MINERAL RESOURCE POTENTIAL OF THE DEVILS DEN ROADLESS AREA, RUTLAND AND WINDSOR COUNTIES, VERMONT

By

John F. Slack, U.S. Geological Survey

and

Andrew E. Sabin, U.S. Bureau of Mines

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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 Devils Den Roadless Area (09-083), Green Mountain National Forest, Rutland and Windsor Counties, Vermont. Devils Den Roadless 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 Devils Den Roadless Area, Vt., has no identified mineral resources except for certain non-metallic commodities. Geochemical sampling found high amounts of barium, boron, copper, gold, lead, silver, and thorium in rocks, stream sediments, and panned concentrates, but not in sufficient quantity to be indicative of a resource potential for these commodities. Airborne and ground radiometric surveys also failed to locate any bedrock concentrations of uranium or thorium. The results of the geochemical survey are not indicative of a potential for metallic mineral deposits within the study area.

The only apparent resources in the study area are small deposits of sand and gravel, minor lenses of pure dolomite marble, and abundant rock suitable for construction purposes. Resources of oil or natural gas may exist at depth, but these cannot be evaluated by the present study.

INTRODUCTION

The Devils Den Roadless Area comprises 8,830 acres of mountainous terrane in the Green Mountain National Forest, Rutland and Windsor Counties, Vt. Ludlow, the nearest large community, is approximately 7 air miles northeast of the study area. The small villages of Weston and East Wallingford are 3 and 5 mi to the south and north, respectively (fig. 1). Total relief is nearly 1,200 ft, from a low elevation of 1,640 ft along the southwestern edge of the area, to a high point of about 2,860 ft in the northwest. Principal access is provided by State Routes 100 and 155 on the southeast and northeast, and by Forest Service Road 10 along the western boundary. Old logging roads and foot trails allow entry to the interior of the study area. Several swamps and one small pond (Moses Pond) are located in topographically low areas. Drainage is principally to the south and southeast by tributaries of the south-flowing West River, ultimately discharging into the Connecticut River near Brattleboro.

The Devils Den area is named[1] for a large undercut cliff (Dale, 1915, p. 21) developed in Precambrian basement rocks. This undercut cliff forms a broad natural cave immediately west of and below Forest Service Road 10 at the head of Mt. Tabor Brook. Another much smaller cave is present in dolomite of probable Paleozoic (Early Cambrian) age on the east side of the same road. This smaller cave apparently is of artificial origin, having been made during early excavations in the mining of the dolomite (Dale, 1915, p. 21). This man-made cave is the only evidence of previous mining activity within the study area.

PREVIOUS AND PRESENT WORK

Little work has been previously done in the Devils Den area. The only geologic study is the reconnaissance mapping by J. B. Thompson, Jr. for

[1] The identification of the smaller man-made cave as the "Devils Den" on the 1955 edition of the 15-minute USGS Wallingford quadrangle apparently is in error. The feature originally named for the Devils Den (Dale, 1915) is actually west of and outside the boundary of the study area.

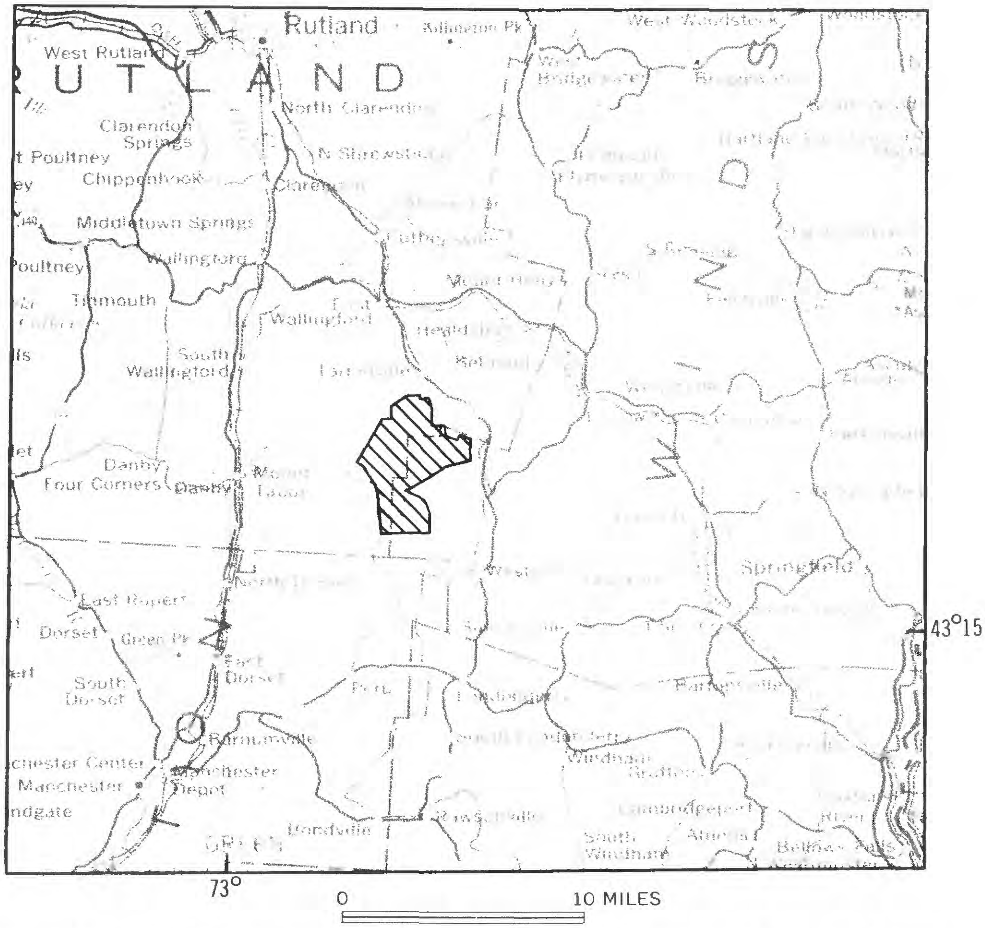


Figure 1.—Index map showing the location of the Devils Den Roadless Area.

incorporation into the Centennial Geologic Map of Vermont (Doll and others, 1961). Additional mapping has been done by Thompson since publication of the state map (Thompson, oral commun., 1981), but this work has not as yet been published. In an older study, Dale (1915) investigated the dolomite near Devils Den as part of a regional survey of calcite and dolomite marbles of eastern Vermont. No other published information is available on the geology of the area.

The present investigation began in the fall of 1980 with field studies by A. E. Sabin and J. G. Jones of the U.S. Bureau of Mines (USBM). During this work, 26 rocks were collected and analyzed for 42 elements by semi-quantitative emission spectrography; quantitative atomic-absorption and fire-assay analyses were also performed for selected metals on most of these samples. In the field, outcrops were examined for uranium and thorium concentrations by the use of a portable gamma-ray spectrometer. Laboratory analyses by fluorometric methods investigated the uranium contents of 21 samples, as well as the thorium level of one sample.

Work by the U.S. Geological Survey (USGS) began with field mapping in the spring of 1981 (and subsequently in 1982) by J. F. Slack and R. A. Ayuso, assisted at various times by A. R. Pyke, R. L. Graves, N. K. Foley, and W. B. Ward. Rock samples collected during the 1981 work, together with stream sediments and panned concentrates obtained by A. E. Grosz, were submitted for geochemical analysis. A total of 72 rocks, 22 stream sediments, and 8 panned concentrates were analyzed by semi-quantitative emission spectrographic methods for 31 elements, and by quantitative atomic absorption spectroscopy for two elements (gold and zinc). Selected rock samples also were analyzed for major elements by standard rapid-rock methods, and for uranium and thorium by neutron-activation techniques. Geophysical coverage of the study area, described by Slack, Buckley, Ayuso, and Raab (in press), includes an airborne magnetic survey and both airborne and ground radiometric surveys.

SURFACE- AND MINERAL-RIGHTS OWNERSHIP

All surface and mineral rights of the Devils Den Roadless Area are owned by the Federal Government. Under authority of the Weeks Act, lands were acquired from private ownership by the U.S. Government in the early 1930's and have been retained to the present.

GEOLOGIC SETTING

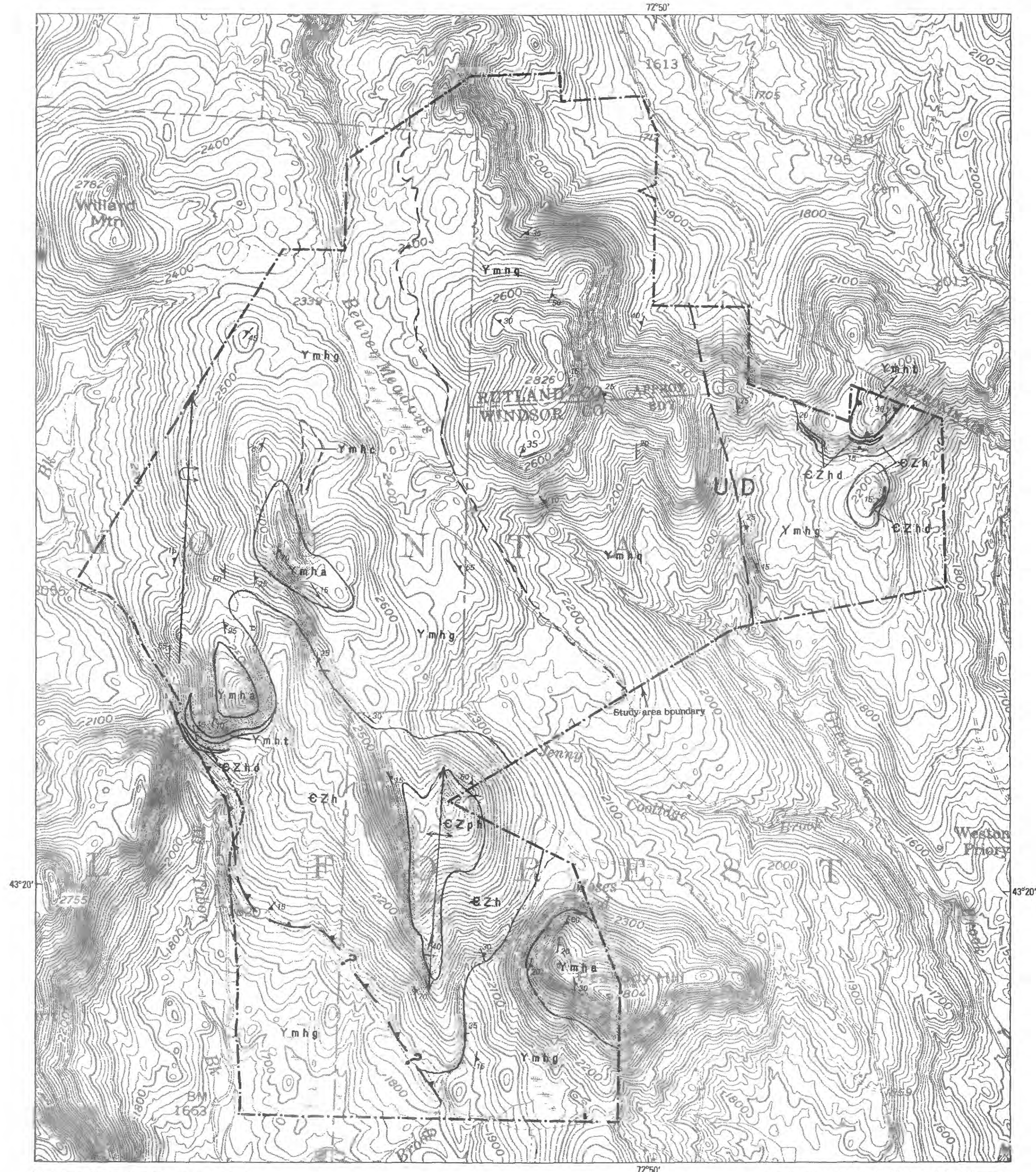
The Devils Den Roadless Area, situated in the core of the Green Mountain anticlinorium, is underlain by metamorphosed rocks of both Precambrian and probable Paleozoic age (fig. 2). Minor glacial and alluvial deposits cover gentle slopes and low elevations. The older Precambrian rocks comprise a basement terrane consisting of diverse lithologies within the Mount Holly Complex of Grenville (approximately 1 b.y. old) age. The Mount Holly Complex is subdivided into several informal units, including felsic gneiss, quartzitic gneiss, amphibolite-bearing gneiss, and minor calc-silicate rock and tourmaline-rich quartzite. Granitic pegmatites are present in the Precambrian gneisses of the Mount Holly Complex, for which they serve as recognition criteria. The younger cover rocks, previously designated the Cavendish Formation during early mapping (Doll and others, 1961), are here separately assigned to the Hoosac and Pinney Hollow(?) Formations of Late Proterozoic and(or) Early Cambrian age; rocks possibly correlative with the Tyson Formation (Doll and others, 1961) are included within the Hoosac Formation. These younger cover rocks include porphyroblastic albite-quartz-mica schist (metapelite) and minor dolomite of the Hoosac Formation, and quartz-mica-chloritoid-magnetite schist of the Pinney Hollow(?) Formation.

The structure of the area is extremely complicated and reflects a deformational history involving Late Proterozoic and Paleozoic (Ordovician, Devonian) events. The basic structure is interpreted as a doubly-plunging recumbent nappe, broken by several faults. The younger cover rocks crop out near the eastern border of the study area in an upright sequence apparently down-dropped by a normal fault (from the upper limb of the nappe), and in the west and southwest along the lower (inverted) limb of the nappe. The older Grenvillian basement rocks occur in an inverted sequence principally in the core of the nappe, overlying a basal thrust fault; a second thrust is inferred for the easternmost boundary of the area.

All of the rocks of the study area show the effects of regional metamorphism to upper greenschist-facies conditions, in which almandine garnet is common in pelitic schists and dark green hornblende is present in mafic rocks. The abundance of granitic pegmatites in most lithologies of the Mount Holly Complex indicates that the Precambrian basement rocks, extensively retrograded to greenschist assemblages as a result of the Taconic (or Acadian) orogeny, originally underwent prograde metamorphism to sillimanite (or greater) conditions.

GEOCHEMICAL SURVEY

Geochemical analyses of rocks, stream sediments, and panned concentrates do not reveal any significant metal anomalies in the study area. Certain metals have slightly anomalous concentrations, but none are suggestive of important mineralizing processes. Histograms for elements of particular interest (Slack, Atelsek, and Grosz, in press) show some enrichments, for rocks as well as for panned concentrate samples. Anomalous values were identified for barium, boron, copper, gold, lead, silver and thorium. Slightly high values obtained for other metals (i.e., chromium, molybdenum, nickel, tin, zinc) are interpreted as normal geochemical distributions, however, and are not considered statisically



Base from U.S. Geological Survey 1:62,500
Wallingford, 1955

1 ½ 0 1 MILE

1 .5 0 1 KILOMETER

Geology mapped by J.F. Slack and R.A. Ayuso, assisted by A.R. Pyke, R.L. Graves, N.K. Foley, and W.B. Ward, 1981 and 1982

Figure 2.--Geologic map of the Devils Den Roadless Area.

DESCRIPTION OF MAP UNITS

€Zph — **Pinney Hollow(?) Formation (Early Cambrian and(or) Late Proterozoic)—Quartz-muscovite-paragonite-chloritoid schist locally with abundant disseminated magnetite and chlorite. Thin lenses and laminae of fine-grained quartz are also common**

€Zhd / €Zh — Hoosac Formation (Early Cambrian and(or) Late Proterozoic)—Coarse-grained quartz-plagioclase-mica schist characterized by albite **porphyroblast**. CZhd = buff to orange, granular dolomite and dolomite marble

Informal Subunits of the Mount Holly Complex (Middle Proterozoic)
(No stratigraphic order implied)

Ymht — Tourmaline quartzite—Thin- to medium-bedded quartzite and vitreous orthoquartzite containing coarse disseminations, segregations, and layers of black tourmaline

Ymhg — Felsic gneiss—Layered quartzo-feldspathic gneiss, locally with mica or chlorite. Small, isolated bodies of granite pegmatite are common

Ymhc — Calc-silicate rock—Coarse-grained rock composed mainly of quartz, diopside, and actinolite

Ymha — Amphibolite-bearing rocks—Felsic gneiss containing minor interlayered epidote-rich amphibolite and metagabbro(?)

Ymhq — Quartzitic gneiss—Impure quartzite and feldspathic quartzite, commonly with minor associated muscovite

30 — Bedding, showing dip.

60 — Foliation, showing dip

Contact, dashed where approximate.

U / D — Fault (approximately located), showing relative movement

Thrust fault, dashed where approximate. Saw teeth on upper plate.

Antiform, showing direction of plunge

Overturned synform, showing direction of plunge significant.

Because of the abundance of glacial materials in and near the study area, it is difficult to unambiguously interpret the results of the stream sediment and panned concentrate surveys. It is quite likely that a large fraction of such material is derived from glacially transported debris, and that the geochemical data for stream sediments and panned concentrates may not be fully representative of the local bedrock. This is especially true for anomalies in samples for which no bedrock source has been established. The anomalies for copper, lead, and radioactive elements (uranium, thorium) fall into this category, such that the significance of the geochemical data for these metals is questionable.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

The Devils Den Roadless Area has no identified mineral resources except for certain non-metallic commodities. Locally anomalous concentrations of certain metals are not suggestive of important metallic-mineralization processes. The only known resources are non-metallic mineral commodities of local interest.

Uranium and Thorium

The Precambrian basement rocks of the study area form part of an extensive terrane in the Green Mountains known to be favorable for uranium and thorium mineralization. Many radioactive anomalies have been discovered in this region, both by airborne radiometric surveys (Popenoe, 1964) and by reconnaissance geochemical sampling (Koller, 1979). Most of the anomalies are related to uranium-rich segregations in granite pegmatite or quartz-tourmaline rocks associated with micaceous quartzite, amphibolite, and feldspathic gneiss of the Mount Holly Complex (Grauch and Zarinski, 1976; Ratte, 1982). The largest known deposits occur on College Hill, near Jamaica, Vt., and on Okemo Mountain and South Mountain (Grant Brook area) west of Ludlow. The deposits on Okemo Mountain and South Mountain are only 3 to 5 mi east of the study area and include rocks commonly containing several hundred parts per million (ppm) uranium (Ratte, 1982); some samples contain over 2 percent U_3O_8 (Sabin and Jones, 1981).

Geologic and geophysical studies of the Devils Den Roadless Area failed to locate any bedrock uranium deposits. Previously, Morrill and Chaffee (1964) reported a uranium prospect within the study area, approximately 0.75 mi to the northwest. Recent airborne radiometric surveys (Slack, Buckley, Ayuso, and Raab, in press) indicate that this prospect has a radioactive low, rather than high signature. Ground checking of this area by USGS personnel yielded only radioactive boulders of clearly glacial origin. The airborne and ground radiometric surveys do not provide evidence of any anomalously high radioactivity in the local bedrock. On this basis, there is no evidence of a potential for uranium or thorium resources in the study area.

Gold

Geochemical analyses of rocks and drainage samples reveal trace amounts of gold in a few materials. Two rock samples from the western part of the study area contain 0.11 and 0.30 ppm gold. Both of these samples are coarse albitic schist of the Hoosac Formation. Gold was also detected in three stream sediments, but at concentrations of only 0.05 ppm. Such low gold values are of general interest, but currently are not indicative of resource potential.

A more favorable gold target in the region is the pyrrhotite deposit at Cuttingsville, Vt., about 10 mi to the north. This deposit consists of gold-bearing massive pyrrhotite contained in marble of the Mount Holly Complex (Doll, 1969). Similar masses of pyrrhotite, although in much smaller pods and lenses, are associated with marble and calc-silicate rocks in a roadcut exposure on State Highway 155, less than a mile from the eastern border of the study area. Judging from the geologic setting, the pyrrhotite bodies appear to be strata-bound and indigenous to the marble and calc-silicate terranes of the Mount Holly Complex. Although one small unit of calc-silicate rock has been mapped within the study area (Slack, Buckley, Ayuso,and Raab, in press), no pyrrhotite zones have been found. Based on the lack of abundant calc-silicate rocks in the study area, there seems to be little evidence for gold-bearing pyrrhotite deposits near the Devils Den Roadless Area. The more extensive belts of calc-silicate rocks elsewhere in the Mount Holly Complex of Vermont (Doll and others, 1961) are more promising, however, and should be prospected for gold.

Iron

A few small deposits of iron have been identified in central Vermont in rock units broadly correlative with those exposed in the study area. Old prospects near Plymouth, Vt., are developed on lenticular masses of iron oxides (chiefly magnetite) that occur in places at the contact between the Tyson and Hoosac Formations. Thompson (1972, p. 226) interprets these occurrences as metamorphosed *terra rossa* deposits derived by subaerial erosion of the impure dolomites of the uppermost Tyson Formation. Field examination of the dolomites of the study area (Slack, Atelsek, and Grosz, in press) failed to locate any such residual iron deposits, thus precluding a potential for iron resources.

Carbonate-Hosted Lead-Zinc

Carbonate rocks of Paleozoic age are economically significant in containing some of the world's principal deposits of lead and zinc. These deposits characteristically occur as sphalerite and(or) galena filling open spaces in collapse (paleokarst) breccias in shallow-water carbonates (Brown, 1967). Some of the larges of such deposits have been mined in the central and southern Appalachians at Friedensville, Pa., at Austinville, Va., and in eastern Tennessee (Hoagland, 1976). The discovery of crystals of galena in the dolomite near Devils Den by J. B. Thompson, Jr. (personnal commun., 1981) suggests that a similar mineralizing process may have operated in the Paleozoic cover rocks of the study area. Although carbonate-hosted lead-zinc deposits are known in the paleozoic shelf sequence of western Vermont and adjoining New York state (Clark and Neeley, 1983), no record exists of lead or zinc occurrences in the carbonates of the eastern belt. In the Devils Den area, these carbonates consist of thin layers of dolomitic marble with local veins of quartz; micaceous zones are abundant in places. Inspection of the dolomite near Devils Den by USGS and USBM personnel (Slack, Atelsek, and Grosz, in press; Sabin and Jones, 1981) failed to locate any galena (or sphalerite). The thin dolomites exposed near the eastern boundary of the study area were also examined and appear to lack sulfide minerals. The small size of the dolomite bodies and the scarcity of galena and sphalerite would seem to preclude the existence of carbonate-hosted lead-zinc deposits in the study area.

Pegmatite Minerals

Most of the study area is underlain by the Precambrian Mount Holly Complex, in which local bodies of pegmatite are common. Pegmatites are of economic interest because they may contain valuable large crystals of mica and feldspar, as well as concentrations of rare metals such as lithium, beryllium, niobium, and tantalum. None of the pegmatites of the Mount Holly Complex have been mined, although the Allen property near Sherburne, Vt. has been prospected for sheet mica (Cameron and others, 1954, p. 295-296). Field studies indicate that the pegmatites of the study area are all very small and lack large crystals of mica or feldspar, as well as any rare metals.

Marble

Marble is an important non-metallic commodity used both in the construction industry and for certain chemical products Suitably pure marbles are valuable in the chemical industry for the manufacture of fillers, refractories, abrasives, and many other products (Carr and Rooney, 1975). In the Devils Den area, geologic mapping has located two dolomite-bearing terranes, one on the extreme east side and the other on the extreme west side of the study area (Slack, Buckley Ayuso, and Raab, in press). Most outcrops of the marble are small and less than 10 ft thick. Common features include a buff- to orange-color, a fine-grained crystalline nature, and an abundance of small quartz veins; micaceous lenses are also present in some outcrops.

Chemical analyses of selected samples indicate that parts of the marble units are essentially pure dolomite (Slack, Atelsek, and Grosz, in press) and comparable in quality to the marbles of the White Crystal dolomite deposit near Gouverneur, N.Y. (Prucha, 1953). The analyses of the Devils Den marbles suggest a high-quality dolomite suitable for chemical use. However, the size of the marble bodies and the commonly contained impurities (quartz veins, micaceous zones) indicate that the amount of pure marble is small.

Crushed stone

Much of the rock exposed in and near Devils Den Roadless Area is suitable for road aggregate and for general construction purposes. However, abundant accessible rock exists outside the study area closer to most markets.

Sand and Gravel

A few small deposits of sand and gravel are associated with some of the local drainages, such as at the head of Utley Brook and along the upper tributaries of Greendale Brook. However, outside of the study area, numerous pits are actively worked that contain large reserves of sand and gravel, including one less than a mile beyond the northeastern boundary.

Oil and gas

Although rocks exposed at the surface of the study area are devoid of hydrocarbons, a possibility does exist for oil and natural gas at depth. Recent seismic studies (Cook and others, 1979; Ando and others, 1982) suggest that the older metamorphosed rocks in the Blue Ridge of the southern Appalachians and the Green Mountains of Vermont overlie a thick sequence of young sedimentary rocks favorable for hydrocarbon accumulation. The Devils Den area is within the so-called Eastern Overthrust Belt which is currently receiving attention by industry (McCaslin and Sumpter, 1981; Bigelow, 1982); recently, large tracts of land in central and western Vermont—including parts of Rutland and Windsor Counties—have been leased in the anticipation of a search for oil and gas. A hydrocarbon resource may exist in the deeper strata underlying the study area, but it cannot be evaluated by the present investigation.

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