MINERAL RESOURCE POTENTIAL OF THE SANDIA MOUNTAIN WILDERNESS, BERNALILLO AND SANDOVAL COUNTIES, NEW MEXICO

By
D. C. Hedlund and D. E. Hendzel, U.S. Geological Survey
and
Richard F. Kness, U.S. Bureau of Mines

STUDIES RELATED TO WILDERNESS

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and related acts, the U.S. Geological Survey and the U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. The act directs that the results of such surveys are to be made available to the public and be submitted to the President and the Congress. This report discusses the result of a mineral survey of the Sandia Mountain Wilderness, Cibola National Forest, Bernalillo and Sandoval Counties, New Mexico. The area was established as a wilderness by Public Law 95-237, February 24, 1978.

MINERAL RESOURCE POTENTIAL SUMMARY STATEMENT

The Sandia Mountain Wilderness has areas of low to moderate resource potential for barite in vein and bedded replacement deposits, low potential for fluorite resources in vein deposits, low to moderate potential for silver and gold resources in vein deposits, and low potential for molybdenum resources in vein deposits.

There is little likelihood that oil, gas, coal, or geothermal energy resources are present, although parts of the Santo Domingo basin that adjoin the wilderness to the north, may have some oil and (or) gas potential. The coal-bearing beds of the Mesaverde Formation are not present in the wilderness.

Localities where limestone and shale of the Wild Cow Formation, Madera Group, are present within the wilderness have a high resource potential for cement clinker. In the vicinity of Tijeras, the Wild Cow Formation has been a source for cement clinker in the quarry operated by Ideal Basic Industries. However, the development of a limestone quarry as a source for cement is unlikely within the wilderness when equal or better resources are available closer to the market and outside the wilderness.

INTRODUCTION

Location and geographic setting

During 1981 and 1982 the U.S. Geological Survey and the U.S. Bureau of Mines conducted field investigations to evaluate the mineral resource potential of the Sandia Mountain Wilderness, Bernalillo and Sandoval Counties, N. Mex. The wilderness encompasses about 61 mi^2 (37,232 acres) within the Cibola National Forest, but the area mapped by the U.S. Geological Survey is about 145 mi^2 and includes areas adjacent to the wilderness boundary.

The Sandia Mountains are a part of an eastward-tilted fault block that is about 18 mi long and 8-10 mi wide and that is continuous with the Manzanita-Manzano Mountain fault blocks to the south of Tijeras Canyon. The range is within the Mexican Highlands section of the Basin and Range province and is bounded by the Manzanita Mountains to the south, the Tijeras coal basin and Monte Largo to the east, and the Rio Grande trough to the west. The Rio Grande trough merges with the Santo Domingo basin to the north (fig. 1).

The physiographic limits of the range are controlled by the Placitas fault to the north, by the Tijeras or Tijeras-Gutierrez rift system on the south, and by a west-facing fault scarp eroded back from the north-trending Sandia and Rincon faults, which are largely concealed by thick alluvial fans. The westward-facing Sandia Mountain front is impressive and of great relief, varying from elevations of 5,800 to 6,400 ft at the base to 10,678 ft at the crest. The eastern physiographic limit is less certain and is separated from Monte Largo by a structural sag formed by the merger of the Tijeras synclinal basin with the Hagan basin to the north.

Access to the area is provided on the north by New Mexico Highway 44, which passes near Placitas, on the south by Interstate Highway 40, which follows

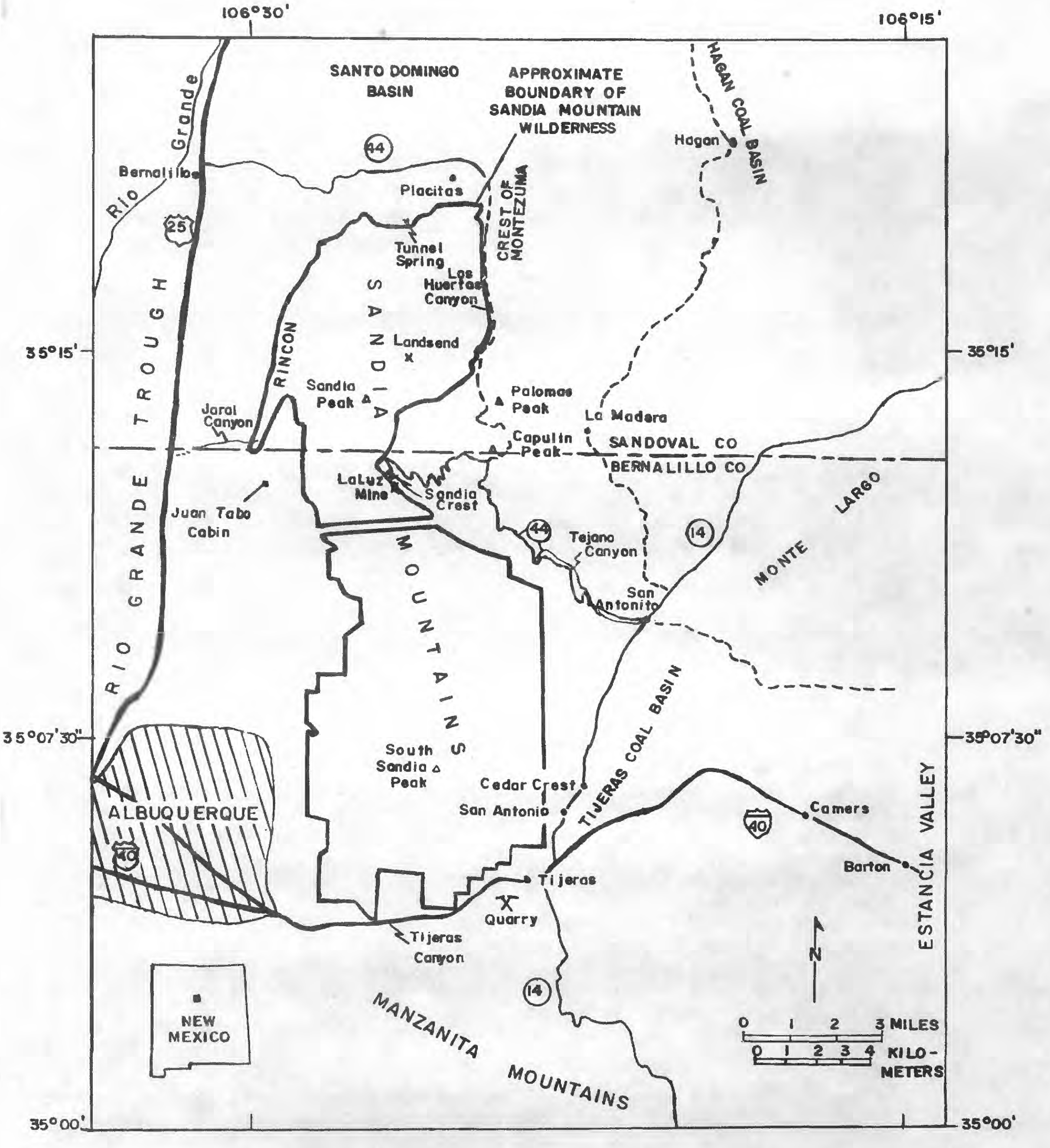

Figure 1.--Index map showing location of the Sandia Mountain Wilderness, N. Mex.

Tijeras Canyon, on the east by New Mexico Highway 14, and on the west by the numerous roads that lead from suburbs of Albuquerque. Numerous secondary Forest Service roads lead from the villages of Placitas, Cedar Crest, and San Antonito. Extensive recreational development along the Sandia Crest and the numerous housing developments along the borders of the wilderness have increased the use of the forest lands.

Present and previous studies

The U.S. Geological Survey investigations included geologic mapping (Hedlund, in press); a geochemical sampling of rocks, veins, stream sediments, and stream waters (Hendzel and others, 1983; Hendzel, in press); and an aeromagnetic map and interpretation (Cordell and Hedlund, in press). The U.S. Bureau of Mines has reviewed past mining activity, and the numerous mines and prospects of the study area were examined and sampled by Kness (1982). During the period of this study, no actual mining was observed within the wilderness, although quarry operations for limestone and shale continued near Tijeras.

Numerous publications and maps by the faculty and students at the University of New Mexico expedited this study. Publications by Kelley and Northrop (1975), Myers and McKay (1976), and Grambling and Wells (1982) were especially useful in the preparation of this map and report. Recent detailed studies of the structure and metamorphism of the Cibola Gneiss and Tijeras Greenstone (both of Kelley and Northrop, 1975) by Connolly (1982) and Condie (1980), and the work by Berkeley and Callender (1979) in the Rincon-Juan Tabo areas have contributed to a better knowledge of the Precambrian rocks. The radiometric ages of the Precambrian rocks have been reported by Brookins (1982).

GEOLOGY

About 40-50 percent of the rocks exposed in the Sandia Mountains are of Precambrian age and include the Sandia Granite (1,445±40 m.y.), which intrudes older biotite schist and gneiss of Kelley and Northrop (1975) and the Cibola Gneiss, and a still older northeast-striking greenstone belt along Tijeras Canyon. The Tijeras Greenstone of Kelley and Northrop (1975), of probable Proterozoic X (Early Proterozoic) age, consists of predominantly dark-greenish-black, blastoporphyritic metabasalt flows, and minor thin lenses of metarhyolite. The absence of pillow structures in the greenstone suggests predominantly subaerial extrusion. The slightly younger Cibola Gneiss is a granitic paragneiss containing intercalated and isoclinally folded quartzite beds. The gneiss and schist of Rincon are highly foliated, biotitic-sillimanitic, metapelitic rocks that have been intricately intruded by the post-orogenic Sandia Granite. Numerous pegmatite and aplite dike swarms that are largely fracture controlled intrude the metapelitic rocks.

A relatively thick (2,500 ft) section of Mississippian, Pennsylvanian, and Permian strata rests unconformably on the Precambrian rocks and forms an extensive east-dipping dip slope on the tilted fault block. The Mississippian strata are thin (50 ft), discontinuous, erosional remnants of cherty limestone. The Pennsylvanian section is about 800 ft thick and is represented by carbonaceous shale and sandstone of the Sandia Formation and an overlying thick (650 ft) sequence of shallow marine limestone beds of the Madera Group (Myers, 1973). No attempt was made in this study to differentiate the various units in this group. A complex Permian and Triassic red-bed section of sandstone, siltstone, mudstone, and thin limestone beds crops out farther down the dip slope. From oldest to youngest these are the Permian Abo, Yeso, and San Andres Formations, and the Triassic Santa Rosa Sandstone and Chinle Formation.

The remaining Mesozoic strata are folded into synclinal basins, such as the Tijeras and Hagan synclines and also fill ramplike depressions near Placitas (Kelley and Northrop, 1975, p. 83). The Jurassic and Cretaceous sedimentary rocks include the Jurassic Todilto, Entrada, and Morrison Formations and the Upper Cretaceous Mancos and Mesaverde Formations. Black carbonaceous shale and thin coal beds are commonly interbedded with thick sandstone beds in the Mesaverde Formation.

Middle Tertiary(?) lamprophyric dikes cut the Sandia Granite along the steep west-facing slope of the Sandia Mountains, and a basaltic dike cuts the Mesaverde Formation about 1 mi northwest of Placitas. The Galisteo Formation of early Tertiary age crops out as an incomplete section north of the wilderness boundary west of Placitas.

The dominant structural element is the east-tilted Sandia fault block, which is controlled on the west by the Sandia and Rincon-Ranchos range-front faults. These faults have as much as 20,000-28,000 ft of throw. The eastward tilt of 15^{o}-20^{o}, formed in conjunction with displacement along these faults, steepens where the Paleozoic section underlies the folded Mesozoic sedimentary rocks of the Tijeras and Hagan basin synclines. The plunging northern terminus of the fault block is near Placitas, but, to the south, the Sandia fault block is contiguous with the Manzanita and Manzano fault blocks. Numerous north-trending faults along the dip slope are considered coeval with the Pliocene and Miocene Sandia-Rincon-Ranchos faults and commonly displace older faults of post-Permian (principally Laramide) age. Most of the north-trending dip-slope faults are downthrown to the east, but the large Ellis fault is an exception and locally reverses the regional east dip so that near Capulin Peak the strata dip gently to the west. Probably the most important effect of these faults has been to bring Precambrian rocks to the surface along the back-slope between Tejano and Tecolote Canyons.

The Placitas-San Francisco, Tijeras, and Gutierrez faults strike northeast to east-northeast along the north and south boundaries of the Sandia Mountains. These faults, principally of Laramide age, locally displace the Upper Cretaceous Mesaverde Formation and are commonly branching or splayed fault systems having combined throws as much as 1,000-3,000 ft. The Tijeras and Gutierrez faults bound the Monte Largo horst and the Tijeras graben and syncline; a scissorslike displacement with some strike-slip displacement is characteristic of these faults. Most of the northeast and east-northeast faults have had numerous periods of movement. For example, the Tijeras fault was probably active in the Precambrian with some left-slip displacement (Connolly, 1982), and again during late Paleozoic, Laramide, middle

Tertiary, and Holocene times. The Placitas-San Francisco fault system probably had a similar history with the principal displacement taking place during Laramide time.

GEOCHEMISTRY

The geochemical survey involved the collection, analyses, and interpretation of analytical data for 140 geochemical samples (Hendzel and others, 1983; Hendzel, in press). Five sample media were selected to represent the area. These included 50 stream-sediment samples, 50 panned concentrates of stream sediments, 11 water samples, 23 nonmineralized rock samples for background geochemical information, and 6 samples of mineralized rock. The average sample density is approximately one sample per 0.67 mi^2.

Stream sediments and panned concentrates were taken from first- and second-order drainages, most of which were dry washes. Samples were taken from areas of geological interest including those of known mineralized rocks; water samples were all taken from flowing springs.

Stream sediments, panned concentrates, and rocks were analyzed for 31 elements by the semiquantitative spectrographic method (Grimes and Marranzino, 1968). Rocks were also analyzed for six elements, including gold, by atomic absorption (Viets, 1978). Panned concentrates were analyzed for gold using methods described in Ward and others (1969). Water samples were analyzed by three methods: atomic absorption for Cu, Mo, Pb, and Zn; ion chromatography for F, Cl, and SO_4; and laser fluorescence for U.

Anomalous analytical values were determined by various methods depending on the element and the statistical data for that element. Twice crustal abundance, as suggested by Hawkes and Webb (1962), or two to three times the geometric mean of the element, were used to determine most anomalous values. Some elements were not considered to be anomalous unless they were many times the crustal abundance, for example, Fe and Mg; whereas others, such as Mo, W, and Zn, were anomalous whenever detected by spectrographic analyses.

Many anomalous values were found within and adjacent to the wilderness, primarily along the east dip slope where faulted limestone of the Madera Group forms extensive outcrops. Barium values of 10,000 parts per million (ppm) or greater were obtained for 22 panned concentrates from drainages along the eastern dip slope. Associated with 13 of these concentrates were strontium values of 10,000 ppm. Anomalous values for Ag, Cu, Mo, Nb, Sn, V, W, and Zr were also associated with some of these same concentrates. Along the steep west slope of the range, in an area of Precambrian rocks, anomalous values for La, Y, Th, W, and Zr were noted.

Areas of known mineral occurrences were sampled to obtain geochemical signatures of mineralized rock. For example, the La Luz mine (fig. 2, locality 3) contained mineralized veins in granite with concentrations of Ag, Cu, Pb, Zn, Bi, and Sb. Just north of the wilderness boundary (sec. 1, T. 12 N., R. 4 E.) in an area of strip mining (fig. 2, locality 8), mineralized fractures in red beds of Triassic age showed concentrations of Ag, Ba, Cu, Mo, Pb, V, As, and Cd. One sample from this area contained 200 ppm silver.

One panned concentrate is worth special mention because of anomalous base-metal values. This sample, from a drainage near the southeast corner of the wilderness (SE1/4 sec. 3, T. 10 N., R. 5 E.), contained high Ba (>10,000 ppm) and Sr (10,000 ppm) values, and Ag (5 ppm), Cu (150 ppm), Mo (5,000 ppm), Pb (>50,000 ppm), V (5,000 ppm), and Zr (>2,000 ppm). The source of these anomalous values was not discovered but the concentration of elements may have been derived from veins along the Flat Irons fault (fig. 2, locality 9).

Two major rock types, the Sandia Granite and limestone of the Madera Group, predominate within the wilderness, and each rock type has its own distinctive anomalous values. For example, the 22 anomalous values for barium are located on drainages crosscutting the gently east-dipping Madera limestones (Hendzel and others, 1983). This suggests the presence of numerous small vein or bedded replacement deposits of barite. Barite, owing to its high specific gravity, is easily concentrated in a stream-sediment environment and therefore does not give an accurate representation of the size of the deposit from which it was derived. Previous intensive exploration for barite has revealed chiefly small barite veins along the Agua Sarca, Pomecerro, Colorado, and Ellis faults; only at the Landsend deposit and in some prospects in the Tunnel Springs subdistrict (fig. 2, localities 1 and 2) does bedded barite occur in minor amounts as replacement deposits in limestone.

On the more rugged western slope of the range numerous pegmatite and aplite dikes cut the metapelitic gneisses of the Rincon. Consequently, monazite and diverse multiple oxides derived from these dikes commonly produce anomalous values for thorium (200 ppm), yttrium (2,000 ppm), tungsten (150 ppm), and tin (50 ppm) in the stream sediments of the western slope.

Most of the panned concentrates were purposely taken on or downstream from mapped faults. The weathering of mineralized faults along the eastern dip slope has yielded panned concentrates having anomalous values for Ag, Cu, Pb, and Mo. Some of these anomalous values can be traced to silver-bearing base-metal veins or to galena-bearing fluorite-barite veins that occur along these faults.

As much as 10,000 ppm of strontium was detected in some of the barite veins, and it is possible that some celestite and (or) strontianite is present in many of the veins. However, barium and strontium are quite similar chemically to the smaller Sr ion (1.27Å, ionic radius), which substitutes freely for Ba (1.43 Å, ionic radius) in the barite lattice. Ratios of barium to strontium have been studied as a possible tool for delineating concealed ore bodies (Warren and others, 1974).

The data indicate that a number of geochemical anomalies occur in the Sandia Mountain Wilderness. Anomalous values of barium and strontium are especially common in panned concentrates along the drainages off the eastern dip slope, whereas anomalous values of rare-earths, thorium, zirconium, and niobium are common along the drainages of the western slope. Anomalous values for Ag, Cu, Mo, V, W, and Zr are associated with the barium and strontium anomalies and may prove useful in locating undiscovered mineralized veins.

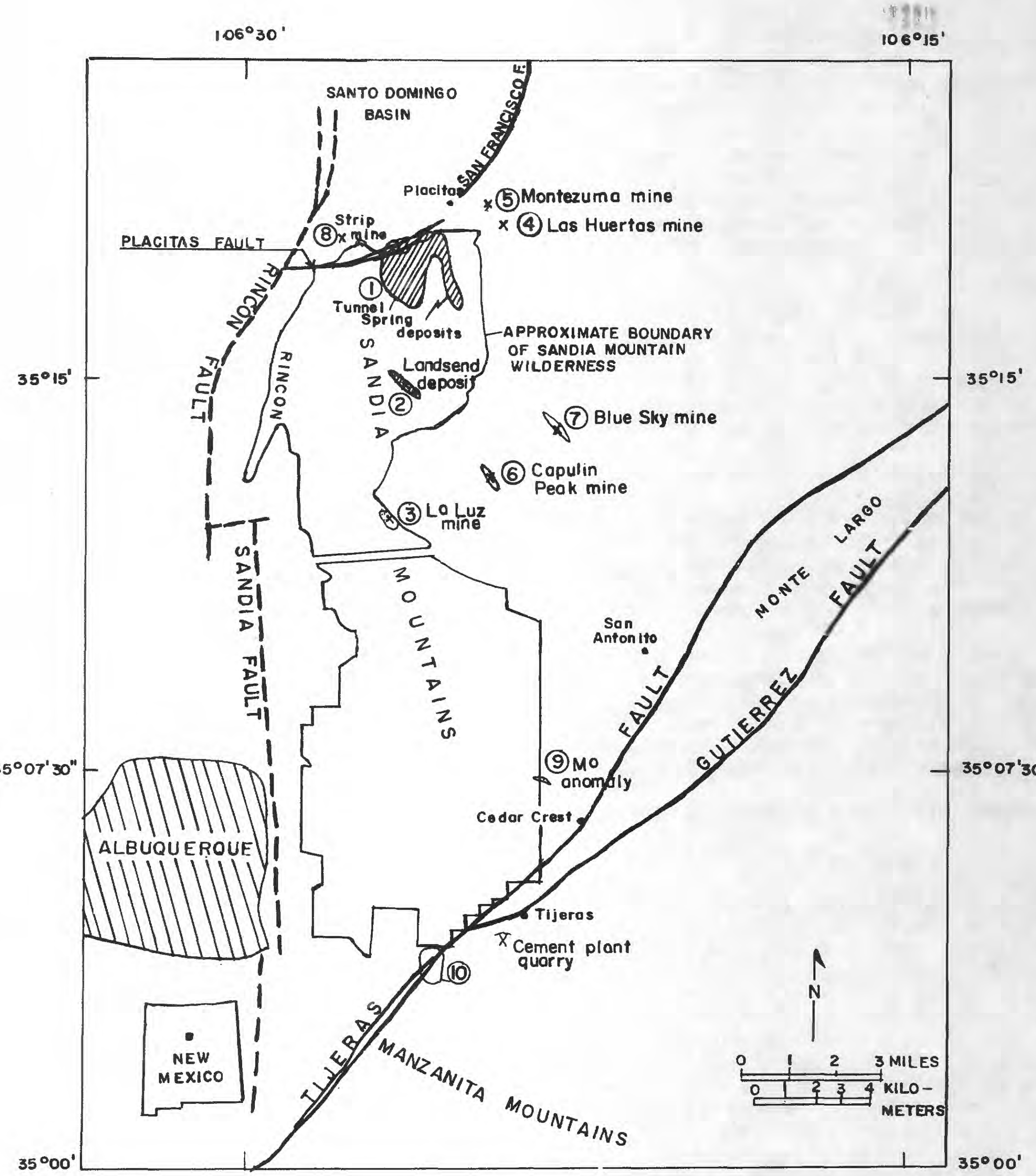

Figure 2.--Map showing locations of mineral occurrences in the Sandia Mountain Wilderness. Areas of low to moderate potential for barite resources are shown in fine cross-hatching. Circled numbers refer to mineralized areas discussed in text.

GEOPHYSICS

The aeromagnetic contours (Cordell and Hedlund, in press) were derived from an enlarged part of a series of three surveys that covered Albuquerque and vicinity (U.S. Geological Survey, 1975a, b, c). Local magnetic anomalies that appear on the aeromagnetic map by Cordell and Hedlund (in press) can be related to both topographic relief and contrasts in rock magnetization that are superposed on the Earth's main field.

The principal negative anomaly is in the Santo Domingo basin where a thick (9,000 ft) section of Paleozoic, Mesozoic, and Tertiary strata dips northward off of, and is faulted downward against, the Precambrian crystalline rocks of the Sandia fault block. This negative anomaly is part of an extensive low that extends westward across the Albuquerque Trough.

Positive anomalies along the Sandia Mountains result from topography, especially along the west-facing range front, and from variations in accessory magnetite within the Sandia Granite. The decreasing magnetic gradient off the Sandia Crest along the dip slope to the east is locally interrupted by positive anomalies over fault slices of uplifted Precambrian rocks.

The regional gravity map of Suits and Cordell (1981) does not indicate any significant mass-distribution anomalies in the wilderness, although a Bouguer anomaly gravity map (Cordell, 1978) does delineate steep linear gravity gradients along the largely concealed Sandia-Rincon-Ranchos faults.

MINING DISTRICTS AND MINERAL DEPOSITS

Mining districts

The Sandia Mountain Wilderness is within the Placitas and Tijeras Canyon mining districts (Kness, 1982). Many subdistricts and camps are included within the Tijeras Canyon district, for example, Carnuel, Tijeras, and Sandia, but the largest gold production (34,488 oz) came from the Tijeras Canyon district within the Manzanita Mountains to the south. Similarly, the Placitas mining district can be divided into subdistricts such as La Luz, Juan Tabo, Capulin Peak, Tunnel Springs, and Montezuma camps.

Most mining claims are located in the northern, southwestern, and southeastern parts of the wilderness; a total of 520 claims are recorded within the wilderness (Kness, 1982). The La Luz claims, near Sandia Crest, are the only patented mining claims in the wilderness and cover approximately 50 acres.

There are no active mines within the wilderness and the nearest current mining operation is at Tijeras, approximately 1 mi southeast of the wilderness boundary. At this locality, Ideal Basic Industries quarries limestone and shale from the Wild Cow Formation of the Madera Group. Annual capacity of the Tijeras plant is about 500,000 tons of Portland cement clinker (Hawley and others, 1982).

Numerous mines, prospects, and mineralized veins were sampled (table 1); 232 grab or chip samples were analyzed by semiquantitative spectrographic, fire assay, and atomic absorption methods. The analytical results from a selected 36 samples are shown in table 2.

Mineralization

Barite prospects typically occur along jasperized and limonitic fault breccias within the limestones of the Madera Group. The faults generally have a northerly strike, displace older faults of Laramide age and are of probable Pliocene and Miocene age. Local concentrations of galena as pods or disseminations in quartz veins are common, and zinc or copper-bearing minerals are present only in minor amounts. Varying amounts of pale-green and purple fluorite are commonly intergrown with the barite, and the high strontium values (10,000 ppm) in some veins suggest the probable presence of celestite. Bedded replacement deposits of barite are not common, but locally occur along veins of the Landsend deposit.

Precious metal veins in the region are of three main types: (1) argentiferous base-metal veins associated with barite and fluorite; (2) silver- and copper-bearing vein and fracture-filling deposits within red-bed strata of Permian and Triassic age; and (3) quartz-pyrite-gold veins in greenstone, quartzite, and gneiss of the Tijeras Greenstone and Cibola Gneiss.

The fluorite deposits are small in size, lack vein persistence, and the fluorite is commonly intergrown with barite. The milling and beneficiation of barite would result in some production of fluorite.

Ten mineralized areas have been defined (fig. 2). Areas 1, 2, and 3 are within the wilderness, area 9 straddles the wilderness boundary, and the others are outside the wilderness. These areas are: (1) barite veins along the Agua Sarca, Pomecerro, and Colorado faults near Tunnel Spring—area 1; (2) barite vein deposits of Landsend—area 2; (3) silver-bearing base-metal veins at the La Luz mine—area 3; (4) barite-fluorite veins of the Las Huertas mine—area 4; (5) silver-bearing veins of the Montezuma mine area—area 5; (6) fluorite vein along the Ellis fault at the Capulin Peak mine—area 6; (7) silver-bearing veins of the Blue Sky mine—area 7; (8) silver-bearing veins with secondary copper minerals within the Triassic red beds of the Chinle Formation—area 8; (9) a possible molybdenum-bearing deposit that is indicated by geochemical sampling within area 9; and (10) quartz-pyrite-gold veins along Tijeras Canyon—area 10.

Area 1 (Tunnel Spring subdistrict)

The numerous barite veins in the vicinity of Tunnel Spring are mainly within the wilderness and are commonly localized along the Agua Sarca, Pomecerro, and Colorado faults. The veins occur within faulted, silicified, and brecciated limestone of the Madera Group, along fault breccias within the Sandia Granite, and along fault contacts of limestone with granite. The limestones are commonly jasperized and highly altered to hematite and limonite adjacent to the veins. Some barite veins are as much as 60 ft long and 3 ft wide and the barite occurs as lenses and pods along the faults. The barite is commonly intergrown with fluorite and analyses of some vein material indicate as much as 15 percent barium and 4.9 percent fluorine (table 2). The barite veins have been extensively exploited.

Numerous small silver-gold veins are located along the Placitas fault at the intersections with the north-trending Agua Sarca and Pomecerro faults. The silicified, brecciated, and hematitized Placitas fault is capped by sporadic gossans in the vicinity of Tunnel Spring (Ellis, 1922). Some of these gossans have been extensively prospected, but the older mine workings are now filled or bulldozed away. The hypogene minerals are not readily identified but include pyrite, chalcopyrite, galena, barite, and fluorite. Kness (1982, p. 5) reported that of 51 samples analyzed in this area the gold content was a trace or less and the silver content ranged from 0.2 to 0.8 oz/ton.

Area 2 (Landsend deposit)

The Landsend barite deposit is within the wilderness, just north of Osha Canyon, and is localized along a fault that strikes N. 50° W. in limestone of the Madera Group. Both the vein and bedded replacement deposits have been extensively prospected by a series of bulldozer cuts and numerous prospect pits over an area of about 2,000 by 50 ft. The vein persists along strike for about 450 ft and in places is as much as 6 ft wide. The barite occurs as coarse crystals in brecciated limestone and as irregular bands that are locally parallel to the bedding planes of the limestone. Minor pale-yellow fluorite and galena are also present and the seven samples collected by Kness (1982) contained as much as 41 percent barium, 4.2 percent fluorine, and 0.1 percent lead. The property was probably developed in the late 1950's or early 1960's, but no production has been reported (Williams and others, 1964, p. 23).

Area 3 (La Luz mine)

The La Luz mine is within the wilderness and is located just off the Sandia Crest near the Sandia Forest Service Ranger Station at an elevation of about 10,040 ft. The mine is one of the oldest in the region and was chiefly worked between 1909 and 1921. Two adits, an open cut, and numerous prospect pits were developed along sheeted breccia zones in the Sandia Granite and yielded an unknown amount of silver ore. The veins strike N. 15° W. and N. 23° W., are about 3 ft wide, and contain appreciable amounts of argentiferous galena, purple fluorite, barite, and manganese oxides. An analysis of unoxidized ore (table 2) indicates 0.43 oz of silver per ton, 2 percent lead, and 0.15 percent barium; the gold content was below the limit of detection.

Area 4 (Las Huertas mine)

The Las Huertas barite-fluorite deposit is outside the wilderness and is located on the west side of the Crest of Montezuma at an elevation of about 6,450 ft (fig. 2). The barite is in the form of a lens 50 ft long and up to 10 ft wide and is localized along a reverse fault that has overturned sandstone and cherty limestone beds of the Sandia Formation (Kelley and Northrop, 1975, p. 106). The white, coarse-grained, tabular barite is intergrown with pale-green fluorite and minor amounts of galena. A sample taken by Williams and others (1964, p. 23) contained 71 percent barite, 9.8 percent fluorite, and 0.17 percent lead. Two chip samples taken by Kness (1982) contained 23.0 and 35.0 percent barium; the fluorine content was not determined; lead values are 0.02 percent. The past production of barite from this deposit is unknown.

Area 5 (Montezuma mine)

The Montezuma mine, also along the west side of the Crest of Montezuma, was chiefly developed along drusy-quartz veins that contained abundant argentiferous galena. Three shafts, a trench, small adits, and numerous prospect pits are located along the Las Huertas fault, which strikes N. 20° W., and a branch fault that strikes N. 15° E. Small shipments of ore in 1920 and 1926 contained as much as 11 oz of silver per ton (Elston, 1967, p. 29), but the analyses of unoxidized ore from the present study indicates only 0.28 oz of silver per ton and 2-3 percent lead (table 2).

Area 6 (Capulin Peak mine)

The Capulin Peak fluorspar deposit is along the Ellis fault, which strikes N. 15° W. and locally displaces the limestone beds of the Madera Group down to the west against the Sandia Granite. Coarse, brecciated, purple fluorite and colorless plates of barite occur along a vein about 120 ft long and up to 3 ft wide. The radioactivity of the vein is about twice background level. Some samples contain as much as 2 percent lead (table 2). The past production of fluorite was small, probably less than a hundred tons; production was chiefly in the 1920's (Johnston, 1928).

Area 7 (Blue Sky mine)

The Blue Sky (Arroyo Seco) silver deposit is developed by a slightly inclined adit along a fault that strikes N. 40-45 W. and that brought a small fault slice of Sandia Granite in contact with limestone of the Madera Group. The drusy-quartz and fluorite veins contain abundant argentiferous galena and minor amounts of sphalerite and chrysocolla. Analyses of unoxidized ore indicate 1.4 oz of silver per ton, 0.4-5.0 percent lead, and fluorine values of 11.5-24.0 percent (table 2).

Area 8 (Area of strip mines)

Numerous bulldozer cuts within mudstone and sandstone beds of the Triassic Chinle Formation have revealed fracture fillings of secondary copper minerals, minor barite, and anomalous amounts of silver. Some samples have silver values of 5.7 oz/ton (table 2, no. 5).

Area 9 (Geochemical anomaly near Cedar Crest)

Panned stream-sediment concentrates in an area about 1 mi northwest of Cedar Crest (SE1/4 sec. 3, T. 10 N., R. 5 E.) have yielded anomalous values for molybdenum (5,000 ppm; Hendzel and others, 1983). The source of this anomalous molybdenum was not discovered, but may be veins along the Flat Irons fault just within the wilderness boundary.

Area 10 (Tijeras Canyon)

Quartz-pyrite-gold veins within fractured quartzites of the Cibola Gneiss and within the Tijeras Greenstone have yielded as much as 0.27 oz of gold per ton and 0.3-0.6 oz of silver per ton (Kness, 1982, p. 8). There is no recorded mineral production from this area.

Miscellaneous nonmetallic and metallic mineral deposits

The Ideal Basic Industries cement quarry near Tijeras has a limestone capacity of 4,000 tons per day and a Portland Cement clinker capacity of 1,600 tons per day, or about 500,000 tons per year (Hawley and others, 1982). The limestone and shale are quarried from the Wild Cow Formation of the Madera Group.

Other small limestone quarries just outside the wilderness have been used for crushed stone aggregate in highway construction. Several quarries are along New Mexico Highway 44 near the Dry Camp picnic area and along the west side of Tejano Canyon.

About 0.5 mi southeast of Tijeras, azurite and malachite occur as fracture fillings within sandstone red beds of the Abo Formation. Four samples from the adit in this area contained from 2.1 to 6 percent copper (Kness, 1982, p. 8).

At the south end of Rincon Ridge near Jaral Canyon numerous small prospects were developed along pegmatite dikes that follow a well-developed N. 60° W. joint direction in micaceous schist and gneiss. Most samples contain less than 0.005 oz of gold per ton, and the silver content of these dikes was less than 0.2 oz/ton. Some of the pegmatites contain minor amounts of beryl.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

The mineral resource potential of the Sandia Mountain Wilderness is related to at least several of six factors or criteria:

1. A favorable geologic environment, such as the presence of numerous faults in a favorable limestone-sandstone host rock
2. Evidence of mineralization in adjacent areas along similar structural trends and in favorable host rocks
3. Anomalous metal or other trace-element values in rock and vein samples, and in stream-sediment concentrates. For example, the presence of anomalous Ba (10,000 ppm or greater), Sr (10,000 ppm), Pb (as much as 5,000 ppm), and detrital fluorite in many stream-sediments along the Sandia Mountain dip slope is compatible with the proximity to barite vein and bedded replacement deposits.
4. Aeromagnetic anomalies. Extreme high and low gamma values in areas of broad magnetic gradients may indicate areas favorable for the discovery of mineral resources. The interrupted magnetic gradient off the Sandia Crest is related to fault slices of uplifted Precambrian rocks, and some of these faults are mineralized; for example, the Ellis fault
5. Alteration halos related to hydrothermal fluids; for example, the formation of jasperized limestone and limonitic halos adjacent to the barite veins
6. Mineralized rock in or adjacent to the established wilderness boundary.

The Sandia Mountain Wilderness and adjacent areas contain small areas having low to moderate potential for barite resources in vein and bedded replacement deposits and for silver resources in veins; and low potential for fluorite resources in veins, for gold resources in veins, and for molybdenum resources in veins. The potential for the occurrence of resources in 5 of the 10 mineralized areas (fig. 2) are discussed.

Area 1, near Tunnel Springs and along the Colorado fault, has a low to moderate potential for barite resources. Many of the barite veins of this area are within the wilderness and occur along the Agua Sarca, Pomecerro, and Colorado faults. Many of the deposits have already been extensively mined and the lack of persistence of most veins has inhibited further exploration.

Numerous, small, gossanized silver-gold veins are located along the Placitas fault in the vicinity of Tunnel Springs. These precious-metal veins are not resources because of the low grade, but the geologic setting does support a low to moderate resource potential for silver and gold in this area.

Area 2, the Landsend barite deposit has a low to moderate potential for barite and fluorite in vein and bedded replacement deposits. This assessment is based on the presence of a large fault that displaces favorable limestone strata in a zone of known barite-fluorite vein and bedded replacement deposits that extend for about 450 ft along the fault. This area is within the wilderness.

Area 3, the La Luz mine area near the Sandia Crest, has a low to moderate resource potential for silver resources and a low potential for fluorite resources in veins. The veins are along sheeted and brecciated faults in the Sandia Granite and contain appreciable amounts of argentiferous galena and purple fluorite, and minor amounts of manganese oxides and barite.

Panned stream-sediment concentrates in an area about 1 mi northwest of Cedar Crest, area 9, have yielded anomalous values for molybdenum (5,000 ppm; Hendzel and others, 1983). The source of these anomalous values was not discovered, but is thought to be in the area along Lorenzo Canyon near Cedar Crest. This area (fig. 2) has a low potential for resources of molybdenum in veins and may extend into the wilderness.

Area 10 (fig. 2), Tijeras Canyon, has a low resource potential for gold in quartz-pyrite-gold veins within fractured quartzites of the Cibola Gneiss and within fractured chlorite schist of the Tijeras Greenstone. The gold assay values are less than 0.3 oz/ton for most veins. The area is outside the wilderness but is in a zone of intensive fracturing along the Tijeras fault, which extends into the south margin of the wilderness.

There is little likelihood that oil, gas, coal, or geothermal energy resources, although the Santo Domingo basin which adjoins the wilderness to the north, may have some potential for oil and (or) gas and coal resources. The coal-bearing beds of the Mesaverde Formation are not present in the wilderness.

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Table 1.--Mineral occurrences in and near the Sandia Mountain Wilderness

[Prospect number corresponds with locality shown on map. All prospects and mines within the wilderness were inactive at the time of fieldwork in 1981 and 1982. Au, gold; Ag, silver; Cu, copper; Fe, iron; Pb, lead; Zn, zinc; Ba, barite; Fl, fluorite; Ls, limestone]

Prospect number	Prospect name	Resource	Development	Brief description	Reference: (1-N) sample localities of Kness, 1982
[1]1	None--------	Cu	Prospect--------	Breccia zone in Precambrian gneiss.	(1-2).
[1]2	None--------	--	--do------------	Small fault in Precambrian schist.	(3).
3	None--------	Ag, Cu	Adit, 80 ft of workings.	Fractured schist adjacent to Rincon fault.	(4-6).
[1]4	None--------	Cu	Prospect--------	Fractured schist with quartz veins.	(7-11).
5	None--------	Ag	Prospect and bulldozer trenches.	Mudstone and sandstone of the Chinle Formation.	(12-13).
[1]6	None--------	Cu	Prospects-------	Splayed branches of Placitas fault in limestone of Madera Group.	(14-18).
[1]7	None--------	Ba	Prospect--------	1- to 3-cm veins of barite in limestone.	(19-20).
[1]8	None--------	Ba	2 adits---------	18- to 36-in. barite vein in altered limestone; veins terminate against against fault.	(21-28).
[1]9	None--------	Ba	--do------------	Barite present in fault breccia at contact of limestone with Sandia Granite.	(29-33). (34-37).
10	None--------	Ba, Fl	2 adits and shaft.	Fault breccia in limestone contains minor barite and fluorite.	(38-50). (41-45). (46-47).
11	None--------	Ba, Fl, Pb	Shaft, adit, and prospect.	Thin vein of barite, fluorite, and galena along fault contact of limestone and granite.	(48-49). (50-54). (55).
12	None--------	Pb	Prospects and adit.	Quartz vein contains galena at fault contact of limestone and granite.	(56-57). (58-60). (61).
13	None--------	Ba	Adit------------	Fault breccia in limestone.	(62-63).
14	None--------	Ba, Cu, Fl	Prospects-------	--do---------------------	(64-66).

Table 1.--Mineral occurrences in and near the Sandia Mountain Wilderness--Continued

Prospect number	Prospect name	Resource	Development	Brief description	Reference: (1-N) sample localities of Kness, 1982
15	None--------	(?)	--do-----------	Jasperized limestone---	(67-69).
16	None--------	(?)	Adit and prospects.	Gossan in limestone----	(70-72).
17	None--------	(?)	Several adits and prospect.	Cherty limestone-------	(73-78).
[1]18	None--------	(?)	Prospect--------	White clay in fault breccia.	(79).
[1]19	None--------	Ba, Fl, Pb	Prospect, shaft, adit, and bulldozer cut.	Irregular barite veins and minor fluorite and galena along Colorado fault.	(80-86); also Kelley and Northrop, 1975, p. 105.
[1]20	None--------	(?)	Prospect--------	Limestone beds of Madera Group.	(87-89).
[1]21	None--------	Ba, Fl, Pb	Prospects-------	Irregular barite veins in fault breccia.	(90, 91).
22	Montezuma mine.	Ba, Fl, Pb, Cu	4 shafts, adit, trench, prospect.	Mineralized fault breccia.	(100-101); also Kelley and Northrop, 1975, p. 100
23	None--------	Fe	Adit and prospect.	Silicified limestone with hematite.	
24	Las Huertas mine.	Ba, Fl, Pb	Adit-----------	Barite veins 4 in. to 6 ft thick along fault contact between Precambrian schist and Sandia Formation.	(102-108); also Kelley and Northrop, 1975, p. 105.
[1]25	Landsend deposit.	Ba, Fl, Pb	11 trenches and prospects.	Irregular barite veins up to 6 ft wide and minor bedding replacement deposits along fault in limestones of Madera Group. Some yellow and colorless fluorite intergrown with barite. Deposit can be traced for about 450 ft along fault.	(109-115); also Kelley and Northrop, 1975, p. 105.
26	Blue Sky mine--	Ag, Pb	Adit with 92 ft of workings.	Quartz-galena vein at fault contact of limestone with Precambrian granite. Vein 8 in. to 4 ft wide.	(116-128); also Kelley and Northrop, 1975, p. 105.
27	Capulin Peak mine.	Ba, Fl, Pb	Shaft, trench, and numerous prospects.	Barite-purple fluorite vein along Ellis fault. Vein 2-4 ft wide.	(129-133); also Kelley and Northrop, 1975, p. 101; Johnston, 1928.

Table 1.--Mineral occurrences in and near the Sandia Mountain Wilderness--Continued

Prospect number	Prospect name	Resource	Development	Brief description	Reference: (1-N) sample localities of Kness, 1982
28	None--------	(?)	Prospect--------	Sparse pyrite along Barro fault.	
29	None--------	Ls	Quarry----------	Limestone of Madera Group.	
30	None--------	Ls	--do------------	--do---------------------	
[1]31 and 31a	La Luz mine--	Ag, Pb, Cu, Ba, Fl, trace of Ag	Open cut--------	Sheeted and brecciated fault zone in Sandia Granite contains appreciable purple fluorite and galena. Veins are as much as 4 ft thick.	Kelley and Northrop, 1975, p. 101, 102.
32	(Jaral Canyon prospects).	Au, Cu	Adit, shaft, prospects.	Aplite and pegmatite dikes in schist.	(209-214).
33	(Jaral Canyon prospects)	Au, Cu	Shaft, adit, and 8 prospects.	--do---------------------	(214-217).
34	None--------	(?)	Prospect--------	Fault breccia----------	(135).
35	None--------	Ls	Quarry----------	Limestone of Madera Group.	(136).
36	None--------	Cu	Adit------------	Irregular thin seams of malachite and azurite along fractures in sandstone.	(137-140); also Kelley and Northrop, 1975, p. 104.
37	None--------	(?)	Prospect--------	Rubble-filled pit------	(141).
38	Ideal Cement Quarry (Ideal Basic Industries)	Ls	Quarry-active---	Limestone and shale of the Wild Cow Formation of Madera Group.	Hawley and others, 1982, p. 8.
39	None--------	Cu	Prospects-------	Tijeras Greenstone-----	(144, 145).
40	None--------	Au, Ag	Numerous adits and prospects.	Prospects along strike of 200-ft-thick quartzite bed in Cibola Gneiss.	(146-165).
41	None--------	Ag(?)	--do------------	Prospects along strike of quartzite bed in Cibola Gneiss.	(182-207).
42	None--------	Cu(?)	--do------------	Prospects in Tijeras Greenstone.	(166-179).
43	None--------	Cu	Shafts----------	Minor copper mineralization along fault in Cibola Gneiss.	(180, 181).
44	None--------	Ls	Quarry----------	Limestone beds adjacent to subdivision.	(208).

[1]Occurrence within wilderness boundary.

Table 2.--Fire assay, atomic absorption, and spectrographic analyses of 36 selected samples from the Sandia Mountain Wilderness and adjacent area, Bernalillo and Sandoval Counties, New Mexico

[USBM, U.S. Bureau of Mines; USGS, U.S. Geological Survey analyses by M. Malcolm, 1981. Tr, trace; --, not found above detection limit; N.A., not analyzed; >, greater than; A.A., supplementary atomic absorption analyses; Au, gold; Ag, silver; Cu, copper; Pb, lead; Zn, zinc; Ba, barium; F, fluorine]

Locality number	Prospect name	Sample type	Description	Fire assay (oz/ton)		Spectrographic analyses (percent)				
				Au	Ag	Pb	Cu	Zn	Ba	F
1 (USBM)	None------	Chip 48 in.	Fractured schist and gneiss; malachite coatings.	--	--	--	0.008	--	--	N.A.
3 (USBM)	None------	Chip 30 in.	Fractured schist with quartz veinlets along fault.	--	1.4	--	.02	--	--	N.A.
4 (USBM)	None------	Chip 48 in.	Fractured schist with quartz pods.	--	--	--	.01	--	--	N.A.
5 (USBM)	None------	Chip 24 in.	Mudstone and sandstone of Chinle Formation.	--	--	--	.004	--	0.2	N.A.
SAN-0110 (USGS)	East Cut--	Grab----	Fractures in Chinle Formation contain secondary copper minerals.	--	5.7	0.03	>2.0	0.002	.01	N.A.
6 (USBM)	None------	Chip 20 in.	Shear zone in Madera Group; malachite staining.	--	--	.01	.09	--	--	N.A.
8 (USBM)	None------	Chip 36 in.	Barite vein along fault in altered limestone.	--	--	.1	.01	--	11.0 (A.A.)	N.A.
		Chip 48 in.	Limestone and mudstone; fault rubble zone.	--	--	.1	.01	--	>1.0	N.A.
12 (USBM)	None------	Chip 48 in.	Quartz vein in limestone breccia.	--	--	N.A.	N.A.	N.A.	N.A.	N.A.
13 (USBM)	None------	Chip 24 in.	Fault breccia in limestone contains barite lenses and pods.	Tr	--	N.A.	N.A.	N.A.	3.7 (A.A.)	N.A.
SC-24-80 (USGS)	None------	Grab----	--do----	--	--	.0005	.0005	--	.20	N.A.
14 (USBM)	None------	Chip 42 in.	--do----	--	--	--	.01	N.A.	5.0 (A.A.)	0.21 (A.A.)

Table 2.--Fire assay, atomic absorption, and spectrographic analyses of 36 selected samples from the Sandia Mountain Wilderness and adjacent areas, Bernalillo and Sandoval Counties, New Mexico--Continued

Locality number	Prospect name	Sample type	Description	Fire assay (oz/ton)		Spectrographic analyses (percent)				
				Au	Ag	Pb	Cu	Zn	Ba	F
19 (USBM)	None------	Chip 36 in.	Irregular barite veins in brecciated limestone.	--	--	0.22	0.02	N.A.	15.0 (A.A.)	4.90 (A.A.)
21 (USBM)	None------	Chip 10 in.	Fault zone contains barite and calcite.	--	--	.07	.01	N.A.	6.0 (A.A.)	2.90 (A.A.)
22 (USBM)	Montezuma mine.	Chip 26 in.	Fault zone contains abundant galena in quartz veins.	--	--	1.95 (A.A.)	.55 (A.A.)	N.A.	--	N.A.
		Chip 20 in.	Fault zone contains minor galena.	--	--	2.10 (A.A.)	.02 (A.A.)	N.A.	--	N.A.
SC-21-80 (USGS)	--do----	Grab-dump.	Fault zone contains abundant galena in quartz veins.	--	0.28	3.0	.003	0.2	.01	N.A.
24 (USBM)	Las Huertas mine.	Chip 24 in.	Thick barite veins in cherty limestone.	Tr	--	.02	.005	N.A.	23.0 (A.A.)	N.A.
	--do----	Chip 20 in.	Thick barite veins in cherty limestone.	Tr	--	.02	--	N.A.	35.0 (A.A.)	N.A.
25 (USBM)	Landsend deposit.	Chip 55 in.	--do----	--	--	.09	--	N.A.	41.0 (A.A.)	2.37 (A.A.)
	--do----	Chip 32 in.	--do----	--	--	.10	.04	N.A.	19.0 (A.A.)	4.20 (A.A.)
26 (USBM)	Blue Sky mine.	Chip 18 in.	Fluorite-galena vein along fault contact of granite with limestone.	--	--	.37	.04	N.A.	--	24.0 (A.A.)
	--do----	Chip 14 in.	--do----	--	--	3.45 (A.A.)	.01	N.A.	--	11.5 (A.A.)
SC-20-80 (USGS)	--do----	Grab-dump.	--do----	--	1.4	5.0	.01	.05	.015	N.A.
27 (USBM)	Capulin Peak mine.	Chip 60 in.	Barite-purple fluorite vein along Ellis fault.	--	--	2.0 (A.A.)	.006	N.A.	6.3 (A.A.)	16.0 (A.A.)

Table 2.--Fire assay, atomic absorption, and spectrographic analyses of 36 selected samples from the Sandia Mountain Wilderness and adjacent areas, Bernalillo and Sandoval Counties, New Mexico--Continued

Locality number	Prospect name	Sample type	Description	Fire assay (oz/ton)		Spectrographic analyses (percent)				
				Au	Ag	Pb	Cu	Zn	Ba	F
31 B-1-80 (USGS)	La Luz mine (upper trench).	Chip 12 in.	Sheeted and brecciated fault zone in Sandia Granite.	--	0.43	2.0	0.05	--	0.15	N.A.
	--do----	Grab	--do----	--	.02	N.A.	N.A.	N.A.	.03	N.A.
	--do----	Grab	--do----	--	.28	N.A.	N.A.	N.A.	.02	N.A.
31-a	La Luz mine (lower trench).	Grab	--do----	--	.014	N.A.	N.A.	N.A.	.07	N.A.
32 (USBM)	None------	Chip 12 in.	Quartz vein in schist near Jaral Canyon.	0.012	--	--	.02	N.A.	--	N.A.
33	None------	Chip 36 in.	Quartz vein in schist near Jaral Canyon.	--	--	--	.03	--	--	N.A.
36 (USBM)	None------	Chip 20 in.	Irregular thin seams of malachite and azurite along fractures in sand-stone.	--	--	--	4.00 (A.A.)	N.A.	.2 (A.A.)	N.A.
39 (USBM)	None------	Chip 19 in.	Metabasalt with quartz vein.	--	--	--	.11	N.A.	--	N.A.
40 (USBM)	None------	Chip 29 in.	Fractured Cibola Gneiss-------	.274	--	--	.01	N.A.	--	N.A.
42 (USBM)	None------	Chip 25 in.	Quartz veinlets in green chlorite schist.	--	.6	--	.005	N.A.	--	N.A.
43 (USBM)	None------	Chip 39 in.	Fractures in Cibola Gneiss	--	.3	--	.002	N.A.	.07 (A.A.)	N.A.