DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

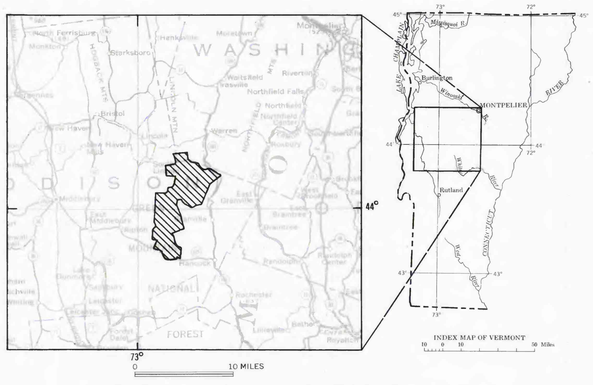

Figure 1.—Index map showing location of the Bread Loaf Roadless Area.

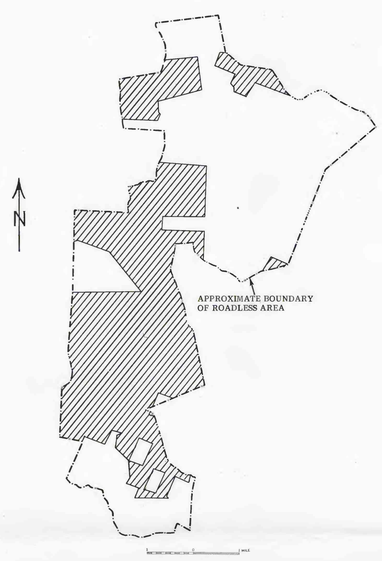

Figure 2.—Areas under application for oil and gas leases (hachured) in the Bread Loaf Roadless Area.

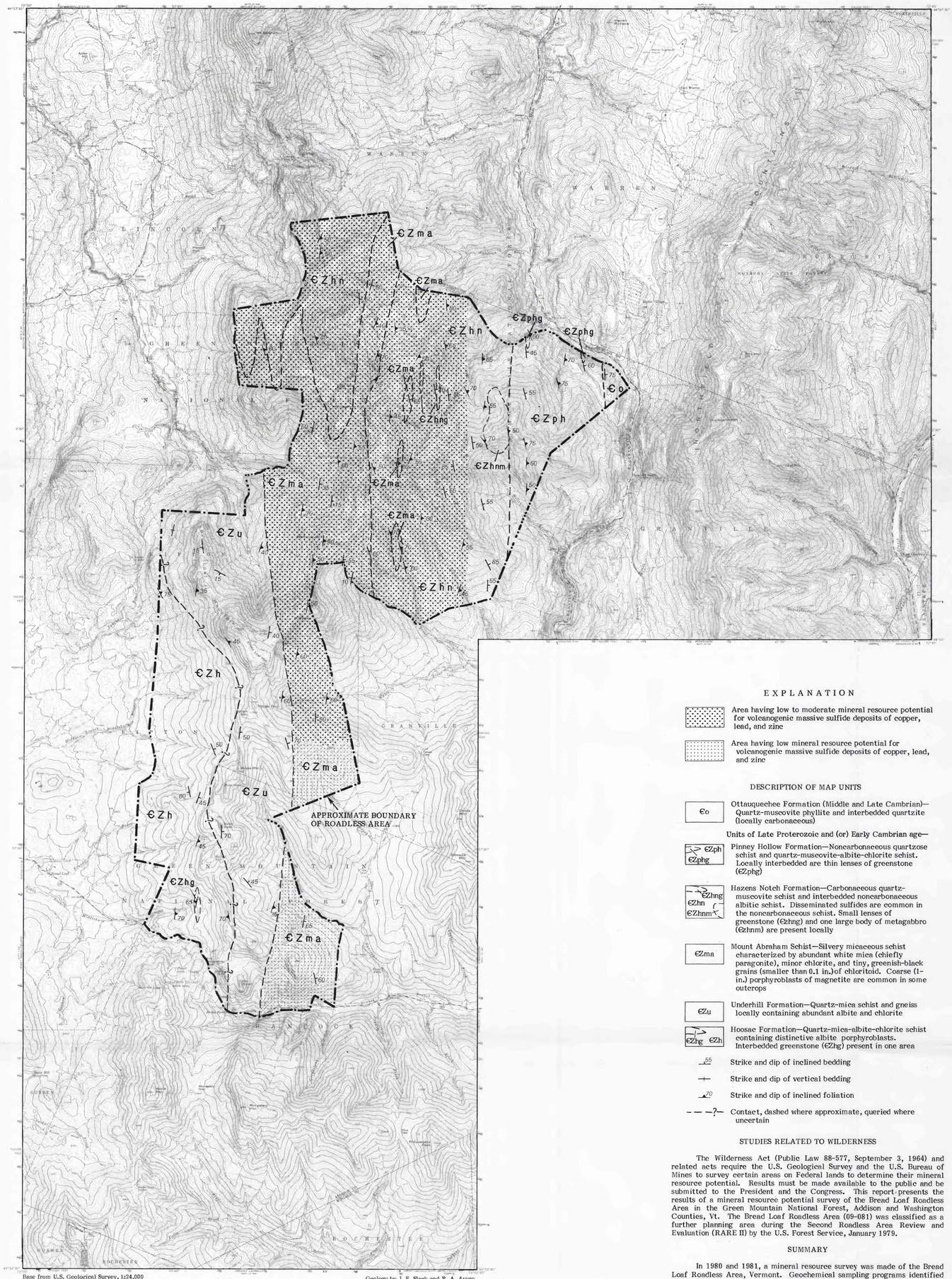

Figure 3.—Geologic map of the Bread Loaf Roadless Area showing areas of mineral resource potential. Geology modified from Cady and others (1962) and Doll and others (1961). Surficial deposits not shown.

MINERAL RESOURCE POTENTIAL MAP OF THE BREAD LOAF ROADLESS AREA, ADDISON AND WASHINGTON COUNTIES, VERMONT

By
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1983

MISCELLANEOUS FIELD STUDIES
MAP MF-1625-A
PAMPHLET ACCOMPANIES MAP

EXPLANATION

- Area having low to moderate mineral resource potential for volcanogenic massive sulfide deposits of copper, lead, and zinc
- Area having low mineral resource potential for volcanogenic massive sulfide deposits of copper, lead, and zinc

DESCRIPTION OF MAP UNITS

- €o — Ottauquechee Formation (Middle and Late Cambrian)—Quartz-muscovite phyllite and interbedded quartzite (locally carbonaceous)

Units of Late Proterozoic and (or) Early Cambrian age—

- €Zph, €Zphg — Pinney Hollow Formation—Noncarbonaceous quartzose schist and quartz-muscovite-albite-chlorite schist. Locally interbedded are thin lenses of greenstone (€Zphg)
- €Zhng, €Zhn, €Zhnm — Hazens Notch Formation—Carbonaceous quartz-muscovite schist and interbedded noncarbonaceous albitic schist. Disseminated sulfides are common in the noncarbonaceous schist. Small lenses of greenstone (€Zhng) and one large body of metagabbro (€Zhnm) are present locally
- €Zma — Mount Abraham Schist—Silvery micaceous schist characterized by abundant white mica (chiefly paragonite), minor chlorite, and tiny, greenish-black grains (smaller than 0.1 in.)of chloritoid. Coarse (1-in.) porphyroblasts of magnetite are common in some outcrops
- €Zu — Underhill Formation—Quartz-mica schist and gneiss locally containing abundant albite and chlorite
- €Zhg, €Zh — Hoosac Formation—Quartz-mica-albite-chlorite schist containing distinctive albite porphyroblasts. Interbedded greenstone (€Zhg) present in one area
- 65 — Strike and dip of inclined bedding
- — Strike and dip of vertical bedding
- 70 — Strike and dip of inclined foliation
- — — —?— — Contact, dashed where approximate, queried where uncertain

STUDIES RELATED TO WILDERNESS

The Wilderness Act (Public Law 88-577, September 3, 1964) and related acts require the U.S. Geological Survey and the U.S. Bureau of Mines to survey certain areas on Federal lands 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 resource potential survey of the Bread Loaf Roadless Area in the Green Mountain National Forest, Addison and Washington Counties, Vt. The Bread Loaf Roadless Area (05-081) 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.

SUMMARY

In 1980 and 1981, a mineral resource survey was made of the Bread Loaf Roadless Area, Vermont. Geochemical sampling programs identified significant concentrations of copper, lead, zinc, and barium in rocks, soils, and drainage samples (stream sediments and panned concentrates), particularly in the northern part of the roadless area. Anomalous amounts of arsenic, cobalt, boron, and manganese were also detected in some samples. The geologic setting and geochemical anomalies suggest a low to moderate potential for volcanogenic massive sulfide deposits of copper, lead, and zinc, in the Mount Abraham Schist and the Hazens Notch Formation. The geochemically most anomalous samples are from the Hazens Notch Formation, near its contact with the easternmost part of the Mount Abraham Schist.

Nonmetallic commodities in the Bread Loaf Roadless Area include minor deposits of sand and gravel, and abundant rock suitable for crushing. However, large amounts of these materials are available in more accessible locations in the surrounding region. Oil and natural gas at great depth may also exist, but this cannot be evaluated by the present investigation.

INTRODUCTION

The Bread Loaf Roadless Area comprises 19,850 acres in the Green Mountain National Forest in Addison and Washington Counties, central Vermont (fig. 1). Total relief is nearly 2600 ft, from a low elevation of 1240 ft at the southeast corner to a high point of 3835 ft on the southern crest of Bread Loaf Mountain. The nearest towns are Warren and Hancock, each a few miles to the northeast and southeast, respectively. Principal access is provided by State Route 100 along the eastern side of the area, and by State Route 125 which forms the southern border; U.S. Forest Service Roads 54 and 59 are near the western boundary. Old logging roads and several foot trails (including the Long Trail) allow entry into the interior, and access to most of the high peaks.

SURFACE- AND MINERAL-RIGHTS OWNERSHIP

Surface and mineral rights in the Bread Loaf Roadless Area are owned entirely by the Federal Government. More than half of the roadless area, however, is currently under lease application for oil and gas exploration. The applications cover about 10,067 acres, mainly in the western part of the area (fig. 2).

GEOLOGIC SETTING

The geology of the Bread Loaf Roadless Area (hereinafter also termed Bread Loaf area or study area) is dominated by a series of typically schistose rocks of Late Proterozoic and(or) Early Cambrian age. Pleistocene glacial deposits are also present locally, particularly at lower elevations where till and outwash are common. The bedrock in the area forms part of an extensive cover sequence unconformably overlying the Middle Proterozoic (Grenville) basement terrane of the Mount Holly Complex to the west (Doll and others, 1961; Cady and others, 1962). The cover rocks (fig. 3) have been assigned by Cady and others (1962) to several formal stratigraphic units, including (from oldest to youngest): 1) the Hoosac Formation, 2) the Underhill Formation, 3) the Mount Abraham Schist, 4) the Hazens Notch Formation, 5) the Pinney Hollow Formation, and 6) the Ottauquechee Formation. Major lithologies within these units are carbonaceous and noncarbonaceous quartz-muscovite schist, quartz-albite-mica schist, quartz-mica-chlorite schist, and schistose impure quartzite. These rocks are interpreted to be mixtures of metamorphosed shale, graywacke, and volcaniclastic sediment. Thin conformable layers of fine-grained greenstone occur locally in the Hazens Notch and Pinney Hollow Formations (fig. 3) and are believed to be basaltic metatuffs. A more unusual lithology represented by the Mount Abraham Schist consists of white mica (chiefly paragonite), quartz, chlorite, and chloritoid.

Many of the rocks in the Bread Loaf area contain sulfide minerals. Pyrrhotite and pyrite are the principal sulfides, occurring mainly in the Hazens Notch Formation and the Mount Abraham Schist. In the Hazens Notch, pyrrhotite occurs as disseminations in noncarbonaceous albite schist; in places, the pyrrhotite constitutes as much as 10 percent of the rock volume. The highly carbonaceous quartz-muscovite schist of the Hazens Notch typically contains euhedral cubes of pyrite (or molds) up to 1 in. in diameter. Pyrite is also common in aggregates of fine-grained crystals in the Mount Abraham Schist, particularly near its eastern contact with the Hazens Notch Formation. Chalcopyrite has been observed in several areas as very small grains intergrown with pyrrhotite (in albitic schist), and as thin films smeared out in the plane of the schistosity of the carbonaceous schist. Minor amounts of malachite have also been noted as stains on several outcrops in the northern and central parts of the study area.

GEOCHEMICAL SURVEY

Geochemical analyses of nearly 500 rocks, soils, and drainage samples (stream sediments and panned concentrates) show concentrations of a suite of elements including arsenic, copper, zinc, cobalt, lead, barium, boron, and manganese. In all cases, these elements were identified in anomalously high amounts in bedrock samples, thus precluding a distant (glacial) source. The geochemical survey also detected minor quantities of silver, gold, nickel, and chromium, but the distribution of these metals appears to be unrelated to that of the anomalous suite. Local concentrations of molybdenum, tin, and thorium discovered in certain drainage samples have not been verified in the bedrock of the study area, and may have been glacially derived from a source to the north.

Geochemical data for 176 rock samples show anomalously high values for arsenic, copper, lead, zinc, cobalt, barium, boron, and manganese, especially for samples from the northern part of the study area (fig. 4 in pamphlet). Samples of micaceous schist contain as much as 200 parts per million (ppm) arsenic, 300 ppm copper, 300 ppm zinc, 5000 ppm barium, 1000 ppm boron, and more than 5000 ppm manganese. Rock samples containing abundant quartz (quartzite, granofels) have up to 700 ppm copper, 200 ppm lead, 1300 ppm zinc, 100 ppm cobalt, 2000 ppm barium, 1000 ppm boron, and 5000 ppm manganese; bismuth and cadmium were also detected (10-20 ppm) in one sample. Histograms for this suite of elements (Slack and Atelsek, in press) show the highest values to be statistically anomalous when compared with data for lithologically similar rocks. Most of the anomalous samples are from a linear belt that conforms, in general, to the western part of the Hazens Notch Formation. Some of the anomalous samples are also from the Mount Abraham Schist, but only for locations close to the contact with the Hazens Notch Formation.

MINERAL RESOURCE POTENTIAL

Potential metallic mineral resources in the Bread Loaf Roadless Area include copper, lead, and zinc in volcanogenic massive sulfide deposits. The nonmetallic commodities in the study area are small deposits of sand and gravel and abundant rock suitable for crushing. Oil and natural gas at depth may also exist, but this cannot be evaluated by the present investigation.

Massive sulfides

The geologic setting and geochemical anomalies identified in the Bread Loaf area suggest a potential for massive sulfide deposits. Typically, such deposits consist of stratabound and commonly stratiform accumulations of sulfide minerals in sedimentary and(or) volcanic rocks. The chief economically recoverable metals are copper and zinc, although many deposits yield significant amounts of silver and lead as well. The deposits are typically conformable within specific rock layers, and, as a result, tend to form stratigraphic units parallel to the trend of the surrounding strata. Where these strata include volcanic rocks, the deposits are believed to be related to submarine volcanism, and are classified as volcanogenic (Hutchinson, 1973; Franklin and others, 1981).

The most favorable location for the occurrence of massive sulfide deposits is in the northern to north-central part of the study area. Bedrock samples showing the highest geochemical anomalies were collected from the northernmost drainage basin, southeast of Lincoln Gap. Other significant anomalies are evident nearby to the south and southeast, particularly at the head of Stetson Brook. These areas coincide, in general, with the distribution of the Hazens Notch Formation and the eastern part of the Mount Abraham Schist, and are assigned a low to moderate potential for volcanogenic massive sulfide deposits (fig. 3). Utilizing the criteria of Taylor and Steven (1983), we designate the geochemically most anomalous areas as having a moderate potential for these types of deposits. A low potential is assigned to stratigraphically equivalent rocks along strike to the south, where no bedrock anomalies are known.

Crushed stone

Much of the rock exposed in the Bread Loaf area is suitable for use as crushed stone for road aggregate or for general construction purposes. However, abundant accessible rock is available outside the study area closer to most markets.

Sand and gravel

A few small deposits of sand and gravel are in the study area, mainly near its southwestern boundary east and northeast of the writers' school at Bread Loaf (fig. 3). Two of these deposits have been worked in the past in small pits. However, there is an abundance of much larger resources of sand and gravel in the surrounding region.

Oil and gas

Although rocks exposed at the surface in the study area are largely 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 accumulations. The Bread Loaf area is within the so-called eastern overthrust belt, which is currently receiving attention from industry (McCaslin and Sumpter, 1981; Bigelow, 1982); recently, large tracts of land in central and western Vermont—including parts of Addison and Washington Counties and parts of the roadless area—have been leased in the anticipation of a search for oil and gas (fig. 2). A hydrocarbon resource may exist in the deeper rocks of the study area, but it cannot be evaluated by the present investigation.

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