UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

Mineral investigation of the Hack Canyon Wilderness Study Area, Mohave County Arizona

U.S. Bureau of Mines Mineral Land Assessment
MLA 37-84
1984

By
McDonnell, J.R., Jr.

This open file report summarizes the results of a Bureau of Mines wilderness study and will be incorporated in a joint report with the U.S. Geological Survey. The report is preliminary and has not been edited or reviewed for conformity with the U.S. Bureau of Mines editorial standards. Work on this study was conduced by personnel from Intermountain Field Operations Center, Building 20, Denver Federal Center, Denver, CO 80225.

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STUDIES RELATED TO WILDERNESS
Bureau of Land Management Wilderness Study Area

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 values. 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 Hack Canyon Wilderness Study Area (AZ-010-033A), Mohave County, Arizona.

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By John R. McDonnell, Jr., Bureau of Mines

SUMMARY

Uranium, copper, silver, gold, lead, cobalt, and vanadium occur within, and have been mined from breccia pipes near the Hack Canyon Wilderness Study Area. Currently (1984) five breccia pipes are known within the study area and uranium minerals have been identified in two of these; additional breccia pipes and associated mineralization could be present. Gypsum beds, up to 4 ft thick, have been reported in Permian limestones that underlie the study area, but the material appears to be contaminated by quartz and limestone fragments. Oil shows in exploratory drill holes and a petroliferous shale have been reported near the study area in rock units that underlie the study area at depth; however, the drill holes have been abandoned and the shale is currently unproductive.

INTRODUCTION

During 1983 and 1984, the Bureau of Mines, in conjunction with the U.S. Geological Survey, studied the mineral resources of the Hack Canyon Wilderness Study Area (WSA), Mohave County, Arizona, on land administered by the Bureau of Land Management (BLM). Bureau of Mines personnel conducted surveys of mineral occurrences to evaluate reserves, and identified resources that are subeconomic but may be converted to reserves through changes in available data, economics, or technology. The Survey assesses the potential for undiscovered mineral resources based on their geological, geochemical, and geophysical evidence. This report presents the results of the study conducted by the Bureau of Mines.

Geographic setting

The Hack Canyon WSA (fig. 1) comprises 63,682 acres in northeastern Mohave County in the Arizona Strip of northern Arizona. The WSA is about 35 mi southwest of Fredonia, Arizona, and about 60 mi southeast of St. George, Utah. Access to the WSA is by improved dirt roads from State Highway 389. Jeep roads to livestock watering areas and abandoned drill sites, and hiking trails provide access within the WSA.

The WSA lies along the eastern margin of the Kanab Plateau, a part of the Colorado Plateau physiographic province. The region is semi-arid and includes plateau benchlands that consist of outcropping sedimentary rocks, eolian sands and silts, and thin, weathered-bedrock soils (LKB Resources, Inc., 1979, p. 6.1). Underlying the benchlands are relatively undeformed, flat-lying Paleozoic sedimentary rocks. The rocks have been cut by stream erosion and form extremely steep and rugged canyons that constitute most of the Kanab Plateau boundary. The WSA includes benchlands of the plateau and parts of Hack, Kanab, and Grama Canyons.

Method of investigation

This investigation included a review of available published and unpublished material related to the mineral resources and mining activity in the Hack Canyon WSA and vicinity. Mining claim information and land status plats were obtained from the BLM State Office in Phoenix, Arizona. Minerals information and production data were collected from Bureau of Mines files and other sources.

In April 1983, two Bureau personnel conducted a seven-day field examination that covered the WSA and known mineral occurrences up to 1 mi beyond the WSA boundary. This examination included reconnaissance by

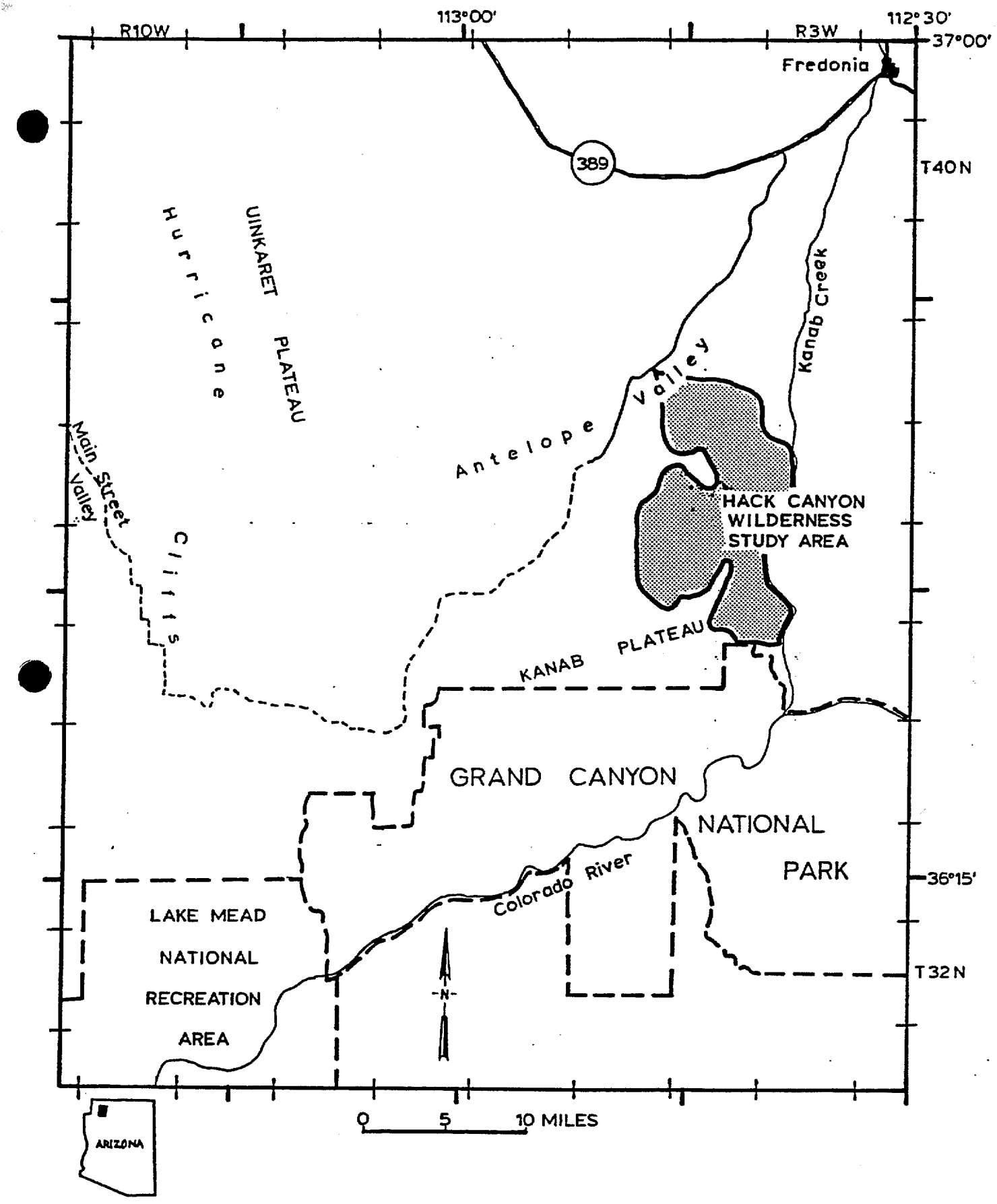

Figure 1.--Index map of the Hack Canyon Wilderness Study Area, Mohave County, Arizona.

fixed-wing aircraft, four-wheel-drive vehicle, and foot traverses across the WSA. No mine workings or evidence of mineralization were found in the WSA and no samples were collected.

Acknowledgements

Personnel at the BLM District Office in St. George, Utah provided the use of BLM facilities. Energy Fuels, Inc. provided regional geologic information and Hack Canyon Mine data. Rodney D. Woodcock assisted with field examination and report preparation.

Mining activity

The Hack Canyon WSA is not within an organized mining district, but prospecting for gold, silver, copper, and lead has been reported in the vicinity since the 1850's (U.S. Department of Interior and U.S. Department of Agriculture, 1981, p.36). The only mining activity within the area studied by the Bureau was related to the Hack Canyon Mine about 1/2 mi outside the western boundary of the WSA. The mine owners also hold unpatented mining claims that cover most of the study area (fig. 2).

The Hack Canyon Mine was discovered in the early 1900's, and was mined intermittently for copper by the Canyon Copper Company until about the end of World War II. From 1937 to 1945, 51,000 lbs of copper and 1,200 oz of silver were produced from 600 tons of ore (Keith and others, 1983, p.28-29); Dunning (1948, p.2) concluded that none of the mining operations "...were successful for any sustained period..."

Uranium minerals were discovered in the Hack Canyon Mine about 1945. Investigations by the Arizona Department of Mineral Resources (Dunning, 1948), U.S. Atomic Energy Commission (Rasor, 1949), and Gruner and Gardiner (1950a; b) studied the geology and mineralization. In 1950, 52, 53, 54, and 64, mine

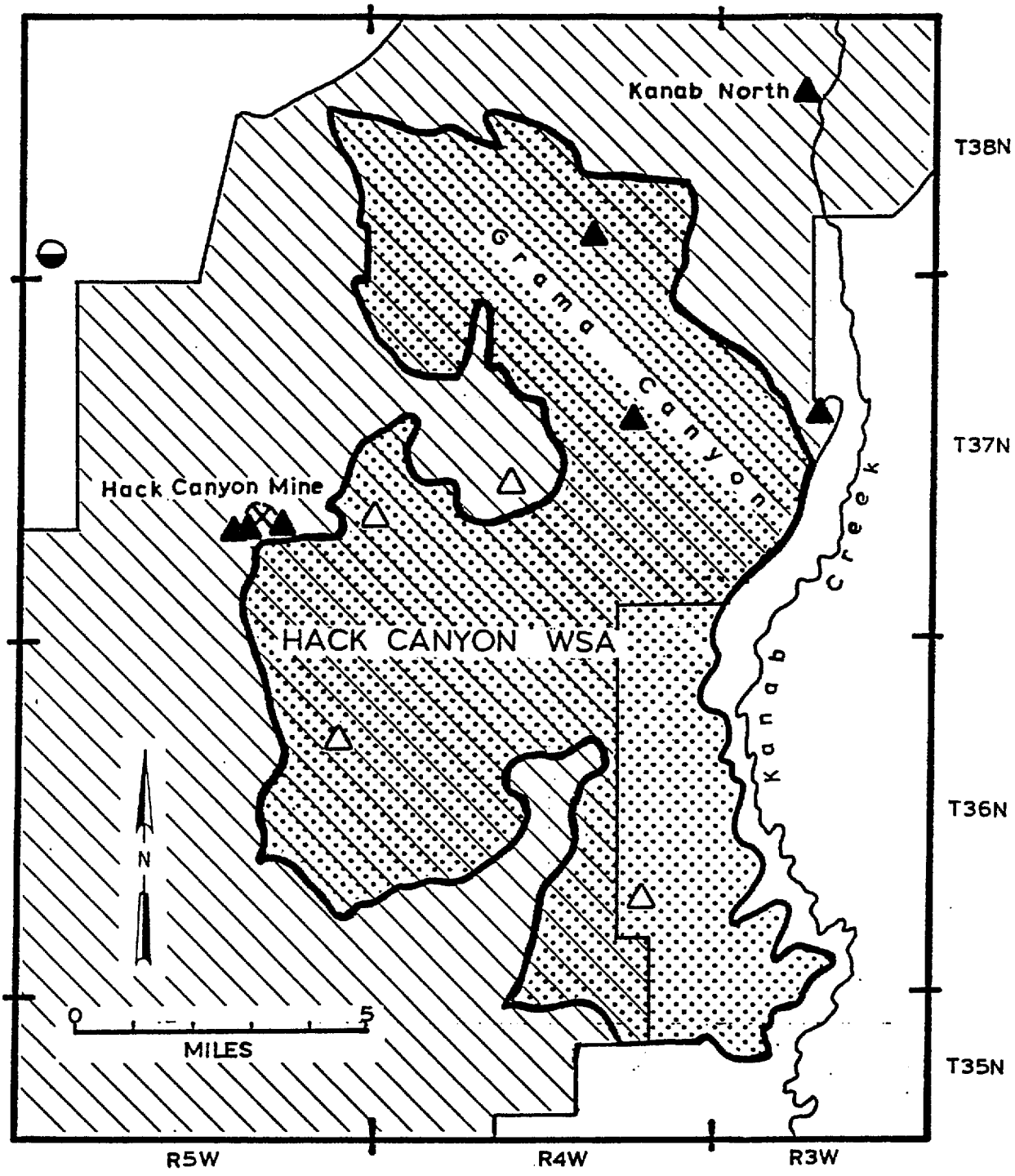

Figure 2.--Mining activity and breccia pipe locations in and near the Hack Canyon Wilderness Study Area, Arizona.

production totaled 1,329 tons of ore containing 0.18 percent U_3O_8 (Scarborough, 1981, p.208). Between 1976 and 1984 two additional uranium ore bodies were discovered in breccia pipes 1/2 mi west of the original mine workings.

In 1984, Energy Fuels, Inc. held a majority interest in the Hack Canyon Mine and was producing uranium from the three ore bodies. By March 1984, Energy Fuels, Inc. had produced 2,436,909 lbs of U_3O_8 from the Hack Canyon Mine and that mine reserves were estimated at about 3,328,000 lbs of U_3O_8 (I.W. Mathisen, Energy Fuels, Inc., oral commun., May 1984).

Energy Fuels, Inc. was also continuing an extensive exploration program on claims in and near the WSA. A combination of geochemical, geophysical, and other exploration techniques has identified eight additional breccia pipes. Uranium minerals have been identified in drill cores from four of the pipes (fig. 2). Exploratory drilling has defined a uranium ore body at depth within the Kanab North breccia pipe, about 2 1/2 mi northeast of the WSA, and Energy Fuels, Inc. was preparing to sink a shaft to further explore the ore (I.W. Mathisen, Energy Fuels, Inc. oral commun., May 1984).

Oil and gas

BLM land status plats (September 1982) show no federal oil and gas leases or lease applications within the WSA.

No oil or gas discoveries are known within the WSA, but oil shows have been reported in several exploratory drill holes 6-20 mi northwest of the WSA. No production has resulted, and the drill holes have been plugged and abandoned. The oil was detected in relatively flat-lying Devonian sedimentary rock units that can be projected at depth beneath the WSA.

A petroliferous shale occurs in the Permian Toroweap Formation, which underlies the WSA. The shale has been mapped from 0.5 to 5.0 ft thick, but there has been no production from this unit (Mathisen, 1981, p.12).

A U.S. Geological Survey report on the petroleum potential of wilderness lands in Arizona rated the hydrocarbon potential of an area that included the WSA as low (Ryder, 1983, p.17). The report concluded that the region was probably flushed by fresh water after uplift and erosional dissection in late Tertiary time.

MINERAL OCCURRENCES

Metallic mineral occurrences

Many metallic mineral occurrences in the Arizona Strip, including the WSA, appear to be epigenetic and structurally controlled by breccia pipes, which provide a favorable environment for mineral deposition. A detailed discussion of the geology and mineralization of breccia pipes in the Grand Canyon Quadrangle, Arizona was presented by Baillieul and Zollinger (1980).

Breccia pipe deposits

Many differing hypotheses have been published regarding the formation of breccia pipes and associated mineral deposits. In and near the Hack Canyon WSA the pipes are generally believed to have originated by solution of the buried Redwall Limestone and subsequent collapse of the overlying strata (fig. 3). The mixing of reactive hypogene fluids and different ground waters from intersected aquifers are thought to have precipitated the minerals in annular fracture zones along the pipe margin and as veins within the breccia. Mineral occurrences are generally confined within the pipe and are relatively high in grade. Some disseminated mineralization occurs in the host rocks (See Bowles, 1977, p.25-26; Baillieul and Zollinger, 1980, p.19-20).

Although many of the known pipes do not contain economic mineral deposits, others have been mined for uranium, copper, silver, gold, lead,

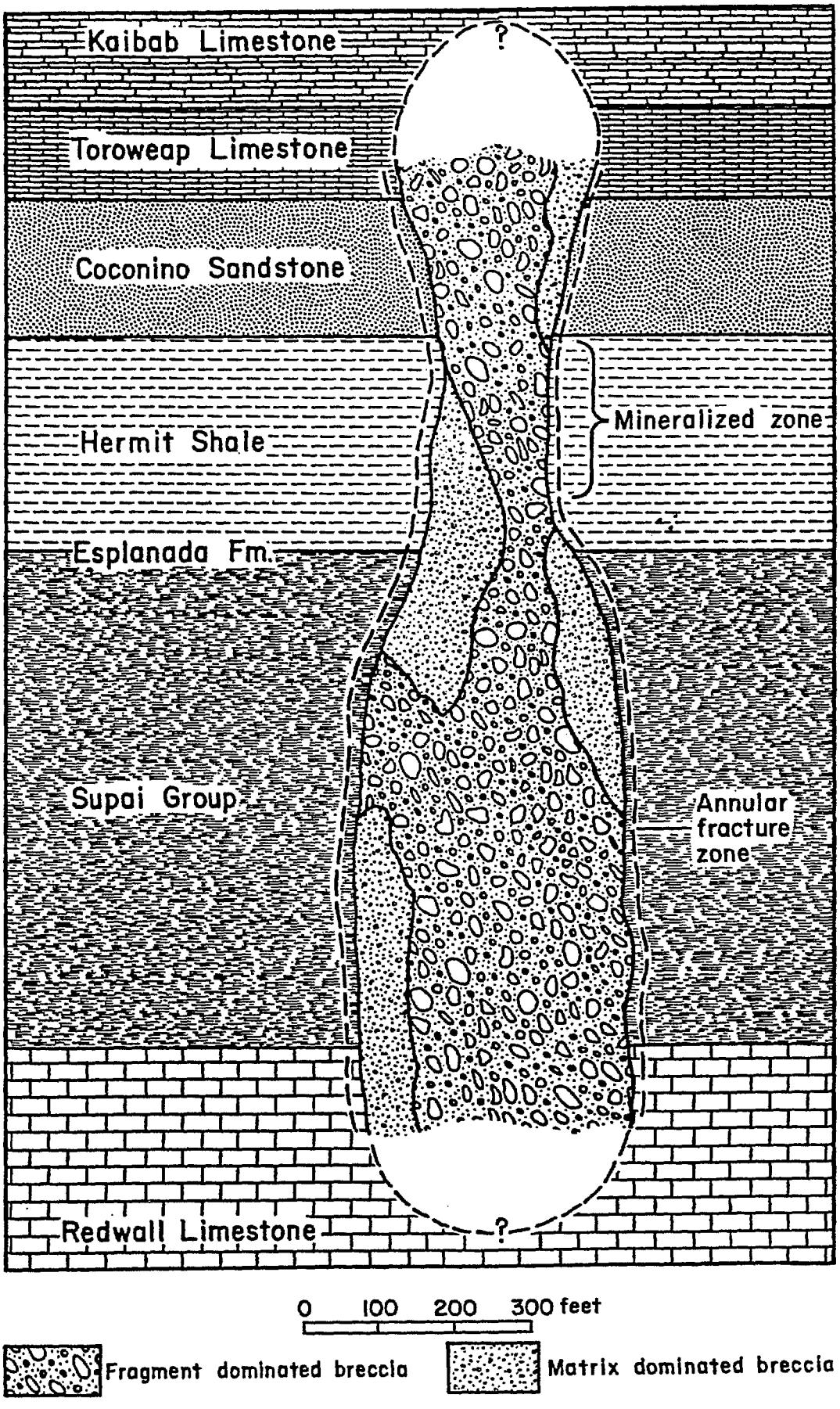

Figure 3.--Generalized cross-section of a breccia pipe (after Baillieul and Zollinger, 1980).

cobalt, and vanadium. Four breccia pipe deposits, the Orphan Mine, Ridenour Mine, Copper Mountain Mine, and Hack Canyon Mine, have recorded copper and uranium production.

In general, breccia pipes are roughly circular in plan view and may vary in diameter from 30 to 300 ft. Most breccia pipes have no conspicuous surface expression, and mineralization at depth may not be identified by individual surface characteristics. Detailed reconnaissance studies employing all geological exploration techniques and exploratory drilling are usually necessary to discover and delineate mineralized breccia pipes.

Hack Canyon Mine breccia pipes

The Hack Canyon Mine, 1/2 mi west of the WSA, is the only active mine in the Bureau's study area. Here three ore bodies occur in brecciated Coconino Sandstone that has collapsed into the Hermit Shale horizon. Because the breccia contains no cavities it was probably cemented under considerable pressure (Granger and Raup, 1962, p.20). The ore bodies consist of primary and secondary uranium and copper minerals that have precipitated and concentrated in the brecciated sandstone. Copper carbonates and sulfides, uranium oxides, and copper-uranium phosphates occur irregularly in fractures, as cementing material, and are disseminated in the groundmass (Rasor, 1949, p.3; Peirce and others, 1970, p.262). Workings consist of several thousand feet of declines, shafts, drifts, and stopes in three mineralized breccia pipes.

In 1984, the combined daily production from the three ore bodies was 200 tons of ore averaging 0.78 percent U_3O_8 (I.W. Mathisen, Energy Fuels, Inc., oral commun., May 1984). If production records and reserve estimates are

combined, they indicate that over 425,000 tons of ore averaging 0.65 percent U_3O_8 may eventually be mined from the three breccia pipes.

Undeveloped breccia pipes

Baillieul and Zollinger (1980, p.12,22) estimated that a number of undiscovered breccia pipe structures may exist in an area that includes the WSA and that these pipes are within an environment favorable for vein-type uranium deposits associated with collapse breccia pipes in sedimentary rocks. Since 1980, exploration by Energy Fuels, Inc. and previous claimants has identified at least ten breccia pipes; five are inside the WSA and five are within 2 1/2 mi of the WSA boundary (fig. 2). Energy Fuels, Inc. has stated that uranium minerals occur in at least two of the pipes in the WSA.

Bureau personnel visited the reported pipe localities and, except for the Kanab North pipe (sec. 17, T. 38 N., R. 3 W.) and a pipe near the southwestern rim of Grama Canyon (sec. 14, T. 37 N., R. 4 W.), no surface expressions could be seen. Some of the reported but undeveloped breccia pipe sites showed evidence of exploratory drilling; however, no evidence of structures or mineral occurrences could be located. Scintillometer readings at the sites varied little from a background level of 30 counts per second.

Two pipes near Grama Canyon are within the WSA (fig. 2) and have been examined by Energy Fuels, Inc. Although the southernmost site was recently "reclaimed", and much of the ground was not in a natural condition, some disrupted breccia pipe outcrops were visible. No breccia pipe outcrops were found at the northernmost site. No evidence of mineralization was seen at either site, even though Energy Fuels, Inc. stated that uranium minerals had been identified in drill cores.

Development potential

Should metallic minerals occur in breccia pipes in the WSA they have a high potential for development, even at marginal economic conditions. This estimate is based on the proximity of an active mine that is producing from similar deposits, the expertise that is readily available at the mine, and the relatively uncomplicated and inexpensive mining methods used in these confined, high-grade deposits.

Non-metallic mineral occurrence

Gypsum beds occur within Permian Kaibab and Toroweap limestones, which are relatively flat-lying and underlie most of the WSA. The gypsum occurs in beds up to 4 ft thick and is interbedded with limestones and red beds. Gypsum samples collected by McKee (1938, p.121-126) and the Arizona Bureau of Mines (Keith, 1969, p.375) ranged from fine-grained, dense, hard, and pure white, to coarse-grained, sugary, soft, massive, and colored by impurities. Commercial deposits of gypsum are generally between 85 and 98 percent gypsum, and average 90 percent (Withington, 1962, p.2). Gypsum beds in the vicinity of the WSA contain abundant quartz sand and limestone fragments as contaminants. The gypsum is probably below commercial grade and has a low development potential because of these contaminants.

CONCLUSION

Mineral occurrences in or near the Hack Canyon WSA are associated with, or controlled by, either collapse breccia pipes or bedded sedimentary rocks. Metallic minerals are present in breccia pipes, gypsum beds occur in Permian limestone, and oil shows and a petroliferous shale have been reported respectively for Devonian and Permian sedimentary rock units that underlie the WSA at depth.

Uranium, copper, silver, gold, lead, cobalt, and vanadium have been produced from breccia pipes near the WSA. Uranium is currently (1984) being mined from the nearby Hack Canyon Mine. Five breccia pipes have been found in the WSA and uranium minerals have been reported in two of them. Breccia pipes are not easily identified by surface exposure and extensive exploration programs would be necessary to define additional mineralized structures. The presence of known occurrences and favorable geologic structures suggest that uranium, as well as copper, silver, gold, lead, cobalt, and vanadium minerals could occur within additional breccia pipes in the WSA. Mineralized breccia pipes that occur within the WSA are favorably situated and have a high likelihood for development, based on production from similar deposits nearby.

Gypsum occurs in relatively flat-lying rock units that underlie the WSA. The gypsum is interbedded with limestones and red beds, and locally contains abundant quartz sand and limestone fragments as impurities. Exploratory work including drilling and detailed testing would be necessary for a complete commercial evaluation of subsurface gypsum occurrences.

Oil shows in exploratory drill holes, and a petroliferous shale have been reported in the vicinity of the WSA. These hydrocarbon occurrences were detected in relatively flat-lying rock units that underlie the WSA at depth, but no shows are known within the WSA. None of the nearby petroleum finds have been developed commercially. The drill holes have been abandoned and potential production from the petroliferous shale is not currently economic. A U.S. Geological Survey report rated the hydrocarbon potential of the region as low, and it is unlikely that the WSA has hydrocarbon occurrences that could be developed in the foreseeable future.

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