UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Mineral Resource Potential of the El Malpais Instant Study Area and Adjacent Areas, Valencia County, New Mexico

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Open-File Report 81-557
1981

This report is preliminary and has not been edited or reviewed for conformity with U.S. Geological Survey standards.

Mineral Surveys

Wilderness Studies Related to

Bureau of Land Management

The Federal Land Policy and Management Act (Public Law 94-579, October 21, 1976), requires the U.S. Geological Survey and the Bureau of Mines to conduct mineral surveys on certain areas to determine their mineral resource potential. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a mineral survey of the El Malpais Instant Study Area and adjacent areas, Valencia County, New Mexico.

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SUMMARY

A geologic and geophysical investigation and a survey of the mineral occurrences have been conducted to determine the mineral resource potential of the El Malpais Instant Study Area, Valencia County, New Mexico. The study area includes the El Malpais basalt field and the west and south flanks of Cebollita Mesa. The basalt field is composed of Quaternary tholeiitic basalt flows, the youngest less than 1,200 years old. Cebollita Mesa, capped by Tertiary basalt flows, is composed of Upper Cretaceous shale, siltstone, and sandstone, with thin coal beds in the uppermost part. Some investigations were also conducted outside the study area, notably in the Precambrian rocks of the Zuni Mountains fluorspar mining district.

Known exposures of mineral resources within the boundary of the study area are limited to basalt, scoria, and coal, none of which are considered a significant resource. Basalt and scoria occur in huge amounts outside the study area, nearer to transportation, where they are more economical to mine. Coal occurs in thin beds, generally less than 1 ft (0.3 m) thick so is not considered an economic resource.

Of the minerals known to occur nearby but outside the study area, only fluorspar can be projected to occur in the subsurface inside the study area, but too deep to be an economic resource. There are no known deposits of oil or gas in or near the study area. The mineral resource potential of the El Malpais Instant Study Area is judged to be very low to nil.

INTRODUCTION

Location and setting

A mineral survey of the El Malpais Instant Study Area and adjacent areas, New Mexico, was made in 1978 and 1979 by the U.S. Geological Survey and the U.S. Bureau of Mines. The area studied consists of two roadless areas, contiguous on either side of State Road 117, in Valencia County, New Mexico, about 5 mi (8 km) south of Grants (fig. 1). The Cebollita area is east of 117 and west of the Acoma Indian Reservation and lies on the west flank of Cebollita Mesa. The El Malpais area is west of 117 and is an area of lava flows and volcanic craters; it includes the El Malpais Natural Area, established as an Outstanding Natural Area by the U.S. Department of Interior in 1974, plus adjacent lands to the west. The two roadless areas occupy a total of about 141,430 acres (57,236 ha) of public lands, including 26,321 acres (10,660 ha) west of the natural area and in the Cebollita area east of road 117, about 84,000 acres (34,020 ha) in the El Malpais Natural Area, and 31,000 acres (12,545 ha) of contiguous lands.

The terrane in the Cebollita area is cut across sedimentary rocks; conspicuous features are remnant buttes and pillars underlain by nearly horizontal beds of sandstone. The terrane in the El Malpais area is characterized by lava flows and volcanic craters. The El Malpais Natural Area contains the more recent flows and is nearly continuously covered by them. The adjacent lands to the west contain older and more weathered flows. Conspicuous features in the El Malpais area are volcanic craters and shield volcanoes, about 500 ft (150 m) high, and scattered islands (called steptoes) of sedimentary rocks surrounded by lava. The most recent of the lava flows, the McCartys flow, occupies a strip several miles wide along the eastern and southern edge of the El Malpais Natural Area. It is estimated to be less than

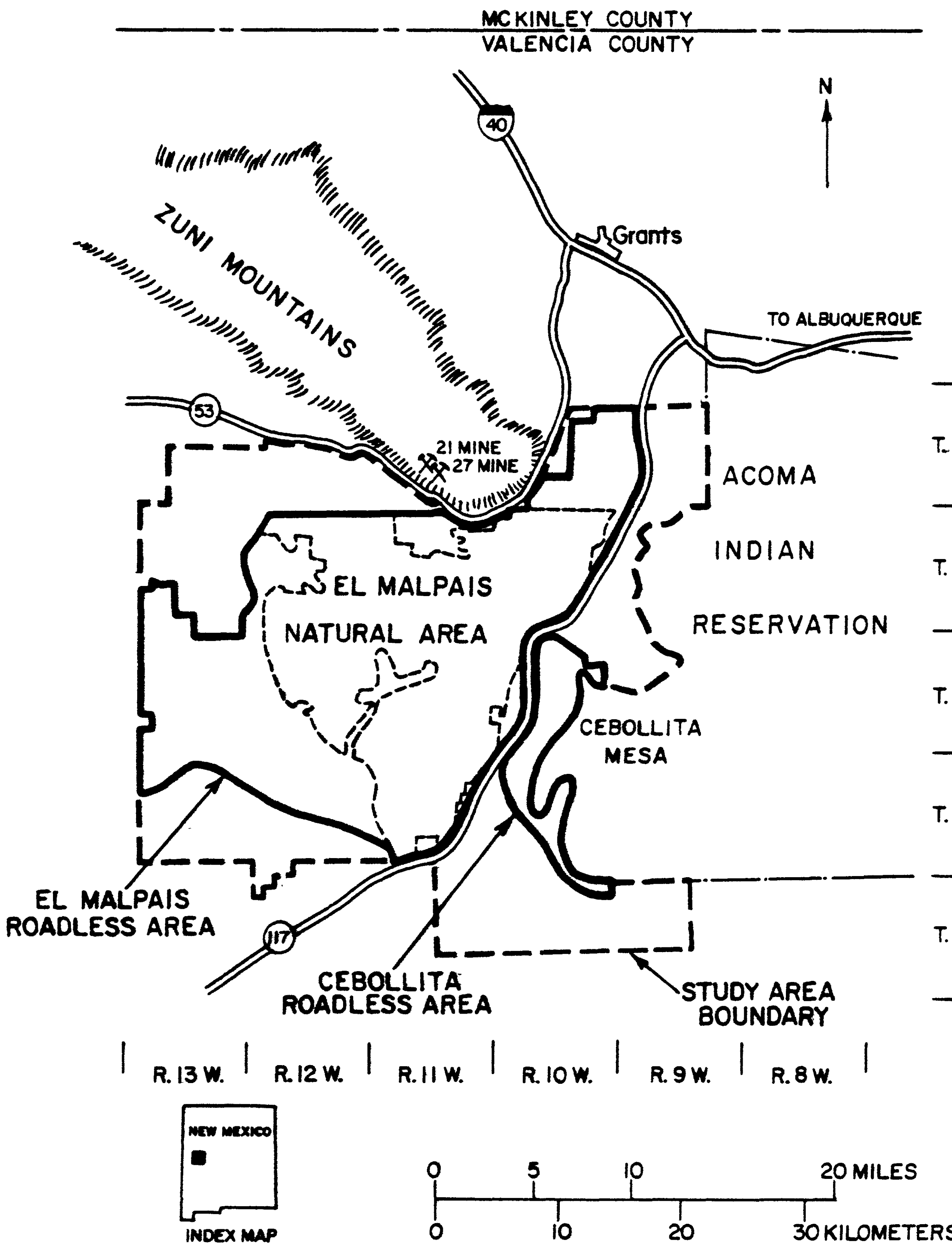

Figure 1.--Index showing location of the El Malpais and Cebollita roadless areas, New Mexico, and locations of the 21 and the 27 fluorspar mines.

1,200 years old (Nichols, 1946). It is bare of vegetation, black colored, and extremely fresh looking. Its surface is mostly ropy textured. Ridges and valleys lie parallel to the direction of flow. Features such as pressure ridges, squeeze-ups, spatter cones, lava tubes, and collapse depressions are displayed in the lava.

Access to the study area is from State Roads 117 or 53. Route 117 leaves Interstate 40 about 5 mi (8 km) southeast of Grants, runs southwest along the east flank of the El Malpais Instant Study Area, and also bounds the Cebollita area to the east. State Highway 53 goes from the west end of Grants, reaches the west flank of the lava flows near where they pass around the southeast toe of the Zuni Mountains, and then goes west, north of the lava and south of the Zuni Mountains. A number of dirt roads, trails, and graveled roads run through the western part of the El Malpais area. In the middle of the El Malpais Natural Area there is an area surrounded but uncovered by lava, reached by a dirt road from the southwest.

Elevation ranges from 6,500 ft (1,980 m) where lava flows cover the northeast end of the study area, to about 8,100 ft (2,470 m) at the rims of craters on the west side of the lava cover; older craters further west reach up to 8,305 ft (2,545 m). The highest slopes of the Cebollita area are about 9,300 ft (2,530 m) at the edge of Cebollita Mesa.

Vegetation in the study area is mostly sagebrush, grass, and clumps of ponderosa pine with mixed piñons and junipers.

Mining activity

Inside the study area past or present mineral activity is limited to shallow gypsum diggings, a road metal quarry, and four geothermal heat-flow gradient test holes, all in the Malpais area. The closest significant mining activity outside the study area was for fluorspar, mostly during the period 1941 to 1953 at the 21 and 27 mines, about 1 mi (1.6 km) north of the study area.

GEOLOGY AND GEOPHYSICS

Geologic setting

El Malpais Instant Study Area occupies part of North Plains, located in the southeastern part of the Colorado Plateau physiographic province, and is bordered on the south by the Datil volcanic field, on the north by the Zuni Uplift, and on the east by the Acoma Embayment of the San Juan Basin. North Plains is floored by Quaternary basalt and alluvium. The Datil volcanic field is not exposed in the study area. The Zuni Uplift is an elongate domal structure with a Precambrian granitic core mantled by gently dipping Permian, Triassic, Jurassic, and Cretaceous sedimentary rocks. The Acoma Embayment includes relatively flat-lying Cretaceous sandstone and shale. Table 1 lists the thickness, lithology, and outcrop characteristics of sedimentary rocks in the study area. Figure 2 is a generalized geologic map of the region showing the approximate outlines of the study area.

The major structural and physiographic units in the study area are Cebollita Mesa on the eastern side, the southern tip of the Zuni Mountains dome on the northern side, and North Plains in the central, southern, and western parts of the area. North Plains and Cebollita Mesa are separated by a complex fault zone that trends N. 25-30° E., west side generally down, and with a postulated right-lateral component. In the northeast corner of the area and to the north the fault zone fans out to eastward- and northeastward-trending faults and into the north-trending, eastward-dipping Grants monocline. The cluster of cinder cones in the western part of the map appears to have been extruded along a series of north-trending en echelon faults in a zone that also trends about N. 30° E. and would also have a right-lateral component of movement impinging on and distorting the southwestern flank of

Table 1.—Thickness, lithology, and topographic expression of the sedimentary rocks in the El Malpais Instant Study Area

[To convert meters to feet, multiply by 3.28]

Geologic age Name of unit	Thickness (meters)	Lithology	Topographic expression
Upper Cretaceous			
Crevasse Canyon Formation	70-90		
Gibson Coal Member	20-25	Sandstone, siltstone, shale, coal beds	Ledgy slopes, rounded hills.
Dalton Sandstone Member	15-20	Sandstone	Cliffs, steep slopes.
Mulatto Tongue-Mancos Shale	0-30	Siltstone, shale	Steep slopes, landslides.
Dilco Coal Member-Crevasse Canyon Formation	35-45	Siltstone, sandstone, shale, coal beds	Steep slopes, landslides.
Gallup Sandstone	80-100		
Upper member main part	20-30	Sandstone, siltstone	Cliffs.
Shale member	40-50	Siltstone, shale	Steep slopes, landslides.
Gallego Member	~20	Sandstone, siltstone	Cliffs, ledgy slopes.
D-Cross Tongue-Mancos Shale	8-20	Shale	Steep slopes, landslides.
Tres Hermanos Member of Mancos Shale	90-100	Sandstone, siltstone, carbonaceous shale	Cliffs, ledges, steep slopes.
Mancos Shale and Dakota Sandstone	140-280		
Shale tongue-Mancos	70-90	Shale	Landslides, steep slopes.
Twowells Tongue-Dakota	1-25	Sandstone, siltstone	Cliffs.
Whitewater Arroyo Tongue-Mancos	23-47	Shale	Landslides, steep slopes.
Paguate Tongue-Dakota	10-30	Sandstone, siltstone	Cliffs, steep ledgy slopes.
Clay Mesa Tongue-Mancos	~10	Shale	Steep slopes, landslides.
Cubero Tongue-Dakota	0-10	Sandstone	Cliffs.
Oak Canyon Member-Dakota	20-30	Sandstone, siltstone, carbonaceous shale	Ledgy slopes and hills.
Upper Jurassic			
Morrison Formation	0-10	Shale, sandstone, conglomerate	Landslides, steep slopes.
Zuni Sandstone	80-150	Eolian sandstone	Cliffs, round steep slopes.
Middle Jurassic			
Summerville Formation	~30	Fluviatile sandstone	Steep ledgy slopes, cliffs.
Todilto Limestone	0-1	Limestone	Ledge.
Entrada Sandstone	~100	Eolian sandstone	Cliffs, steep rounded slopes.
Triassic			
Chinle Formation	360-460	Shale, siltstone, sandstone	Broad flats, badlands.
Moenkopi(?) Formation	0-15	Sandstone, conglomerate, siltstone	Ledges and cliffs.
Lower Permian			
San Andres Limestone	35-44	Limestone, minor shale	Cliffs, dip slopes, hogbacks.
Glorieta Sandstone	45-50	Sandstone	Cliffs, hogbacks, dip slopes.
Yeso Formation	~400	Siltstone, sandstone, shale, gypsum	Flats, broad slopes.
Abo Formation	~400	Sandstone, siltstone, shale	Cliffs, ledges, steep slopes.
Precambrian			

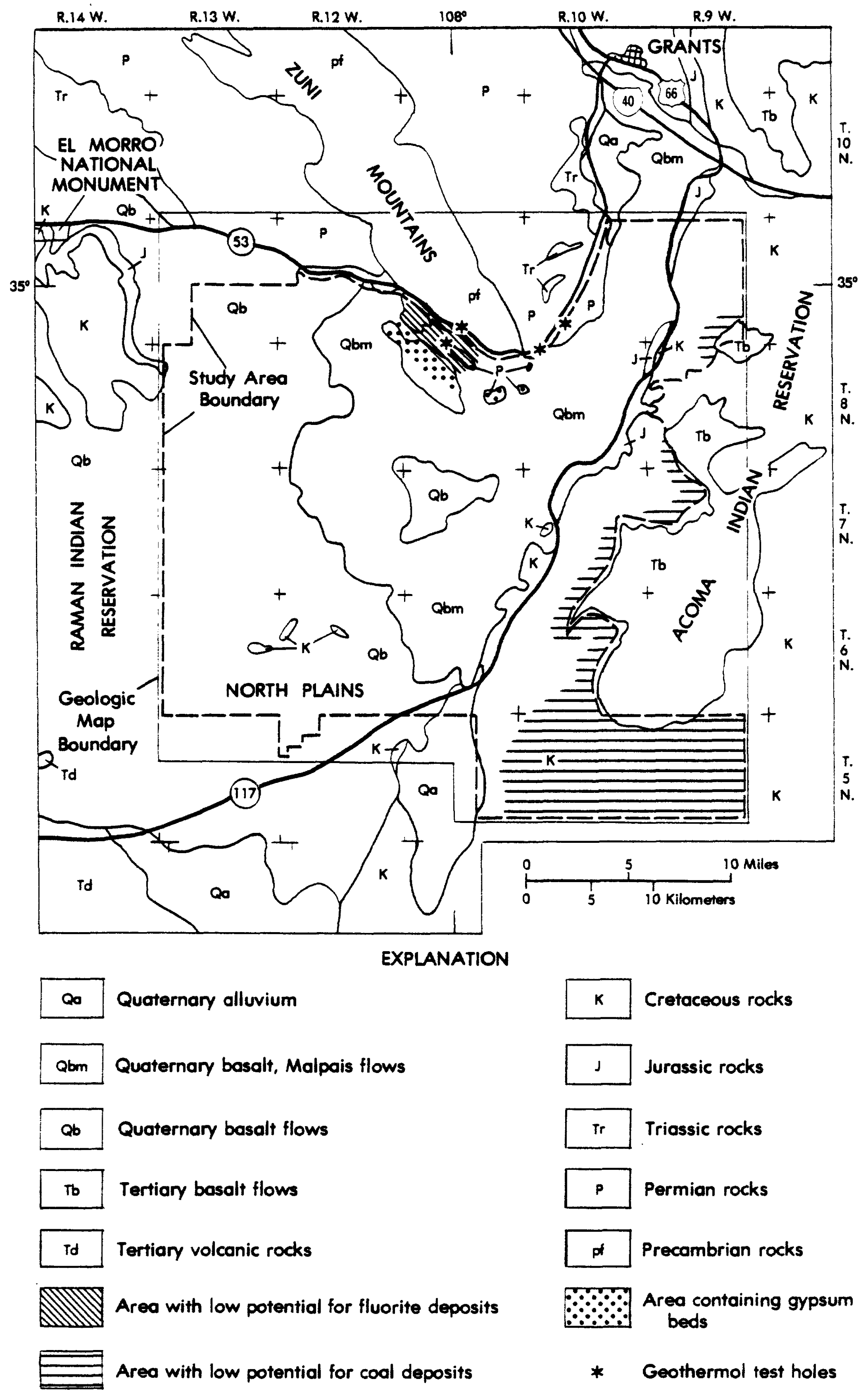

Figure 2.--Mineral resource potential and generalized geologic map of the El Malpais Instant Study Area and adjacent areas, Valencia County, New Mexico.

the Zuni uplift. The positions and attitudes of several steptoes of sedimentary rocks in the basalt flows south of the Zuni uplift imply the presence of faults or folds with a north to west trend, now completely hidden by the lava cover. Three prominent Holocene faults in the southern part of the area, and extending several kilometers to the south, are expressed in the lava flows by a series of short en echelon open crevices or fissures. The lack of alluvial fill in the fissures indicates a very young age for the faulting. Numerous, small fault scarps preserved in unconsolidated alluvium near the eastern edge of North Plains are also very young.

Aeromagnetics

The lava flows that comprise most of the El Malpais Instant Study Area are composed of tholeiitic basalt ranging from about 1 m.y. to 1,200 years old or less. Steptoes in the basalt field include Permian Yeso Formation, Glorieta Sandstone, and San Andres Limestone in the northern part, and Cretaceous Dakota Sandstone in the southern part.

Cebollita Mesa, along the eastern side of the study area, is composed of relatively flat-lying Cretaceous Dakota Sandstone, Mancos Shale, Gallup Sandstone, and the coal-bearing Crevasse Canyon Formation, capped at the top by Tertiary basalt flows.

Precambrian rocks in the core of the Zuni Mountains are exposed on the northern border of the study area and are flanked by outward-dipping Permian Abo Sandstone and Yeso Formation.

The aeromagnetic data (Maxwell, in press) include several prominent anomalies, all but one of which closely match known geologic features. Two magnetic lows correspond to outcrops of sedimentary rocks at Cerritos de Jaspe and the Narrows. Several small, sharply defined highs and lows on Cebollita Mesa correspond well with lava cones and vent areas, some as lows, others as highs, and Cebollita Peak as a sharp high and shallow low. A north-south elongation of the highs and lows matches the observed and postulated N-S faults and the alinement of vents on the mesa. A broad zone of small anomalies in the western part of the study area corresponds to a cluster of cinder cones; several cones coincide with sharp highs and several with the lows, but an equal number of highs and lows have no corresponding surface expression. An anomaly in the northeastern part of the study area is not easily explained by the surface geology; part of the high is over the same sedimentary rocks as the lows mentioned above, and the remainder is over the same sequence of lava flows that continues to the south and west of the anomaly. The anomaly may be the expression of a heretofore unsuspected intrusive, or lava flows whose vent or source area has been covered by subsequent flows.

MINING DISTRICTS AND MINERALIZED AREAS

Mining districts and known mineralized areas

There are no mining districts inside the area. Past and present mineral and drilling activity within the El Malpais Instant Study Area has been limited to shallow gypsum diggings, a road metal quarry, and four geothermal heat-flow gradient test holes, all in the El Malpais area.

Near the El Malpais area there are a number of road metal cinder pits and small gravel quarries, along State Highway 53 around the southeast end of the Zuni Mountains. The cinder pits are northeast and northwest of Bandera Crater. There is a limestone pit east of the Bonita Canyon road and rotten granite pits west of the 27 mines road both north and south of Highway 53.

About 4,000 acres (1,620 ha) in the El Malpais area and 3,000 acres (1,215 ha) in the Cebollita area were under oil and gas lease at the time of the record plat examination, and most all of the Federally owned oil and gas in the townships adjacent to the study area on the southeast were also in oil and gas leases, but there are no known deposits of oil and gas or any other leasable mineral other than coal and possibly geothermal resources in or near the study area.

The eastern edge of the Cebollita area is an area of potential mineral interest because it is partly underlain by two possibly coal-bearing members of the Crevasse Canyon Formation. In the El Malpais area, localities of possible mineral interest are apparently limited to two areas. One, near the Zuni Mountains, is an area of potential geothermal resource and has fluorspar veins which might also occur at depth in the Precambrian rocks. The other area is in the Cerritos de Jaspe and eastward where gypsum beds crop out in the Yeso Formation.

Cebollita area, eastern edge

The Cebollita area lies across the northwestern margin of the Datil Mountains Coal Field, where coal is present in the Dilco and the Gibson, the basal and the uppermost members, respectively, of the Crevasse Canyon Formation of Late Cretaceous age. Reported coal seam thicknesses within 6 mi (10 km) north of the Cebollita area are of beds of carbonaceous shale and coal 1.6 to 4.9 ft (0.5 to 1.5 m) thick in the Dilco Member and less than 3.3 ft (1 m) thick in the Gibson Member (Maxwell, 1977). Coal seam thickness is also reported, ranging from 3 to 7 ft (0.9 to 2.1 m) in the general area of 10 sections nominated for coal leasing in 1976 during the Bureau of Land Management's EMARS program, within 8 mi (6.4 km) northeast and southeast of the Cebollita area.

El Malpais area, near the Zuni Mountains

The north edge of the lava in El Malpais Natural Area laps onto the Precambrian gneiss of the Zuni Mountains, which contains mined fluorspar veins. The 27 mine and the 21 mine areas are about 1 mi (1.6 km) north of the Malpais area. The fluorite veins consist mostly of coarsely crystalline, green fluorite and also of mixed fluorite and wall-rock breccia cemented by fine-grained, purple fluorite. Some calcite, quartz, and barite are contained with the fluorite, but sulphides are notably absent. The veins range from several inches to 15 ft (5 m) thick and strike mostly northeast to east and dip steeply southeast to east. They are interpreted to be open-space fillings in fissures developed along faults of small (about 3 ft or 1 m) displacements. The veins are thickest where the strike or dip abruptly changes (Goddard, 1966).

The fluorspar vein closest to the study area (Goddard, 1966) is about 2,000 ft (600 m) north of Highway 53; it is exposed for about 20 ft (6.1 m) along a grassy hillside, trending approximately N. 65° E. and dips 60° SE. About 2 in. (5 cm) of green fluorite in silicified breccia is apparent, and a 2-in. (5-cm) chip sample (no. 1) across the material contained 95.7 percent CaF_2. A 5-in. (13-m) chip sample (no. 2) was also taken across adjacent footwall material and contained 41.1 percent CaF_2.

Further north, two fluorspar prospects were sampled. One, the Mack prospect, is about 3/4 mi (1.2 km) north of Highway 53 and 1/4 mi (0.4 km) west of the Bonita Canyon road. The working consists of a partly filled trench about 120 ft (37 m) long, 4 ft (1.2 m) wide, and as much as 7 ft (2.1 m) deep. An irregular vein of brecciated, purple and green fluorspar is exposed, 3 in. (7.6 cm) thick at most, on the trench floor, striking N. 20° E. and dipping 80° NW. Brecciated, intermixed fluorspar and wall rock is also present in the dump. A 3-in. (7.6-cm) chip sample (no. 3) was taken across the vein and contained 71.7 percent CaF_2.

The other prospect is a shallow, sloughed-over trench about 40 ft (12 m) long, about 900 ft (275 m) south of Highway 53, opposite the 27 mine road. A grab sample (no. 4) taken from among rock debris surrounding the trench assayed less than one percent CaF_2.

A fluorspar vein at the portal of Tunnel No. 1, the northeasternmost working in the 27 mine area, was also sampled. The vein was of green fluorspar, 18 in. (45.7 cm) across. The sample (no. 5) contained 98.0 percent CaF_2.

The entire Zuni Mountain region is of interest due to its potential for dry, hot-rock geothermal energy sites (Laughlin and West, 1976). In late winter 1978, four heat-flow gradient test holes were drilled near Highway 53 and the north boundary of the study area off the southeast end of the Zuni Mountains. The drilling was done by Geothermal Services, Inc. of San Diego, California, for Sunoco Energy Development Co. of Dallas, Texas. Hole locations and depths (A. O. Ramo, written commun., 1979) are given below.

Hole No.	Depth	Location
2A	440 ft (134.2 m)	NW1/4SW1/4, sec. 28, T. 9 N., R. 10 W.
4A	300 ft (91.5 m)	NE1/4NE1/4, sec. 3, T. 8 N., R. 11 W.
5	360 ft (109.8 m)	NE1/4SW1/4, sec. 10, T. 8 N., R. 11 W.
6	400 ft (122.0 m)	SE1/4NE1/4, sec. 6, T. 8 N., R. 10 W.

Because there is much groundwater influence in this area (B. Williams, oral commun., 1979), the heat flow measurements may not have been reliable, and it is not known whether any other measurements were made. The Sunoco Energy Development Co. reports (A. Ramo, written commun., 1979) that the data acquired in this drilling program were inconclusive in the determination of the geothermal potential of the area.

El Malpais area, Cerritos de Jaspe and Little-Hole-in-the-Wall

Gypsum occurs in the upper member of the Yeso Formation, cropping out in the Cerritos de Jaspe and on the east sides of a steptoe in the Little-Hole-in-the-Wall east of Cerritos de Jaspe. At the south end of the Cerritos de Jaspe, a 6-ft (1.8-m) layer of gypsum occurs between gypsiferous earth and siltstone, trending about N. 40° W. and dipping about 20° SW. A 10-in. (25.4-cm) specimen chip (no. 8) taken across bedding in the gypsum contained about 55 percent SO_4 and 19 percent combined water, or a stoichiometric equivalent 97 percent $CaSO_4.2H_2O$.

On the east side of the Little-Hole-in-the-Wall Steptoe, gypsum is exposed in a 150-ft (45-m) sequence of gypsum and gypsiferous rock striking about N. 60° W. and dipping about 20° SW. Evidence of some digging work is vaguely apparent, and a mining claim was reportedly staked here, although abandoned after one or two days work. Two, 1-ft (0.3-m) specimen chips (nos. 6, 7) were taken, one from a 4-ft (1.2-m) gypsum bed at the top and the other from a 5-ft (1.5-m) gypsum bed near the middle of the sequence. Both samples assayed approximately 53 percent SO_4 and 19 percent combined water, for an equivalent 93 percent $CaSO_4 \cdot 2H_2O$.

Past and present mining activity, production data

The closest significant mining activity outside the study area was for fluorspar, mostly during the period 1941 to 1953; the 21 and 27 fluorspar mines are located in secs. 21 and 27, T. 9 N., R. 11 W., respectively, about 1 mi (1.6 km) north of the study area at the southeast end of the Zuni Mountains (fig. 1). Total production from both these properties was 166,146 tons (150,728 t) (Williams, 1966).

There is no known production from within the study area.

MINERAL RESOURCE POTENTIAL

The mineral resource potential of the El Malpais Instant Study Area is low to nil. Known exposures of mineral resources within the boundary of the El Malpais Instant Study Area (fig. 1) are limited to basalt, scoria, gypsum, and coal (fig. 2). The basalt and scoria are not considered a significant resource because of the great quantities of these materials, generally present in this region, that are found outside the boundaries of the study area. The gypsum occurs in lenses generally less than 6 ft (2 m) thick and is usually impure; it is possible that thick, clean beds of gypsum do occur, but they would be of negligible importance compared to the vast deposits of pure, fine-grained, more readily available gypsum elsewhere in the region in the Middle Jurassic Todilto Limestone.

There is some indirect evidence for geothermal energy in the north part of the study area, but the rocks have not been adequately tested by drilling.

The minerals that are known to occur in economic deposits outside the study area include fluorspar, and uranium, but only fluorspar might reasonably be projected to occur in the subsurface inside the study area.

Geothermal energy

The study area lies within an area of anomalously high heat flow (Reiter and others, 1975). Within the anomaly, local hot spots may occur, indirect evidence (Laughlin and West, 1976) for which includes a continuous 3 million year period of intermittent volcanic activity, ending with the McCartys flow about 1,200 years B.P.; a range of tholeiitic to alkalic compositions within short distances in basalt flows, possibly indicating diverse depths and individual conduits; ultramafic inclusions and strontium isotope ratios in basalt, indicating deep origins; alinements of craters, indicating fissure-type eruption; an intersection of the supposed Jemez-Globe lineament trending northeast from Arizona with the Zuni-Sacramento lineament trending northwest from Texas; and ERTS imagery and a negative gravity anomaly, indicating a buried pluton off the southwest flank of the Zuni Mountains.

The only known geothermal test work in the area was the drilling of the four shallow holes for Sunoco Energy Development Co. The company reports that the data collected in these holes was inconclusive.

Fluorspar

In the Precambrian rocks of the Zuni Mountains there are numerous, mined fluorspar veins, and there is a potential for fluorspar also in the Precambrian rocks underlying the study area, but the great depths at which the fluorspar would exist make this potential low.

The depth to the Precambrian is least where the study area is closest to the Zuni Mountain exposures. This is at the north edge of the El Malpais area, on the upthrown side of a fault, west of Bonita Canyon. The Precambrian rocks here probably lie directly beneath the lava flows, the thickness of which is not known, but may be on the order of 150 ft (50 m).

Since the Precambrian is deformed into an elongate domal structure by the Zuni Mountains uplift, it dips away from the crest and its depth increases in all directions into the study area. Fluorite veins in the Precambrian rocks indicate an economic potential for a relatively low-value commodity in the northernmost part of the area, but projected to such a great depth below the surface that any potential value becomes negligible.

Although there is a potential for fluorspar in the Precambrian rocks at depth in the study area, any veins present would be less than 15 ft (4.6 m) thick and would dip at least 70° in comparison with the Zuni Mountain exposures. Extensive drilling exploration would be necessary, and due to depressed prices, foreign competition, and known fluorspar reserves elsewhere, the search would be extremely risky. At a Precambrian dip of perhaps 500 ft per mi (93 m per km) the great depths would be prohibitive to subsurface exploration over all parts of the study area except the extreme north edge of the El Malpais area, bordering the Zuni Mountains. The potential for metallic mineral deposits is considered low.

Uranium

The Upper Jurassic Morrison Formation and Middle Jurassic Todilto Limestone, which are host rocks for the major uranium deposits to the north of the El Malpais area, are not present in the study area; the Todilto pinches out near the northern border of the geologic map, and the Morrison is cut out by pre-Dakota erosion at the northern edge of the map.

Other sediments older than and lying below the Morrison and Todilto that contain minor uranium occurrences in the region are the basal sandstones and conglomerates of the Chinle and the Abo Formations and in the uppermost part of the Entrada Sandstone (Hilpert, 1969). These sediments may occur in the study area, but no anomalous radioactivity or any other indications of uranium were detected in these units in or near the El Malpais area.

The rocks bordering the contact between the Zuni Sandstone and the Dakota Formation are carbonaceous and locally altered and bleached, similar to rocks near uranium deposits, but any potential occurrences would project outside the study area.

Coal

Coal-bearing units in the region are the Gibson and Dilco Coal Members of the Crevasse Canyon Formation and, locally, the Tres Hermanos Member of Mancos Shale. These formations are present in the eastern third of the map area, underlying the basalt on Cebollita Mesa. An unpublished U.S. Geological Survey administrative report by D. E. Ward, W. J. Mapel and W. L. Yesberger describes results of drilling for coal in 1979 on the Acoma Indian Reservation; seven of their drill holes are shown on the accompanying map. Most of the subbituminous coal beds encountered in the drill holes were less than 1 ft (0.3 m) thick and only a few were as much as 2 ft (0.6 m) thick, all in the Dilco Coal Member. Coal beds in outcrops south of Cebollita Mesa appear to be about the same thickness; a few local lenses of highly carbonaceous shale and coal as much as 5 ft (1 1/2 m) thick indicate the possibility of local lenses of minable thickness. Coal-bearing units could not reasonably be projected to underlie the basalt anywhere in the map area.

Other resources

The El Malpais Instant Study Area contains large quantities of volcanic cinders and lava rock suitable for decorative stone; however, similar deposits outside the boundaries of the study area are more readily available.

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