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MINERAL RESOURCE POTENTIAL OF THE SNOWBIRD ROADLESS AREA GRAHAM COUNTY, NORTH CAROLINA

By

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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 results of a mineral survey of the Snowbird Roadless Area (08-061), Nantahala National Forest, Graham County, North Carolina. The area was classified as a further planning area during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

MINERAL RESOURCE POTENTIAL SUMMARY STATEMENT

The Snowbird Roadless Area includes 8490 acres of rugged wooded terrain in the Nantahala National Forest, Graham County, N. C. The area is underlain by folded metasedimentary rocks of the Great Smoky Group of Late Proterozoic age, and has a low potential for mineral resources. Abundant stone suitable for rough building stone and crushed rock is the only identified mineral resource. Oil and gas and massive-sulfide deposits have an unknown potential. All surface and mineral rights are under Federal ownership.

Recent seismic studies in the southeastern United States indicate the presence of a thick sequence of younger, less metamorphosed sedimentary rock beneath layers of older metasedimentary rocks of the Blue Ridge. These younger rocks are a potential source of oil and gas, but additional seismic studies and exploratory drilling are needed to evaluate the potential. Speculative oil and gas lease applications have been filed for more than 30,000 acres in Graham County, including all of the Snowbird Roadless Area.

The roadless area lies on strike between the Ducktown mining district of Tennessee and the Fontana-Hazel Creek mining area of North Carolina. The upper part of the rock unit that contains the massive-sulfide deposits of Ducktown is exposed in the northern part of the roadless area. A geochemical survey found no anomalous values for elements likely to be associated with massive-sulfide deposits, but the area must be considered as having a potential for such deposits because the more favorable part of the ore-bearing formation may be present at depth.

Gold, silver, and uranium are present in trace amounts in some of the rocks in the Snowbird Roadless Area, but the potential for finding minable concentrations of any of these elements is low.

INTRODUCTION

The Snowbird Roadless Area includes all of the drainage basin in the upper reaches of Snowbird Creek and its tributaries for about 11 mi upstream from the parking lot at Junction, which is about 5.5 mi by gravel road from the intersection of Snowbird and Little Snowbird Creeks (fig. 1). The area contains about 8490 acres of rugged ridges and narrow stream valleys in the Unicoi Mountains of southwestern North Carolina, about 6.5 mi west of Robbinsville, Graham County, N.C. Access to the parking lot at Junction is by North Carolina State Road 1120 and U.S. Forest Service Road 75 that follow the roadbed of the now-abandoned Buffalo-Snowbird logging railroad along Snowbird Creek. Forest Service trails follow the railroad bed up Snowbird Creek and also along the ridges that rim the drainage basin from Junction to Big Junction, a high point on the Tennessee-North Carolina border. The highest point in the area is Hooper Bald at the north end, 5429 ft above sea level; the lowest point is 2600 ft along the creek below Junction. Local relief ranges from 1000 to 2000 ft; most of the hillsides are steep. Forest cover consists chiefly of second-growth oak and yellow poplar and minor amounts of hemlock and pine. Large areas are covered with dense growths of rhododendron and mountain laurel.

Previous Work

The earliest published account of the geology in the general area was by Safford (1856, p. 151-152) who

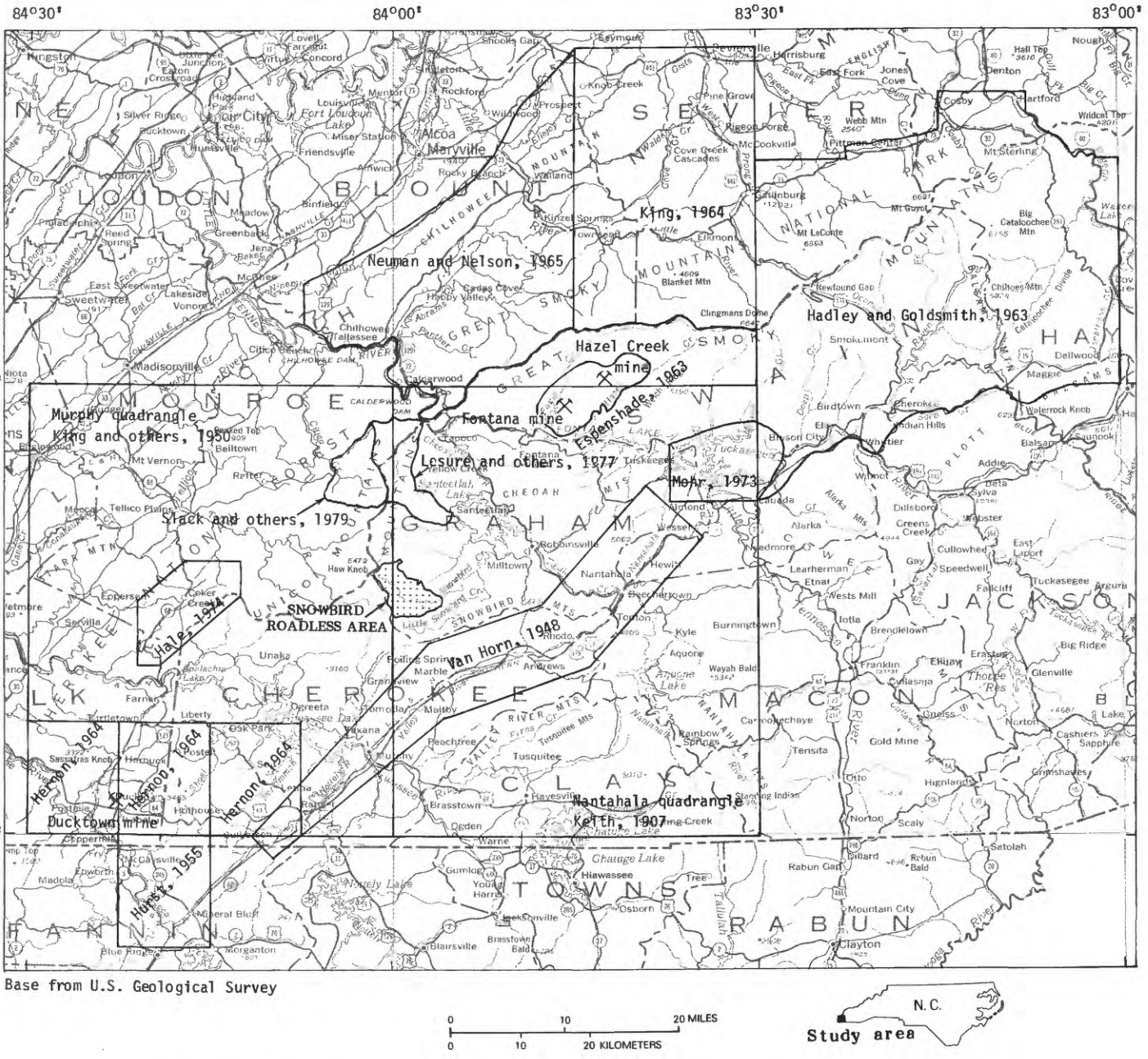


Figure 1.--Index map showing location of the Snowbird Roadless Area, the Ducktown, Fontana, and Hazel Creek mines, and references to published geologic mapping in adjacent areas.

noted many thousands of feet of interlayered conglomerate and slate in Monroe County, Tenn. He named these rocks the Ocoee conglomerates and slates from exposures in the narrows of the Ocoee River west of Ducktown, Tenn., 26 mi southwest of the Snowbird Roadless Area. Later, Keith (1907) mapped several quadrangles in the Blue Ridge of North Carolina and Tennessee as part of the folio series of the U.S. Geological Survey (USGS). Keith divided the rocks that Safford had called Ocoee into several formations, including the Great Smoky conglomerate and Nantahala slate, which he mapped in what is now the roadless area.

Between 1946 and 1955, geologists of the USGS mapped much of the Great Smoky Mountains National Park and some surrounding territory about 15 20 mi north and northeast of the Snowbird area (Hadley and Goldsmith, 1963; King, 1964; Neuman and Nelson, 1965). This work redefined the stratigraphy used by Keith and divided the Ocoee series of Stose and Stose (1944, 1949) into several groups (King and others, 1958, p. 955). Hurst (1955) mapped the Mineral Bluff quadrangle, Georgia, about 23 mi southwest of the Snowbird area and divided the Great Smoky conglomerate of Keith (1907) into four formations. Parts of the lower two, the Copperhill and the Hughes Gap Formations of Hurst (1955, p. 9-35), are probably present in the Snowbird area. Hernon (1964) mapped the Ducktown, Isabella, and Persimmon Creek quadrangles, Tennessee and North Carolina, which are 10 to 25 mi to the southwest. Hernon (1969) redefined the limits of the Copperhill and named the Wehutty Formation, a distinctive group of rocks between the Copperhill and Hughes Gap Formations, that is also probably present in the Snowbird area. Reconnaissance mapping by Hadley and Nelson (1971) of the Knoxville $1^{\circ} \times 2^{\circ}$ quadrangle included traverses near but not in the roadless area. Their map shows the rocks to be of the Great Smoky Group, undivided.

Studies on geology and mineral resources in surrounding areas include those of the Joyce Kilmer-Slickrock Wilderness (Lesure and others, 1977), the Citico Creek Wilderness Study Area (Slack and others, 1979), the Murphy talc district (Van Horn, 1948), the Coker Creek gold district (Hale, 1974), the Fontana copper mine (Espenshade, 1963), and the Ducktown district (Magee, 1968).

Two flight lines from the aeromagnetic and radiometric studies of the National Uranium Resource Evaluation Program (U.S. Department of Energy, 1979, 1980) cross the Snowbird Roadless Area; one north-south flight line crosses the eastern boundary and one east-west flight line bisects the study area.

Present Investigation

M. L. Chatman and R. M. Thompson, U.S. Bureau of Mines, conducted a reconnaissance of the Snowbird Roadless Area in the fall of 1980. Fourteen samples of metasandstone and schist and five samples of vein quartz were collected for analysis (Chatman, 1982). Seventeen pan concentrates were collected and examined microscopically to identify the heavy minerals. Three concentrates from a suspected gold-bearing area were analyzed by emission spectroscopy. A hand-held four-channel gamma-ray scintillometer was monitored on several traverses, and samples were collected where anomalously high radioactive readings were obtained.

F. G. Lesure, assisted by J. H. DeYoung, Jr., J. R. Estabrook, A. E. Grosz, and W. D. Rowe, Jr., USGS, mapped and sampled the area in reconnaissance, April 1-14, 1981. They collected 53 stream-sediment, 13 panned-concentrate, 116 soil, and 113 rock samples, which were analyzed in the USGS laboratories, Denver, Colo. Complete analyses of these samples are available in Erickson and others (1983).

Acknowledgments

Mapping in the roadless area was greatly aided by discussions on the geology of the Ocoee Supergroup with Leonard S. Wiener and Carl E. Merschat, North Carolina Geological Survey, Asheville, N.C., who also provided a preliminary map compilation of the geology of the southern Great Smoky Mountains (Merschat and Wiener, 1973). Cities Service Co., Copperhill, Tenn., provided information on mineral exploration in the region.

SURFACE- AND MINERAL-RIGHTS OWNERSHIP

The Federal Government owns all surface and mineral rights for the study area. Recent oil and gas lease applications filed with the U.S. Bureau of Land Management include the entire roadless area. None had been approved as of July 1981. A base-metals prospecting permit (BLM-A-024858) covering 500 acres of the northern part of the study area was relinquished in 1954 after preliminary exploration. Two base- and precious-metals prospecting permits, which are in the Snowbird Roadless Area (fig. 2, table 1), have been applied for by Gulf Oil Corp., Denver, Colo.

GEOLOGY

The Snowbird Roadless Area contains garnet-grade metasedimentary rocks of the Great Smoky Group of Late Proterozoic age (Lesure, in press [a]). These rocks are divided into three mapping units (fig. 3) that are tentatively correlated with units to the south described by Hurst (1955) and Hernon (1969).

The oldest unit, which is tentatively correlated with the Copperhill Formation of Hurst (1955) as restricted by Hernon (1969, p. A49), consists of 2000 ft or more of metasandstone interlayered with lesser amounts of dark-gray slate, mica schist, and metagraywacke. These rocks are poorly exposed in several broad low folds in the central and northern parts of the roadless area. The amounts of dark-gray graphitic or carbonaceous slate and metagraywacke increase upward as this unit grades into the overlying Wehutty Formation. The main exposures of the Wehutty form a belt about 2800 ft wide, trending northeast across the southern third of the roadless area. Thick masses of dark slate, dipping generally northwest, are exposed in the northern part of the study area from Hogjaw Gap to Hooper Bald. Abundant dark slate and metagraywacke exposed in shallow synclines at Dillard Top and Pantherflat Top in the western part and at King Meadows in the eastern part of the study area, are also interpreted to be Wehutty (fig. 3).

The youngest unit of the Great Smoky Group in the area consists of several thousand feet of garnet-mica schist and interlayered arkosic metasandstone and metagraywacke probably correlative with the Hughes Gap Formation of Hurst (1955). Extensive

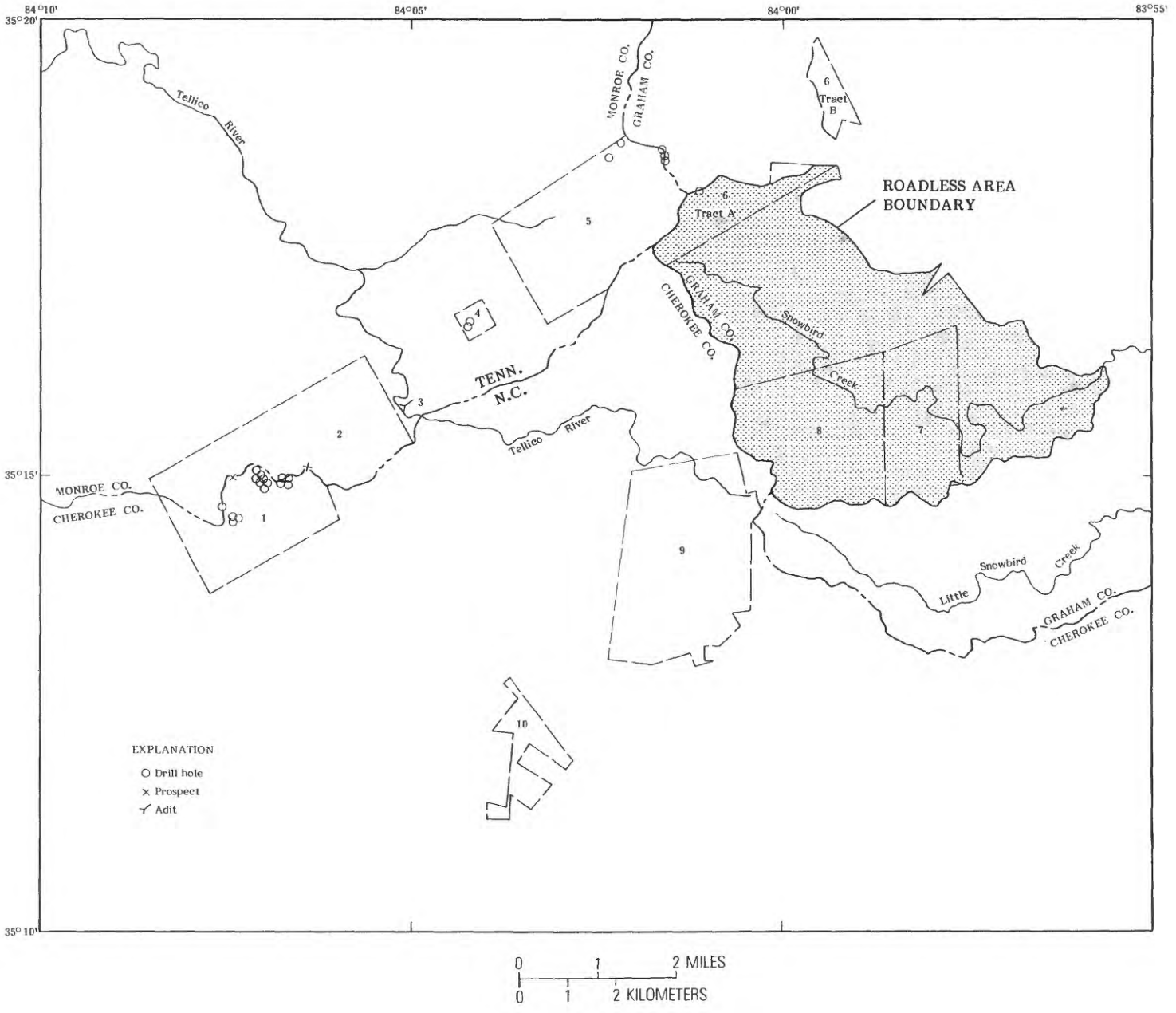


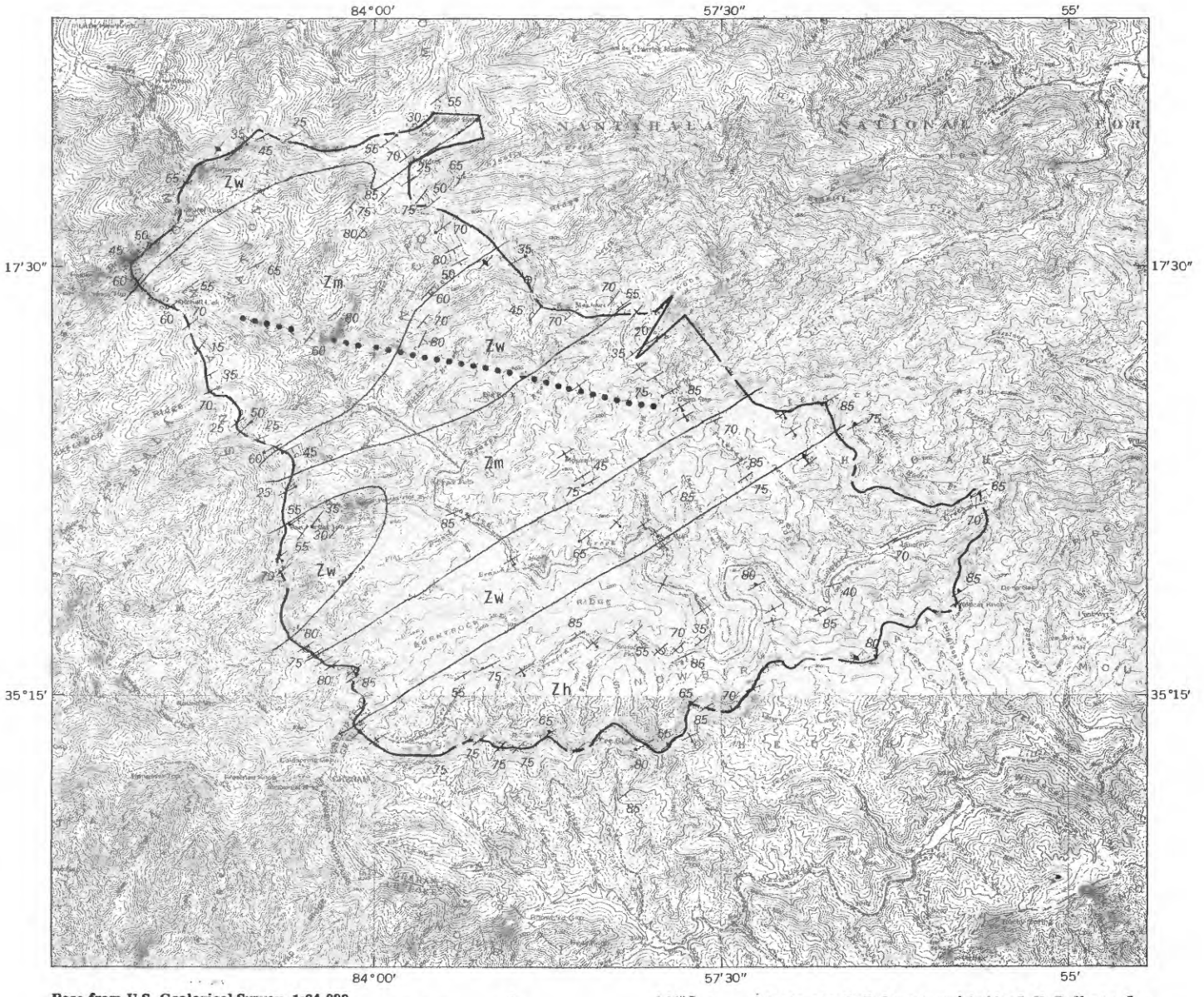
Figure 2.—Map showing base- and precious-metal prospects and prospect permit areas. See table 1 for details.

Table 1.--*Base- and precious-metal prospecting in and near the Snowbird Roadless Area*

[Data from files of U.S. Bureau of Land Management (BLM); Cities Service Co. Copperhill, Tenn.; and Cohen (1944). Localities shown on figure 2]

Prospect permit area name and locality number	BLM lease or application no.	Size in acres	Status	Commodity	Description of work
1) Beaverdam Bald, NC	A-024390	1220	Permit relinquished 1954	Cu, Fe, Zn	Dip-needle magnetic survey, 1930-31;[1] Hotchkiss Superdip magnetic survey and core drilling (13 holes totalling 3,812 ft, maximum depth 625 ft) in early 1950's.[2] Prospect includes Tate-Woodbury and Davis tracts.
2) Beaverdam Bald, TN	A-024399	1730	do	Cu and other metal sulfides	Dip-needle magnetic survey, 1930-31;[1] two small prospect pits dug by T. J. McDonald, Coker Creek, Tenn., 1938-40; Hotchkiss Superdip magnetic survey and core drilling (2 holes, 329 ft and 285 ft) in early 1950's.[1] Prospect pits in thin gossan derived from disseminated iron sulfides in dark slate.
3) Unnamed adit	--	--	--	Probably Cu and other metal sulfides	Adit, 25 ft, opened probably before 1930
4) Ellis Tunnel	A-024856	92	Permit relinquished 1954	Cu and other metal sulfides	180-ft adit opened prior to 1930; dip-needle magnetic survey, 1930-31; Hotchkiss Superdip magnetic survey and core drilling (2 holes, 400 ft and 500 ft), early 1950's.[1]
5) Haw Knob Prospect	A-024857	1900	do	do	Dip-needle magnetic survey, 1930-31;[1] Hotchkiss Superdip magnetic survey and core drilling (6 holes totalling 2000 ft, maximum 500 ft), early 1950's.[2] Core in 4 holes consists of interlayered dark slate, metagraywacke, and metasandstone containing disseminated and minor amounts of massive iron sulfides.[2]
6) Big Junction Prospect	A-24858	Tract A 543.6 Tract B 227.7	do	Cu, Fe, Zn	Dip-needle magnetic survey, 1930-31;[1] Hotchkiss Superdip magnetic survey and core drilling (2 holes, 300 ft and 212 ft), early 1950's.[2] 500 acres of tract A is in Snowbird Roadless Area.
7) Unnamed prospect	ES-28274	1252.68	Permit request filed 6/14/81; not issued as of 9/9/82	Cu, Pb, Zn Au, Ag	Includes U.S. Tract N-3501 and south-central part of Tract N-252-J.[3]
8) Unnamed prospect	ES-28273	1895	do	do	Includes southwest part of U.S. Tract N-252-J.[3]
9) Unnamed prospect	ES-28269	2502.84	do	do	Includes part of Nature Conservancy Tract N632.[3]
10) Unnamed prospect	ES-28273	401	do	do	Includes U.S. Tract 796.[3]

[1]Exploration by Tennessee Copper Co., Knoxville, Tenn.
[2]Exploration by Tennessee Corp., Knoxville, Tenn.
[3]Exploration by Gulf Oil Corp., Denver, Colo.



Base from U.S. Geological Survey, 1:24,000
Big Junction and McDaniel Bald, 1957 (photorevised 1978); Marble, 1938 (photorevised 1973); Santeetlah Creek, 1940 (photorevised 1978)

Geology by F. G. Lesure, assisted by J. H. DeYoung, Jr., J. R. Estabrook, A. E. Grosz, and W. D. Rowe, Jr., 1981

Figure 3.—Geologic map describing mineral resource potential for each geologic unit in the Snowbird Roadless Area.

EXPLANATION

Ocoee Supergroup (Late Proterozoic)

Great Smoky Group

Zh — Hughes Gap Formation of Hurst (1955)—Garnet-mica schist interlayered with arkosic metasandstone and metagraywacke. Suitable for crushed rock and rough building stone. Iron sulfides abundant locally but are not a potential resource

Zw — Wehutty Formation—Interlayered slate, metasandstone, and metagraywacke. Suitable for crushed rock and rough building stone. Iron sulfides abundant locally but are not a potential resource

Zm — Copperhill Formation of Hurst (1955) as restricted by Hernon (1969, p. A49)—Interlayered massive metasandstone and lesser amounts of slate, metagraywacke, and schist. Suitable for crushed rock and rough building stone. The Copperhill Formation contains massive-sulfide deposits at Ducktown, Tenn., probably in the lower part of the formation. In the study area, areas underlain by the Copperhill Formation have a potential for similar deposits

— — — Approximate boundary of Snowbird Roadless Area

——— Contact, approximately located

Strike and dip of bedding

70 Inclined

55 Inclined; top of beds observed

Vertical

Vertical; top of beds observed in direction of ball

Horizontal

85 Overturned

Strike and dip of foliation or cleavage

65 Inclined

Vertical

• • • • • • Topographic lineament showing prominently on aerial photographs (unexplained)

areas of schist and metasandstone are present along Sassafras Creek, on Sassafras Ridge, and along Snowbird Creek below Big Falls. Bedding and foliation in this unit are generally vertical or steeply dipping to the southeast. A few northwest dips suggest the presence of tight isoclinal folds, which would make it impossible to measure the thickness of this unit.

The metasedimentary rocks of the Snowbird Roadless Area are folded and have a well-developed cleavage or foliation. No obvious large-scale faulting was observed. Several relatively broad upright to slightly overturned folds trend northeast across the northern part of the area and plunge at low angles either northeast or southwest.

The original sedimentary rocks have been progressively metamorphosed to garnet grade at the north end and to staurolite grade at the south end of the study area. Garnets, especially in slate and schist, become coarser grained and more abundant from north to south. Chlorite pseudomorphs after staurolite are present but rare in slates of the Wehutty Formation and in garnet-mica schist of the Hughes Gap Formation.

GEOCHEMICAL SURVEY

The USGS made a reconnaissance geochemical survey of the Snowbird Roadless Area (Lesure, in press [b]) to test for indistinct or unexposed mineral deposits that might be recognized by their geochemical halos or by the patterns formed by the distribution of trace-elements. Similar geochemical surveys based on trace-element analyses have been credited with the discovery of many types of mineral deposits (Hawkes and Webb, 1962). Analyses of the samples collected suggest that the rocks in the area contain generally normal amounts of the 32 elements for which they were tested. The analytical data are not indicative of any areas of potential metallic-mineral resources. Gold was detected in only one rock sample, which contains 0.15 parts per million (ppm) gold, and in one stream-sediment sample, which contains detectable gold but less than 0.05 ppm. This is in contrast to the nearby Joyce Kilmer-Slickrock Wilderness, where in a similar survey 23 samples were found to contain trace amounts of gold (Lesure and others, 1977, p. 23).

Barium appears to be slightly more (two to three times) abundant in the rocks of the Snowbird area as compared with the average sandstone or shale. Further exploration elsewhere in rocks of the Great Smoky Group may be warranted to search for deposits of bedded barite, but the potential for such deposits in the Snowbird area is probably low.

The metals cobalt, copper, lead, and zinc, commonly associated with massive-sulfide deposits like those at Ducktown, Tenn., are present in normally-expected concentrations in samples from the Snowbird Roadless Area. Uranium is present in amounts ranging from less than 0.05 to 3.5 ppm U, which is about average for the rock types in the area.

MINERAL PROSPECTING

Prospecting has been conducted in and near the Snowbird Roadless Area during the last 50 years (table 1), but no mining has been done there (Chatman, 1982, p. 8). The roadless area was included in a program of systematic prospecting by reconnaissance magnetic surveying for metal-sulfide deposits, conducted in 1930-31 between the Fontana mine and Ducktown by the Tennessee Copper Co. This work outlined magnetic anomalies at the north end of the Snowbird area and in the region to the north and west. Exploration at the Ellis Tunnel project (table 1, fig. 2) during that time encountered insignificant sulfide mineralization. T. J. McDonald, Coker Creek, Tenn., dug two prospect pits on Beaverdam Bald sometime between 1938 and 1940, finding only insignificant disseminated iron sulfides in metasedimentary rock (Cohen, 1944, p. 1).

In the early 1950's, the Tennessee Copper Co. and the Tennessee Corp. prospected for metal sulfides using Hotchkiss Superdip magnetic surveys on 11,000 acres in the region, including the Big Junction and Haw Knob permit areas at the north end of the roadless area (fig. 2, table 1). In the Big Junction permit area, two adjacent core holes were drilled in a positive magnetic anomaly at the northern boundary of the roadless area. Six holes in the adjacent Haw Knob permit area, outside the study area, contain disseminated sulfides, primarily pyrrhotite.

Core drilling totalling 8,900 ft and magnetic survey traverses totalling 139,000 ft in permit areas between Fontana and Ducktown revealed that the magnetic anomalies are the result of minor concentrations of magnetite in graphitic slates in the Copperhill Formation of Hurst (1955) and the Wehutty Formation. Analyses of mineralized rock from the cores show that sulfur content does not exceed 7.8 percent and copper content does not exceed 0.11 percent. The exploration program was abandoned in 1954. Recently, Gulf Oil Corp. conducted geophysical and geochemical exploration on several areas in the region and has applied for prospecting permits on four areas in and near the Snowbird Roadless Area (fig. 2, table 1).

MINERAL RESOURCE POTENTIAL

Stone suitable for use as rough building stone and crushed rock is the only identified mineral resource in the Snowbird Roadless Area (fig. 3). Similar stone, however, is abundant throughout the region in areas where it is more readily available.

A potential for oil and gas exists but is untested. Oil and gas lease applications have been made for much of the National Forest land in western North Carolina, including all of the roadless area.

Although no anomalous concentrations of metals were found in the geochemical studies, the Copperhill Formation, which is the host rock of massive-sulfide deposits at Ducktown, may contain analogous deposits at depth within the study area. This potential has not been tested. Deposits of gold, silver, or uranium are unlikely.

Oil and Gas

Recent seismic studies indicate that the Blue Ridge of North Carolina contains a thick sequence of younger sedimentary rocks beneath the metamorphosed rocks exposed at the surface (Cook and others, 1979; Harris and others, 1981). This inverted rock sequence is the result of thrusting of the old metamorphic rocks westward at least 100 mi over the younger rocks, which have an unknown potential for oil and gas (Harris and others, 1981, p. 2504;

Hatcher, 1982, p. 980). The Snowbird Roadless Area is 14 mi south of an exposure of some of the younger sedimentary rocks in a window or hole eroded through the thrust fault, and is 15 mi southeast of the eroded western edge of the thrust plate of older rocks. Further seismic work and deep exploratory drilling are needed to evaluate the oil and gas potential of the western edge of the overthrust belt of which the Snowbird area is a part.

The potential for oil and gas accumulations in the younger sedimentary rocks buried beneath the thrust sheet has resulted in speculative leasing (Cook and others, 1980). Oil and gas lease applications have been filed on 228,000 acres in western North Carolina, including the entire Snowbird Roadless Area.

Massive-Sulfide Deposits

The Snowbird area lies between the massive-sulfide deposits of Ducktown, Tenn., and the Fontana copper mine, Swain County, N.C. (fig. 1). The Copperhill Formation, exposed in the northern half of the study area, is the host rock of the massive-sulfide deposits at Ducktown. The metasedimentary rocks that contain the ore at the Fontana and Hazel Creek mines are part of a phyllite or slate unit that may also correlate roughly with the Copperhill Formation. Regional mapping by Hernon (1968) and detailed work by the Tennessee Copper Co. (Magee, 1968, p. 218-219) suggest that the Ducktown deposits are stratigraphically several thousands of feet below the contact between the Copperhill and the overlying Wehutty Formation. Similarly, the phyllite at the Fontana and Hazel Creek mines also may be stratigraphically low. Although only the upper part of the Copperhill is exposed in the Snowbird Roadless Area, the area must be considered to have a potential for massive-sulfide deposits at depth even though our geochemical sampling does not show anomalous amounts of the metals commonly associated with such deposits. Detailed geophysical studies might be of use in evaluating the potential for massive-sulfide deposits at depth.

Gold, Silver, and Uranium

Gold is a widespread trace element in rocks of the Ocoee Supergroup in southwestern North Carolina and southeastern Tennessee (Lesure and others, 1977, p. 23-27; Slack and others, 1979, p. 24-28; Hale, 1974). Small deposits of gold have been mined in the Coker Creek district of Tennessee (Hale, 1974) and along the Valley River in Cherokee County, N.C. (Blake, 1860; Nitze and Hanna, 1896, p. 192-193). The rocks of the Coker Creek district have been correlated with the Snowbird Group, which is older than the Great Smoky Group (Merschat and Hale, in press); the rocks along the Valley River are part of the Murphy syncline and are younger than the Great Smoky Group (Hurst, 1955; Keith, 1907). Only small placer deposits and isolated traces of gold have been reported from rocks of the Great Smoky Group. Small amounts of gold were recovered in the late 19th century from placers along Long Hungry Branch and West Buffalo Creek near Santeetlah Lake, about 5 mi northeast of the Snowbird Roadless Area (John Parris, *The Asheville Citizen*, April 23, 1982). U.S. Mint records show a production of 9.954 oz gold and 1.42 oz silver in 1896 and 4.419 oz gold and 0.39 oz silver in 1897 from Graham County, N.C., the first and only recorded production for the county between 1880 and 1978 (Ardrey, 1898, p. 181-187; Clanton, 1898, p. 191-199; J. H. DeYoung, Jr., USGS, oral commun., 1982). Most of the recorded gold production from rocks of the Great Smoky Group, however, is by-product gold recovered from the massive-sulfide deposits at the Ducktown, Fontana, and Hazel Creek mines, all of which contain traces of gold and silver. The average grade of ore mined at the Fontana mine, 1931-1942, was 7.37 percent copper, 2.11 percent zinc, 0.0072 oz gold per ton (0.2 ppm), and 0.385 oz silver per ton (13 ppm) (Espenshade, 1963, p. I 28).

Only two samples out of the 295 collected by the USGS in the Snowbird Roadless Area contain detectable gold, and only three samples have traces of silver (Erickson and others, 1983). Thirteen rock samples collected by the U.S. Bureau of Mines contain detectable gold and 20 contain detectable silver (Chatman, 1982, p. 13-14). None of the panned concentrates contain visible gold. The gold and silver potential in the study area is low.

The graphitic slate of the Wehutty Formation is slightly more radioactive than the other rocks in the study area. Traverses made using hand-held four-channel gamma-ray scintillometers showed consistent readings of 15 to 30 counts per second (cps) in areas of metasandstone, 25 to 40 cps in areas of mica schist, and 30 to 50 cps in areas of graphitic slate. Analyses of slate from areas having higher background readings show a range in uranium content from 1 to 6 ppm and a thorium content that does not exceed 22 ppm. The potential for uranium deposits in the Snowbird Roadless Area appears to be low.

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