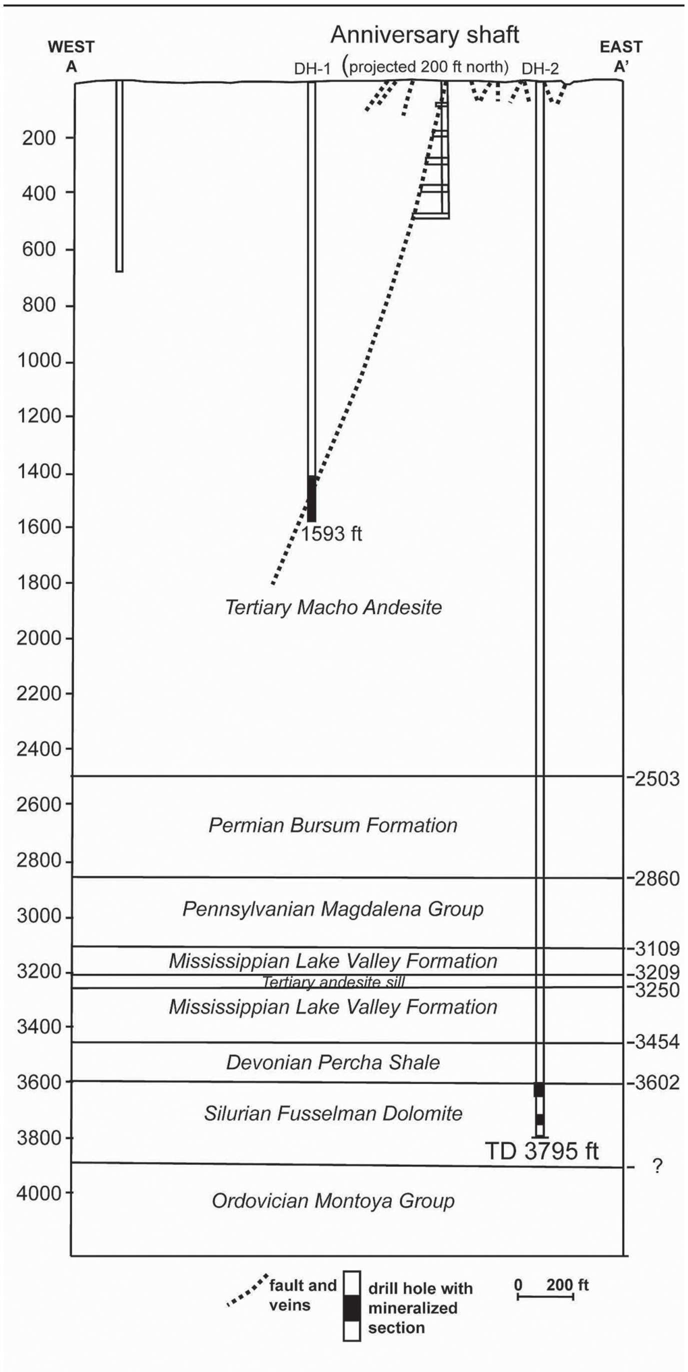

FIGURE 3. Cross section in the Macho district (modified from Nicor Mineral Ventures, Inc., NMBGMR file data). Location of cross section is in Figure 2. See Table 3 for chemical analyses of mineralized sections.

within these mining districts are found along ring-structures surrounding the Emory caldera (Elston, 1994).

Volcanic-epithermal veins in the Macho district are hosted by the poorly exposed Macho Andesite (Fig. 2; Jicha, 1954). The Macho Andesite in the district consists of porphyritic pyroxene andesite and andesitic breccias. A latite tuff from the Macho Andesite is dated as 40.7±1.4 Ma (biotite, K-Ar; Loring and Loring, 1980). Seager et al. (1982) and O'Neill et al. (2002) included the Macho Andesite as part of the Rubio Peak Formation. The Macho Andesite overlies sedimentary rocks, including the Fusselman Dolomite at approximately 1,097 m depth (Fig. 3); drilling indicates the dolomite is locally mineralized. Numerous faults cut the andesite. Silicification and argillic alteration is prominent.

DESCRIPTION OF MINERAL DEPOSITS

Five or more veins in the Macho mining district strike north-south to N40°E and are steeply dipping to the west (Fig. 2; Jicha, 1954). A vein is exposed in the Greg Hills, approximately 1.6 km south along strike of the main workings (Table 2). Textures typical of volcanic-epithermal vein deposits elsewhere in New Mexico are found in the Macho mining district, such as banding, sharp contacts with host rocks, multiple periods of brecciation, quartz replacing calcite, and late-stage vug-filling quartz. The vein at the Anniversary and Old Dude shafts consist of galena, sphalerite, chalcopyrite, argentite, anglesite, cerussite, silver, gold, vanadinite, hemimorphite, and wulfenite in a gangue of quartz, pyrite, calcite, barite, iron and manganese oxides, and clay minerals. Oxidized minerals such as plumbojarosite, smithsonite, willemite, vanadinite, descloizite, wulfenite, aurichalcite, and cerargyrite in a gangue of limonite, manganese oxides, quartz, and calcite are found in the upper 18-30 m. The Anniversary-Old Dude vein is cut off by a weakly mineralized northeast-trending vein. The Bulldog and other veins north of the Anniversary and Old Dude mines contain galena, anglesite, cerrusite, cerraygrite, silver, gold, and vanadinite in a gangue of quartz, calcite, barite, iron oxides, and clay minerals. The veins are typically small, less than 1 m thick, and surrounded by fractured altered, bleached country rock, approximately 0.3-1.8 m thick, and consists of low-grade ore material. The mineralized veins are less than 152 m long and 152 m deep, and the mineralized structural zone is more than 2.4 km long (Fig. 2).

The alteration in the host rocks adjacent to the mineralized veins is crudely zoned. The innermost altered zone, 0.6-1 m wide, is silicified and consists of quartz, clay minerals, iron oxides, and locally alunite, which produced a bleached zone resembling a dike-like feature (Jicha, 1954). The ore zone is surrounded by this inner altered zone. This light-colored, bleached inner zone grades into a yellowish-gray intermediate zone of quartz-sericite and, finally, to an outer green chlorite zone, which is up to 15 m wide.

Grades of ore shipments ranged from 5 to 23.7 oz/short ton Ag (0.1-0.7 g/mt) and 3 to 50% Pb with minor amounts of Au (<0.16 oz/short ton or 0.005 g/mt), Zn (5-11%), Cu (0.02-0.3%), and V (<10%). A 16-short ton (14.5 mt) shipment in 1977 contained 0.16 oz/short ton (0.005 g/mt) Au, 31.5 oz/short ton (0.92 g/mt) Ag, 49.4% Pb, 5.2% Zn, 0.12% As, 0.10% Sb, and 0.02% Bi. Analyses of samples collected for this study are in Table 3. Significant gold, silver, and base metals are found along the veins (Table 3, Figure 4). Lovering and Heyl (1989) reported a jasperoid sample from the Anniversary shaft contained 2% Pb, ~1% Zn, ~1,000 ppm of both Cu and Ag, ~0.5 ppm Au, and high concentrations of as much as >0.5% Ba, 1,300 ppm Bi, 150 ppm Cd, 300 ppm V, 500 ppm As, 30 ppm Co, 4 ppm Hg, 50 ppm Ni, 1,000

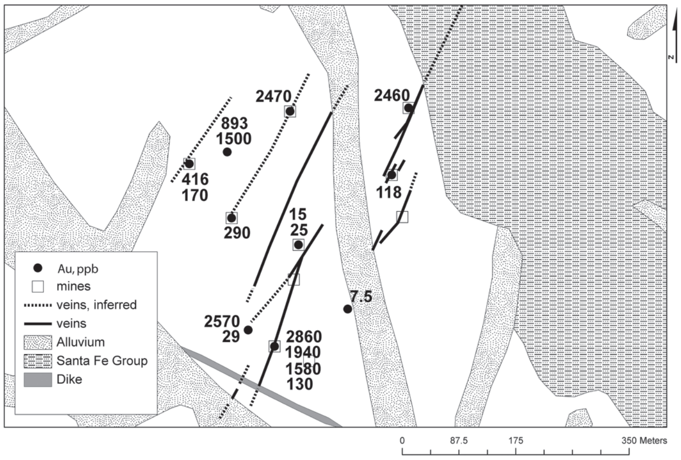

FIGURE 4. Gold analyses of samples collected in the northern Macho mining district. Does not include samples collected south of the main workings (Table 2, Appendix 1). Sample descriptions are in Table 2.

ppm Sb, 1.6 ppm Te, and 50 ppm W. The geochemical data do not indicate any district zonation.

Assays of drill core samples drilled by Nicor Mineral Ventures, Inc. are in Table 4. Nicor found mineralized zones within the Fusselman Dolomite at the contact with the overlying Percha Shale containing calcite, pyrite, galena, and sphalerite (NMBGMR file data).

ENVIRONMENTAL GEOLOGY AND HYDROLOGY

Most of the shafts are flooded; the depth to water table is estimated at approximately 3-18 m. Pyrite is common in most of the dumps, indicating some acid-producing potential for most mine waste rock piles in the district, but the arroyos flow only after major storms. Geochemical analyses indicate that the mine waste rock piles contain local elevated concentrations of Pb, Zn, As, Sb and Cd (Table 3). The Bulldog shaft and adjacent pits in the northern portion of the district were backfilled during late summer 1995. The Anniversary and Old Dude shafts were plugged at approximately 9-15 m.

MINERAL RESOURCE POTENTIAL

The Anniversary and Old Dude mines contain additional lead-silver resources. The mine waste rock piles contain approximately 4,000-5,000 short tons (3,630-4,540 metric tons) of 3-4% Pb and 1.8-2.7 oz/ton (0.05-0.08 g/mt) Ag (historic resource; Harley, 1934; NMBMMR files). In 1964, historic mineral resources were estimated as 43,000 short tons (39,000 metric tons) of 10% Pb and 6 oz/ton (0.2 g/mt) Ag above the 500 ft (152 m) level in the Anniversary shaft (NMBGMR file data; Don Fingado, written communication, June, 1982). Although, gold production was small, the area does have additional resource potential for gold, as evidenced by the gold analyses (Table 3, 4). The Anniversary and Old Dude veins likely have additional mineral potential,

TABLE 4. Chemical analyses of drill core samples by Nicor Mineral Ventures, Inc. from the Macho mining district. The drill hole was located 400 ft (121m) N84°E from the Old Dude mine shaft in SW¼ 20, T19S, R7W (Fig. 2, 3). The drill hole was 3,795 ft (1157m) deep (NMBGMR file data).

Interval (ft)	Au ppm	Ag ppm	Cu ppm	Pb ppm	Zn ppm
2685–2695	0.01	2.3	36	29	91
2982–2992	0.01	2.4	20	18	14
2992–3001	0.01	2.5	30	18	20
3148–3158	<0.01	3.8	12	28	32
3158–3168	<0.01	3.9	11	29	26
3558–3567	0.02	2.1	9	133	198
3593–3602	<0.01	1.3	64	74	275
3602–3614	0.02	3.2	17	407	692
3614–3625	0.02	3.6	29	227	834
3624–3635	0.01	2.6	19	157	229
3635–3644	<0.01	1.8	5	80	95
3644–3653	<0.01	2.2	6	102	49
3653–3670	<0.01	2.1	10	56	147
3670–3679	<0.01	1.9	10	53	119
3679–3690	<0.01	2.4	7	53	93
3690–3700	<0.01	2.9	16	50	106
3700–3712	0.02	3.4	22	73	81
3712–3722	0.01	4.8	10	640	68
3722–3732	<0.01	2.9	10	194	79
3732–3745	0.01	2.1	15	33	96
3745–3754	0.02	1.9	15	4	38
3754–3766	<0.01	2.1	12	60	68
3766–3775	<0.01	1.7	8	6	85
3775–3784	0.02	2.1	8	255	142
3784–3795	<0.01	2.0	12	5	68

but more drilling is required along strike of the veins and within the mineralized structure to better estimate the mineral resource potential. Drilling by Nicor Minerals Ventures, Inc. proved that mineralized zones occur in the underlying Fusselman Dolomite, which is 1,097-1,128 m deep.

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REFERENCES

Chapin, C.E., Wilks, M., and McIntosh, W.C., 2004, Space-time patterns of Late Cretaceous to present magmatism in New Mexico; comparison with Andean volcanism and potential for future volcanism; in Tectonics, geochronology and volcanism in the southern Rocky Mountains and Rio Grande rift: New Mexico Bureau of Geology and Minerals Resources, Bulletin 160, p. 13-40.

Cox, D.P., and Singer, D.A., eds., 1986, Mineral deposit models: U.S. Geological Survey, Bulletin 1693, 379 p.

Elston, W. E., 1994, Siliceous volcanic centers as guides to mineral exploration: review and summary: Economic Geology, v. 89, pp. 1662-1686.

Green, G.N. and O'Neill, J.M., 1998, Digital earth science database, Caballo resource area, Sierra and Otero counties, south-central New Mexico: U.S. Geoligcal Survey, Openfile Report OF-98-780, CD-ROM.

Harley, G. T., 1934, The geology and ore deposits of Sierra County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 10, 220 p.

Jicha, H. L., Jr., 1954, Geology and mineral deposits of Lake Valley quadrangle, Grant, Luna, and Sierra Counties, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 37, 93 p.

Korzeb, S. L., Kness, R. F., Geroyan, R. I., and Ward, D. A., 1995, Mineral resource assessment of the Caballo Resource Area, Sierra and Otero Counties, New Mexico: U. S. Bureau of Mines, Open-file Report MLA 5–95, 177 p.

LeMaitre, R.W., ed., 1989, A classification of igneous rocks and glossary of terms: Blackwell Scientific Publications, Oxford, Great Britain, 193 p.

Loring, A. K., and Loring, R. B., 1980, K/Ar ages of middle Tertiary igneous rocks from southern New Mexico: Isochron/West, no. 28, pp. 17-19.

Lovering, T. G., and Heyl, A. V., 1989, Mineral belts in western Sierra County, New Mexico, suggested by mining districts, geology, and geochemical anomalies: U. S. Geological Survey, Bulletin 1876, 49 p.

McIntosh, W.C., Kedzie, L.L. and Sutter, J.F., 1991, Paleomagnetic and $^{40}Ar/^{39}Ar$ dating database for Mogollon-Datil ignimbrites, southwestern New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 135, 79 p.

McIntosh, W.C., Chapin, C.E., Ratté, J.C. and Sutter, J.F., 1992a, Time-stratigraphic framework for the Eocene-Oligocene Mogollon-Datil volcanic field southwestern New Mexico: Geological Society of America Bulletin, v. 104, p. 851-871.

McIntosh, W.C., Geissman, J.W., Chapin, C.E., Kunk, M.J. and Henry, C.D., 1992b, Calibration of the latest Eocene-Oligocene geomagnetic polarity time sale using $^{40}Ar/^{39}Ar$ dated ignimbrites: Geology, v. 20, p. 459-463.

McLemore, V.T., 1996, Volcanic-epithermal precious-metal deposits in New Mexico; *in* Cyner, A.R. and Fahey, P.L., eds., Geology and ore deposits of the American Cordillera: Geological Society of Nevada Symposium Proceedings, Reno/Sparks, Nevada, April 1995, p. 951-969.

McLemore, V. T., 2001, Silver and gold resources in New Mexico: New Mexico Bureau of Mines and Mineral Resources, Resource Map 21, 60 p.

McLemore, V.T., Hoffman, G., Smith, M., Mansell, M., and Wilks, M., 2005a, Mining districts of New Mexico: New Mexico Bureau of Geology and Mineral Resources, Open-file Report 494, CD-ROM.

McLemore, V. T., Krueger, C. B., Johnson, P., Raugust, J. S., Jones, G.E., Hoffman, G.K. and Wilks, M., 2005b, New Mexico Mines Database: Society of Mining, Exploration, and Metallurgy, Mining Engineering, February, p. 42-47.

McLemore, V.T. and Lueth, V.W., 1996, Lead-zinc deposits in carbonate rocks in New Mexico, *in* D.F. Sangster, ed., Carbonate-hosted lead-zinc deposits: Society of Economic Geologists, 76th Anniversary Volume, Special Publication 4, p. 264-279.

North, R. M., and McLemore, V. T., 1986, Silver and gold occurrences in New Mexico: New Mexico Bureau of Mines and Mineral Resources, Resource Map 15, 32 pp., scale 1:1,000,000.

North, R. M., and McLemore, V. T., 1988, A classification of the precious metal deposits of New Mexico; *in* Bulk mineable precious metal deposits of the western United States Symposium Volume: Geological Society of Nevada, Reno, Symposium held April 6-8, 1987, pp. 625-660.

O'Neill, J.M., Lindsey, D.A., Hedlund, D.C., Nutt, C.J., and Ratté, J.C., 2002, Geology of the Lake Valley area; in J.M. O'Neill, ed., Geologic investigations in the Lake Valley area, Sierra County, New Mexico: U.S. Geological Survey, Professional Paper 1644, 92 p., http://geology.cr.usgs.gov/pub/ppapers/p1644/

Seager, W.R., Clemons, R.E., Hawley, J.W., and Kelley, R.E., 1982, Geology of northwestern part of the Las Cruces 1° by 2° sheet: New Mexico Bureau of Mines and Mineral Resources, Geologic Map 53, scale 1:250,000.

Texas Rare Earth Resources, 2011, Macho district, Sierra Co., New Mexico: unpublished report, 29 p. http://texasrareearth.com/Websites/texasrareearth/Images/Macho%20Presentation%2004.2011.pdf, accessed on 8/5/11.