MISCELLANEOUS FIELD STUDIES
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PAMPHLET

MINERAL RESOURCE POTENTIAL OF THE HELLS HOLE FURTHER PLANNING AREA GREENLEE COUNTY, ARIZONA, AND GRANT COUNTY, NEW MEXICO

By

James C. Ratté, Jerry R. Hassemer, and Ronny A. Martin, U.S. Geological Survey
and
John P. Briggs, U.S. Bureau of Mines

Studies Related to Wilderness

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and the Joint Conference Report on Senate Bill 4, 88th Congress, 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 results of a mineral survey of the Hells Hole Further Planning Area, Apache National Forest, Greenlee County, Arizona, and the Gila National Forest, Grant County, New Mexico.

SUMMARY STATEMENT

The Hells Hole Further Planning Area (RARE II) has a moderately high potential for the discovery of base- or precious-metal deposits related to igneous intrusions of middle to late Tertiary age, and a lower potential for discovery of porphyry copper of Laramide age beneath the younger Tertiary volcanic rocks that cover the area. There is little or no potential for the discovery of oil or gas, geothermal energy resources, uranium, or other mineral resources of economic value within the area.

INTRODUCTION

During 1979, the U.S. Geological Survey and the U.S. Bureau of Mines conducted field investigations to evaluate the mineral resource potential of the Hells Hole Further Planning Area. The investigations included geologic mapping, geophysical studies, geochemical sampling, and a survey of known mines, prospects, and mineralized areas. This report summarizes the results of those studies.

Location and geographic setting

The Hells Hole Further Planning Area encompasses a 34,330-acre (13,869 ha) area which straddles the Arizona-New Mexico border (fig. 1). Approximately 18,860 acres (7,619 ha) are contained within the Gila National Forest in Grant County, New Mexico; the remainder lie within the Apache National Forest in Greenlee County, Arizona. The area is bounded on the north by Arizona-New Mexico Highway 78, on the west and south by the National Forest, and on the east by various unimproved roads. Access to the area is provided by a network of secondary forest and county roads. Duncan, Arizona, is 25 mi (40 km) to the southwest via Arizona Highway 75 and a gravel road in Bitter Creek drainage. The Clifton-Morenci area is about 24 mi (39 km) to the northwest via New Mexico Highway 78 and U.S. Highway 666. Mule Creek, New Mexico, is 3 mi (5 km) east of the northeast corner of the study area along New Mexico Highway 78.

Present and previous studies

Present investigations by the U.S. Geological Survey and the U.S. Bureau of Mines include a mapped area of about 100,000 acres (40,000 ha) in and around the study area. U.S. Geological Survey investigations include geologic mapping at scales of 1:24,000 and 1:62,500 (Ratté and Hedlund, 1982), aeromagnetic and gravity surveys (Martin, 1981), and geochemical sampling of rocks and stream sediments (Hassemer and others, 1981b). The U.S. Bureau of Mines has reviewed past and present mining activity and has surveyed all known mines and prospects within the mapped area (Briggs, 1981). U.S. Geological Survey analytical data have been reported in Hassemer and others, 1981a.

Previous geologic studies in the area have been largely of a reconnaissance nature (Weber and Willard, 1959; Wilson and Moore, 1958; Gillerman, 1964). More detailed work includes reports on the geology of the Steeple Rock mining district (Griggs and Wagner, 1966; Russell, 1947) and a description of the proposed Mule Creek caldera (Rhodes and Smith, 1972). The mid-Tertiary volcanic geology of parts of Greenlee County,

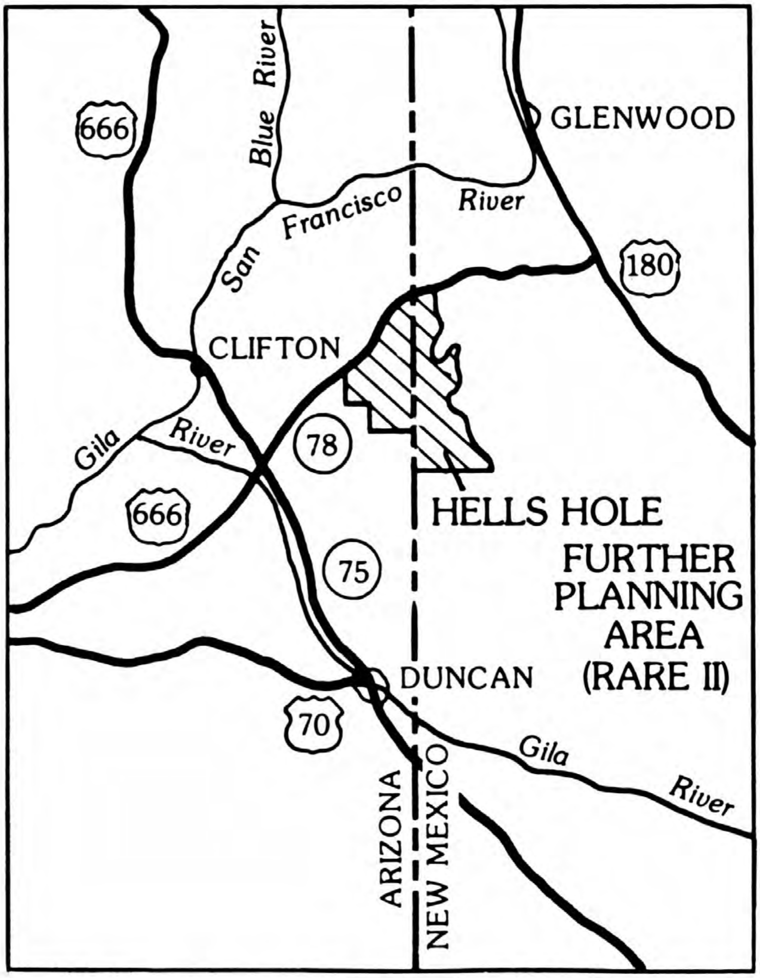

Figure 1.--Index map showing location of Hells Hole Further Planning Area (RARE II), Arizona and New Mexico.

Arizona, and Grant and Hidalgo Counties, New Mexico, is the subject of a doctoral dissertation at the Arizona State University (Wahl, 1980), which includes a discussion of the economic geology and mineral resource potential of the area within and adjacent to the Hells Hole Further Planning Area.

Geologic setting

The Hells Hole Further Planning Area is in the southwestern part of the Mogollon-Datil volcanic field of middle to late Tertiary age, which covers part of the transition zone between the Basin and Range and Colorado Plateau structural provinces. The study area is toward the northwest end of a fault-bounded, mountainous block that is about 70 mi (110 km) long and 25 mi (40 km) wide, which has the Precambrian-cored Burro Uplift at its southeast end. No pre-Tertiary rocks are exposed in the mapped area; however, Precambrian rocks overlain by Paleozoic or Mesozoic sedimentary rocks are present at several localities on the southwest side of the fault block. The nearest such basement rocks to the mapped area crop out 5-6 mi (8-10 km) to the west, where Coronado Quartzite and Longfellow Limestone of Cambrian and Ordovician age, respectively, overlie Precambrian granitic, gabbroic, and metasedimentary rocks (J. E. Cunningham, written commun., 1980). A more complete section of Paleozoic rocks is exposed a few miles farther west in the Clifton-Morenci area (Lindgren, 1905). About 12 mi (20 km) southeast of the mapped area, Mesozoic rocks unconformably overlie Precambrian granitic rocks without any intervening Paleozoic rocks. Major porphyry copper deposits are being mined at Morenci, Arizona, 20 mi (30 km) northwest, and at Tyrone, New Mexico, 50 mi (80 km) southeast of the study area. These large, disseminated copper deposits occur in quartz monzonite intrusives of early Tertiary age, which are overlapped by mid-Tertiary volcanic rocks; similar deposits could underlie mid-Tertiary volcanic rocks in the intervening area between these deposits.

Mining activity

In the mapped area, exploration and claim staking are the current mineral-related activities; Fraser-Martin Mines has located a block of unpatented mining claims over the southeast corner of the mapped area. The block overlies the old Yellowjack (Yellowjacket?) mine (fig. 2) on the west flank of Yellowjacket Peak, which was probably worked for secondary copper minerals, and the Telluride mine on Sawmill Creek (Rattè and Hedlund, 1982), which was developed on a gold- and silver-bearing quartz vein, probably during the mid-1920's.

The northern portion of the Steeple Rock mining district adjoins the southern boundary of the study area. Large blocks of unpatented mining claims, located by Exxon Minerals and Fraser-Martin Mines, overlie much of this part of the district, which was worked for its gold, silver, and copper-bearing fissure veins at a half-dozen different localities, primarily prior to World War I and during the late 1930's.

GEOLOGY, GEOPHYSICS, AND GEOCHEMISTRY

Geology

The Hells Hole Further Planning Area and adjacent parts of the mapped area are underlain entirely by middle to upper Tertiary volcanic rocks or by volcaniclastic sedimentary rocks derived from them (Rattè and Hedlund, 1982). The southwestern part of the mapped area, largely outside the Hells Hole Further Planning Area, consists of gently northeastward-dipping andesitic to rhyodacitic lava flows and a single outflow sheet of rhyolitic ash-flow tuff. The remainder, which includes most of the study area, is the site of a major intrusive-extrusive volcanic center that was active over a period of approximately 10 m.y., between about 28 and 18 m.y. ago. The rocks of this center include lava flows and subvolcanic intrusive rocks that range in composition from andesite to high-silica rhyolite, and they overlie or intrude the older andesitic lava flows of the southwestern part of the study area.

The volcanic center is expressed as a sequence of volcanic structures, the earliest of which is a large stock or small rhyolitic batholith about 10 mi (15 km) in diameter, which rose to the surface over a broad area where its outcrop now dominates the central part of the Hells Hole Further Planning Area. The arcuate form of the large rhyolite body suggests ring-fracture control of its emplacement, but there is no evidence for related cauldron collapse (Rattè and Hedlund, 1981). Volcanic activity continued with the extrusion of andesitic to rhyolitic lava flows and domes that may have formed a local stratovolcano having a radiating, silicic dike swarm and a small central stock of coarsely porphyritic andesite 2-3 mi (3-5 km) in diameter. And finally, highly differentiated, high-silica rhyolite pyroclastics and lavas were erupted through the older rhyolite from vents in the central part of the mapped area and other vents peripheral to the rhyolite stock or batholith, north and northeast of the mapped area.

Altered rocks are confined largely to local fumarolic areas within the large rhyolite body and to the younger rhyolite vent, or to the coarsely porphyritic andesite stock. Fumarolic alteration consists mainly of hematite and manganese stains, silicification, and minor argillic alteration, and is most strongly developed in a small area between McMullen Peak and Tillie Hall Canyon (Rattè and Hedlund, 1982). The porphyritic andesite stock is weakly propylitized throughout and is cut by numerous aplitic dikes 1 in. (2-3 cm) to greater than 100 ft (30 m) near its contacts with the older rhyolite intrusion. The aplitic dikes are extensively altered and may be cogenetic with the andesite. The andesite is most highly propylitized along its western and southern margins, where it intrudes the rhyolite of Hells Hole. Quartz veins cut the andesite intrusive along upper Sawmill Creek, and vesicular zones in the upper part of the andesite commonly are filled with quartz crystals.

The rocks of the mapped area are broken by high-angle faults of two major regional systems:

1. Northwest-trending faults are prevalent in the southwestern part of the area, are mineralized, and represent the extension of vein systems from

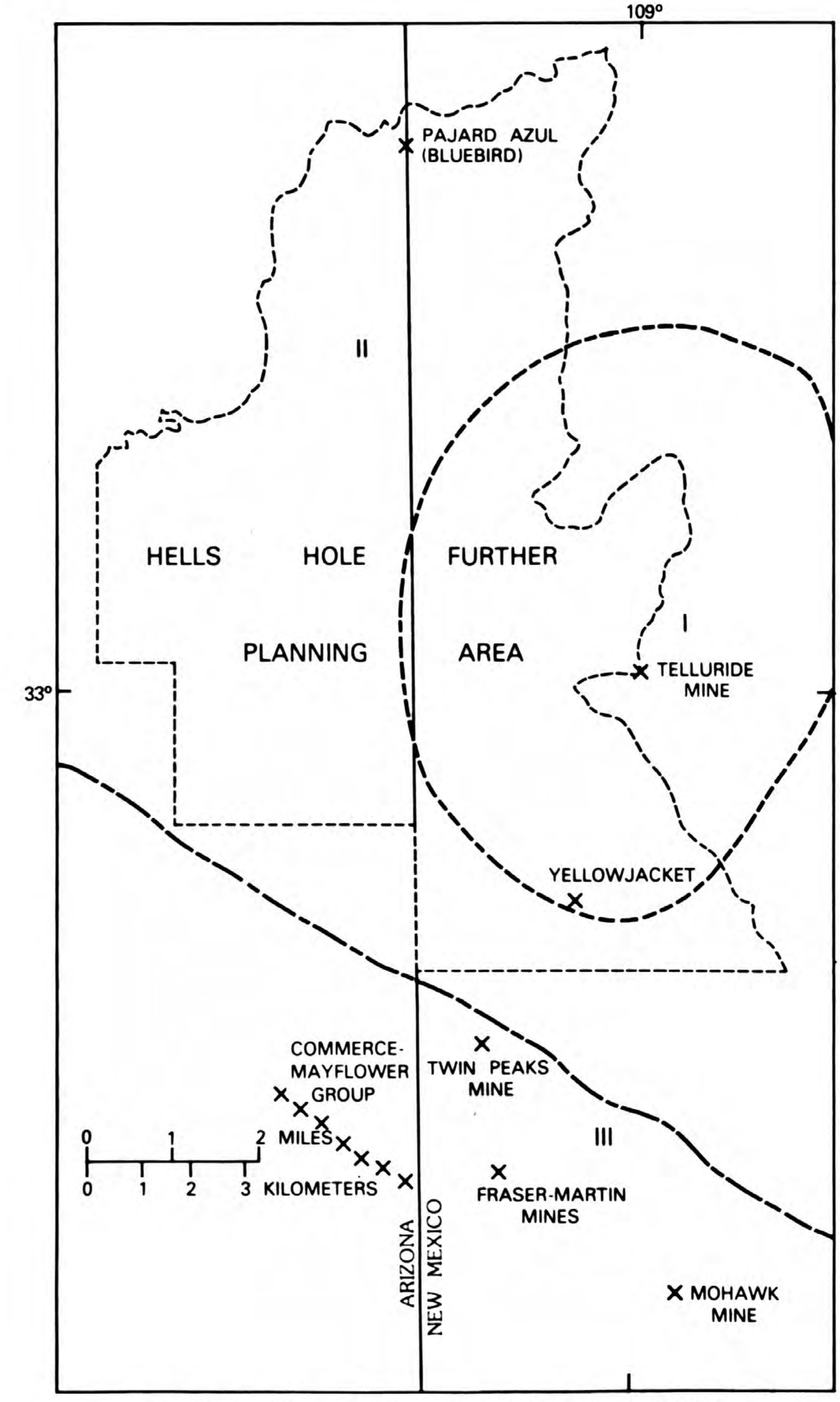

Figure 2.--Mineral-resource potential map of the Hells Hole Further Planning Area (RARE II), Arizona-New Mexico, showing areas I, II, and III of different mineral-resource potential (separated by dashed lines) as discussed in text.

the adjacent Steeple Rock mining district.

2. Northeast-trending faults are most common in the northeastern part of the area and are not mineralized.

The main trends of mafic and silicic dikes in the mapped area are concordant with the northwest and northeast fault systems, respectively.

Geophysics

Aeromagnetic and gravity maps of the Hells Hole Further Planning Area and vicinity (Martin, 1981) show the geophysical expression of some of the major geologic structures, and contribute significantly to their interpretation. A broad magnetic low, or negative anomaly, of about 300 gammas dominates the northern part of the study area, and conforms closely to the distribution of the main outcrops of the rhyolite of Hells Hole. The form of the magnetic low further confirms the geologic interpretation that the rhyolite stock, or small batholith, has steep contacts and a considerable extension in depth, and suggests that this partly hidden body extends much farther north and east than can be determined from surface exposures alone.

A positive magnetic anomaly, or magnetic high, of about 400 gammas corresponds closely to the outcrop pattern of the coarsely porphyritic andesite intrusive; smaller positive magnetic anomalies within the area of the broad magnetic low indicate that other, hidden intrusives of intermediate to mafic composition may be buried beneath the surface.

Some of the volcanic and subvolcanic structures that are so well represented on the aeromagnetic map are partly obscured on the gravity map (Martin, 1981) by a strong northeast regional gravity gradient. However, the coarsely porphyritic andesite intrusion is well defined by a 10-15 mgal gravity high. In fact, the gravity high extends for several miles as a northeastward-plunging nose that corresponds to the northeast-trending zone of silicic dikes near the east edge of the mapped area. The major rhyolite body, on the other hand, has weak gravity expression at best. On a residual gravity map of the Gila Wilderness Study Area (Ratté and others, 1979, plate 2A), there is closure of a weak gravity low with an east-west axis where the residual gravity map overlaps with the Hells Hole Further Planning Area.

In the southwestern part of the mapped area, the aeromagnetic map (Martin, 1981) mainly shows the northwest structural grain of the region adjacent to the study area, and the gravity map shows a continuation of the northeast-trending gravity ridge through the Twin Peaks Mine area (fig. 2). The coincidence of a 2 to 3 mi (3 to 5 km) diameter gravity and magnetic low just west of the Twin Peaks Mine may be above a rhyolite intrusion that did not reach the surface. It lies outside the study area.

Geochemistry

For the purpose of mineral resource appraisal, the distribution of metals in the mapped area was determined from analyses of 61 samples of altered and mineralized rocks and 186 samples of stream-sediment concentrates (Hassemer and others, 1981b). Widespread, anomalous metal values were found to occur in two separate but overlapping areas:

1. The major volcanic center that underlies most of the study area.
2. The northwest-trending fracture system that is the extension of the northern part of the Steeple Rock mining district, and is adjacent to, but largely south of, the study area.

Stream-sediment concentrates show anomalous beryllium and niobium over the volcanic center, particularly on outcrops of the rhyolite of Hells Hole and near the vent for the rhyolite of Mule Creek. Anomalous tin, boron, barium, and tungsten, though more dispersed, are also most common over or peripheral to the volcanic center. Anomalous silver, copper, molybdenum, lead, zinc, bismuth, antimony, and arsenic, on the other hand, are concentrated both over and around the volcanic center and along the northwest fracture zone. Samples of altered and mineralized rocks associated with the volcanic center show metal values of as much as: 200 ppm beryllium, 150 ppm niobium, 20 ppm tin, greater than 5,000 ppm barium, 10 ppm molybdenum, 100 ppm silver, and 1,000 ppm copper. Altered and mineralized rocks from the northwest fracture zone include selected rock samples having: silver to 300 ppm, copper to greater than 2 percent, molybdenum to 1,000 ppm, zinc to 0.7 percent, lead to 0.07 percent, barium to 3,000 ppm, and one sample having 15 ppm gold from the Twin Peaks Mine. Fluorite is common in the concentrate samples in the northwest fracture zone, but was not seen in concentrates that might be associated with the rhyolites of the volcanic center within the Hells Hole Further Planning Area.

MINING DISTRICTS, MINING CLAIMS, AND MINERALIZED AREAS

The Hells Hole Further Planning Area does not lie within an organized mining district. There are no patented mining claims within the area nor has there been any recorded production from within its boundaries. Actual mining has been limited to two small workings. One is located on the west flank of Yellowjacket Peak, where secondary copper minerals occur in a narrow shear zone at the Yellowjacket prospect; the other is at the Telluride mine on upper Sawmill Creek, where a narrow zone of discontinuous quartz veins is exposed in the stream bed (fig. 2). The only other prospect of note is the Pajaro Azul (Bluebird) uranium prospect on Coal Creek in the northeastern part of the area (fig. 2) where a siliceous cemented fault zone, which cuts rhyolite breccia, is anomalously radioactive. Approximately 850 unpatented mining claims (80 percent or more outside the study area) have been located within or adjacent to the mapped area, of which 650 are in compliance with federal recordation requirements (Briggs, 1981). The strip of claims connecting the Telluride mine and Yellowjacket Peak represents recent base- and precious-metal exploration efforts within the study area by Fraser-Martin Mines, Inc.

The southern portion of the study area adjoins the Steeple Rock (Mayflower, Twin Peaks) mining district. Sporadic mining activity in the district dates back to 1860 (Russel, 1947); the first production period was 1880-1897 (Graton, 1910). Subsequent periods of major production coincided with increased demand for metals during World Wars I and II and the Korean War, and were followed by periods of little or no activity.

Production from the district totals about $7 million in silver, gold, and minor base metals and fluorite, chiefly from the Carlisle and East Camp mines (Griggs and Wagner, 1966) 6-8 mi (10-12 km) south of the study area. Recently, in the central part of the district, Summit Minerals, Inc., a small mining company headquartered at Duncan, Arizona, reopened two mines about 6 mi (10 km) south of the mapped area and has been shipping 800 tons of ore weekly (D. Hansen, Summit Minerals, Inc., oral commun., 1979). Gold and silver associated with base-metal sulfides are recovered from a fissure vein at the Center mine, and a quartz vein system containing gold is mined at the Summit Mine. This characteristic, northwest-trending, fault-fissure vein system extends into the northern part of the district south of the study area. The large blocks of mining claims staked over this portion of the district reflect both past and present mineral activities. Exxon Minerals is conducting a base- and precious-metal exploration program centered on a tract west of the Arizona border and south of the western half of the study area. On the New Mexico side, Fraser-Martin Mines, Inc. is conducting a similar program. Exploration work has included drilling, geologic mapping, and geochemical and geophysical surveys. No recent production has been recorded from this northern portion of the district; past production includes 1,115 oz (34.7 kg) gold, 3,640 oz (113.2 kg) silver, and 1,965 lbs (891 kg) copper.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

A moderately high potential for the discovery of base- or precious-metal deposits within the Hells Hole Further Planning Area is related to:

1. A favorable geologic environment as determined by geologic mapping and geophysical interpretations.
2. Evidence of mineralization provided by present and past mining activity in areas adjacent to the Hells Hole Further Planning Area, and anomalous metals in stream-sediment concentrates and rock samples of veins and hydrothermally altered rocks locally within the mapped area.

The favorable geologic environment consists of a middle Tertiary volcanic center and subjacent shallow stock or batholith of silicic to intermediate composition that is interpreted as underlying most of the study area. Volcanism and intrusive activity were sustained over an interval of about 10 m.y. during which time the magma, or magmas, evolved from andesite through rhyodacite and low-silica rhyolite to high-silica rhyolite. Ore-deposit models indicate that this geologic environment is most conducive to the formation of stockwork molybdenum deposits, or epithermal precious-metal deposits of the fissure-vein type which occur in the nearby Steeple Rock district. The geologic setting is also generally favorable for the occurrence of porphyry copper deposits, except for the important consideration that such deposits almost invariably are early Tertiary or Late Cretaceous in age in this region. However, because of the proximity of major porphyry copper deposits at Morenci, Arizona, and Tyrone, New Mexico, the possibility that a similar deposit is buried beneath mid-Tertiary volcanic rocks within the study area has to be considered in this appraisal. A tin porphyry system is also possible in this geologic environment (Sillitoe and others, 1975), and although it would be a unique and unlikely occurrence in this region, the strategic importance of tin makes even the possibility of a tin porphyry system noteworthy.

Although niobium in pseudobrookite and ilmenite (Hassemer and others, 1981b) forms as much as 1 1/2 percent of the magnetic fraction of the gravel in some drainages across the major rhyolite outcrops, there is little likelihood of sufficient volume or grade for economic niobium placer deposits.

The silicic volcanic rocks, particularly the high-silica rhyolite of Mule Creek, are suitable source rocks for uranium-bearing solutions. A single prospect (Pajaro Azul) in the northwestern part of the study area has revealed a uranium occurrence, formed most likely by the movement of uranium-bearing ground water along a fracture zone in rhyolite. No evidence of other occurrences of this type was found, nor evidence for other types of uranium deposits within the mapped area.

There is a very low probability for the discovery of oil, gas, exploitable geothermal energy resources, or any other mineral resources of economic value, other than those cited above, within the Hells Hole Further Planning Area.

For the purpose of resource assessment, a mineral resource potential map (fig. 2) is divided into 3 parts, two largely within the study area, but the third largely outside the study area. The moderately high potential of the 3 areas differs mainly in degree: Area I provides somewhat more specific ore-deposit targets than Area II; and Area III, which has the most obvious indications of mineral resource potential, is outside the study area.

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