

PART 2. FIELD STUDY

The market study (Part 1), which was the first step of the filler project, was completed in January 1987. The information provided by that study served as a guideline for initiating mineral investigation in the field. Field studies were restricted by ground staking, federal park land regulations and time. A list (Table 9) has been compiled of mineral occurrences and deposits studied where a filler application may present itself. Refer to Figure 6 for locations of each occurrence or deposit.

the field study. Some (barite, talc, kaolin, silica and diatomaceous earth) are used in local industry, but the total tonnage consumed tends to be small and an operation providing filler grade of each mineral would have to look to Upper Canada or the United States for markets. After the in situ grade was determined then further study could be undertaken to determine whether beneficiation was required to meet market standard, and finally an estimate on available tonnage was made if the material did show potential.

Analyses were conducted by the Minerals Engineering Centre of the Technical University of Nova

Table 9. List of filler mineral occurrences and deposits in Nova Scotia which were studied in 1987. See Figure 6 for location map.

Mineral	Location
Barite	Scotsville, Inverness County
Diatomaceous Earth (Anderson, 1990)	Brora Lake, Pictou County Gamble Lake Pond, Colchester County Little River (Factory Bog) Digby County
Kaolin	Hardwood Lands (West Indian Road), Hants County Chegoggin Point, Yarmouth County
Limestone and Marble	Glencoe, Inverness County Marble Mountain, Inverness County
Muscovite	Port Mouton, Queens County Mica Hill, Victoria County Chegoggin Point, Yarmouth County
Titanium Sands (MacDonald, 1989)	Shubenacadie River, Colchester County
Wollastonite	Lime Hill, Inverness County
Talc (MacDonald, in prep.(a))	Stirling, Richmond County Soapstone Brook, Victoria County Soapstone Mine, Inverness County
Silica (MacDonald, in prep.(b))	Chegoggin Point, Yarmouth County

Calcium carbonate is the dominant filler material used in the Atlantic Provinces. For this reason and the fact that Nova Scotia has some quality limestone and marble deposits, calcium carbonate was the most important commodity to investigate.

Other indigenous minerals and their potential to reach marketable grade were also investigated during

Scotia, Halifax. Lab procedures for limestone analysis involved calcium determination by E.D.T.A. titration and silica by colourmetric method. Magnesium, alumina and iron were all determined by atomic absorption. A few more complex analyses were completed at the Canada Centre for Mineral and Energy Technology in Ottawa and by English China Clay in Georgia. Fine grinding tests were completed on some of the samples acquired

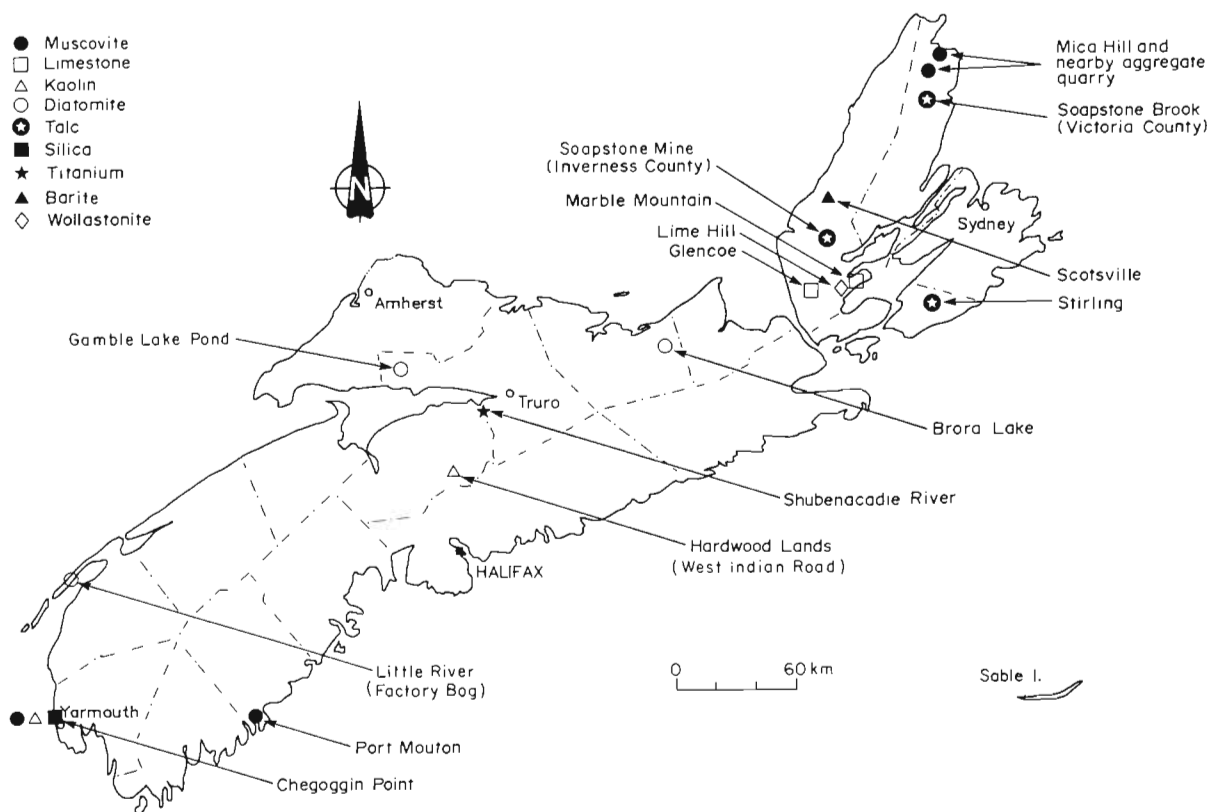


Figure 6. Field study location map, 1987

during the spring/summer 1987 by the late Mr. Dennis Stone of Magstone Development Corporation, Debert, Nova Scotia.

BARITE

Barite ($BaSO_4$) can occur in various geological settings including all three of the major rock types. The majority though tends to occur as replacements in sedimentary rocks. It is characterized by its high specific gravity (4.5).

The majority of the worlds barite production, since the early 1920s, has been for its role as a weighting agent in the muds circulated in gas and oil well drilling. Barite is ideally suited for this because it is nonabrasive, chemically inert, heavy, clean and inexpensive compared to many other available heavy materials.

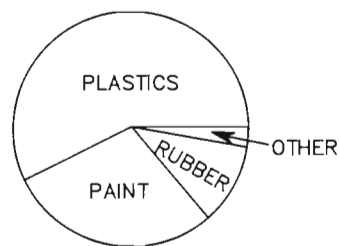
Barite's major role as a filler is in the plastics industry. It is used mostly to increase the specific gravity of the end product such as home appliance base parts. In paints, barite makes a very good filler for primer paints, but its high density is a detriment for use as an indoor or outdoor paint (Fig. 7).

Local Resources

Nova Scotia has well over 50 occurrences of barite

throughout the Province and one operating quarry in Brookfield, Colchester County. This barite is eventually processed into a pharmaceutical grade. Very small amounts are used by the local paint manufacturers as a filler.

Some of the highest grade barite in Nova Scotia can be found on the shores of East Lake Ainslie, Inverness County, in the Scotsville area (Fig. 6). This vein deposit nearly reached production before a drop in the offshore exploration activity in the early 1980s crippled the local demand for barite.



Based on Figures From C.H. Kline and Associates (1986)

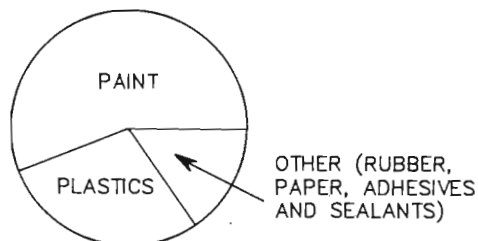
Figure 7. 1985 North American consumption of barite (Total = 64 864 t)

Nystone Chemicals, Brookfield, Colchester County, have shown barite production does not have to be solely reliant on the oil drilling industry. A high quality stone such as the Scotsville barite could supply other markets such as the filler industry.

DIATOMACEOUS EARTH

Diatomaceous earth is a sediment principally consisting of the fossilized siliceous skeletal remains of the diatom. The diatom is a unicellular aquatic plant related to algae. There are numerous species of diatoms, each varying in size and shape. The species type is very important in determining the possible end uses of the diatomite. Diatomite can be identified in water basins throughout the world, but only with the ideal environmental conditions can it be found in economic quality and quantity. Essential are a large shallow basin for deposition, abundant supply of soluble silica and nutrients and the absence of growth inhibiting constituents and clastic material.

Diatomite has a unique particulate structure and chemical stability, so it can be used for particular industrial applications where other forms of silica are unacceptable. A filter aid in liquid (i.e. beer, wine) processing is a prime example of such an application. Diatomite's high absorptive capacity, high surface area, low abrasiveness and low density make it an ideal filler in the paint industry for flat paints (Fig. 8).



Based on Figures
From C. H. Kline and
Associates (1986)

Figure 8. 1985 North American consumption of diatomite
(Total = 50 349 t)

Local Resources

An extensive study of diatomite occurrences was undertaken in 1987-88 by the Nova Scotia Department of Mines and Energy under the supervision of A. R. Anderson. Anderson (personal communication, 1988) found significant occurrences of quality diatomaceous earth in over 18 lakes throughout the Province.

The majority of these occur in the Cobequid Highlands between Springhill and Earltown. Brora Lake, Pictou County, may have the best potential for development for mining of diatomaceous earth as a

possible filter or carrying agent for insecticides (Fig. 6) (Anderson, personal communication, 1988). Applications as a filler would require more testing.

Diatomaceous earth at Brora Lake and indeed all diatomaceous earth in Nova Scotia is derived from the Pinnate species with a mean particle size range of 12-15 μm which is a bit oversized for most filler applications. Generally, diatomaceous earth in Nova Scotia is highly fragmented. The ideal diatomite filler consists of nonfragmented diatoms. Further research may reveal other more suitable uses for Nova Scotia's diatomite.

Local industrial consumption of filler diatomite is minor, but could increase if local diatomite was produced. A small, but feasible, market opening exists for a local producer of diatomite as a filter and carrying agent.

KAOLIN

Kaolin consumption in the filler and extender industry by far exceeds the use of any other industrial minerals. There are four grades of kaolin, water washed, air floated, delaminated and calcined, produced from different types of processing that the crude kaolin undergoes (Fig. 9). Prices vary for each.

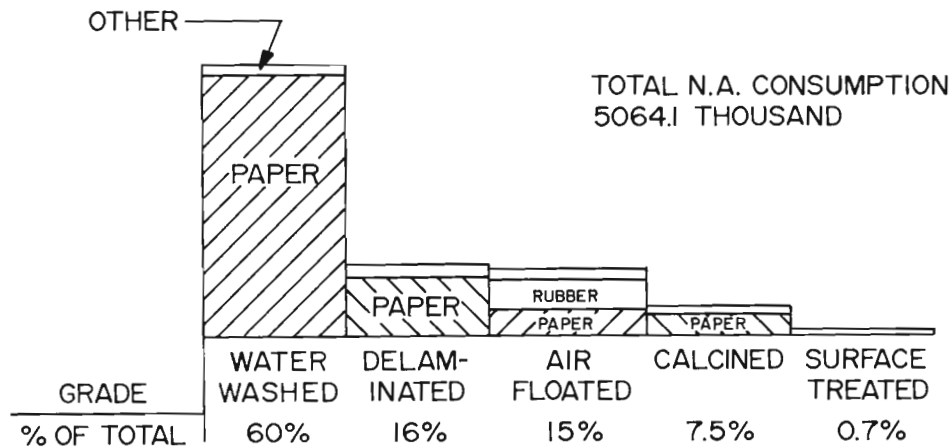
Kaolin's major applications are as a filler in industries such as paper, plastics and paint. The platy crystal structure, natural binding ability and high brightness make it acceptable for many uses. Kaolin is used in ceramics where it acts as the primary structural component as well as a pigment and binder. The mineral also is used in brick making, refractories and even in the electronics industry.

Georgia and South Carolina have the highest quality and most easily processed kaolin deposits of North America (C. H. Kline and Associates, 1986). These deposits supply over 90% of the filler and extender kaolin in North America.

There are two types of kaolin on the basis of genesis, primary and secondary. Primary deposits are developed in situ by the alteration of minerals such as feldspar or other aluminum silicates to kaolin. Secondary kaolin is deposited as sediment. Secondary kaolin, in the form of sedimentary deposits, yields the majority of kaolin which is used in the filler and extender industry. These deposits should be a neutral colour because only the white kaolin is widely used.

Local Resources

In Nova Scotia the Cretaceous deposits of the Musquodoboit and Shubenacadie Valleys contain, not only sand with a purity of 95%+ silica, but also play host to kaolinitic clay beds of various colours.



Based on Figures
From C.H.Kline and Associates (1986)

Figure 9. 1985 North American consumption of kaolin (Total= 4 594 101 t)

Postdepositional weathering of the original soils to form these high purity deposits involved rainwater reducing the feldspar in the soil to kaolinite and transporting this and dissolved silica, out of the system. Initially these clay beds may have been deposited as montmorillonite and kaolinite, then altered by deep weathering to produce pure kaolinite.

These deposits appear to be the only major source of kaolin in the Province, although altered granites such as those found at the East Kemptville Tin Mine were also looked at briefly for their kaolinitization.

Colours of the Musquodoboit and Shubenacadie clays vary from black to reddish to buff. The area chosen to more closely examine the kaolin was at the West Indian Road silica pit at Hardwood Lands, Hants County (Fig. 6). This Cretaceous deposit is confined to a large sinkhole with deformed lenses and beds of light purplish-grey kaolin.

The pit owner and operator, Nova Scotia Sand and Gravel, has removed and stockpiled the kaolin while extracting the silica sand for processing. The stockpile is easily accessible and light coloured. Samples were taken from West Indian Road for analysis. Kaolin lenses in the pit are over 1.8 m thick in places, but pinching and swelling makes them impossible to trace. This makes a tonnage estimation impossible without detailed drilling and mapping.

A 45 kg sample was taken from the kaolin waste pile and another much smaller sample (25 kg) was extracted from the settling pond of the silica sand wash plant at West Indian Road. These were analyzed at the Technical University of Nova Scotia, Halifax, for clay content and elemental analysis (Table 10).

A 9 kg sample from the waste pile was subsequently sent to English China Clay America Inc., Sandersville, Georgia, where analytical testing revealed a nondesirable sample for the filler industry due to poor colour quality (Table 11).

There is low potential for local kaolin in the filler industry, because of low tonnages and probable high beneficiation costs to bring the clay up to filler grade standard. The kaolin is being tested, through Nova Scotia Sand and Gravel, for its potential in other end uses such as ceramics. Test results are unavailable.

Two other locations in the Province have been investigated for their kaolin potential. The East Kemptville Tin Mine, Yarmouth County, and Chegoggin Point-Lake George area, Yarmouth County, are both primary deposits (Fig. 6). At the East Kemptville Tin Mine kaolin, in the form of altered feldspar and mica, occurs in the granites. A reconnaissance survey of the quarry and the tailings pond did not uncover any quantity that could be recovered economically.

A section of drill core from a recent diamond drilling program by the Nova Scotia Department of Mines and Energy (MacDonald, in preparation (b)) in the Chegoggin Point-Lake George quartzite unit (White Rock Formation) was sampled. The drillhole, CH-LG-87-6, contained a 1.93 m clayey section at 69.2 m which had an off white-buff colour. This was sampled in 0.46 m, 0.61 m and 0.91 m sections. The analyses from the top section returned high iron, therefore it is probably siderite or clay ironstone. The remaining sections are quite possibly just rock flour. This is probably a fault zone with very minor kaolin (Table 12).

Table 10. Hardwood Lands (West Indian Road), Hants County, kaolin clay content.*

Sample	Clay %	Silt/Sand %	SiO ₂ %	Results of Analysis on Clay Fraction						
				Al ₂ O ₃ %	Fe ₂ O ₃ %	K ₂ O %	Na ₂ O %	CaO %	MgO %	LOI %
Clay	81.3	18.7	47.59	35.20	1.42	1.82	2.67	0.11	0.23	9.89
Settling Pond	37.0	63.0	48.66	30.66	2.57	1.70	4.34	0.28	0.36	9.51

* Technical University of Nova Scotia, Halifax

Table 11. Analytical results for Hardwood Lands (West Indian Road), Hants County, kaolin*

CRUDE PROPERTIES

Brightness

Crude	63.6%
Waterwashed	65.5%
Waterwashed & bleached	66.4%

TiO ₂ content	0.89%
Fe ₂ O ₃ content	1.37%

Particle Size Analysis

Passing Through Sieve Dimension

10 μm	91%
5 μm	75%
2 μm	50%
1 μm	38%
0.5 μm	28%
0.25 μm	18%

Residue +325 mesh 6.4%

* English China Clay America Inc., Sandersville, Georgia.

Markets exist in Maine for paper grade kaolin filler, but local deposits are probably too small and impure. The high beneficiation costs for filler grade kaolin and the presence of the long established operations in Georgia, would make competition very difficult.

MUSCOVITE

Muscovite is a very common mineral occurring in siliceous igneous rocks, especially characteristic of pegmatites and also in various grades of metamorphic rock. Crystals can measure from a few microns to over 2.1 m across depending upon rock type and conditions prevalent during formation.

Table 12. Analysis of clay sample from DDH CH-LG-87-6 (percentage by weight), Chegoggin Point-Lake George, Yarmouth County

	DDH 87-6-46 69.2-69.8 m	DDH 87-6-45 69.8-70.7 m	DDH 87-6-30 70.7-71.1 m
SiO ₂	18.91	28.20	41.70
Al ₂ O ₃	11.92	18.47	30.98
Fe ₂ O ₃	40.57	24.31	4.84
CaO	1.02	1.33	0.68
MgO	1.79	3.40	2.94
K ₂ O	0.64	0.71	1.38
Na ₂ O	0.04	0.04	0.09
LOI	20.59	16.48	11.02

* Technical University of Nova Scotia, Halifax

Muscovite is the most desirable mineral of the mica group for industrial consumption because of its neutral colour. Pegmatite deposits are of the most commercial interest. These can range from large sheet size muscovite crystals which are processed as sheet mica for use in the electronics industry to much smaller size muscovite crystals ground up for use as scrap and filler mica.

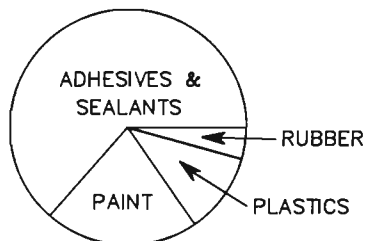
Sheet mica production is dominated by third world countries, India being the largest producer. Low labour costs play a major role in economically competitive sheet mica production because the mica must be quarried, split and trimmed manually with care not to damage the sheet itself. Demand for sheet mica is presently diminishing because of technological advancements in electronics phasing out many of the roles played by mica. This reduced demand causes more difficulties for potential North American developers competing with low cost Indian products.

North Carolina is the largest mica producing state in America (Chapman, 1983). Pegmatite of the Blue Ridge Mountains is quarried for virtually all its mineral constituents such as feldspar, silica, spodumene as well as muscovite. Generally large runs of book mica in

these commercially mined pegmatites make up as little as 2-6% of the rock.

Mica receives very little competition as a filler in most applications because of its unique platy structure and excellent dielectric properties. These two characteristics make muscovite an excellent filler for plastics. C. H. Kline and Associates (1986) have forecast a five year growth of 24.8% per year for mica consumption in the plastics industry.

Both surface treated muscovite and nontreated muscovite as well as phlogopite are included in this figure. Besides its use in the filler/extender industry (Fig. 10), mica also is used in well drilling muds, roofing shingles and in mica electrical insulating paper.



Based on Figures
From C. H. Kline and
Associates (1986)

Figure 10. 1985 North American consumption of mica
(Total = 109 588.5 t)

Local Resources

In Nova Scotia, three muscovite occurrences were investigated, each present in a different rock type and each with its own unique characteristics (Table 13).

Table 13. Location and rock type of three muscovite occurrences in Nova Scotia.

Location	Rock Type
Port Mouton, Queens County	muscovite in pegmatite veins
Mica Hill, Victoria County	muscovite in pegmatite dyke
Dingwall, Victoria County	muscovite/biotite in schist

Port Mouton, Queens County

Areas in Nova Scotia with abundant pegmatite veins are few (Kontak and MacDonald, personal communication, 1987) and those that do have high numbers of pegmatite dykes locally are probably not of any economic significance.

One of these areas, Port Mouton was visited in July 1987 (Fig. 6). Port Mouton is approximately 6 km southwest of Liverpool on Highway 103 to Yarmouth. Along the shoreline is a concentration of pegmatites, but these are at maximum 0.6-0.9 m in width and not continuous. The muscovite content of these pegmatites is approximately 5-10%, but the pegmatite concentration and thicknesses do not appear to be economically viable.

Mica Hill, Victoria County

Nova Scotia's best muscovite deposit occurs in the Cape Breton Highlands at Mica Hill which is approximately 10 km south of Dingwall (Fig. 6). This deposit is a zoned pegmatite with large flake muscovite occurring in a pink feldspar zone. The bulk of the pegmatite dyke is pure white bull quartz. The dyke has an approximate width of 30 m and is exposed along strike for over 100 m. The trend of the dyke is essentially east-west. There is also more large bull quartz on the small knoll immediately to the north which may indicate another zoned pegmatite.

The only literature found on the occurrence is by Fletcher in Young (1919) who noted that several test pits had been sunk into the hill though the exact date and results of this testing are not known.

Muscovite samples from Mica Hill were collected in July 1987. Approximately 4.5 kg were sent to the Canada Centre for Mineral and Energy Technology, Energy, Mines and Resources Canada, Ottawa, for analysis (Appendix 1). The samples were crushed and sized. Results showed the muscovite to be high quality and with good industrial potential. Samples from Mica Hill were also examined at Magstone Development Inc. laboratory in Debert, Nova Scotia (Appendix 1). These samples were finely ground with extremely good results indicating filler grade mica.

Further exploration at the site is not possible at the present time because it is situated 4 km within the Cape Breton National Park and the present policy of the Park is that all minerals are nonextractable.

Dingwall, Victoria County

A muscovite/biotite schist was briefly examined in an aggregate quarry approximately 2 km east of South Harbour in Victoria County in July 1987. Blasting and quarrying of a pegmatitic granite revealed a flaky schist. The schist has not been traced for any length because of overburden. Samples were taken and an ensuing thin section analysis revealed the main constituents of the rock to be quartz, muscovite and biotite. The surface in contact with the pegmatite is much flakier (possibly due to weathering) than the bulk of the unit and a thin section could not be made of it. A sample was crushed manually though and revealed under microscope a composition of 90-100% mica, with approximately equal parts of muscovite and biotite. Through the schist, which is about 1 m thick, the quartz content increases to

a maximum of 50%. A point count was administered on a thin section of a sample extracted near the bottom of the section. A 500 point total revealed 22% muscovite, 21% biotite and 48% quartz. The other 9% was minor constituents, predominantly garnet. The average grain size was in the 3-4 mm size range.

More detailed examination of this occurrence would be worthwhile because the muscovite could be easily separated from the biotite using magnetic separation and is already at a workable grain size, requiring only fine grinding. The location is within 10 km of deep water at Dingwall and is also nearby the Mica Hill muscovite deposit.

Other Sources

The andalusite/garnet schist at Doughboy Point, Guysborough County, may be another source of filler grade muscovite. If this stone were to be processed as a source of aluminum, the fine grained muscovite present might be separated for market consumption. This property was staked by private interests and was inaccessible to Departmental employees.

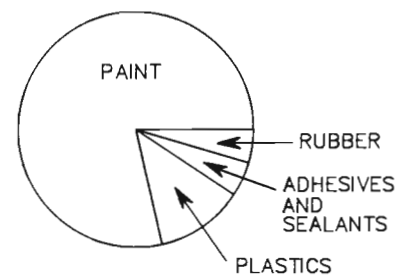
Finally, a bag sample of the fines from the East Kemptville Tin Mine tailings pond was recovered for examination for its mica content. A microscope analysis revealed the muscovite content to be minor and have no apparent economic potential.

Muscovite appears to have a great future in the filler industry. Two local sources, Mica Hill and Dingwall, may have potential for such applications. There may be other muscovite sources in Nova Scotia that have been overlooked during the field study.

GROUND SILICA

Quartz is one of the most widely distributed minerals in the world and is the source mineral for the ground silica used in various industries. It occurs in both igneous and metamorphic rocks and is abundant in clastic sediments. High purity sources are not quite as prevalent though, especially those where the quartz is easily ground and separated from other constituents. The major source of ground silica in the filler industry is from friable rock or from natural high grade sands. Rarely do sands approach a level of pure silica quality which would require a minimum of beneficiation for commercial use.

Ground silica's major problem as a general bulk filler is its high abrasiveness. In some applications this can be advantageous, for example increased scrubability in certain grades of paint (Fig. 11). Generally the wear on machinery silica causes during processing of an end product is undesirable.



Based on Figures
From C. H. Kline and
Associates (1986)

Figure 11. 1985 North American consumption of ground silica (Total = 134 718 t)

Local Resources

Silica sand deposits and sandstones in Nova Scotia are not thought to be of sufficiently high grade for filler use. With a very small local market for filler silica and no indications of a major need in the New England region, any local source that would have to undergo beneficiation might not be feasible to produce.

One opportunity that may exist though is in the White Rock Formation quartzites, most notably the high purity Chegoggin Point to Lake George band in Yarmouth County (Fig. 6). This bed of silica consistently registers over 99% SiO₂ and, if quarried in the future, the fines may be acceptable as filler product. This deposit was drilled in the late summer and fall of 1987 by the Nova Scotia Department of Mines and Energy (MacDonald, in preparation (b)).

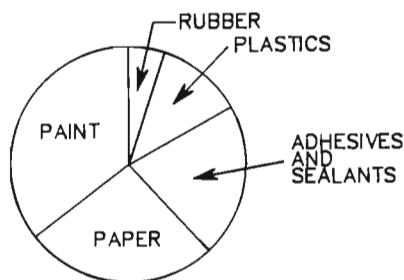
TALC

Talc usually occurs as a secondary mineral, the result of alteration or hydration of magnesium silicate rocks or it can be found occurring in metamorphosed dolomites. Most economically important deposits have been formed under low grade regional metamorphism.

Its platy particle shape, high oil absorption and high degree of brightness make it a valuable filler. Along with having a major share of the filler market, talc is also consumed in large amounts in both the ceramics and cosmetics industries (Fig. 12).

Local Resources

Talc, known in its massive form as soapstone, has been identified in such places as Soapstone Brook, Victoria County, and Soapstone Mine, Inverness County (Fig. 6). These occurrences are impure and minor. A higher grade of talc has been noted at depth in the old Stirling Mine, Richmond County. Its economic potential has yet to be determined.



Based on Figures
From C.H. Kline and
Associates (1986)

Figure 12. 1985 North American consumption of talc
(Total = 452 688 t)

Because there are only very minor occurrences of talc in the Province and the quality is poor, little time was spent investigating the mineral. More information on talc in Nova Scotia can be obtained from MacDonald (in preparation (a)).

TITANIUM DIOXIDE

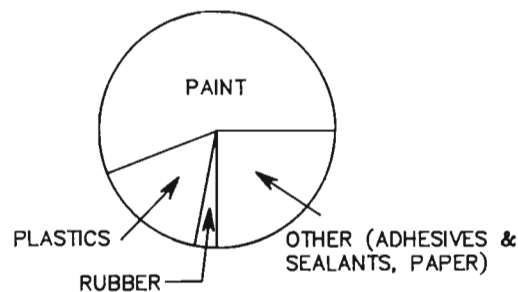
The mineral ilmenite (FeTiO_3) is the source for over 90% of the world's supply of titanium dioxide pigment production. Plutonic rocks are the principal host for ilmenite, but a considerable amount is recovered in placer mining operations from beach sands. Commonly, beneficiated ilmenite is referred to as synthetic rutile.

Natural rutile and its polymorph anatase are other important forms of titanium, but do not play as large a role in the pigment market as ilmenite. Rutile is more expensive and finds its major end use in titanium metal.

Titanium dioxide pigment is unchallenged as a surface coater in the paper, paint and plastics industries (Fig. 13). Its high refractive index, which allows it to impart unparalleled degrees of whiteness, opacity and brightness to all end products, finds competition only in some forms of silica, alumina hydrate and calcined kaolin. Competition is either a result of demand for TiO_2 being greater than supply or of the high cost of titanium dioxide relative to other pigments.

Local Resources

In Nova Scotia, placer deposits in the form of beach sands constitute the major source of titanium which could be investigated for quality and quantity. Two locations have been noted to have quite dark sands which could be titanium rich. One of these locations is on Sable Island which, due to government restrictions, makes investigation of the sand units impossible.



Based on Figures
From C.H. Kline and
Associates (1986)

Figure 13. 1985 North American consumption of titanium dioxide (Total = 901 747 t)

More accessible are the dark sands of the Shubenacadie River (Fig. 6). Initial investigations were performed by MacDonald (1989) in November 1986 and a subsequent testing of samples recovered in April 1987. The samples were taken at the Gosse Bridge near South Maitland and assayed over 20% TiO_2 . Although the unit or layer of dark sands on the surface is not thick (7.6 cm), MacDonald (1989) suggested more detailed and systematic sampling be carried out to locate possible areas of high concentration and to determine whether or not these lenses repeat themselves throughout the sand deposit.

Titanium dioxide is in great demand in the industrial world. Operations producing TiO_2 pigment are large scale because beneficiation of the raw ore to a pigment end product is very detailed and expensive. It is questionable whether or not the sands of the Shubenacadie River could support such an operation, in quantity and environmental conservation is a concern.

WOLLASTONITE

Wollastonite is a new industrial mineral as far as consumption and use are concerned, dating back to 1949 when an industrial plant was built in New York State to manufacture wollastonite products.

This calcium metasilicate (CaSiO_3) occurs as a contact metamorphic deposit formed between limestone and igneous rock or in silicated metalimestone that has been affected by regional metamorphism. Deposits of economic size and purity are rare.

There are very few wollastonite producers in the world, the largest being NYCO, a division of Processed Minerals Inc., working the Fox Knoll Mine near Willsboro, New York State.

The largest consumption of wollastonite is as a filler and extender. Its acicular shape, chemical inertness and high brightness make it ideal for the plastics industry (Fig. 14). Since quality deposits of wollastonite are rare, the mineral does not play a major role in the filler

industry. Because of its characteristics, demand will always meet supply and, for this reason, investigation of Nova Scotia's wollastonite occurrences is worthwhile.

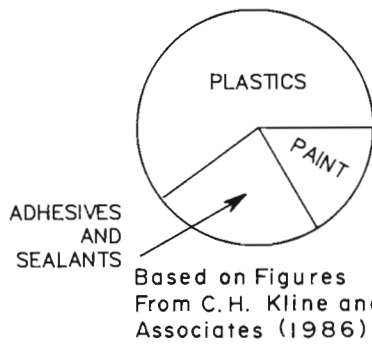


Figure 14. 1985 North American consumption of wollastonite (Total = 40 823.5 t)

Local Resources

Wollastonite has been identified both in drill core and in outcrop at Lime Hill, Inverness County (Fig. 6). This George River Group hosted occurrence does not have the in situ purity of the New York State deposits, but recent analysis by the Canadian Centre for Mineral and Energy Technology, Ottawa, indicated that with further processing acceptable grades could be reached.

These grade standards include an Fe_2O_3 content of <0.2%, a brightness in the 90% range and a concentrate of at least 90% CaSiO_3 . Whether or not these grades can be attained economically is unknown.

The Lime Hill deposit is part of the band of George River Group metasedimentary rocks stretching along the southeastern slope of North Mountain on the West Bay coast of the Bras d'Or Lakes in Inverness County. This band of highly altered and mineralized limestone is an attractive possibility for occurrences of wollastonite. Exploration in the area may reveal similar occurrences to the Lime Hill showing.

Unfortunately time restricted this type of exploration. The Lime Hill occurrence was inaccessible to Departmental investigation because the area has been staked by private interests.

GROUND CALCIUM CARBONATE

Limestone and its metamorphosed equivalent marble are North America's major source of calcium carbonate and also two of the earth's most common mineral commodities.

In terms of total consumption, ground calcium carbonate is the second most important mineral in the filler industry. This can be attributed to its widespread

availability, low beneficiation cost, high brightness (brightness is a measure of the total percentage of light reflected from a sample in comparison with a theoretical (100%) or physical standard), low abrasiveness, functional particle shape and low overall production cost.

Because of the abundance of limestone and marble deposits in the world, purity, tonnage and accessibility to market are some of the determining factors in deciding whether or not a deposit has economic potential in the filler industry.

Desirable grades vary depending upon end use (Fig. 15). In the paper industry, standards require a high brightness reading in the range of 95%+, a CaCO_3 content of approximately 98% and a mean particle size in the range of $1\ \mu\text{m}$. Ground calcium carbonate to be used in the carpet backing industry, however, does not require such a high brightness reading (approximately 90%), a CaCO_3 content only in the 94% range and a mean particle size in the 20-30 μm range. For obvious reasons prices vary greatly depending upon end use because of increased or decreased beneficiation costs.

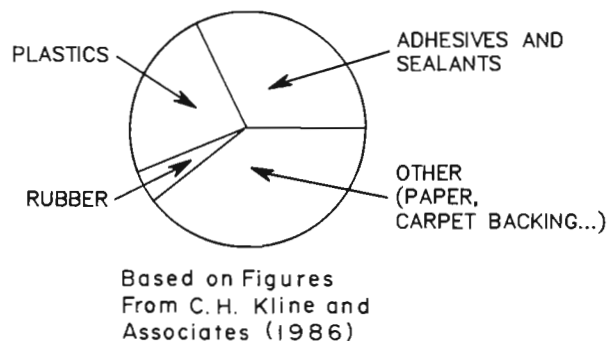


Figure 15. 1985 North American consumption of ground calcium carbonate (Total = 2 783 259 t)

Local Resources

In Nova Scotia, the major limestone/marble deposits belong to either the Carboniferous Windsor Group or the Hadrynian George River Group of Cape Breton Island. Windsor limestone tends to be fossiliferous and lower grade than the George River marbles so investigations focused on the George River stone. Metamorphism of the George River carbonates effectively cleaned the stone in many areas of its organic constituents. Two locations in particular, Glencoe and Marble Mountain, Inverness County, received the majority of attention (Fig. 6). Previous drilling had shown that there were some high grade zones occurring in the Glencoe area. Marble Mountain was chosen because of its high grade stone potential beneath the quarry floor.

In the field investigation a limestone/marble with a white to off white colour was desirable with a subsequent chemical analysis of high calcium, low magnesium, silica and alumina, and trace quantities of all other elements. Dolomitic stone is less desirable by industry because of the increased hardness and abrasion on machinery. The same also holds true for a high silica content.

Proximity to market is an essential factor to consider. The cost savings in transportation rates could outweigh less desirable attributes such as higher grinding costs. Dolomite is available at Cape Dauphin which could find a place in the markets because of its reduced handling and transportation costs.

Glencoe Limestone Deposit

Introduction

The Glencoe limestone deposit is located in Inverness County, Cape Breton Island. The deposit was sampled and mapped by Murray and Shea (1969), Milligan (1970), Scotia Limestone (MacNeil, 1974) and studied extensively by MacNeil (1972). Drilling in 1974 by Scotia Limestone consisted of 19 holes for a total of 2004 m of core recovered (MacNeil, 1974). The deposit was drilled again in 1975-76 and 1976-77 (MacNeil, 1977).

This extensive drilling program was initiated by the Nova Scotia Department of Mines and Energy and the Canada Department of Regional Economic Expansion in 1975 (MacNeil, 1977). By the completion of the 1975-76 and the 1976-77 programs a total of 85 holes were drilled and 12 347 m of core recovered. This drilling was accomplished using a fence pattern with each panel spaced 609.6 m apart following the dogleg shape of the deposit. The 1976-77 program provided infilling. Drillhole spacing along each panel was 122 m and each hole was drilled at a 45° angle into the dipping limestone beds up to a maximum of 167.64 m in length. These programs indicated reserves for cement grade limestone of 163.3 million t and metallurgical limestone of approximately 190.5 million t.

The crystalline Glencoe limestone is found in a variety of colours and chemical grades, ranging from pure white to reddish to grey black. The stone can also be found as pure as 98% CaCO₃.

Glencoe Drill Core Analyses

The drilling information and core from the 1975-77 Glencoe diamond drilling program was reviewed (MacNeil, 1977). Because of the variety in impurities in the limestone much of the chemically high grade stone was not white in appearance, but had a blue or grey hue. Some appeared graphitic. Fifteen crushed samples, each representative of a 3 m drillhole section,

were retrieved from the Nova Scotia Department of Mines and Energy warehouse in Debert. These were chosen based upon their high chemical purity.

Many of the samples chosen were graphitic and a froth flotation test was used to remove as much graphite and free silica as possible. A brightness test before and after flotation was done to reveal the degree of success (Appendix 1).

The silica decreased in total percentage after the flotation. The magnesium, tied up in the chemical compound MgCO₃, was not really affected. Brightness generally improved after the flotation, but not drastically. Another method would have to be designed to successfully remove the graphite economically and have a clean product.

Field Sampling

Sampling during Spring 1987 was to help delineate an area of high purity limestone to be drilled at close space to prove a tonnage figure for potential filler grade limestone. Samples were gathered either on the basis of whiteness of outcrop or on surface projection of quality stone identified in previous drilling programs. Forty-two samples were collected and analyzed (Fig. 16; Table 14).

One area, in particular, provided both good colour and high CaCO₃ values. A bulk sample was taken using an excavator in the fall of 1987. Stripping of the overburden revealed an extensive section of quality white stone with some minor staining throughout. Random analysis from the pit, which is located in the vicinity of RS8 (Fig. 16), revealed that the grade of stone was acceptable for consumption in some filler markets. This area of filler grade stone appears to be only one of many such zones found at Glencoe (MacNeil, 1977). Some of this sample was taken to Magstone, Debert, for cleaning and fine grinding and to Tibbetts Paint Company, Trenton, for testing in paint samples.

Tibbetts Paint Company Limestone Testing

One of the major consumers of filler minerals in the Atlantic region is Tibbetts Paint Company, Trenton, Pictou County, Nova Scotia. Calcium carbonate is used in large quantities for many of the paint products and in particular for their highway grade coater. Over 400 t annually of Snowwhite 452, from Steep Rock Calcite Company, Perth, Ontario, is added to this paint mixture. This is the largest single product used by the Tibbetts Paint Company.

Thirty pounds of carbonate from the bulk sample pit was finely ground to three different micron sizes at Magstone Development Ltd., Debert, Colchester County. Three samples were ground wet, and the fourth was ground in varsol which is a solvent used in the highway paint. The three wet ground samples were pulverized and then micronized in a paddle mill, test 44 for

Table 14. Results from Glencoe limestone deposit, Inverness County field sampling. See Figure 16 for sample locations.*

Sample No.	CaO %	MgO %	SiO ₂ %	Al ₂ O ₃ %	Brightness (Photovolt)
RS- 1	49.38	2.08	2.10	1.30	70.3
RS- 2	51.82	1.32	2.17	0.64	84.3
RS- 3	54.34	0.59	0.44	0.13	66.5
RS- 4	48.37	5.92	0.55	0.14	87.2
RS- 5	55.10	0.39	0.57	0.18	75.8
RS- 6	55.44	0.33	0.33	0.18	79.1
RS- 7	54.85	0.70	0.29	0.27	80.5
RS- 8	53.67	0.44	0.47	0.23	87.2
RS- 9	52.91	0.33	0.59	0.24	74.9
RS-10	53.33	0.11	0.42	0.07	91.1
RS-11	55.35	0.24	0.71	0.26	61.3
RS-12	55.35	0.36	0.42	0.21	73.9
RS-13	55.52	0.35	0.42	0.14	80.7
RS-14	54.76	0.77	0.38	0.06	72.9
RS-15	52.49	2.97	0.42	0.14	71.9
RS-16	55.01	0.29	0.78	0.14	74.2
RS-17	54.01	0.43	0.30	0.27	72.8
RS-18	55.27	0.56	0.76	0.29	78.1
RS-19	54.34	0.34	0.37	0.07	80.5
RS-20	42.56	0.56	19.79	0.58	61.1
RS-21	47.44	0.58	13.59	0.18	59.2
RS-22	53.00	0.66	1.85	0.28	81.1
RS-23	53.75	0.54	0.69	0.25	92.9
RS-24	50.47	0.74	6.37	1.37	56.0
RS-25	48.87	4.24	5.95	0.72	85.9
RS-26	49.04	2.52	7.58	2.49	80.6
RS-27	47.53	5.10	1.00	0.51	85.5
RS-28	49.46	1.89	5.73	0.86	87.0
RS-29	52.74	1.19	1.20	0.95	83.7
RS-30	44.08	2.63	11.27	2.71	76.4
RS-31	41.47	12.03	0.65	0.57	77.2
RS-32	51.40	3.03	0.77	0.85	84.4
RS-33	46.60	7.38	0.79	0.43	74.2
RS-34	46.60	5.65	1.64	1.29	72.8
RS-35	48.62	5.94	1.66	0.73	83.4
RS-36	46.77	7.70	0.74	0.21	80.7
RS-37	54.34	0.25	0.37	0.22	50.6
RS-38	54.51	0.39	0.74	0.29	51.2
RS-39	54.34	0.81	0.53	0.18	49.9
RS-40	55.01	0.51	0.45	0.26	50.5
RS-41	55.01	0.57	0.41	0.09	88.4
RS-42	38.70	14.94	0.57	0.16	73.4

* Minerals Engineering Centre, Technical University of Nova Scotia, Halifax, July 1987

5 minutes, test 54 for 10 minutes and test 65 for 15 minutes. A mean micron size analysis test was not performed, but Mr. Dennis Stone who ran the grinding test estimated that sample 44 was in the 12-16 μm size, test 54 in the 6-10 μm range and test 65 approximately 2 μm .

The samples were analyzed at the Technical University of Nova Scotia for chemical purity and brightness (Table 15).

Fred Hughes, assistant chemist at Tibbetts, reported that the Glencoe limestone would make an acceptable substitute for the Snowwhite 452 (Appendix 1).

If the Glencoe stone is acceptable for Tibbetts product line, it probably could be used by the other three paint producers in the Atlantic region.

Table 15. Chemical analysis and brightness for samples from Glencoe, Inverness County.*

Test No.	CaO %	SiO ₂ %	Al ₂ O ₃ %	MgO %	Brightness (Photovolt)
44	53.28	1.56	0.92	0.62	85.4
54	53.64	1.12	1.14	0.51	91.0
65	53.21	0.96	0.91	0.50	91.6
75 [varsol]	52.15	1.13	1.46	0.53	87.8

* analyses by Minerals Engineering Centre, Technical University of Nova Scotia, Halifax

Glencoe 3-Dimensional Model

A scale model of the Glencoe deposit was designed and constructed out of plexiglass and wood at the Nova Scotia Science Museum from data from the drilling programs carried out in the seventies. This model delineates zones of various limestone grades in the deposit on plexiglass cross-sectional panels. The limestone quality separations (metallurgical, cement, filler grades) are based upon chemical criteria. The model can be viewed at the Industrial Minerals Section of the Nova Scotia Department of Mines and Energy's head office in Halifax.

Computerization of Assay Values

In the past year all of the chemical assays for the 1975-76 and 1976-77 drilling programs were entered into a data base that can be accessed through the Engineering Section at the Nova Scotia Department of Mines and Energy. A program was devised to pick out sections of the drill core encompassed by a preset

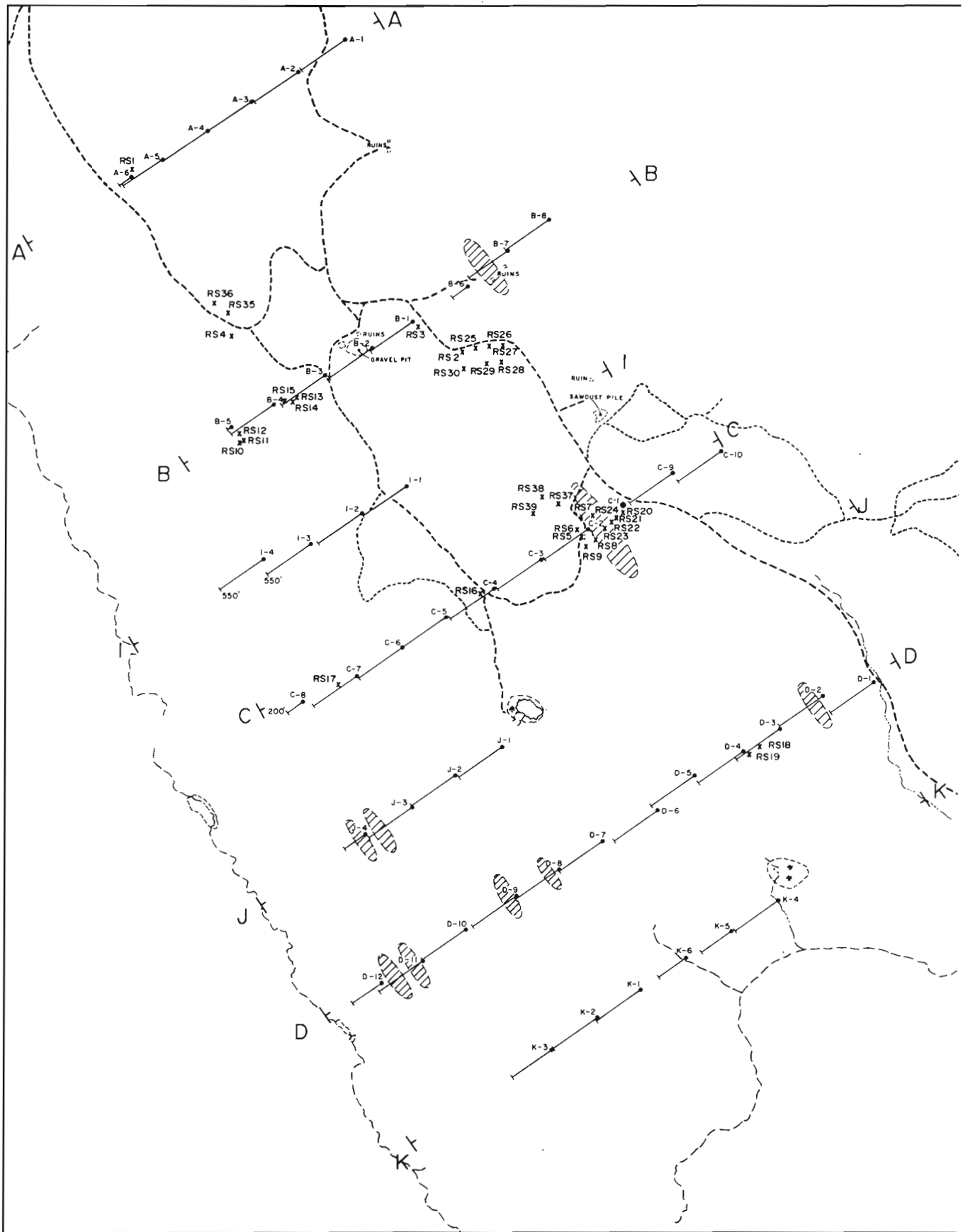


Figure 16. Location map of samples collected and analyzed, Glencoe limestone deposit, Inverness County

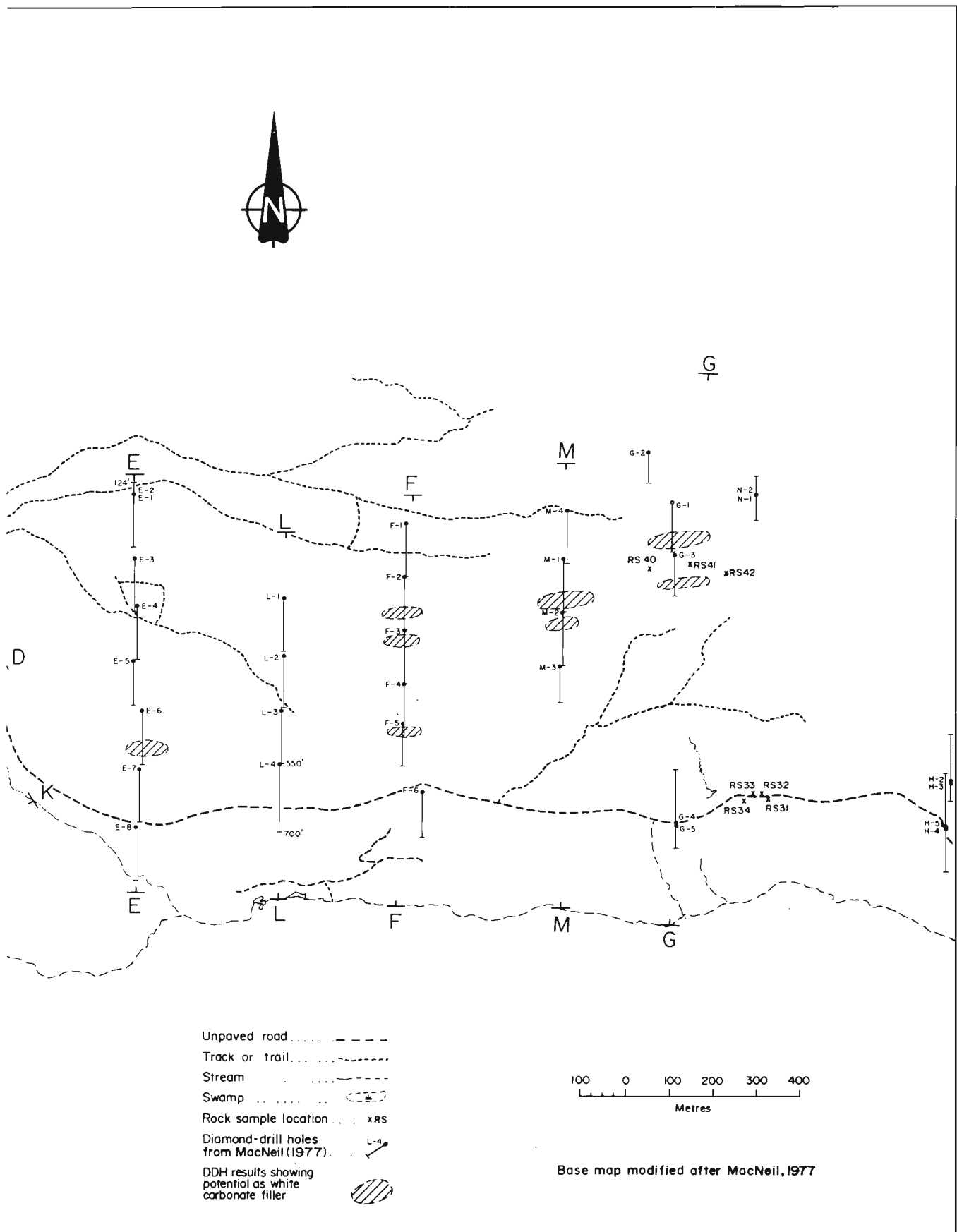


Figure 16. Continued

number of chemical values i.e. CaO >50%, MgO <2%, SiO₂ <2%. This can prove valuable and time saving when keying in on zones of similar grade stone.

Marble Mountain Quarry

Introduction

The Marble Mountain limestone deposit is part of a band of George River Group metasedimentary rocks which stretch along the southeastern slope of North Mountain on the West Bay coast of the Bras d'Or Lakes, Inverness County.

The quarry at Marble Mountain was operated from 1886 until the early 1920s. Besides the main quarry which was operated on three separate benches, there is also a second smaller quarry directly to the north which contains fairly dolomitic stone. The majority of stone was used as burned lime and for blast furnace flux. Quarrying ceased due to intolerable levels of magnesia and contractual problems with the lease.

Geology

The Marble Mountain deposit is typical of many of the George River Group limestone bodies. Beds are difficult to trace, colours vary throughout the deposit, and chemical values are erratic ranging from very pure marble to low quality in terms of magnesia and silica values.

Alterations and mineralization due to the intrusions of granitic bodies are very prevalent. In the old quarry serpentinization, as well as mineralization in the form of trace pyrrhotite, pyrite and galena, can be found.

The deposit was mapped by Milligan (1967) as a synclinal structure plunging almost 50° along a 220° strike.

Previous Work

After over 40 years of inactivity, Marble Mountain was drilled in 1965 by the Provincial government. A total of 4 holes and 162 m of recovered core gave little indication of the potential of any marble remaining under the quarry floor. Subsequent mapping and sampling by Milligan (1967) showed a variety of marble with regard to colour and chemical constituents. Milligan (1967) felt there could be high grade stone still available beneath the quarry floor.

The only activity ongoing in the quarry has been the extraction of minor amounts of white marble by Nova Scotia Sand and Gravel for use as marble chips.

Current Investigation

Random sampling by the author during Spring 1987 of

some of the whiter stone and subsequent analytical testing confirmed both Milligan's (1967) and MacNeil's (1977) acknowledgments of high quality stone still in the quarry (Table 16).

Table 16. Random and chip samples from Marble Mountain quarry, Inverness County*

Sample	Interval m	CaO %	MgO %	SiO ₂ %	Al ₂ O ₃ %
RS-MM-1		54.17	0.48	1.5	1.18
Chip Sample	0-3	54.85	0.63	0.44	0.21
Chip Sample	3-6	52.83	3.08	0.60	0.38
Chip Sample	6-7.6	47.97	5.18	1.53	1.0

* analyses by Minerals Engineering Centre, Technical University of Nova Scotia, Halifax

This initial sampling and subsequent literature review of the area was followed up with a chip sample taken across the section of white stone on bench number 2 that is quarried by Nova Scotia Sand and Gravel. Analyses (Table 16) show excellent chemical results for the first 3 m and then an increase in the magnesium content for the remaining 4.6 m.

Samples from Marble Mountain and Glencoe were sent to English China Clay American, Georgia, for analysis. The results for Marble Mountain in particular were very promising, showing a high brightness reading and low magnesium and insoluble values (Table 17). These results compare favourably with many products in the filler industry.

Four holes were drilled in the early 1960s, but only one drillhole was collared in a location that seemed highly likely to intersect quality stone. The core from the Nova Scotia Department of Mines and Energy office in Stellarton was split and reanalyzed at the Technical University of Nova Scotia, Halifax. The results for hole 2 show some zones of high purity white limestone (Appendices 2 and 3). Five more holes were drilled in January 1988 to intersect this same quality stone and delineate a rough tonnage.

Marble Mountain Drilling Program

A diamond drilling program for the Marble Mountain quarry was initiated in January 1988 (Fig. 17). The five drillhole locations and angles were based upon Milligan's (1967) structural interpretation of the quarry. Milligan (1967) described the quarry as a synclinal structure plunging approximately 50° along a 220° strike. Based on this, MM-88-1 was collared in a location which approximated the axis of the syncline and drilled on a 45° angle in a 030° direction into the plunging syncline. Core recovered was 91.44 m. Results from this hole

Table 17. Analytical results from Marble Mountain and Glencoe limestones.*

Sample	Brightness ¹	CaCO ₃ ² Wt%	Insolubles Wt%	MgCO ₃ %
Marble Mountain				
Coarse Ground ³	93.2	96.62	2.64	0.74
Floated & Fine Ground ⁴	97.1	97.48	1.89	0.63
Glencoe				
Coarse Ground ³	84.5	95.56	2.50	1.94
Floated & Fine Ground ⁴	93.8	97.85	1.61	0.54

* analyses by English China Clay American, Georgia

¹ Elrepho - AACC

² By EDTA method - some evidence of Fe interference

³ Approximately 50% retained on 325 mesh screen and 10% on a 100 mesh screen

⁴ ACC float ground by sand grinder to 91% <2 μm

were very promising and revealed a considerable section of high brightness marble of fairly consistent colour and chemical purity. Drillholes MM-88-3 and MM-88-5 were collared along the same strike (030°) as MM-88-1 and revealed thicknesses of the whiter units with chemical consistency along strike.

MM-88-2 and MM-88-4 were both drilled on the limbs of the syncline. MM-88-2 was drilled on the eastern limb to a depth of 55.78 m. It was hoped to drill 60+ m deeper, but due to swelling in the core barrel from clay which had infiltrated the many fractures in the marble, drilling was slow and time restraints meant this was not possible. MM-88-4, on the western limb of the syncline, was drilled at a 45° dip with a bearing of 310°. It encountered various colour grades of marble including a thin band (~8 m) of light grey-white stone. This is probably the same band that is exposed along the high western wall of the quarry and that is also intersected on the other side of the quarry in MM-88-2.

Rough tonnage estimates based on drill results show that there could be up to 900 000 t of high purity white-off white marble in the Marble Mountain quarry. Extraction of this stone would not be difficult and facilities for shipping could be made at the base of the quarry. Trucking or rail may also be options.

More exploratory work on the quarry would

further delineate the high purity zone. Trenching across the northeastern end of the quarry perpendicular to the strike of the syncline would reveal the extent of the zone by channel or chip sampling the length of the trench.

Summary of Nova Scotia Calcium Carbonate Resources

The Glencoe limestone is a good quality material probably best suited for carpet backing and road paints because of its slightly low brightness values. The staining of the minor fractures and veinlets lower the colour grade dramatically. Our work encompassed just one small area of this massive deposit so there could be more zones present of even better quality stone.

The carpet backing and road paint industries in Nova Scotia alone use at least 1.7 thousand t of this quality of limestone annually. Beneficiation costs for such a product would be minimal. The Glencoe deposit is <20 km away from railway transportation and the consumers are on rail lines.

Marble Mountain appears to be a higher quality stone with vast potential in the filler industry. High brightness, chemical purity, large tonnage and convenient location near water transport make it a prime development property.

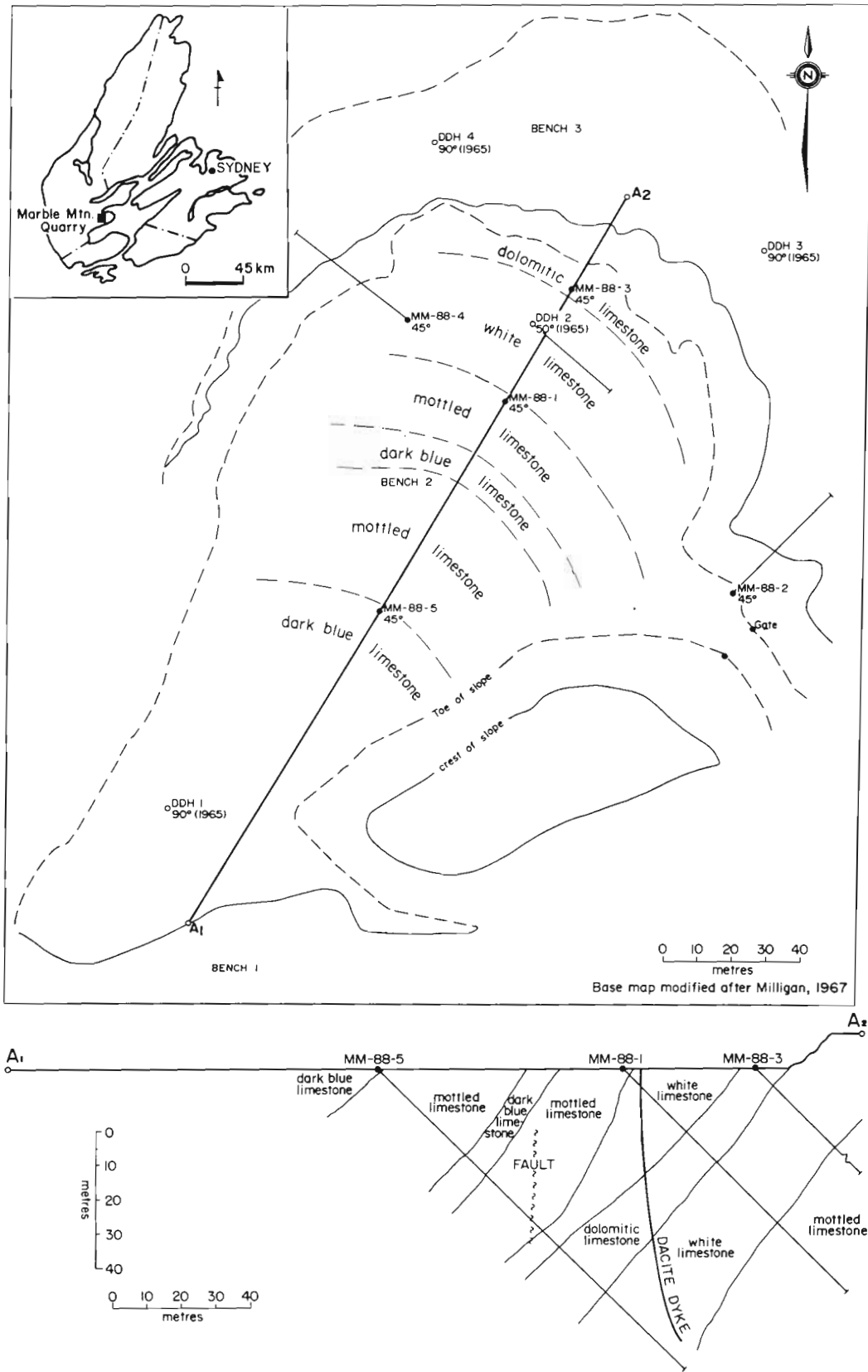


Figure 17. Drillhole location map and cross-section of the Marble Mountain quarry, Inverness County