MINERAL RESOURCE PROVINCES
OF
VERMONT

A current look at Vermont's
mineral resources potential and
mineral industries.

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by

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THE CARBONATE PROVINCE

MARBLE

Vermont's dimension stone marble is known the world over. The Danby Imperial white marble, the Isle La Motte black marble (limestone) and the green Verde Antique (serpentinite) are among the industries most noted products. The Verde Antique has been discussed under the ultramafic province since it is truly a product related to ultramafic geology and not carbonate geology. The major operator of Vermont's marble industry is the Swiss firm OMYA, Inc., a Pluess-Staufer Company.

In addition to dimension stone, the Vermont marble industry supplies an increased international demand for a finely-ground calcium carbonate product. Quarries at East Middlebury and Wallingford supply the White Pigment Co. mills at New Haven Junction and Florence, and the Smokerise quarry at Brandon supplies the Vérmarco Company mill at Florence. The OMYA, Inc. mill at Florence is also supplied by the white marble quarry at East Middlebury.

The most sought after marble for both the dimension stone and ground products industries are the white marbles. The Columbian member of the Ordovician Shelburne Formation where thickened by folding or faulting has proven to be the most successful geologic target for the industry. The quarries listed above are located in this stratigraphic-structural setting. The Shelburne Formation is shown on the state geologic map (Doll, 1961) in the Champlain and Vermont Valleys from Colchester to Bennington. Minor production has come from the Upper Cambrian Sutherland Falls member of the Clarendon Springs Formation, and from the Lower Ordovician Bascom Formation.

The fossiliferous Crown Point member of the Middlebury Formation harbors the one black marble (limestone) quarry used for dimension stone. The quarry is located on Isle La Motte in Grand Isle County. It was last worked in the late 1960's-early 1970's. This limestone abounds in fossil remains of Ordovician gastropods, Maclurites magnus and Raphistoma striatum.

The Danby Imperial quarry located on the northeast flank of Dorset Mountain in Danby, Vermont is perhaps the world's largest operating underground marble quarry. Stone from this quarry also is located in the Columbian white marble of the Ordovician Shelburne Formation.

The Smokerise quarry at Brandon commenced operation on December 13, 1979 and is the first new quarry to come on line since 1964. Rock from this quarry is supplying the mills at Florence, once supplied by the Loveland quarry which was depleted in 1979. Several former dimension stone quarries...
are currently being considered for re-activation to supply the ground products mills.

LIMESTONE

With the exception of the black limestone quarry on Isle La Motte which supplies the dimension stone industry, all other limestone quarries produce crushed stone for a variety of uses. The primary use is for road base and bituminous concrete aggregate for highway construction. Both permanent quarries and small single-contract rock-borrow quarries exist throughout the (marble-limestone) Carbonate Province.

The permanent quarries are located in Swanton (The Swanton-Shelburne Limestone Corp.), Winooski (Frank W. Whitcomb Construction Corp.), Shelburne (The Swanton-Shelburne Limestone Corp.) and New Haven (Pike Industries Inc.). The marble companies discussed above also produce crushed stone for aggregate, agricultural lime and other uses.

Several formations with dominantly carbonate lithologies are exploited by the crushed stone industry. The Beldons member of the Ordovician Chipman Formation is quarried at Swanton and New Haven, the Ordovician Shelburne Formation provides the rock for the Shelburne Limestone Corp. quarry at Shelburne, and the Cambrian Winooski Formation is quarried in Winooski by Whitcomb. These formations are present as disconnected belts throughout the Carbonate Province.

The northwestern margin of the Carbonate Province is in New York state and does not show on the mineral resource map of Vermont (see Plate I). This margin extends from Champlain (New York) through Chazy (New York), to Ticonderoga (New York) and back into Vermont at Chipman Point.

Crystalline limestones associated with the Devonian Waits River Formation in eastern Vermont, and carbonate lenses of limited occurrence in other formations (Pinney Hollow, Underhill) have been quarried in the past but offer no significant resource.
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LIME -- LIMESTONE


Granitic plutons assigned to the Devonian New Hampshire Pluton Series are known to exist the entire length of the state from the Black Mountain pluton in Dummerston to the large pluton of Averill Granite in Norton and Averill in northeastern Vermont. Although granite has been quarried in nearly all these plutons at one time, the most active quarries today are in the Barre pluton at Graniteville and Websterville. The dominant exposures of granitic rock of the New Hampshire Series lie north and east of Barre. This region can be designated as Vermont's Granitic Province and it is here that future exploitation will most likely occur.

Barre Granite: Barre granite is the name given to the medium-textured uniformly gray colored granodiorite. It was mapped and described by Murthy (1957). Two quarry companies operate five quarries in the Graniteville-Websterville mining district which is approximately three miles southeast of the town of Barre (pronounced like "berry"). The Rock of Ages Corp. operates the Wetmore-Morse, Smith, Rock-of-Ages, and Pirie quarries, and the Wells-Lamson Quarry Co. operates their Wells-Lamson quarry at Websterville.

Woodbury Granite: The Woodbury Granite mapped and described by Konig (1961) is found in several small exposures in the towns of Woodbury and Hardwick. The Woodbury granite is light to medium gray, generally with medium-textured grains, however grain size and texture vary in the several exposures in the region. Quarries east and northeast of the town of Woodbury once supplied a very prosperous granite industry in Hardwick. The center of the industry has since shifted to the Barre area and only one operator, John Swenson Granite Co. (Concord, N.H.), is currently quarrying the Woodbury granite.

Adamant Granite: The Adamant granite mapped and described by Cady (1956) and Konig (1961) occurs as sills trending northeasterly in the village of Adamant (Calais township). This granite is a mottled gray varying in texture from medium-coarse equigranular in the thicker sills to porphyritic in the thin sills. Until recently the Garand Teed Quarries, Inc. produced rough blocks from a quarry in one of the thicker sills of Adamant granite. The present owner does not anticipate further commercial use of the Adamant quarries.

Derby Granite: The Derby granite (not officially named) has been mapped and described by Doll (1951). It occurs in several large plutons exposed in the towns of Derby, Charleston, Barton, Irasburg and Westmore. The granite is light to dark gray, medium to coarse grained and varies from equigranular to porphyritic texture. The old Willey Granite Quarry northwest of Derby Center is currently operated by Granite Hills, Inc. providing rough granite blocks for the Rock of Ages Corp.
COLORED GRANITES

**Bethel White Granite:** The Bethel granite was mapped and described by Ern (1963). One small exposure of this granite is located on Quarry Hill northeast of the village of Bethel. A large quarry which provided highway aggregate for construction of Interstate 89 can be seen just west of this highway approximately two miles north of Interchange #3. The Rock of Ages dimension stone quarry is a short distance west of this site.

The rock is medium to coarse grained and nearly pure white. It is composed almost entirely of leucocratic minerals quartz, oligoclase, orthoclase, microcline and muscovite. Minor quantities of biotite and epidote provide cloudy, dark splotches in the rock. The rock has been classed as a quartz monzonite (Ern, 1963).

**Braintree Granite:** The Braintree granite was also mapped and described by Ern (1963). This pluton is located west of the village of East Braintree and like the Bethel White granite pluton lies to the south of the main granitic province. This granite, where quarried has a medium gray color with a faint pinkish tint. It is a medium to coarse textured, equigranular rock. The pluton is also composed of a dioritic phase that makes up the western half of the Braintree pluton. Mr. John Murray of Randolph actively quarried the rock for personal use only. The quarry property is currently owned by Mr. Murray.

Extensive exploration in Vermont seems unwarranted. The various occurrences of granitic rocks are well known. There is an interest in locating colored varieties of igneous rock suitable for monumental and dimension stone. Known occurrences of unaltered, medium to coarse grained, mafic igneous rocks are few and the expectations of finding large plutons of such rocks in Vermont are minimal. Rock within the boundaries of current mining districts is apparently ample for foreseeable needs. Numerous abandoned granite quarries exist throughout the granitic province and in other small granitic plutons outside the province. These quarries have exploited rock of Precambrian age in a small granitic body west of Tyson, Vermont, and Mesozoic granitic rocks at Mount Ascutney in Brownsville (West Windsor).
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THE KAOLINITIC CLAY PROVINCE

The kaolin province forms a narrow belt along the base of the Green Mountain Front in western Vermont. The history of production goes back to 1793 when local clay was used for the manufacture of pottery and firebrick by Norton Pottery near Bennington. Deposits have been reported in Pownal, Bennington, Shaftsbury, Dorset, South Wallingford, Tinmouth, North Clarendon, Rutland, Brandon and Monkton. These deposits form discontinuous links in the kaolin belt.

Iron (as limonite) and manganese (as psilomelane, pyrolusite, and manganite) ores associated with the kaolin deposits were mined until the early 1900's, iron ore at Brandon (Forestdale) and Bennington, and manganese ore at South Wallingford. Early scientific workers (Dale 1903-04, Woodworth, 1903-04, Burt 1927-28) in the province attribute the origin of the kaolin to the residual weathering of feldspathic rocks caught up in the fault zone along the western base of the Green Mountains. More recently Ogden (1960 and 1969) has proposed a hydrothermal origin for the Monkton Kaolin deposit.

Kaolin deposits in the Shaftsbury-Bennington area were actively mined and processed and provided raw material for the paper, pottery, fireclay and brick industries. Greatest production came in 1930 when 11,000 tons of clay was mined by the Vermont Kaolin Corporation. The clay mining business in southwestern Vermont was a victim of the business depression of the 1930's. In recent years (1977) the Darlington Brick & Clay Products Company of Darlington, Pa. and (1979) the Holland Chemical Company of Adams, Ma. have shown an interest in these deposits.

The Brandon (Forestdale) kaolin deposit was worked from 1902 to 1925 and produced 80,000 tons of kaolin. This deposit is reported to be practically worked out (Jacobs, 1933-34).

The Monkton kaolin industry got underway in the early 1800's having been perhaps the first kaolin deposit to be discovered in the U. S. in 1792. The American Kaolin Company produced an average of 2000 tons per year from 1883–1890. Various firms produced kaolin intermittently until 1930. From 1930 until 1944 the firm of Frank E. Bushey & Sons produced about a thousand tons per year to supply the needs of the Rutland Fire Clay Company. In 1956 the Vermont Kaolin Corporation purchased mineral rights from Mr. Leon V. Bushey. After several years of exploratory work, laboratory testing and plant construction, only 9,235 tons of clay were produced and in 1966 the operation closed down. Apparently the beneficiation process was not sophisticated enough to remove discoloring impurities, particularly graphite material. In addition, the natural product being quite coarse textured required expensive grinding, separating and drying techniques. The cost to market a product meeting the specifications of the modern paper making industries became prohibitive.
KAOLIN --- CLAY


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Kaolin/Clay--Con't


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THE OIL AND GAS PROVINCE

The first attempt to find oil and gas in Vermont was made in the Lake Champlain Basin in the spring of 1957. A wildcat well was drilled to a depth of approximately 4,500 feet on the Isadore Yandow farm four miles northwest of St. Albans. Since that time four additional wells have been drilled in the Champlain sedimentary basin, the Gregoire I and II drilled at Mallet's Bay in Colchester in 1959-60, the Petrofina well drilled on the Harry Hutchins farm in So. Alburg in 1964, and the E. S. Baker #1 well drilled in 1968 on the Everett S. Baker farm on Grand Isle. Some gas shows were reported, but all wells were abandoned. The deepest well (Gregoire I) is reported to have penetrated to a depth of 5,075 feet. Although commercial quantities of natural gas have been discovered in the Canadian extension of the Champlain sedimentary basin little interest has been generated in Vermont since the abandonment of E. S. Baker #1 at 3,500 feet.

The Cambrian Potsdam formation is believed to be the potentially productive horizon, as well as bioherm and biostrome zones in carbonate rocks. In the Champlain basin Ordovician dolomites and shales thickened by faulting and folding cover the Potsdam. A potential for oil and gas traps in sedimentary horizons beneath the Green Mountain overthrust sheet (northern extension of the Eastern Overthrust Belt) extends the province eastward beyond the Green Mountain Front.

There are occurrences of natural gas in water wells in northwestern Vermont. A report was made by the Federal Energy Research and Development Administration in 1975 on the presence of soil gas in the Milton area. The amount and nature of this gas being comparable to that found above productive gas fields elsewhere. This evidence plus positive finds of commercial quantities of natural gas in Canada encourage continued speculation on the oil and gas potential of the western Vermont sedimentary basin. A proposal submitted to the Federal Energy Research and Development Administration in 1976 by the Vermont State Geologist and the Vermont Energy Office to drill a deep stratigraphic test hole and hydrocarbon probe was not funded.

The area west of a line drawn somewhat west of the central spine of the Green Mountains from Richford (north) to Stamford (south) can be considered as Vermont's Oil and Gas Province. The results of future exploration may alter the dimensions of this province.

In 1981 the Ohio Oil and Gas Company, a leasing brokerage from Fowler, Ohio obtained oil and gas leases on over 250,000 acres in western Vermont. In January of 1982 Columbia Gas Transmission Company and Louisiana Land and Exploration Company announced the purchase of these leases from the Ohio Company, and their intent to start seismic exploration in the summer of 1982.


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THE SLATE PROVINCE

Current slate production comes from the Cambrian St. Catherine Formation and the Ordovician Poultney and Indian River Slate Formation as mapped by Shumaker (1967) which are dominant formations within the Taconic Allochthon in southwestern Vermont (see Mineral Resource Province Map). An outline of this formation essentially parallels the margins of the slate province. The Vermont portion of the Vermont-New York Slate mining district is located in a narrow belt bordered on the west by the state line and on the east by the thrust line delineating the western margin of the western Bird Mountain Slice of Shumaker (1967).

Some of the first slates to be quarried in Vermont came from the Devonian Littleton Formation in Dummerston, Brattleboro and Guilford in southeastern Vermont. These quarries were mentioned in the first state geologist's report on the Geology of Vermont (Adams, 1845). Slate has also been quarried from the Devonian Northfield Formation in Northfield. These slates are black or dark gray in color and perhaps are better classified as phyllites. There has been no commercial production from these quarries since the early 1900's.

The current production of slate in Vermont comes from the Vermont-New York Slate Mining District in southwestern Vermont-east central New York. Approximately ten quarries are currently being operated in Vermont. The quarrying and milling operations employ approximately 300 people and the size of the operations vary from a two or three man family working part-time, to the larger quarrying-milling operation of Vermont Structural Slate Co. The Vermont-New York slates are unique in durability and color. The colors are red, unfading green, fading green (will turn brown in time), purple and mottled (green and purple). The slate is used for floor and counter tile, roofing slate, flagging, monumental, building veneer and other structural items.

The U. S. Bureau of Mines is currently conducting research on the use of waste slate as a resource. Several products have been produced at the research level. These include glass ceramics and fibers, lightweight concrete aggregate and skid resistant highway aggregate. Whether or not these products can be produced and marketed economically is not yet known.

Vermont slate supplies local, national and international markets.

Current practice of the slate industry is to continue to deepen existing quarries or to extend them along strike. Also several old quarries have been reactivated. An abundance of resource has not yet required off-property exploration.

Arthur D. Little, Inc. completed a comprehensive study of the Vermont-New York Slate industry in October, 1980. This study conducted under a U. S. Bureau of Mines contract presents several recommendations for improving quarrying, milling and marketing techniques in the slate industry.


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THE SULFIDE PROVINCE

Vermont's Orange County Copper Mining District and the Essex Copper mine lie within the Connecticut Valley-Gaspe' Synclinorium and Bronson Hill Anticlinorium Tectonic Provinces and the large Appalachian province of stratabound (massive) sulfide deposits (Gair and Slack, 1979). Other small mines, prospects and noted metallic sulfide mineral occurrences lie within this major tectonic-mineral province. Isolated occurrences are known within the Green Mountain Anticlinorium tectonic province.

Lead-zinc sulfide mineralization is known to exist in the Cambrian Winooski-Dunham lithologies which extend from Franklin (north) to Bennington (south) Counties. The only known mines (now abandoned) were the Oram prospects at Brandon. This narrow, linear province with sporadic occurrences of galena-sphalerite may be thought of as the Foreland lead-zinc province. Lead-zinc occurrences in this province may be similar to those in the southern Appalachian zinc province where the sulfide mineralization is associated with both tectonic and collapse breccias or localized along faults and fault intersections in Cambrian (Knox-type) dolomitized limestones. This Foreland lead-zinc province warrants detailed exploration.

No metallic minerals are currently being mined in Vermont. The sulfide ores in the Orange County district were discovered in 1793 and mines began to operate for the production of copper in the early 1830's. Vermont was the chief copper producer in the United States until the Michigan copper ores were exploited in 1846. The Vermont mines operated sporadically through the 1950's. The closing of the Elizabeth mine at South Strafford in 1958 brought an end to metal mining in Vermont. Ore minerals have not been exhausted in the Orange County copper district. However, the ore grade is marginal and the complexity of the structure makes mining extremely difficult. No strong interest has been shown in the district for more than twenty years.

The district was left to remain as a significant scar on the surrounding landscape. Nature has been incapable of healing the acid-sulfur wastes. Strong environmental opposition is likely to deter future mining in the district unless it can be demonstrated that the present day mining technology is capable of rehabilitating the landscape including existing as well as newly generated wastes and mining scars.

Known sulfide mineralization including old prospects and mines are indicated on the Mineral Resource Province Map by the letter S. No attempt has been made to outline a province.
COPPER, LEAD, ZINC AND OTHER SULFIDES


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COPPER SUPPLEMENT:


Molybdenum


SGL—Available at the Office of the State Geologist, Montpelier, Vermont.
Asbestos: The asbestos mining district is located in the upper Missisquoi River Valley in Orleans and Lamoille counties. Current mines and milling operations are located on the eastern flank of Belvidere Mountain in the towns of Lowell and Eden. The mines and mill are being operated by the Vermont Asbestos Group, a primarily worker-owned industry whose main office is at Hyde Park, Vermont. Although production is small compared with that of producers in Quebec, Vermont ranks second in the production of chrysotile asbestos in the United States. Vermont's asbestos industry supplies both national and foreign markets.

Asbestos minerals are associated with serpentinized ultramafic bodies. The larger bodies are composed of central cores of massive dunite and peridotite which grade outward to massive or sheared serpentinite. Chrysotile asbestos occurs sparcely as cross-fiber veins in the more massive portions of the ultramafic bodies and as slip-fiber veins in the highly sheared serpentinites.

Modern theories on the tectonic emplacement of the ultramafic bodies may modify exploration procedures and encourage more extensive off-property searches. Current industry practice involves the expansion of existing open pit mines which has been successful in meeting market demands.

The Vermont Centennial Geologic map (Doll, 1961) shows the "ultramafic belt" extending the full length of the state with ultramafic bodies located in the Hazens Notch, Stowe, Ottauquechee, and Missisquoi Formations of Cambrian and Ordovician age. This map, with some modification, (see Mineral Resource Province Map) serves as a mineral province-mineral potential map. The Upper Missisquoi Valley asbestos mining district occupies the northern extremity of the ultramafic province.

Current environmental concerns regarding the protection of the health of asbestos workers and users has placed stringent air quality standards on the mining and milling of asbestos in the United States. Former user markets for asbestos are seeking substitutes. Both factors have had a major impact on the Vermont asbestos industry.

Talc and Soapstone: Like the asbestos mineralization described above, talc (and its massive variation - soapstone) is associated with serpentinized ultramafic bodies. The ultramafic bodies containing talc (steatite) are composed of a central core of serpentinite surrounded by a shell of talc-carbonate rock followed by an outer shell of talc (steatite). The production of talc and serpentine asbestos are genetically related but the steatitization is the latest, more extended metasomatic event which did not affect all of the ultramafic bodies in the province. Metasomatism involved the movement of H2O, CO2, MgO and SiO2.

The talc-soapstone mineralization coincides with that described above for asbestos and is included within the ultramafic province. Known occurrences in north central Vermont are at Johnson (currently being mined by Eastern Magnesia Talc Co.), the Rousseau prospect, and Sterling Pond prospect in Lamoille County, the Barnes Hill, Waterbury and Mad River localities in Washington County, and the East Granville locality in Orange County. These known occurrences are contained in the northern talc mining district (see Plate I).
The talc mines of Windsor Minerals Inc., in Hammondsville and Ludlow, the Vermont Talc Company mine in Andover, and the Vermont Soapstone Company mine in Chester are included in the southern talc mining district (see Mineral Resource Province Map).

Vermont leads the nation in talc production. Products manufactured from Vermont talc are popular in the national and international marketplace.

**Verde Antique (Serpentine):** "Verde antique marble" is the commercial name applied to the highly polished dark green serpentinite which has shear fractures cemented by veins of white carbonate mineralization. Verde antique is currently mined by the Vermont Marble Company (OMYA) at Quarry Hill, Rochester, Vermont. An abandoned verde antique mine is located in Roxbury. Verde antique quality serpentinite is also found at the Waterbury, Barnes Hill and Mad River localities. These serpentinite bodies are included in the northern talc mining district.

Because of the natural mineralogical associations of serpentine asbestos and talc similar environmental health concerns prevail in the mining, milling and product use where these resources are concerned. Particular attention must be given to quality control where these products are sold for human consumption.

**Chromite:** Chromite mineralization is known to exist in several of the serpentinite bodies. Noticeable quantities of chromite have been encountered at the Rochester verde antique quarry and Belvidere Mountain.

**Magnetite:** Magnetite has been mined in Troy, Vermont.

**Ultramafic Rock as a future resource:** Future resources may be realized from the use of ultramafic rock as a heat retention material in solar heat storage facilities. Research on serpentinite mine waste conducted in Canada (University of Sherbrooke) and in the United Stated (Bureau of Mines, Federal Highway Administration) has produced several potentially marketable products. Among these are light weight concrete aggregate, refractory bricks, and synthetic skid resistant road aggregate.
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The Uranium Provinces

Knowledge of the existence of anomalous radioactivity in various geologic settings in Vermont dates back to the early 1950's. Reconnaissance surveys of Vermont's current and abandoned quarries and mines, and old mineral prospects conducted by the U. S. Geological Survey in cooperation with the U. S. Atomic Energy Commission (McKeown, 1951, Grauch and Zarinski, 1976, and U.S.A.E.C.–U.S.G.S. report RME-4106 TID UC-51, 1969) confirmed the presence of anomalous radioactivity and in some cases uranium mineralization at several localities. A sporadic search for uranium and other radioactive minerals continued through the 1960's and 1970's, the most noted being that of the National Uranium Resource Evaluation program which is being conducted by the federal government (ERDA now DOE).* In recent years (1978-1979) private uranium firms started to explore in Vermont. Discoveries of ore grade mineralization in Precambrian terrane of southern Vermont prompted extensive land leasing for exploration and mining rights in the vicinity of Jamaica, Vermont. Citizen concern developed into well organized opposition to exploration, mining and milling of radioactive minerals in Vermont. Restrictive legislation was passed in 1980 that discouraged industry from further exploratory work in Vermont.

The Sedimentary Province

Uranium and phosphate mineralization is known to coexist in Franklin and Chittenden Counties. Uranium is present in a uranophosphate mineral, hydroxylapatite, where uranium substitutes for calcium in the mineral structure. The mineral occurs in clasts and as cement in an

*ERDA = Energy Research and Development Administration
DOE = Department of Energy
intraformational breccia-conglomerate in the Cambrian Clarendon Springs Formation. The Clarendon Springs Formation extends (in western Vermont) from the Canadian border at Highgate to Bennington.

Radioactive anomalies have been identified in the Clarendon Springs Formation by ground surveys at Highgate, Milton and Shelburne. Samples collected from the anomalous rock at Highgate and Milton have been analyzed for uranium, thorium and phosphate content:

<table>
<thead>
<tr>
<th>HIGHGATE</th>
<th>MILTON</th>
</tr>
</thead>
<tbody>
<tr>
<td>(U_3O_8 = 3.17 \text{ ppm} )</td>
<td>(U_3O_8 = 0.04%)</td>
</tr>
<tr>
<td>(\text{ThO}_2 = 3.4 \text{ ppm} )</td>
<td>(\text{ThO}_2 = 9 \text{ ppm})</td>
</tr>
<tr>
<td>(P_2O_5 = 25.64%)</td>
<td>(P_2O_5 = 16.98%)</td>
</tr>
</tbody>
</table>

In the winter of 1969-1970, Rio Algom, a Canadian mining firm, conducted a limited (2 holes) core drilling program on the Highgate anomaly after drilling several holes on the same anomaly in Canada. The uranium analyses on several samples representing 756' of core produced results ranging from 0.02 lbs/ton to 0.46 lbs/ton. At the time this was considered to be considerably below ore grade.


The Texas Instruments Corporation flew an airborne radiometric survey in 1976 for the National Uranium Resource Evaluation program (NURE). This survey covered all of Vermont (as well as New York and other New England states). The Milton and Shelburne anomalies as well as anomalies near Mechanicsville and Monkton Ridge were detected, however, the Highgate anomaly was not picked up by this survey. To the south in the Vermont
Valley anomalies were located near Tinmouth and Danby by both aerial surveys (Popenoe, 1964 and Texas Instruments, Inc., 1976). These anomalies are associated with the Clarendon Springs Formation or similar lithologies (Dunham Formation).

The U.S.A.E.C. report (RME-4106) indicates anomalies exist at the Lyon Hill* Lead-Zinc prospect in Leicester and at the Brandon "Silver" mine** in Brandon. These were not detected by the Texas Instruments airborne survey but are believed to be located in Clarendon-Dunham lithologies.

The Crystalline Province

Vein-type. Vein-type occurrences within strata-bound sulfide deposits are known to exist in Vermont's metamorphic terrane. The old Udall Copper mine at Wolcott, first reported by Butler, et. al. (1962), is located in Cambrian-Ordovician schist of the Stowe Formation. A sample from this site was analyzed for the U.S.A.E.C. (in RME-4106) and reported to contain 0.06% uranium. Anomalous radioactivity is reported (in RME-4106) at the Old Boston Copper mine in West Berkshire, and at the Sherbrook Lead prospect*** in Newport. No analytical data is available from these last two reported "probably vein-type" occurrences in Cambrian-Ordovician schist. These localities were not detected by the Texas Instruments, Inc. airborne survey.

Precambrian. The first report of anomalous radioactivity in Vermont's Precambrian terrane (located in the central Green Mountains

*Location not well documented.

**Not the same as the Brandon lead-zinc prospect in Forestdale but located on the hill (elev. 1209') east of Sugar Hollow (see U. S. G. S. 7 1/2-minute quadrangle Brandon, Vermont).

***Location not well documented.
from Lincoln south to the Massachusetts border in Stamford, Readsboro and Whitingham) was at Snow Valley, in Winhall. This anomaly was reported in the U.S.A.E.C.-U.S.G.S. reconnaissance report RME-4106, TID UC-51. Analytical data is available (McHone and Wagener, 1980). This anomaly was not detected by the 1976 airborne survey conducted for the NURE program by Texas Instruments, Inc., however, the anomaly does show up on the 1964 U.S.G.S. aeroradioactivity survey (Popenoe, 1964).

Uranium mineralization in Vermont's Precambrian terrane (all rock types are metamorphic and undifferentiated--known as the Mt. Holly complex) is stratigraphically and structurally controlled having been mobilized and reconcentrated during subsequent Paleozoic metamorphic events. The mineralogy of these Precambrian occurrences is not well known and mineral associations vary from place to place. Radioactive anomalies are associated with quartz-tourmaline pegmatite in micaceous quartzites and gneissoid feldspathic quartzites. Biotite and graphite-rich zones in quartzite also show anomalously high radioactivity. Dark, schist-like occurrences of fine-grained biotite and tourmaline, probably resulting from hydrothermal alteration, in sheared quartzite are often highly radioactive.

Samples collected in the vicinity of Ludlow (Okemo) Mountain in the towns of Mt. Holly, Ludlow and Weston were analyzed in the fall of 1979 for the Vermont Division of Geology and Earth Resources, Agency of Environmental Conservation. The results are as follows:

- Okemo Mt. (top near fire tower) 3000 ppm or 0.397% U.
- Grant Brook (near South Mt., Ludlow)
  1. elev. 2105' 105 ppm U.
  2a. elev. 2040' 750 ppm or 0.075% U.
  2b. elev. 2040' 520 ppm or 0.06% U.
The Grant Brook anomaly was detected by the Texas Instruments, Inc., aerial survey and the Ludlow (Okemo) Mountain anomaly by the U.S.G.S. airborne survey (Popenoe, 1964).

Both aeroradiometric surveys detected additional anomalies in both Precambrian and Paleozoic terranes. Ground checks of these anomalies have been conducted and samples collected for assay by the NURE program geologists. The results have been published in reports listed in the uranium bibliography (McHone and Wagener, 1980, and Field and Truesdell, 1980).

**The Granitic Province**

Anomalous radioactivity and the potential for uranium occurrences exist in granitic rocks and associated pegmatites of the Devonian New Hampshire plutonic series (northeastern Vermont), and the Jurassic-Cretaceous White Mountain plutonic series (Mt. Ascutney in Brownsville, Granite Hill in Cuttingsville, Barber Hill in Charlotte, and Monadnock Mt. in Lemington). The Popenoe (1964) aeroradiometric survey recorded an anomaly at Granite Hill and Mt. Ascutney, and one in the Devonian pluton at Bellows Falls-Walpole, New Hampshire. No anomaly was detected by the Texas Instruments, Inc., airborne survey at Barber Hill. Neither survey covered the area of Monadnock Mt. in far northeastern Vermont.


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