PROVINCE OF NOVA SCOTIA
DEPARTMENT OF MINES

Memoir 7

GEOLOGY
of the
GEORGE RIVER SERIES
Cape Breton

Stratigraphy, Structure, and Economic Geology

By
G.C. Milligan

Halifax, Nova Scotia

1970

HON. PERCY GAUM, Minister

J.P. Nowlan, Deputy Minister

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Price – $4.50

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Note

Ozolid maps of Marble Mountain (1" = 40 ft.) and New CampbeUton (1"= 200 ft.) are available from **the** Department of Mines, Halifax.

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INTRODUCTION

STATEMENT OF PURPOSE

This project was begun, in 1962, as an investigation into possible guides to mineralization in the George River series, of Cape Breton. A number of sulphide occurrences are known. It appeared reasonable to suppose that there should be some associated features which are characteristic, and which could be used by prospectors to guide the search for ore bodies.

This is equivalent to asking what is abnormal about the series in the vicinity of concentrations of valuable minerals. Though one might anticipate that the sulphide deposition should be controlled by structural features and by composition of specific "favourable" host rocks, the combinations of these and other features associated with the 'ore' obviously must represent an abnormal situation - otherwise the whole series would be ore-bearing.

Recognition of guides (that is, the recognition of abnormal features or combinations thereof) pre-supposes a knowledge of what is normal in the series. It speedily became apparent that knowledge of the character of the George River series was spectacularly limited.

PREVIOUS WORK

The George River series has previously received relatively cursory attention. This is not very surprising; the ultimate economic justification for, and the preoccupation of, the past geological work was coal, gypsum, and other economic minerals, most of which are found in the Carboniferous rocks in Cape Breton. During regional mapping, therefore, the George River rocks were usually not sub-divided and were separated only as a group from the Carboniferous formations. Indeed, in some cases, the associated igneous rocks were also included, and the whole assemblage distinguished only as pre-Carboniferous.

Hugh Fletcher, of the Geological Survey of Canada, during the years 1876 to 1884, mapped all the areas containing George River rocks. His work is of the extremely high quality which make Fletcher and Faribault famous names in the history of geological exploration of the Maritimes. The very careful and exact geological maps which he produced are models of field mapping techniques under difficult conditions. It is unfortunate that modern compilers do not make better use of his maps to guide their interpretation of aerial photographs. Were they to do so, there would be fewer shadows mapped as streams, and fewer tributaries connected to the wrong brooks.

Fletcher did not subdivide the George River rocks, though he did distinguish outcrops of limestones, and other items of potential commercial value by special symbols on his maps. His reports are descriptions of the sequence of rocks, in order. as he encountered them in his mapping of the brooks. Unfortunately, his descriptions are not of the same high calibre as his maps. Though the rock descriptions are necessarily brief, they are usually lucid enough. However. descriptions of locations or of sequences of rocks are often ambiguous, so that one may not know the location of the feature he describes within several miles. In extreme cases, even after examining a brook, one still cannot recognize the things Fletcher describes, though his map of the brook itself may be remarkably good.

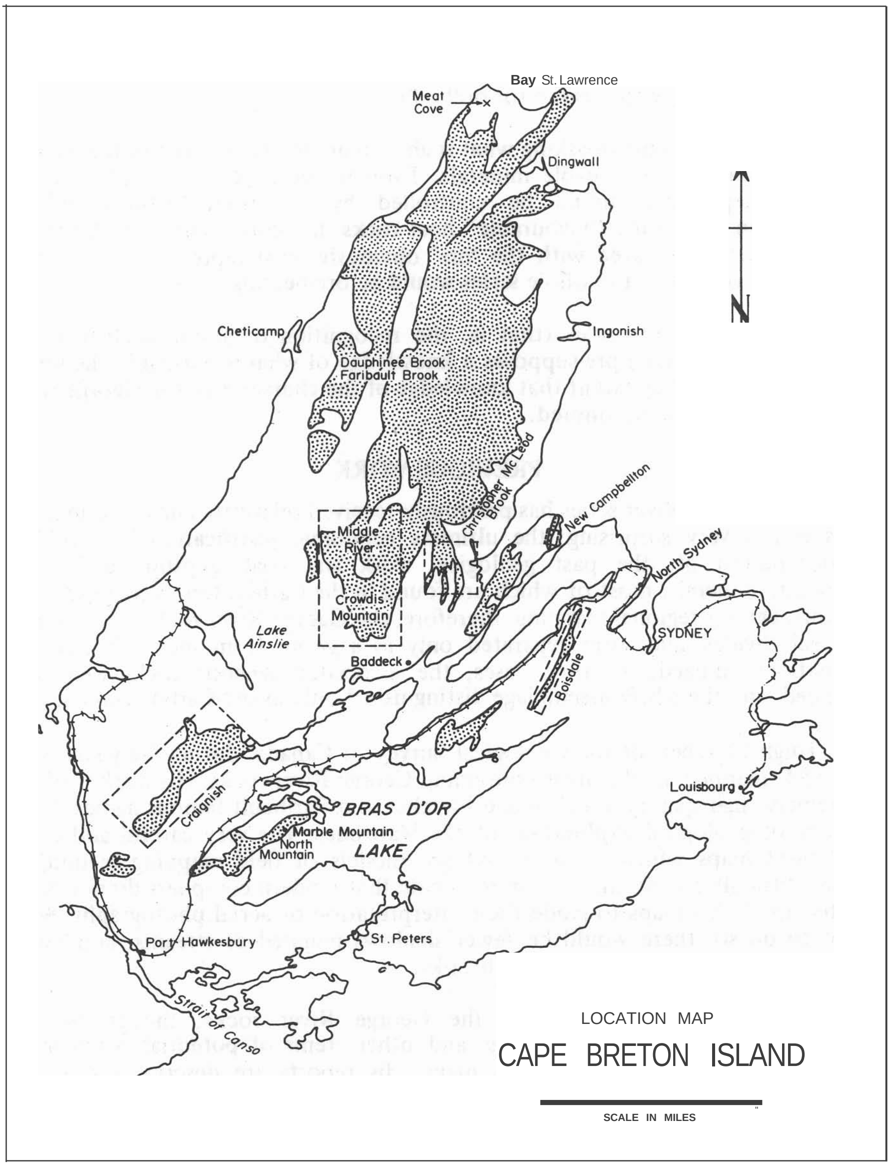


FIGURE 1 Location map.

Gurnsey, in 1927, made a map of the Marble Mountain-River Denys area, which was published by the Geological Survey of Canada as Map 223A and accompanied part C of the Summary Report for 1927.

Bell and Goranson, in the course of regional studies of the Carboniferous basins, mapped the George River rocks in the Boisdale Hills. In this area the rocks are dominantly quartzites and carbonates; this may be the reason for the widespread impression that the series is mostly carbonate, though Fletcher of course, had long ago described the great variety of rocks actually present.

D.G. Kelley, in 1952 and the following years, mapped a very extensive area of Cape Breton for the Geological Survey of Canada. This work included essentially all the George River rocks here described. Comparison of his maps with the present ones will show that there is some increase in detail, and changes in interpretation, but that Kelley's boundaries have not been changed very extensively.

There is very little other published material on the George River rocks, though considerable work was done from time to time in the search for minerals. A gold mine was operated briefly at Second Gold Brook, near Middle River, about the turn of the century, but it was closed during the First World War. There was an attempt, apparently ill-judged and ill-managed, to develop a copper mine at Faribault Brook, near Chelicamp, in the 1890's.

In more recent years there has been extensive, but sporadic, exploration. Several of the larger mining companies, and a number of smaller firms, consultants, and individuals, have carried on exploration. One of the most persistent has been Dr. B. J. Keating, of St. Francis Xavier University. Some of these firms and individuals have been very generous in making information available to assist in this study.

PRESENT FIELD PROGRAM AND METHODS

General Considerations

Very early in this project it became apparent that any assessment of abnormalities associated with mineral deposition required some knowledge of the normal character and behaviour of the rocks of the series. To evaluate possible structural controls it is necessary to know the structure; to know this, it is necessary to know the stratigraphy, and vice versa. Similarly, recognition of wall rock changes requires a knowledge of the metamorphic history.

Therefore, routine mapping became the initial step in the program.

The Craignish Hills were chosen as an area where metamorphism appeared to be minimal, where it was hoped the structure would not be too complex, and where there would be some chance of establishing the stratigraphic units. Mapping was done during the summer field seasons of 1962 and 1963. During this period, (1962), brief examination of the very complex area of Marble Mountain-Lime Hill-River Denys was made and approximately a month was spent in mapping the George River area in the Boisdale Hills between Scotch Lake and Steele's Crossing (1963). Mr. Roger C. Parsons, assistant during these two seasons, made a preliminary study ot the structure of the Craignish Hills the subject of his M.Sc. thesis at Dalhousie University (1964).

During 1964 and 1965 the author was absent on study leave in Europe, but the program was resumed in the summer of 1966.

Mapping was then continued into the largest area of George River rocks. This extends, apparently almost unbroken, through the Cape Breton Highlands from near Baddeck to north of Pleasant Bay. Starting northward from Hunter's Mountain, near Baddeck, in 1966, we reached Northeast Margaree and Big Intervale during the 1967 season. An attempt was made to map all the George River rocks between the line of the Cabot Trail (Middle River-Northeast Margaree) and the North Baddeck River. It was found, however, that some areas between the upper reaches of North Baddeck and Middle rivers are essentially inaccessible, and that the time and expense involved in mapping them were not presently justifiable. This work Was therefore postponed pending improved accessability, which will come with completion of woods roads now under construction. In 1967, also, work was begun on the narrow belt of George River rocks extending northward from west of SI. Ann's. This work reached as far as MacDonald Brook, a tributary of North River.

The field work of 1966 and 1967 traced George River rocks from a relatively low grade of metamorphism through to strongly metamorphosed gneissic phases grading into granitic types.

Work to date has yielded a fair preliminary view of the lithological units present in the series, some information on their possible variations from place to place, and their character when metamorphosed from low to very high grade. Some understanding of the structure has also been obtained.

It is now possible to consider the geology in the vicinity of the known mineral occurrences, and to compare it with that of the series in general. Mc. A. K. Chatterjee is investigating this as his doctoral research problem at Dalhousie, with special attention to the mineralogy of the larger known sulphide occurrences, and to the wall rock alteration associated with them. His progress and conclusions to date are outlined in a separate chapter below.

Mapping Methods

The field methods have been adjusted from time to time in response to differing conditions and increased experience.

During the rapid examination of the Lime Hill-Marble Mountain-River Denys area, in 1962, the general plan was to make traverses across the structure at intervals of about a quarter of a mile. It was generally possible to arrange traverses so they followed brooks; only rarely are the brooks so spaced as to require intermediate traverses. The majority of outcrops are, in fact. in the brooks, and this scheme worked reasonably well.

In the Craignish Hills the brook traverses were continued but additional lines were run. It was noted that some exposures were found between the brooks and, in 1963, in the area westward from Blue's Mills, in addition to the examination of every tributary and branch of every brook, traverses were rUD, more or less across the trend of the drainage, at intervals of approximately 300 yards.

In the Boisdale Hills in the same year, this system was also used.

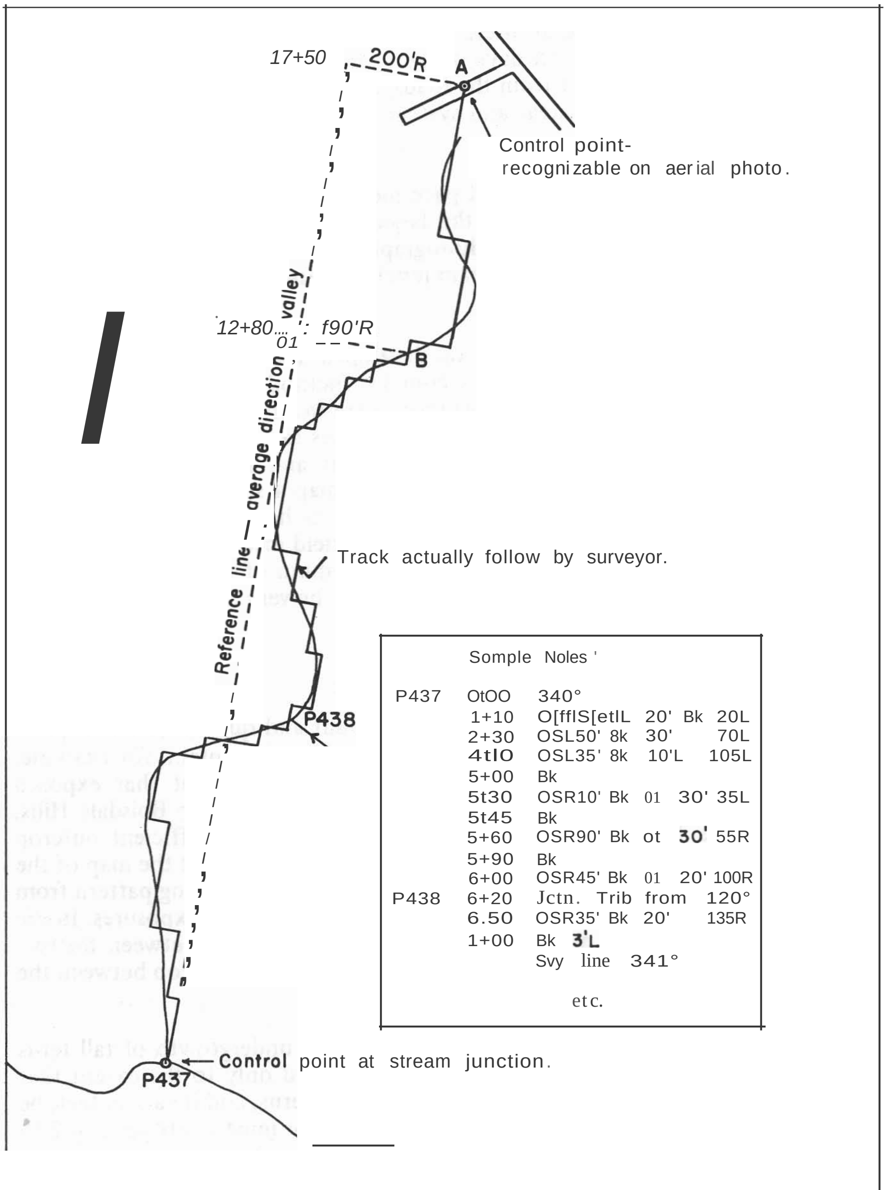


FIGURE 2 *Parsons Technique for Brook Survey. Forward distance and **offsets**, are measured. Plotting requires only adjustment of the end of the line. at A; all other points, such as B, are plotted by distributing errors in forward distance by use of slide rule.*

In the area between Hunter's Mountain and Northeast Margaree traverses between the streams were abandoned. There have been extensive pulp-cutting operations in this area, and haulage roads were made by bulldozing. The main roads are still open and the outcrops exposed on the roads are still visible. It was found profitable to examine all these roads - a time-saving operation because it could conveniently be done on days of light rain, when normal brook traverses are not very practical. Apart from the roads, absolutely no outcrops were found outside the brooks in this area, and systematic traversing between brooks was not used.

Traversing was by compass and pace methods, using aerial photographs to assist and guide the work. Only in the larger streams (e.g. Middle River) does detail of the stream show on the photographs; even more rarely do outcrops show, and then usually on cliffs. Stream junctions, and similar fixed points were used to control the traverses.

A new technique of traversing was developed. Bearings and distances were very quickly found to be an impossibly complex method in winding brooks. Too many corners, bearings, and short distances were involved; the resultant errors made the traverses impossible to close. Mc. Parsons rapidly evolved an obvious (but apparently unique) system of offsets, right and left from the average direction of a valley, which made it possible to map a stream as fast as a man could search it for outcrops and almost as fast as he could walk. The great advantage of his scheme is that adjustment of the field measurements to the base map can be done in a single step and with a minimum of time and effort. The technique was used for four seasons and found to be very simple, effective, and accurate.

Quality of Exposures

There is considerable variation in the amount and quality of outcrop. In the Crowdis Mountain-Middle River area, and at Skye Mountain, for example, absolutely no outcrop was found outside the brooks, except that exposed artifically by bull-dozing for haulage roads. By contrast, in the Boisdale Hills, and from Blue's Mills to Glendale in the Craignish Hills, sufficient outcrop occurs between the brooks to justify exploring there. A glance at the map of the Boisdale Hills will show that it is possible to follow the traversing pattern from the outcrops shown, and this is nearly random sampling of the exposures. In the North Mountain area, the quantity of outcrop is intermediate between the two extremes indicated above, Le. there is a limited amount of outcrop between the brooks.

Vegetation is chiefly mixed hardwoods with an undergrowth of tall ferns and small bushes. Cross-country traversing is hindered only to the extent that one must be cautious of poor footing hidden by the ferns, and it can, in fact, be very pleasant under the canopy of trees. Most outcrops must be stripped of 2 to 10 inches of moss and similar vegetation to expose the rock.

Extensive areas of softwood are not abundant and present only the usual and characteristic traversing difficulties, which vary with the age of the trees. On former farm land the characteristic overgrowth is spruce. This is recognizable on aerial photographs by its uniformity, and by the rectangular outlines of former fields still visible in the vegetation pattern. When only a few years old, such growth is essentially impenetrable; when mature, it is composed of very tall trees with no undergrowth whatever. In any case, it is essentially devoid of outcrop, or even of boulders; the latter were all gathered off the fields into the stone fences which now run through the woods.

Outcrops in brooks are the chief source of information. Because very shallow scraping exposed bedrock in many places on roads, it is evident that the mantle of overburden is thin in many areas. For this reason also, the brooks quickly cut through to the bedrock beneath.

Though there are exceptions, it is generally worthwhile to follow every brook wherever it has an appreciable gradient, regardless of its size. There is usually not much outcrop where the brook runs over the surface of the plateau out of which the valleys have been carved; where flat enough to permit alder swamp to develop, outcrop is ordinarily absent. The larger brooks have good exposures in most places, and cliffs over 100 feet high occur in some, though there are also those with only a few outcrops per mile. The smaller brooks, and their still smaller tributaries, generally have small outcrops which are very poorly exposed under banks or beneath boulders and logs and it is necessary to walk in the brook to see them. The south bank of Diogenes Brook, near Melford, is an extreme case; even very tiny tributary streams, hardly more than a trickle, have exposed a few outcrops, most of which are less than a foot in diameter.

In evaluating outcrops from the brooks it is necessary to bear in mind that there may be a sampling bias because of the location. In some cases it is evident that the location of the brook is fault-controlled. In other cases, the location is controlled by the lithology of the bedrock, or by some structural feature. Except when a brook is running on strike, this bias presents no problems if it is recognized. There are very many cases, however, where such a bias may be present, hut not known, and where needless complications could have been introduced unwittingly into the maps.

Late glacial deposits have not been moved far from their source area. if moved at all. It is therefore useful to examine the soil and glacial material for indications of the bedrock beneath. It is possible to "bridge" between outcrops, to some degree, by noting the dominant boulders - generally those above about 12 inches in diameter. This technique proved very useful in both the western part of the Craignish Hills and in the Crowdis Mountain area. In some cases, the boulders may be almost exclusively of one type. Such boulder areas are noted on the maps by the letter F = float}.

For this reason, also. it is often worthwhile to examine the stone fences and the piles of stone in and around abandoned fields. The very labour of picking stones ensures that they are now not far from the source in the field.

Base Maps

The maps which accompany this report were drawn on base maps which were compiled from several sources.

For the Craignish Hills, Marble Mountain-River Denys, and Boisdale Hills, the planimetric base map was supplied by the Nova Scotia Department of Lands and Forests. It had been used in preparing the forest inventory, and was originally prepared by Belanger and Bourget, forestry engineers, of Montreal.

For the area north of Baddeck, the base maps used in the field were again planimetric maps supplied by the Department of Lands and Forests. These had been compiled from enlargements of the original drawings for the 1:63,360 maps of the National Topographic Series. There had been some amendments based upon interpretation of aerial photos, and the boundaries of all timber leases had been added from new surveys. The scale was four inches to one mile. The topographic base map, including the contours, which was used for the accompanying maps of Crowdis Mountain and Middle River, was supplied by the Surveyor General, as photographic negatives enlarged from the originals for the National Topographic Series maps.

In the accompanying maps, details of streams have been adjusted to fit the field measurements, using the base maps and aerial photographs as control. In some cases, it has been necessary to reconcile field observations, base map and topographic contours by adjusting all three.

A limited amount of instrumental survey has demonstrated that the elevations indicated by the contour lines are seriously in error, and that relative differences in elevation may also be in considerable error even within short horizontal distances. The general shape and appearance of the topography is reasonably represented, however, and is quite adequate for our present purposes, provided one does not take too seriously the exact position shown for geological boundaries located by projection of planar features, such as faults, from their exposures in the brooks.

Compilation and field maps were prepared at four inches to one mile, and reduced photographically for publication.

ACKNOWLEDGEMENTS

It is impossible to acknowledge individually the assistance received from so many people in Cape Breton. To many, I am indebted for hospitality shown to myself and to my assistants; to many more, for a courteous and friendly interest in our work and for local knowledge freely given. Special mention must be made of hospitality and assistance given by Mr. and Mrs. Malcolrn MacDonald, Valley Mills; by Mr. and Mrs. Ainslie MacDonald, Middle River; by John Murphy, Northeast Margaree; by Robert Mason, Crowdis Mountain; of hospitality and an encyclopaedic local knowledge provided by Mr. and Mrs. Alastair MacPhail, Marble Mountain. I am indebted also for the cooperation given by N. S. Pulp Company and Mr. Kelly, the Manager of their Baddeck division; for much assistance provided by C. G. Johnson, of Sullico Mines limited, and by Gordon Cranton, of Frizzleton; for assistance from Patino Mining Corporation, and from A. G. MacKenzie of Mareast Explorations, as well as from Mr. McCallum, of A. C. A. Howe, Umited.lam greatly indebted to John Skotynsky, of Big Intervale, and, for many favours and much help, to Jarnes Grey of North Sydney.

Professor B. J. Keating of St. Francis Xavier University has a very extensive knowledge of George River rocks, acquired over many years and all of Cape Breton. For his assistance, discussions, and criticism, I express my thanks.

I am indebted, for patient and painstaking personal assistance in the field, to Roger C. Parsons during 1962 and 1963, to Robert M. Creed, in 1966, and to Gregory MacKenzie in 1967. In 1967, Mr. Creed and A. K. Chatterjee, formerly of the Geological Survey of India, worked together as a mapping tearn.

Dr. Brian White, assisted in the field by Alan MacLaughiin in 1966 and by H.S. Swinden in 1967, did some very careful field mapping and a great deal of the petrographic work involved in the study of the metamorphism of the series. Dr. White was supported, as a post-doctoral fellow, by Dalhousie University, and this assistance to the project is gratefully acknowledged.

I am also indebted to the National Research Council of Canada, and to the Geological Survey of Canada, for research grants in support of parts of the investigation outside the normal program and responsibilities of the Nova Scotia Department of Mines.

I must acknowledge also the cooperation and willing assistance of the Mines Department staff, especially of Frank S. Shea in connection with the field work, and the patience of Or. *JP.* Nowlan with a project which has dragged on for several years beyond its originally scheduled life.

ACCESS

Roads

One hardly expects to find access a matter for discussion in this area and, generally speaking, it is not a serious problem. There are, however, some extensive areas, especially north of Baddeck in the Cape Breton Highlands, **where access is a problem.**

It is a general rule that the George River rocks and the related intrusive types, stand up as hills above the valleys, which are underlain by the soft Carboniferous rocks. The highways and railways, of course, follow the valleys.

In the Craignish and Boisdale hills the zone of George River rocks is narrow enough that roads exist on both sides of the ridges. The same is true of North Mountain (Lime Hill-Marble Mountain-River Denys). In the Craignish Hills, also, there are roads remaining from the days when the flat hill tops were farmed. These are now used for lumber and pulp haulage. None of these roads is capable of supporting heavy traffic, but they do provide access routes, and they could be improved readily. The Trans-Canada highway passes along the south side of the Craignish Hills.

In the Hunters Mountain-Crowdis Mountain area, north of Baddeck, the same situation exists. The Cabot Trail goes through Middle River, on the west side of the ridge. As mentioned above, there is a network of roads for hauling pulp on the mountain top, though most are now beginning to grow over. In addition, Nova Scotia Pulp Limited has two main haulage roads; one goes eastward from Frizzleton (Northeast Margaree) over the mountain to Oregon, on North River, and is known as the Fielding Road. The other branches off the Cabot Trail at Hunters Mountain and follows the height of land between Middle River and North Baddeck River to join the Fielding Road. In 1967 this had been completed to about 2 miles south of Sarach Brook. These two are excellent gravelled roads and are built to carry large semi-trailers hauling heavy loads at highway speed.

Ar present, the area east of Middle River and north of Second Gold Brook is difficult of access; north of Bothan Brook it is difficult to reach, even on foot. Completion of the road from Hunters Mountain to the Fielding Road will put any part of that area within a couple of miles of a road.

The area north and east of Frizzleton is not served by roads. North of Big

Intervale, there are effectively no roads to the headwaters of the Northeast Margaree River. From Cheticamp, there is a "jeep road" to Rocky Brook and a similar road leads from Petit Etang to the "Silver Cliff" prospect on Dauphinee Brook but otherwise this area is essentially devoid of roads.

Railways

The Sydney line of Canadian National Railways passes along the north side of North Mountain (Marble-Lime Hill-River Denys). There is a dirt road around the end of the ridge via Malagawatch, but there is no longer a passable road connection to the railway across the mountain from the south side.

The railway also passes the north end of the Boisdale Hills at Scotch Lake.

The Inverness Branch of the railway passes some miles to the north of the Craignisn Hills area but there is no effective road connection from that area to the railway. Probably the most practical connection to rail from the Craignish Hills is via Highway 5 (Trans-Canada) to Port Hastings.

With these exceptions, there are no rail services in the area of George River rocks here discussed. The area of the Cape Breton Highland is completely without any rail connections.

Shipping

There are a number of harbours available, which could offset to some degree the lack of rail communication. The Bras d'Or Lake has direct connection at its eastern end to the Atlantic via the Great Bras d'Or; at the western end there is connection via the SI. Peters Canal. On the Bras d'Or Lake, Baddeck has a good sheltered harbour and handles a few ships loading pulpwood for Europe. There are regular gypsum shipments from Little Narrows to the United States, and there are probably a number of other such harbours possible; Marble Mountain, for example, has shelter and good deep water close in to the shore.

Maximum Dimensions for Vessels in Locks

	SI. Peters Canal		Canso Causeway	
Length	270 feet -	83 meters	660 feet -	202 meters
Width	55	16.9	75	23.1
Draft	17	5.2	28	8.6

On the Gulf of SI. Lawrence side, there is a fishing habour at Cheticamp which could handle small freighters. Most of the other harbours on that side are too small, or poorly sheltered, to accommodate ocean-going ships. North of Cheticamp around to Bay St. Lawrence there are no harbours. On the Cabot Strait side, Dingwall has been used for shipment of gypsum, but required regular dredging. Ingonish Ferry and SI. Ann's Bay are probably the only practical harbours southward to Great Bras d'Or.

There are full scale harbour facilities at North Sydney, Sydney, and Port Hawkesbury; facilities for very large ships are now being built at the latter. All three operate the year around.

CHAPTER II

LITHOLOGY AND STRATIGRAPHY

GENERAL SUMMARY

The George River series is probably of late Precarnbrian age. It consists of at least 15,000 feet of quartzites, impure quartzites and greywackes, slates, limestones and dolomites, and their metamorphosed equivalents, together with minor amounts of other sedimentary rocks. There are present also volcanic rocks of rnafic to intermediate composition. Some occur as flows; other parts appear to have been of pyroclastic origin. Siliceous volcanic rocks are of minor amount.

Intrusive into the George River rocks are diorite, syenite, and granite, and special phases of these. Gabbro is known locally, but some of this may be a phase of the volcanic assemblage rather than a later intrusive. There are late lamprophyre dykes cutting the granitic intrusives, though some others are older than the granites. Radioactive dating has shown that granites in the Boisdale and Craignish hills are pre-Devonian and many of the other intrusive rocks may be pre-Devonian also, instead of the Devonian age formerly assumed for them.

The George River rocks are unconformably overlain by Horton sandstones and conglomerates in a number of places. According to Creed, they are also overlain by rhyolite of the Fisset Brook formation (Upper Devonian) at East Side Lake AinsJie, though his correlation with the Fisset Brook is mainly lithoJogical and the present mapping has not included the relations in its type locality at Fissett Brook.

The Devonian McAdam Lake formation is not seen in contact with George River rocks in the Boisdale Hills. Though good exposures are separated by only a short distance, the grade of metamorphism is distinctly different; and there appears to be little doubt that the Devonian rocks are the younger.

Bell and Goranson report that, west of Scotch Lake, sedimentary rocks containing middle Cambrian fossils rest unconformahly upon volcanic rocks which, in turn, overlie rocks of the George River series. This makes the George River rocks pre-Middle Carnbrian, at least. Confirmation of this has recently come from the absolute dating of the granite near Sandy McLeod Lake, in the Boisdale Hills. The K-Ar age is 493 million years. This granite invaded and metamorphosed the George River rocks, but the Palaeozoic sediments are not altered.

Somewhat greater ages (505 and 515 million years) have recently been obtained by Cormier for granitic types from the Craignish Hills. The accompanying map shows these as intrusive into the George River group, but the related metamorphism is anomalous and the field relationships are not as clear as one would wish.

The lack of a metamorphic halo around the intrusive rocks would be explained if the sedirnents had been deposited unconformably upon them. Other than the lack of metamorphic effects, there is nothing to indicate such an unconformity.

UTHOLOGY

SEDIMENTARY ROCKS

Conglomerate

Conglomerate is found in very few places in the George River rocks, and in only one area has it been traced for a significant distance. A few outcrops were found at Iron Mines, near Whycocomagh, and again on the hilltop (Mullach) north of Whycocomagh, in the general area of the copper prospect there. Similarly, isolated single outcrops of conglomerate occur in the upper part of Fourth Gold Brook.

The only area of any extent is near *Second Gold Brook* where a conglomerate band 3S feet thick occurs in the brook just below the site of the mill building of the former gold mine. It can be followed up both sides of the valley for several hundred feet. A similar conglomerate occurs on the north side of Middle River just to the west and may be the extension of this same band. Some distance stratigraphically above and below these conglomerates there is a zone where coarse opalescent quartz grains appear in the slaty sandstones. This apparently represents a transition to the conglomerate horizon. Such coarse grits or pebbly sandstones also occur in Third Gold Brook, at a few places on the north bank of Middle River nearby, and on the north bank of Gillis Brook, but no true conglomerate phase was found at these places.

The character of the conglomerate differs from place to place, so a "typical" phase can hardly be said to exist. At *Second Gold Brook,* the pebbles are well-worn, closely packed, ellipsoidal, and average about I inch in longest dimension, though some are as much as 8 inches by I inch on the exposed surface. There is a notable parallelism of the pebbles, which probably results from deformation of the rock, and in consequence the pebbles resemble quartz and felsite lenses in the dark, slaty, strongly-layered matrix. The pebbles form 40 to 60 per cent of the rock and are composed of vein quartz, grey and reddish quartzite, micaceous "sandy" quartzite, and a diorite. The reddish pebble gives a characteristic reddish streak on the outcrop because it is usually very elongated; where the present surface cuts along two long axes of the pebble the result is an elliptical reddish patch on the surface. Higher in the bed the pebbles decrease in **number.**

The source of the dioritic pebbles has not been recognized.

.North 0/ Whycocomagh the conglomerate differs from the Carboniferous conglomerate of the same area in that the latter contains limestone. The Carboniferous (Horton) conglomerate contains fragments of granite, as well as the familiar dolomitic limestone, white coarse-grained crystalline limestone, slates, and quartzites from the George River series. The pebbles are rounded to angular; the angular pebbles have the edges rounded. The George River conglomerate here resembles that of the Horton, but it does not contain any limestone fragments and it has many angular boulders and fragments, so that in places it resembles breccia. There is some structural discordance with the Carboniferous rocks as well.

At Iron Mines, the average pebble size is about ¾ to I inch, though some slate pebbles are up to 12 inches long. The pebbles are vein quartz, slate, greenstone (1) and quartzite; the matrix is chloritic. Slate pebbles are angular, but the others are well rounded. The rock is grey and the pebbles very hard to

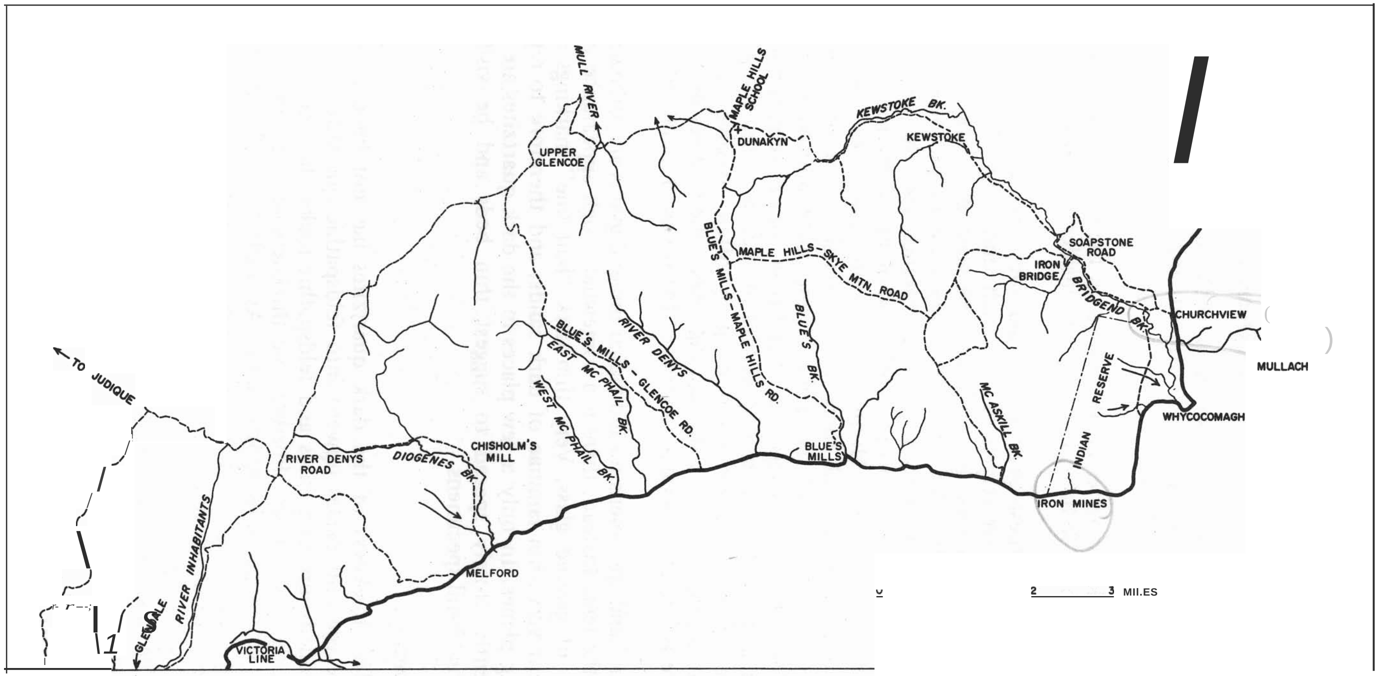


FIGURE 3 ***The Craignish Hills. Map to show location of places mentioned in the text.***

see. The best exposure is only 80 feet thick, and the whole seems to represent pebble lenses in a sandy sequence now converted to quartzite,

A tiny exposure of similar conglomerate was found in the most northerly brook tributary to Bridgend Brook on the Whycocomagh Indian Land.

Dark Quartzites

The dark quartzites are so called to distinguish them from a thick sequence of very light-coloured quartzites, without conveying any implications as to their relative stratigraphic positions.

The dark quartzites in the brooks on the east side of Skye Mountain, on the Whycocomagh Indian Land, may be considered typical.

In outcrop, these quartzites are massive, very fine grained, almost cherty in appearance. They are very hard and tough, and many of them will break with a sub-conchoidal fracture. In colour they are generally black to very dark greenish and bluish grey, though a few lighter grey varieties also occur; smooth surfaces of some have a distinctly metallic appearance, like the grey surface of steel. Bedding is very difficult to recognize, and on many outcrops it is not Visible. To the westward on Skye Mountain the pure quartzites give way to impure feldspathic varieties, and there is, of course, a transition zone where the feldspathic types are interlayered with the purer quartzites. Locally, as on the road above the "Iron Bridge" at Churchview, 20 per cent or more of feldspar is present and visible because recrystallization has increased the grain size. In the absence of such recrystallization, it is often possible to distinguish the feldspathic variety only by the fact that, when the hammer point is drawn across it, there is left a thin scratch, instead of the streak of metal left on the quartzite.

In hand specimens no individual mineral grains are ordinarily recognizable under the lens. Instead, there is a somewhat rough appearance suggestive of the surface of ground glass. Very thin dark "hair line" markings are assumed to represent very thin laminae of dark sands, and therefore to represent original bedding planes. In only a few places in the dark quartzites are these markings sufficiently closely spaced to suggest thin beds and be visible as such in individual hand specimens.

Thickness

The thickness of the dark quartzites has not been measured directly. Because the unit passes upward into feldspathic quartzites through a zone of interbedded pure quartzites and feldspathic rocks. the thickness assigned must necessarily be arbitrary. Further, the thickness derived from measurements on the maps can be only approximate. As well. there are numerous exposures showing slickensiding; but in rocks devoid of marker horizons it has not been possible to recognize duplication by faulting, if it exists.

The thickness estimated from the maps is about 2,500 feet at Skye Mountain.

Elsewhere an extensive area, or considerable thickness, of dark quartzites has not been recognized. Though dark quartzitic rocks do occur elsewhere, they are usually as relatively minor interbands in other rocks, and therefore represent brief intervals of quartz sand deposition in a sequence dominated by other materials.

Relation to Other Units

Positive primary criteria of bedding tops were not recognized. Structural interpretation in the Craignish Hills, based ultimately upon minor folds, suggests that the dark quartzites are the oldest unit exposed there. The few exposures of conglomerate suggest that a coarser basal zone may exist, but, if the present structural interpretation is correct, the conglomerate is, in fact, in the upper part of the exposed dark quartzite zone. More probably it represents local and temporary zones of higher energy in an environment of sand deposition.

Feldspathic Quartzites

These rocks, and their metamorphic equivalents, are certainly the most extensive, and probably the most abundant, in the George River series.

The name used here is chosen as descriptive of the wide range of compositions included in this *unit.* Detailed studies of smaller areas may permit subdivision into a number of phases or sub-units. At present, such subdivision does not appear warranted and this unit is used to describe a varied assemblage of rocks which represent a long period of transition from conditions where deposition was predominantly sandy to those where mud was the dominant deposit.

Some phases, even where fine-grained, are recognizable as material which is commonly called greywacke by workers in the Precambrian and, except for absence of rock fragments, such phases are identical in field appearance with that of the typical greywacke of the Harz Mountains. We have avoided this name because we have no real evidence of the former presence of any abundance of sediments derived from mafic rocks, nor of the presence of rock fragments, as would be implied by the use of that name, and because the unit includes a greater range of composition than the term would permit.

The rocks included in this unit range from quartzite with small amounts of feldspar and mafic minerals, to those which might well be mapped as sandy slates with poorly-developed cleavage. In the field, it was often necessary to make an arbitrary decision and assign an outcrop to either this unit, or to the slates. No objective test was found, such as that used to distinguish it from the "pure" quartzites. Furthermore, it was necessary, in many places, to make a similar decision about a whole outcrop which is, in fact, composed oflayers of both slate and more sandy material. Each case was decided on its own merits, but such criteria as colour, slaty cleavage, proportions of visible minerals, and relative amounts of slaty and more massive rocks were commonly used.

The layers of differing compositions are interbanded in a considerable range of scales and thicknesses. In the present work we ignored, for practical purposes, layers of slate or schist a few rnillirneters thick in a dominantly massive and quartzitic member. More commonly, the slaty bands are a few inches to a few feet thick. Where such were estimated to form more than 50 percent of an outcrop, it was mapped as slate. Slate layers 25 to 50 feet thick were distinguished as such during the field work; during the reduction of the maps for publication, these distinctions were lost in many cases and the slate bands combined with the "feldspathic quartzites" with which they are interbanded.

There is a gradation of the feldspathic quartzites into the slates. In the same way that the dark quartzites pass into the feldspathic quartzites through a zone of increasing nwnbers of feldspathic layers, so the feldspathic quartzites pass gradually into the slates through a zone of increasingly abundant slate layers.

For this unit also, the "type locality" is the Craignish Hills.

Description

At one extreme in this unit is a somewhat impure quartzite; at the other, a sandy slate. With such a range, there is no typical material.

In some phases, this is a fine-grained rock, dark brownish-grey to black on the weathered surface, and dark brownish-grey on the fresh surface. As pointed out above, it is difficult to distinguish from the dark quartzite, Especially when damp, it may even be difficult to separate from the dark fine-grained amphibolite. In short, in its finest form the individual minerals ale not recognizable, and the rock is recognizable only by its brownish colour, somewhat "cherty" appearance on the fresh surface, and slightly lesser hardness than the quartzite.

The most abundant phase is also dark brownish grey to black, but the grain size is 0.1 to 0.5 mrn., and the individual mineral grains can usually be recognized under a hand lens, but only rarely with the naked eye. The composition is variable: quartz forms 60 to 90 per cent; feldspar, 10 to 30 per cent; and biotite, 2 to 5 per cent, though it may be as much as 15 per cent in a few bands. Muscovite OCCUIS with the biotite in some cases. The more feldspathic and mica-rich phases of this impure quartzite, as just described, would have about the overall composition of a greywacke.

This "greywacke" grades towards a slate through a phase which was called "slaty greywacke" in the field. In appearance this differs from that just described only in having a development of slaty cleavage, but to a degree much less marked than characteristic of slate and with a wider spacing between the cleavage planes as seen on the OUtClOp. Layers of such slaty greywacke 4 inches to several feet thick are interbedded with the male massive kind in many places. This development appears to represent a somewhat higher content of clay-slzed material in the interband which has now developed the cleavage effects. With **further increase in the "slaty" component, the rock grades into a slate.**

Under the microscope, a typical sample shows a well-foliated micaceous feldspathic quartzite, Quartz is approximately 85 per cent of the rock and occurs as sutured grains from 0.5 to 1.0 mm. in diameter, Feldspar, in grains 1.0 to 1.5 mrn., forms IOta 12 per cent; both orthoclase and plagioclase are present **but composition is obscured by severe alteration. Chlorite, sericite, and minor** amounts ofbiotite are present, along with a few scattered grains of magnetite.

Thickness and Relation to Other Units:

As mentioned above, the impure feldspathic quartzite grades into the dark quartzites on the one hand, and into slates on the other, In both cases, the gradation is through a broad zone of interbedding of two types, so that boundaries and thicknesses are arbitrarily set.

No section was found sufficiently well exposed to permit detailed measurement of the thickness of this unit. In the Craignish Hills, the thickness which is predominantly composed of feldspathic quartzite is about 3,000 to

4,000 feet, as estimated from the map. This thickness is probably of the correct order of magnitude, but in this area of rather poor exposures there is. of course the possibility of duplication by faults or folds not recognized.

The thickness exposed in the Boisdale Hills is only a few hundred feet. The maximum width exposed is about 1,500 feet, and this is known to include some duplication by small scale folding.

At North Mountain, again, the thickness is small. One of the wider exposures is in Mill Brook, east of Marble Mountain, and there is good reason to believe that it is duplicated by the synclinal fold visible in the quarries nearby. In this area it seems that the feldspathic quartzite represents only local interbands in the slates and limestones, rather than a major depositional unit.

Between Middle River and Nile Brook, the thickness appears to be very substantial, but again poor exposures prevent reliable estimates. Dip of the layering is generally steep, and the strike is more or less uniformly eastward. Simple measurement off the map, would indicate a thickness of about 4 miles. However, there is a small fold east of Lake O'Law, trending northward, and there is no real reason to suppose that similar folds do not occur in the poorly exposed areas to the eastward. This probably means that the thickness is much less than the wide areal extent would suggest, though it is probably substantially more than in the Craignish Hills.

The impure feldspathic quartzite is considered to be younger than the dark quartzites. This is based almost entirely upon the present interpretation of the structure in the Craignish Hills, and this, in turn, is based upon a few minor folds as indicators of the major structures. Essentially no primary criteria of bedding attitude were recognized, and certainly not in sufficient number to reveal complexities of the structure.

Quartz-Feldspar-Biotite (-Muscovite) Gneiss

In addition to the compositional variations in the feldspathic quartzite which presumably reflect differences in the components of the original sediment, there is superimposed a mineralogical variation due to metamorphism. The ultimate product is a quartz-feldspar-biotite gneiss which approaches granite in appearance. An intermediate stage was mapped simply as "quartz-feldspar-biotite rock".

In the Craignish Hills, the metamorphic changes are slight, and result in a slight increase in grain size only. This is most noticeable on the road which leads to the top of Skye Mountain from the Iron Bridge, at Churchview, especially in the brook at the first hairpin bend above the bridge, and on the other bends just above. The result is a quartz-feldspar-biotite rock, in which the individual mineral grains are easily recognizable. This coarser-grained phase occurs in a few places only. Presumably the larger grain size represents slight metamorphism, but at Skye Mountain this material is apparently overlain conformably by normal slates and schist which do not show the effect. Similar coarser quartz-feldspar-biotite-muscovite rock also occurs north of Glendale and Melford.

Elsewhere in the Craignish Hills, the "impure quartzite" is the fine-grained variety described above.

In the *Boisdale Hills,* also, much of the impure feldspathic quartzite is the brownish, fine-grained variety in which individual minerals are not recognizable and which looks much like a quartzite. There are some coarser quartz-feldspar-biotite phases as well, but again the volume does not seem to be large. They are mainly on Frenchvale Brook near Sandy McLeod Lake, and at Upper Leitches Creek.

In the *Middle River area,* however, metamorphism and recrystallization are extensive. In the southern part - such as at Gillis Brook on Crowdis Mountain - the fine-grained, dark, brownish-grey phase is dominant. Northwestward, in McLean Brook, the upper parts of the Gold brooks, Fortune Brook, and a number of smaller brooks draining into Lake O'Law and Harvard Lake, this rock is generally the coarser-grained variety. In Nile Brook and the "Back Brook" at Murphy Settlement, the rock grades into a quartz-feldspar-biotite gneiss, and the boundary between the two has been arbitrarily set at the garnet isograd. To the eastward, more or less from Duncan Brook to Nile Brook, the gneiss is the major rock type.

For mapping purposes, it is called "quartz-feldspar-biotite-(muscovite) rock" when the individual constituent minerals are easily recognizable under the hand lens or to the unaided eye. Further metamorphism produced "quartz-feldspar-mica gneiss" and the boundary between is arbitrarily drawn to coincide with the garnet isograd – above which the gneissic foliation is usually present.

Description

The characteristic quartz-feldspar-biotite rock is grey to dark grey in colour; medium grained, with individual mineral grains up to 1mm but averaging about ½ mm; and it has a compositional banding which is especially marked on approach to the boundary with the gneiss, into which it grades.

The banding obviously reflects original compositional layering in the sediment. This is accentuated by the colour differences, because the sandy layers recrystallize to light bands of quartz and feldspar, while the other layers are rendered dark by the biotite they contain. In the less severe stages of this development the bands are thin and the effect is simply to accentuate the bedding laminae. As the gneiss is approached, the individual bedding laminae are destroyed by the recrystallization and, in the gneiss, layers half an inch to several feet thick are essentially uniform.

The gneiss, at about the garnet isograd, as seen south of Bothan Brook on Middle River, is banded on both a large and a small scale. In general, two types are present, with intermediate varieties in smaller amount. The more mafic variety *is* black to dark grey, schistose, and marked by large muscovite flakes on the foliation layers. Quartz is a relatively minor constituent, and forms about 25 percent of the rock. Mica, including both biotite and muscovite, probably is about 10 per cent, but because of the foliation it looks very much more abundant. The balance is grey feldspar. This rock appears as very dark bands interlayered with the lighter types. The lightest phase has a faint foliation visible on the weathered surface, which is brownish grey and shows small (less than 5mrn) porphyroblasts of feldspar. Large porphyroblasts (up to 2 cm) are present in a few places. The fresh surface is also brownish grey with a faint foliation. Quartz forms 50 to 60 per cent and mica (which is almost exclusively muscovite) about 3 to 5 per cent of the rock. The balance is light grey to bluish-grey feldspar. Garnet is present in many layers, but it appears to be very sensitive to compositional variations and immediately adjoining layers may be with, and without, garnet. Pegmatite and aplite occur as large sills and almost concordant dykes, as well as in the form oflarge stringers. Such dykes have muscovite flakes up to I cm. or larger.

Elsewhere, as on Fortune Brook, the dark bands may be thick arnphibolites, with a very thin internal layering. There is no doubt that these were originally sediments, though the amphibolites, in general, are a problem, as discussed below.

In an area marginal to the granite, such as Nile Brook, the gneisses show alteration effects related to it; most noticeable are augen gneisses and a red "granitic" rock.

The augen gneisses are brownish weathering and contain rounded feldspar grains about 1 cm in diameter and sufficiently abundant to give an impression of feldspar grains separated, and outlined, by thin septa of mica. Actually, there may be up to 20 per cent quartz, as elongate grains, also present in the interstices between the feldspars. On the fresh surface the augen are not so obvious and the rock looks much like a gneissic granite. The feldspar is distinctly red in coJour, and no grey feldspar is present. Average grain size, outside the porphyroblasts, is about I mm.

The red "granitic" rock is best exemplified in the lower part of South Nile Brook. In contrast to the true granite to the northeast, it is gneissic and has, in some places, the sandy appearance of the paragnetsscs, though the layering is generally much less obvious. The suspicion that this "granite" is just the grey paragneiss, with a red feldspar or hematite alteration added, was reinforced by discovery of red alteration adjacent to fractures. In one outcrop one can see the complete gradation from single fractures, with a ½-inch alteration halo, to numerous intersecting fractures, the alteration haloes of which have merged one with the other to give a completely altered appearance to the rock. This is probably basically the origin of the red granitic gneiss. But the colour itself is due to hematite, which is related to biotite from which it is probably derived. The microscope also shows that the hematite increases toward the surface of specimens and is the result of a weathering effect on the biotite.

The augen gnetsses may have a similar origin as the result of feldspathization. Large feldspar porphyroblasts have been found as a halo around granodiorite dykes cutting the gneisses.

At the highest grade of metamorphism, and in the vicinity of the granitic rocks, there is an increase in the amount of aplite. This occurs as dykes and sills, usually one to two feet thick, and probably forming less than five per cent of the total rock. Such aplite appears to be directly related to the intrusive rocks, and is probably derived there from. The gneisses do not ordinarily have the swarms of thin, branching, and interfingering aplite stringers characteristic of the sillirnanite-zone gneisses in the Canadian Shield.

Slates and Phyllites

Slate is a widespread type in the George River rocks. As with the other units, the Craignish Hills are considered to be more or less the type locality. The best exposures are on Blue's Brook and the smaller streams immediately east of it, though there is an extensive area of slate between Maple Hills and the Soapstone Road. Very considerable areas of slate also occur on Middle River, especially near Muskrat Brook. There are lesser amounts in the Boisdale area, and near Campbell and Dallas Brooks in the North Mountain area.

On the maps two types only are distinguished: one is dominantly brown and black slates, and the other composed of slates of different shades of grey. There is, of course, some degree of interbedding of these units and of the feldspathic quartzites and greywackes. A fairly representative section is well exposed on Blue's Brook. This was measured foot by fool. Rather than include this detailed log in the present text, it has been filed with the N.s. Department of Mines as an appendix to this memoir, and may be consulted there by anyone who may be interested in the details.

Grey Slates

Grey slate is the most abundant variety. In outcrop this is typically light grey to pearl grey in colour, very fine grained, and cleaves into layers, which may be as much as 1/4 to 1/2 inch thick or as thin as paper. In some cases, the colour has a distinctly greenish cast, presumed to reflect the chlonte content of the rock. In extreme cases, individual minerals are not recognizable because of the fine grain of the rock. More commonly, biotite is recognizable on the cleavage surfaces with, or without, muscovite or sericite. The latter gives the characteristic silvery sheen to the surface of the phyllites. In some cases, quartz and feldspar grains are also recognizable; as the grade of metamorphism is increased, so too is the grain size and, at Middle River for example, the individual mineral grains can be recognized in many places.

A section of typical material shows a thinly laminated slate containing about SO per cent fine-grained quartz (0.01 mm) and 2 or 3 per cent each of potash feldspar and plagioclase (Ab9S) in grains about the same size. The remaining 40 per cent, approximately, is in grains smaller than 0.01 mm, and is composed of sericite, larger flakes of muscovite, about 3 per cent of biotite, I or 2 per cent of chlorite, S per cent quartz and a few grains of opaque minerals. Some sections contain smaU amounts of epidote,

Black Slate

The black slate typically is dead black to brownish-black on the fresh surface, black, greenish black, Or dark brown on the weathered surface, is very fine grained, and usually has good laminae up to 1/4·inch thick. The laminae are marked by a slight colour difference on the weathered surface, which has a brown limonitic stain in many places. In some cases this is due to very sparse disseminated pyrite; in others, it may be derived from the contained micas. A thin section shows 30 per cent quartz in grains from 0.01 up to 1.0 mm. These give the rock a "pebbly" appearance in the slide and represent fine sand grains in a matrix of about 40 to 4S per cent "mud," of grain size less than 0.01 mm. Similar rounded grains of kaolinized orthoclase and slightly altered a1bite (Ab9S) each amount to about 8 per cent of the rock. The fine matrix is composed of quartz (10 per cent), sericite (IS per cent), biotite (S per cent) and minor chlorite, with a few scattered grains of magnetite.

Graphitic Slate

A black graphitic slate occurs on Campbell Brook (North Mountain) and north of Glendale on some of the small tributaries on the west side of River

Inhabitants. In the latter case, there was some small production of graphite about 100 years ago. according to FIetcher. These slates were recognized only in these two areas.

The graphitic slate differs little in appearance from the normal black slate though. of course. the colour of the powdered rock is different, and there is sufficient very fme graphite to blacken the hands.

Thickness

Thickness of the slate units is known only for the Blue's Brook section. Estimates made from the map indicate a total thickness of about 2,700 feet. mainly grey slate, between the upper end of River Denys and Maple Hills. Eastward. there is considerable interbedded feldspathic quartzite and greywacke; on BIue's Brook the total thickness of slate is 1.690 feet. Just less than 1.400 feet of this is in two bands in the lower part of the brook; they are separated by 600 feet that is dominantly greywacke.

The breakdown of thicknesses (in feet) for the complete Blue's Brook section is given below:

TABLE 1

Top of Section: Blue's Mills

Division	Slate	Impure feldspathic quartzite	Interbedded feldspathic quartzite (including slaty varieties)	Quartzite	Obscured
I	245	35			
2	45	560		40	
3	1,140	25			100
4	15		185		380
5	210		75		380
6	30		275	75	1,010
7	5	485		95	1,655
Total	1,690	1.105	535	210	3,525

Bottom of Section: Bridge on Maple Hills-Bkye **Mountain Road**

In the *Oowdis Mountain* area, at Muskrat Brook. measurements off the map indicate about 1.400 feet of slate. mostly of the black variety. On McLean's Brook. at Finlayson, there is a similar indication of about 1.400 feet of grey slate. but this is not continuously exposed and includes a possible thick interband of amphibolite.

In the *North Mountain area.* the slate is apparently much thinner. The maximum thickness. estimated from the map. is about 900 feet. on a tributary of Campbell Brook about three quarters of a mile northwest of the MacMillan farm buildings. Elsewhere in the North Mountain area. the apparent thickness of the slate has probably been increased by close folding.

In other areas, slate is of minor importance in the section. In the *Boisdale Hills,* slate is a negligible part of the section mapped. North of Middle River, to Northeast Margaree, the metamorphic grade is sufficiently high to have recrystallized the slates if they were present.

Relation to Other Units

Based almost entirely upon the current interpretation of the structure of the Craignish Hills, the slates are considered to be overlying the impure feldspathic quartzites and other more siliceous rocks. The table on page 25 shows that there is much interbedding of the sandy with the pelitic material, with a marked upward increase in the proportion of slate. The map also shows a lateral variation and interfingering of the slate with the quartzitic units. Presumably this represents a lateral facies variation in the basin of deposition, and encroachment, at irregular intervals, of sandy material into the margin of an area of mud accumulation. The interbedding of greywacke and impure quartzites in other places (e.g. McLean Brook and Second Gold Brook) also suggests the same type of deposition on a basin margin.

It should be pointed out, however, that all is not as clear cut as the above may seem to indicate:

(1) In the River Denys-Blue's Mills area, the interfingering of rock units is interpreted from stream traverses as much as 1½ miles apart, plotted on a map without contours, on which correction for topographic displacement of dipping beds could not be made. The supposed depositional pattern may, therefore, be merely incorrect correlation of units, though the general *proportions* of slate and other rocks are probably valid.

(2) The north side of Skye Mountain seems to be free of such interfingering of units. This would be not unreasonable if the slates there represented the former westward continuation of the grey slates at River Denys, i.e. if they have a fault boundary with the quartzites all along the north edge of the mountain. But it is not reasonable *if* they represent the north limb of an anticlinal fold - for there is no reason to suppose that one limb of the fold would represent a depositional environment so much different from the other limb less than a mile away.

The slates are overlain by limestones in the Craignish Hills. The general spatial relation can be seen in the upper part of River Denys, but the contact is there complicated by faulting in the brook, and there is a wedge of greenstone between the slate and the limestone at Upper Glencoe. To the east of Campbell Brook (North Mountain) the nearly vertical black slates are succeeded eastward by limestones; here, too, drilling has shown that there is faulting at the contact and that at least ISO feet of dark quartzites intervene between the limestones and the slates. In the Crowdis Mountain area, the slates have greenstones interbedded and are associated with extensive greenstones.

The evidence, on the whole, suggests that the deposition of limestones in the Craignish Hills was contemporaneous with vulcanism in the Cape Breton Highland area, that the edge of the area ofvulcanism extended into the Craignish for a time, and that this change in conditions coincided with the end of mud deposition.

Limestone and Dolomite

The descriptions which follow concentrate especially upon the aspects of these rocks which are visible in the field.

The accompanying maps show subdivision of the carbonate rocks only into limestone and dolomite, with a further distinction between light and dark limestones in the Craignish area. This is entirely a field distinction and is based primarily upon the reaction of the rock to cold dilute HC!. In practice, of course, one makes such distinctions as dolomite, calcareous dolomite, dolornitic limestone, etc., based partly upon the reaction to HCI, and partly upon the amount of dolomite in the rock, as indicated by the characteristic sandy weathered surface of the dolomite. Many staining tests on sawn and etched surfaces of the rock were also made to aid in judging the amount and distribution of dolomite in the carbonates of the Craignish Hills.

There is, in fact, a wide variety of carbonate rocks. There are many colour variations, the content of acid insoluble material varies widely (as does the mineralogy of the insoluble fraction), and the character and texture of the rocks also shows a great range.

Field Correlations within the Carbonates

The problem of correlation from one brook, traverse line, or even outcrop, to the next becomes acute in the carbonates. Detailed mapping in the Marble Mountain quarries, where individual layers could be followed, showed that small-scale complex folds are to be expected in the carbonates. Furthermore, in some of the limestones there, a streakiness, or foliation, approaching layering in appearance is parallel to the axial plane of the folds. Whatever the mechanism that produced it, the practical result is an uncertainty about the validity or significance of layering found in isolated outcrops: is it bedding or foliation?

Colour and textural variations are potentially the most useful criteria for field correlation. They are the basis for correlation on the accompanying maps, but the results are something less than satisfactory. A special effort was made in the small area of the Boisdale Hills. The following table shows the recognizable varieties of carbonates, but they could not be followed as mappable units, even though the traverse lines were separated by 300 yards, or less.

TABLE 2

Variations in Carbonate Rocks

(George River Quarry to Steele's Crossing)

A.	White, crystalline limestone with irregular black streaks and patches
B.	Pearl-grey, fine-grained limestone with irregular black streaks
C.	White, coarse-grained, crystalline dolomite
D.	Greyish-white to pinkish-white limestone
E.	Bluish-white to white llmestone
F.	Pure white, coarse-grained crystalline limestone
G.	White. medium to coarse-grained limestone, with brown spots
H.	Dark, bluish-grey fine-grained limestone
l.	Greenish-grey, fine to medium-grained limestone
J.	Greenish-white limestone
K.	Brownish-grey, medium to coarse-grained, crystalline limestone
L.	Blue-grey dolomite, usually with a "sandy" weathered surface

M. Dark grey dolomite
N. Black. fine-grained limestone
O. Blue-grey limestone. with lighter and darker bands ¼ to I inch thick
P. White to light-grey dolomite, with greenish-grey streaks
Q. White limestone, with grey streaks
R. Buff to blue-grey, fine to medium-grained limestone

Some of these appear to grade into one another.

This raises the whole question of the cause of the colour *in* the limestones. (There are some practical implications here; some of the marbles have very pleasing colour, but if it is not a primary feature the possibility of commercial quarrying is much reduced.) In the black limestones the colour is apparently due to small amounts of clay, or other very fmely divided material, which forms a part of the acid insoluble fraction of the rock. This presumably is primary and therefore useful for identification, though subject to regional variation. Similarly, some pink and reddish marbles owe their colour to finely divided material, probably hematite. But there are cases, as at Campbell Brook, where the colour is related to fractures and faults, therefore secondary, and of no value for correlation. This presents no problems provided one recognizes that the colour is secondary.

It is probable that colour and textural variations can be used for field correlation of the limestones, but this probably also requires that the individual units be followed by "walking them out".

An attempt to use, *in* addition, the amount and mineralogy of the insoluble residue shows some promise, but has not yet been sufficiently developed.

Distribution

Limestone and dolomite are a large part of the assemblage in the type area at George River, but the largest area of carbonate is probably that at Upper Glencoe and north of East MacPhail Brook, *in* the Craignish Hills. there is also a considerable area at Maple Hills, Kewstoke. Smaller areas occur *in* the valley of River Inhabitants north of Glendale, and as a band across, and along the south face of, North Mountain.

Dolomite is a relatively minor part of the carbonates. At George River it is an important feature commercially, as it was formerly at New Campbellton and at Marble Mountain. It occurs also *in* a few places (MacPherson's Brook, west of Glendale; Diogenes Brook, north of Melford) *in* the Craignish Hills, and two outcrops were found near Fionnar Brook, in the Middle River area. Dolomitic limestone, as *distinct* from nearly pure dolomite, is more abundant, and many of the limestones described above have some dolomite within them.

There is singularly little carbonate in the Crowdis Mountain and Middle River areas. Except for a narrow band on Middle River near Fionnar Brook, and another on that brook itself, there seems to be essentially none *in* that whole district. One presumes that the absence of limestone and the increased amount of amphibolite represents a period of vuleanism here more or less contemporaneous with limestone deposition *in* other parts of the George River basin. (The character of the amphibolite is discussed below, page 33, but one should here point out that its volcanic origin is by no means certain.)

Description of Limestones

White to bluish-white, coarse-grained marble is a common type. This has crystals up to 1/8 inch (3mm) visible on the fresh surface, though the average grain size is probably about I mm. In this variety, the marble is essentially uniform and pure, with only a few dark specks due to magnetite, garnet, or other impurities. Variations of this include greenish-white and pale buff colours, into which the white rock may grade, and a rock with brown spots, each with a tiny black grain of magnetite or garnet in its centre.

A white rock with light grey, bluish-grey, greenish-grey, or bluish streaks appears to be a variant of the above. The streaks are, in some cases, very faint and discontinuous; in others, long irregular lenses up to ¼ or ½ inch thick; in still others, they approach a regular banding suggestive of bedding. In some places, as at Marble Mountain, the streaks are parallel to the axial planes of folds, and are therefore analogous to axial plane cleavage. In other cases, they may be bedding layers disrupted and deformed by folding, plastic flow, and recrystallization.

A grey limestone may be considered as an intermediate phase between the white and the dark varieties. Several variants also occur within this: in the field they were described as light blue-grey (about a battleship grey), light grey, light grey with black streaks, greenish-grey, "grey thinly-laminated limestone with ridges weathering up", and "blue-grey limestone with white calcite stringers." The last two are probably variants of two very dark varieties described below.

The most abundant limestones are dark grey, dark bluish-grey, black, or bluish-black. These too may be massive and fine to coarse grained; or may have a strong and regular banding which evidently is bedding. In most cases, the banding is shown by dark layers, of slightly different colour and ¼ to ½ inch thick, but in some cases about a third of the layers are white. The dark limestones, on the whole, tend to be fine grained.

The first of two characteristic varieties within the dark limestones is a dark bluish-black, fine-grained rock cut through in all directions by stringers of white calcite up to an inch thick. This gives almost the appearance of a breccia, and the rock was, for convenience, described in the field as "blue-black brecciated limestone". The white calcite veins are obviously fillings of randomly oriented fractures, but there is nothing to suggest that this is related to a fault or other tectonic feature. The fracturing, rather, appears to have been restricted to a single horizon or member.

The second of the two varieties is characterized by minu te laminae high in clay, which weather up as tiny ridges on the surface of the outcrop. These laminae are much contorted, with the individual crinkles I to 5 millimetres across, and much resemble stylolites. In some cases the thin laminae have been broken during recrystallization; they may be merely disrupted, or the rock may have patches of the "stylolitic" pattern separated from one another by several inches where it is essentially absent. Generally, the laminae are exceedingly thin; in a few places they are thicker and tiny garnets were recognized in one or two laminae where the metamorphic grade was appropriate to produce them from this muddy interlayer. This rock was called "stylolitic limestone," in the field, though there is some doubt that the pattern involves a solution phenomenon.

Though the above descriptions are based primarily on the observations recorded from Upper Glencoe and from Marble Mountain, a comparison with the table on page 23 will show that they are representative also for the limestones of the Boisdale Hills.

Outside the neat categories of light and dark limestones are two unusual varieties. These are described below:

In the Marble Mountain quarries there is a brownish cale schist. This lies beneath the so-called "Fourth White" limestone, and forrns much of the talus slope above the third bench of the lower quarry. In its more massive form this is a reddish-brown, mottled, fine to medium-grained limestone; in its extreme form it weathers out of the quarry wall like coarse sand. The most common appearance is in rhombic prisms or flat plates a few inches long. These separate readily and ate the source of the fragments at the base of the quarry wall. A rock such as this would weather rapidly and it is probably only because of the quarry that it is exposed here; it has not been recognized except in the immediate area of this quarry. One supposes that the closely jointed to schistose character is due to interlayer movement during the folding of the limestones.

The second unusual rock occurs in a number of places: Several outcrops occur at an old mill site by the lake at the beginning of Dallas Brook (North Mountain) and to the northwest between there and the upper branches of Campbell Brook. A number of scattered outcrops also occur between the upper branches of Diogenes Brook and the Glendale-vUpper Glencoe Road.

This rock weathers to a buff Ot brown surface, with the deeper weathering on joint edges which is characteristic of the limestones, and the outcrop looks like that of a limestone. The fresh surface is very fine grained and bluish-black to bluish-grey; in only a few places is it white. It is generally very tough, and in some cases, it breaks with a rounded fracture approaching sub-conchoidal. The rock will effervesce in cold HCI, sometimes strongly, but is also hard enough to scratch the steel of the hammer.

From these characteristics one supposed, in the field, that it was a sandy limestone such as the *Kieselkalk* of the Alps, which it resembles exactly. Now, the Alpine *Kieselkalk* is a unique and extensive rock. never more than 20 metres thick, which has been followed all the way across the Swiss Alps. Apparently there the peculiar conditions necessary for its deposition did not occur more than once. On the assumption that this unique rock, then, is not likely to occur a number of times in a depositional sequence, there was some hope that it might be a useful marker horizon to aid in working out the structure.

In the course of his petrographic work, Chatterjee examined some sections of this rock. Instead of the sand grains expected, he found oolitic grains and some siliceous material which looked as if it might have been organic in origin. Sections of this were examined by Professor Francesco Barbieri, of Parma, but he does not consider the material diagnostic; it is neither possible to identify the form, if organic, not to prove that it is not organic. Photographs taken by Barbieri are reproduced below as Plate I.

Description of Dolomite

The dolomite appears to be interbedded with the limestones. In the Boisdale area, where it is perhaps most abundant, there are layers of dolomite a few feet thick within the limestones and conformable with them. The distribution of the dolomite shows no recognizable relation to the faults, fracture zones, igneous rocks, or other possible sources or channels for the supply of the magnesium necessary if the dolomite is the result of alteration of a limestone.

New Campbellton may be an exception. In the east wall of the quarry, there is a large irregular mass of limestone which is made up of a number of slices separated by small thrust faults. This has been interpreted as a remnant left from the alteration of a limestone bed to dolomite. In the next valley to the west, two pods of granite occupy the same stratigraphic position. However, it is possible that the limestone simply represents portions of the main limestone band, which is a few feet to the north, thrust upward into view. Further, it is also possible to read the limestone as the core of a tight fold, and the granite, of course, is a much later rock. But this latter possibility is not entirely compelling. for there is no other evidence for the presence of such a fold.

Dolomite weathers light brown with a characteristic rough, sandy surface. The fresh surface is white, in some places a bluish or greenish cast, and the rock is typically coarsely crystalline, with grains up to 3 or 4 mm, though the average size is about I mm. At George River, and at Marble Mountain, there is extensive alteration. It occurs as tiny yellow spots and stringers which are, in many places, associated with fractures, or filling them. More extensive alteration renders the whole rock yellow. and the most severe alteration produces a dark greenish mass of serpentinized rock. Much of this severely altered dolomite has the smooth greasy feel of talc, which is a secondary alteration product. It also contains enough calcite to react to dilute HCl, and Chatterjee has shown that this calcite is a by-product of the serpentinization of the dolomite. At George River this alteration is extensive and yellowish masses form a substantial part of the quarry wall. In the upper quarry at Marble Mountain, the alteration is much less severe, and extends into the rock as a yellowish halo for about half an inch from all fractures.

Alteration

Metamorphism of the limestones and dolomites, except for the yellowish serpentinization just described, produces no effects which are obvious in the field. Many are recrystallized to coarse marbles. but there are generally no obvious mineralogical changes. Early in the work this caused some concern: For example, the white marbles at McAskill's Lake (North Mountain) are separated from granitic outcrops only by the 300 foot width of the lake, yet appeared to be completely unaltered except for recrystallization. Serious consideration was given to the possibility that the marbles might be silting upon the granite. Later, petrographic work showed that this was a completely unwarranted supposition, and that wollastonite and other high temperature metamorphic minerals are, in fact, present as they should be.

The limestone at Meat Cove has been more obviously altered. There is serpentinization, though not as extensive as at the George River quarry, and there is additional development of brucite, with its characteristic round white grains on the weathered surface.

The petrographic details of the altered carbonates are complex for all except the ver;' pure varieties, Primary and secondary alteration have produced an elaborate suite of mineral assemblages which are treated in detail by Chatterjee in Chapter IV.

The "carbonate-bearing zone," so called, on Fionnar Brook (Middle River) merits brief comment. The direct evidence for it is three outcrops in the brook, separated by gneisses.Tust south of it there are two zones of dark, ,hornblende·rich gneisses, one of which is cJosely associated with a band of marble on the north bank of Middle River, and with some dolomite on Fionnar Brook. Southward, in Sarach Brook, there is another band, and a couple of isolated outcrops, of limestone. The above suggests the possibility that the dolomite and limestone may be nearly pure carbonate bands in a sequence that contained some marl or similar impure carbonate - now metamorphosed to the hornblende-rich gneiss – and that the size and proportion of the purer carbonate layers may increase northward on Fionnar Brook. It is this reasoning that has led to the special labelling to draw attention to the zone on that brook.

Upper Quartzites

Overlying the limestones are light-coloured quartzites. As with the orher units, the relations are those shown in the Craignish Hills, especially the area, north of Melford, between Diogenes Brook and East MacPhail Brook. Good examples of these rocks can be seen in the tributaries on the north side of Diogenes Brook, where the quartzites form high ridges, and the streams run across them in steep valleys and gorges with many falls. Quartzites of this group occur west of the Glendale-Upper Glencoe Road north of Glendale, and also about half a mile north of its junction with the Melford-Judique Road. In both of these last two areas, the map includes as quartzite some of the *"Kieselkalk"* described above.

Quartzite, considered to be the equivalent of the above, also occurs as a narrow band ro rhe east of the limestones at Campbell Brook, but this unit does not appear to be extensive in the North Mountain area. Quartzites also are found in the type area in the Boisdale Hills. The present work covered only a stretch of about 12 miles from George River Station southwest to Steele's Crossing. Within this area, and the part of it shown as quartzite by Bell and Goranson on G.S.C. Map 360 A, there are present white and brownish-white quartzites very similar to those of Diogenes Brook. Fairly good examples can be seen in the quarry where Highway 23 crosses George River.

In the Boisdale area, the correlation of the clean, light-coloured quartzites with the "Upper" quartzites of rhe Craignish Hills is complicared by the presence of impure feldspathic quartzites and greywackes. Such should be separated from the upper quartzites by the limestones and dolomites, if the present interpretation of the sequence is correct. No matter how one interprets the major structure, the feldspathic quartzites at Upper Leitches Creek are anomalous. However, in the Craignish Hills there are interbands of feldspathic quartzite, greenstones, and greywacke in the main zone of the "Upper" quartzites. It is possible that the irregular band at Leitches Creek is the equivalent.

Description

The typical "Upper" quartzite weathers white, pale brown, or buff; is very resistant to erosion and therefore forms ridges and cliffs; in some places it is strongly jointed and tends to break into large prisms. The rock in many places is very tough and difficult to break. Its fresh surface is white, grading through various shades of brownish white, to a buff variety which owes its overall colour to brownish spots. The rock is composed of clean, well-rounded quartz grains cemented by quartz. Grain size is less than one millimeter, averages less than half that, and in any particular unit is generally remarkably uniform; the sorting in the original sand must have been very good. Typically also, the quartzites are massive and bedding laminae are not well developed. Individual bands may be several feet thick, with nothing more than faint discontinuous streaks suggesting bedding. Samples of the c1eanest and whitest phases, from Diogenes Brook, contain approximately 98 per cent SiO_2.

In addition to the typical material just described, this zone of "Upper" quartzites contains rocks coloured greenish-white, greenish-grey, grey, and bluish-grey; but otherwise, apparently, differing in no important aspect. Locally there is a reddish quartzite which, in places, has a distinct purplish cast (called in the field the "mauve quartzite") and a dark quartzite with very elongate red and dark green streaks.

Thickness

For this unit, even more than for the others, the original or present thickness is not known.

In the Boisdale Hills, the area shown as underlain by quartzite (based in part upon occurrence of float) suggests a total thickness in excess of 3,000 feet. On Frenchvale Brook there are very gently plunging folds a few hundred feet across and with steeply dipping limbs. The map gives a greatly exaggerated impression of the few feet of rock actually involved. There is also considerable faulting. There is really no way to tell if this same situation obtains for the poorly exposed quartzite area. Such poor exposure of this resistant unit in itself suggests something is abnormal.

In the Craignish Hills. there is a very extensive area of quartzite, nearly all dipping very steeply. There are many fault zones on West MacPhail and other brooks there. Some have substantial displacement; others have apparently only minor movement; not all are shown on the map.

The probable minimum thickness seems to be about 2,000 feet, based upon exposures north of Diogenes Brook. One of the more continuous sections is on a tributary which joins Diogenes Brook just east of the site of the former "Chisholm's Mill"; but this section, too, may have some thickening by duplication.

In the North Mountain area, and at Middle River and Crowdis Mountain, quartzite is a relatively minor component.

West of St. Ann's, there is a high bald ridge of white quartzite extending northward from Christopher MacLeod Brook, apparently for many miles. This is light coloured, clean rock typical of the "Upper" quartzite. To the east, on Goose Cove Brook, is impure quartzite and greywacke. The total thickness of the white quartzite on the ridge is at least 2,000 feet. This is interpreted as part of a sheet thrust over the Horton, and part of the quartzite is probably missing.

CERTAIN UNUSUAL OR PROBLEMATIC ROCKS

Red and Green Striped Quartzite and Felsite

In a number of places, but especially on Muskrat Brook. there is a characteristic quartzite with parallel red and green, and in some cases white or

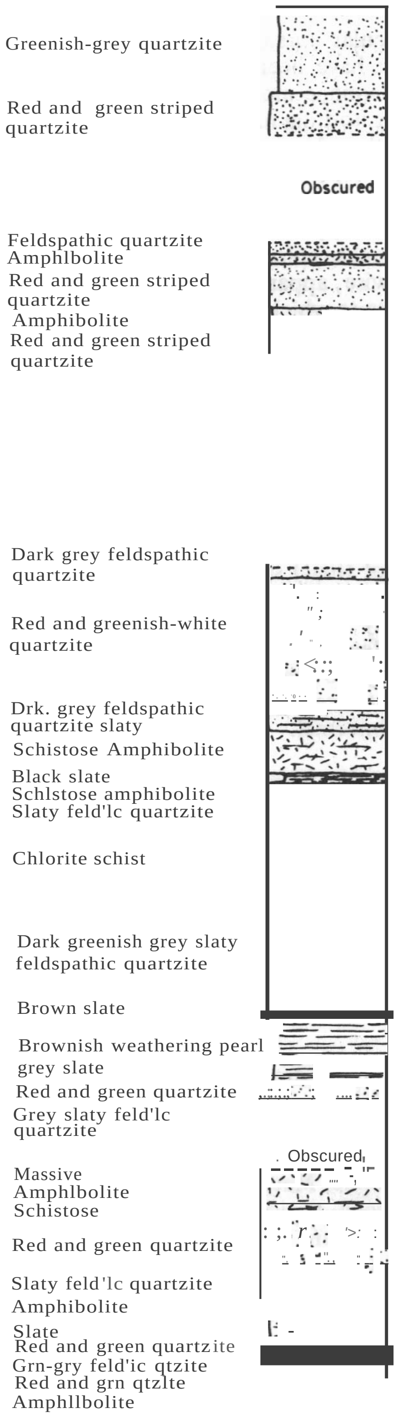


FIGURE 4 *"Red and green striped quartzite" is interbedded with normal sedimentary rocks. Diagram also shows normal variation in types within a single map unit.*

grey stripes. Where such a rock appears in other places, e.g. "Mill Brook" at Marble Mountain, or east of Blue's Brook, it is generally thin and forms a small part of the whole. On Muskrat Brook it has an aggregate thickness of about 150 feet, though there is much additional interbedded material.

Its relations to other types are shown on the adjacent diagram. There is no doubt that we have here a normal sedimentary rock of a characteristic colour.

The appearance in outcrop varies somewhat. Most outcrops are rather limited and, within their extent, parallel colour bands about ¼ inch to ½ inch thick are regular and continuous. These no doubt are bedding layers. In other places it grades through discontinuous layers into long lenses and streaks which may be somewhat irregular, or even contorted. In extreme cases, the lenses become small and give the rock a lineation, rather than a foliation.

In most cases, the mineralogy is not evident. The rock usually is very fine grained, and hard. In a few places very tiny needles, altered to chlorite, are visible in the green layers, and grains of feldspar can sometimes be recognized in the lighter layers.

Elsewhere, there has been some difficulty with rocks of similar appearance. In a number of cases, a fault zone in greenstone has been altered by silicification and the addition of feldspar. If the zone were originally schistose, the result of a lit-par-lit introduction is often a very hard, dark green, fine-grained rock with tiny lenses, longer streaks, or even layers, which are high in feldspar, with the whole resembling very closely the quartzite described above. In the limited exposures of the brooks, it may only be after much work and confusion that the fault zone is recognized as such.

The problem is well exemplified in the upper part of McLean Brook at Finlayson. This was described at the time in the following journal entry:

"We have been mapping a 'red (or pink) and green striped quartzite' which is very hard, looks like quartzite, and has all its attributes - except that it is too fine grained for mineral identification. The dark streaks in it are discontinuous, rather than continuous layers and. in a few places, have been lineation rather than foliation. Even where foliated, the foliae are of hairline thickness and are continuous for only about 5 mm (2 inches) maximum. Then we came upon an outcrop where the 'quartzite" is interfingered with greenstone, and has an edge such as might be formed by a dyke interfingering with a very schistose wall rock ... Then we found a cliff with 'red and green quartzite' CUlling greenstone. The dark green streaks are here up to I cm. - and these wide streaks are truncated squarely by the lighter material, which must therefore be a felsite. Finally, today, we found the 'quartzite', complete with pink layers, and the whole cut by stringers of the same felsite that formed the laminae."

Red Quartzite and Syenite

A red quartzite causes similar difficulties. As mentioned above, the "Upper" quartzites locally include a reddish-brown variety. Where sufficiently coarse grained, the individual grains of the original sand are recognizable; where not, the rock simply has a fine-grained, somewhat glassy, fresh surface. Now, small stringers and dykes from the granite and syenite, especially the laller, are fine grained and glassy, because chilled, and they approach the quartzite closely in appearance. When such occur as small sills they may be regularly mistaken for quartzite or rhyolite interbands in the normal sequence.

AGE OF THE SEDIMENTARY ROCKS

A thick sequence of sedimentary rocks was deposited upon an unknown – or unrecognized - basement. The conglomerates, which form a very small part of the lower units, contain pebbles of sedimentary material, some of which could conceivably be pieces of the surrounding materials, re-worked or transported prior to complete consolidation. Such an explanation is inadequate for the pebbles of vein quartz and dicrite, which must represent a still earlier and unknown source.

Dating of the complete assemblage is based, in the final analysis, upon lithological correlation. That is, identification of the rocks of the Craignish, Middle River, and North Mountain areas with those of the George River area, is based upon lithological similarities only.

In the Boisdale Hills, the age of the sedimentary rocks is established as pre-Middle Cambrian. Bell and Goranson reported, on G.S.C. Map 360A, based upon field work of 1930 and 1931, that at Long Island fossiliferous Middle Cambrian rocks overlie pyroclastic and other volcanic rocks which, in turn, overlie the George River rocks. In this area. too, the George River rocks have been invaded and metamorphosed by granites. Recent dating by the Geological Survey of Canada has shown an age of 493 million years for a sample of granite from near Sandy McLeod Lake.

A similar line of reasoning gives a somewhat greater age for the sedimentary rocks of the Craignish Hills. Dykes CUlling the George River rocks on McAskill Brook at Skye Mountain have recently been dated by Cormier. His two samples give ages of 505 and 515 million years, which would again be a Cambrian age. The age of the George River rocks must be greater than that of the dykes and of the intrusive body with which they are associated and from which it is assumed they are derived. There is a difficulty. however.

The metamorphic grade of the George River rocks is anomalous. Parsons examined many sections from the slates of that area; he could find no garnet, staurolite, sillirnanite, or other minerals characteristic of a metamorphic grade greater than the biotite zone, and, in fact, the rocks are obviously only slightly metamorphosed. Yet the main mass of slate, near Blue's Mills is about three-quarters of a mile from the intrusive and, at the upper end of Blue's Brook, the impure feldspathic quartizites are only a few hundred yards away from it.

Though the metamorphic grade is low, the age relations seem to be definite. Numerous red granite dykes, such as those dated by Cormier, and from the intrusive in question, are found cutting the impure quartzites in McAskill Brook, at the eastern end of Skye Mountain. Strangely enough, this seems to be the only place where they are numerous; none are recorded, for example, from Blue's Brook or the three streams to the east of it.

There are three alternatives, apparently:

(1) the intrusive did not metamorphose its roof rocks, or

(2) there is an unrecognized structural break and the age of the granitic

mass may then have no relation to that of the rocks it is thought to intrude, or

(3) there has been a subsequent regional metamorphism which has reduced the grade of all rocks, the granite included, to the equivalent of the biotite zone. In the latter case, the radiometric age may well be that of this metamorphic event.

At present, none of these alternative is particularly appealing; there is only the above negative evidence for any of them.

IGNEOUS ROCKS

Andesite and Basal!

Mafic volcanic rocks Occur in several places; in addition there is a very large volume of arnphibolite of doubtful genesis, but which is probably of volcanic origin. The andesites and basalts between Upper Glencoe and Maple Hills are the major mass. Smaller amounts of basaltic rock in the upper part of George River may be of volcanic origin, and there are pyroclastics on Crowdis Mountain (McRae Brook). But in only two or three places in the large area of amphibolite east of Middle River, are there primary features (pillow structure) which definitely identify the rocks as lavas. On the strength of this, the whole is assumed to be of volcanic origin, though it may include metamorphosed sediments, and possible also some intrusive gabbro.

The Craignlsh area between Upper Glencoe-Maple Hills and the upper extremities of East MacPhail Brook and River Denys is underlain chiefly by andesite, with minor amounts of more mafic lava. Pyroclastic material appears to be a minor part, but on abandoned farms just south of Maple Hills School, there is some andesite breccia and a thinly laminated rock; the latter may be air-laid tuff. The andesite is more resistant to erosion than either the limestone above or the slates beneath. Accordingly, erosion of the slates has formed a shallow basin which is occupied by the numerous brooks forming the headwaters of River Denys; most of the brooks actually begin near the contact of the slates with the main mass of the volcanic rocks.

Andesite is not found everywhere between the slates and the limestones. This is probably due to faulting in many places, but there appears to have been some interlayering. There are 10 to 15 foot interbands of andesite in the slates at the headwaters of River Denys, although the amounts are small. There Is also interbanding of thin flows with the limestone, marking both the upper and outer limits of the activity. Good examples of this can be seen east of an old saw mill site on the Blue's Mills-Upper Glencoe road, where the thin layers of andesite in the limestone have been broken up by faulting.

Dykes up to 20 feet thick cut the slates, limestones, and lower quartzites in a number of places. The "greenstones" reported In the detailed log of Blue's Brook (See page 21) are included here; though many are sills and not all show chilled margins, it is probable that they are the same as the dykes, which they resemble very closely. It is probable that all are feeder dykes for the Flows.

Description

The andesite is generally massive, and the grain size is about 0.l mm. It is dark greenish-grey to dark greenish-black on the weathered surface, and almost the same colour on the fresh surface. In many places there is a characteristic red

weathered "rind" about ¼ inch deep; in a few places small "pin-hole" vesicles are present. Where individual minerals are recognizable, they are feldspar and greenish, chloritized, hornblende and biotite.ln shear and fault zones the rock is altered to a chlorite-blotite-feldspar schist; there are all gradations from this to the massive rock. In a few places, bleaching adjacent to fractures has produced a mottled effect on the rock, assumed to be due to leaching of iron.

A thin section of a typical sample, from a mile southwest of Maple Hills School, contains an estimated 40 per cent feldspar (Abss), 35 per cent hornblende, and 20 per cent carhonate, with about 20 per cent magnetite and pyrite, and smaller amounts of chlorite and epidote. (Disseminated pyrite is visible in the hand specimen). Clusters and spots of carbonate are closely associated with the untwinned feldspar, which also has considerable clay-like alteration. The hornblende is probably a high-iron cummingtonite; the magnetite and pyrite are closely associated with it, and it was apparently the source of the iron for the pyrite.

Pillow structure was found in the western part of the andesite **area - in a "cut-over" area east of some abandoned farms at Upper Glencoe. The pillows are** good enough to indicate that the rocks were lavas, but none are reliable indicators of the attitude of the flows.

A large outcrop about half a mile south of the Maple Hills School, in an open field and about a hundred yards east of the former road to Blue's Mills, is the only large exposure of pyroclastic material. It has angular fragments up to ½ inch (1 cm.), hut averaging less than ¼ inch, in a matrix of the same material, which weathers out to leave a roughened surface. Another 6-foot band of similar breccia, with 4-inch fragments, was found to the west.

This rock was termed "flow breccia," **in 1963. and considered to have** been formed by the break up of a lava as it flowed along during solidification. Comparison with the palagonite tuff deposits of the south coast of Iceland **suggests that the** "breccia" **may, in fact, be a similar tuff.**

A single exposure of fresh, reddish-brown, amygdaloidal basalt was found north of Dunakyn.

In the Nortn Mountain area, greenstone was found in 1962 on the road along the shore of West Bay, where it is crossed by Dallas Brook, and .als.o on the same road, at Melnnis Brook, west of the old Lime Hill church. A similar rock occurs in one or two other places nearby, particularly in the quarry on the Carson property.

In the field this is a nondescript, fine-grained, black. rnafic, **schistose rock. The outcrops on Mc1nnis and Dallas brooks show numerous lenticular openings,** which might once have been gas vesicles, and there was a faint suggestion of pillowed structure and of thin bands resembling flow layering in the outcrop at **Dallas Brook. Since then, improved exposures. due to road construction, look more like volcanic rock.**

Another problematic rock occurs east of Mill Brook, between Marble Mountain and Malagawatch. This rock also is very fine grained, black or greenish-black, and is severely shattered and strongly foliated where seen in the brooks. lt is very uniform, several hundred feet thick, and with no suggestion of bedding or other compositional variations, except a jointing or ridging which is very regular in attitude; individual "joints" mark layers of uniform thickness. The thin surface weathering shows approximately 60 percent feldspar; the fresh surface shows a few black crystals which may be hornblende. This has previously been mapped as volcanic rock, but none of the usual volcanic characteristics were found. The outcrop suggests limestone - which it is not - but it could possibly be a marI, or other impure limy bed, metamorphosed to an amphibolite.

A few outcrops of "greenstone" were found on and near. the southwest tributary of Campbell Brook. This is the normal medium-grained rock with 60 per cent grey feldspar and 40 per cent greenish-black hornblende, the latter partially altered to biotite. Just south and west of the buildings of the abandoned MacMillan farm, about a mile to the northeast of the outcrop in the brook, there is a large exposure of a similar, but finer grained rock which may be a dyke.

In the Oowdis Mountain area, the andesitic rocks have been a problem. In only one exposure (in Fourth Gold Brook) were definite piLlowed structures found; a few others have vague suggestions of such, but nothing definitive. In many exposures there are suggestions of vesicular patterns, but nothing that is diagnostic. Similarly there are no good arnygdules or other such primary volcanic features. The rocks vary from fine to coarse grained, in extreme cases with grains of hornblende up to ¼ inch, and are remarkably uniform. Coupled with all this, there are in the area, mafie dykes similar in appearance to the amphibolites, and of two distinct ages, about the intrusive nature of which there can be no doubt whatever. Accordingly, there is a distinct possibility that some of the rocks mapped as amphibolite in the Crowdis Mountain and Middle River areas are gabbro or diorite, though it is thought that most are probably volcanic in origin. This is a disagreement with Fletcher, who mapped as diorite the arnphibolites of Leonard McLeod and Garry brooks, presumably on the evidence of the mafic dykes just mentioned.

The amphiboJite of Leonard McLeod Brook is typical. In its coarser phases it weathers greenish grey, with a smooth surface which is only locally marked by black spots where hornblende occurs. The surface is weathered and altered ro a depth of about 5 mm, and is whitened by clay minerals developed from the feldspars. There is a reddish hematite stain just beneath the weathering zone. The fresh surface is dark greenish grey to greenish black. Where coarse grained, there is a spotted appearance due to the glistening cleavage faces of the hornblende, which is in prisms up to 2 or 3 mm across. In the fine-grained phases the individual minerals are not usually recognizable, and the whole has a chlorite-green colour. Feldspar forms approximately 60 per cent of the rock; the balance is hornblende. Magnetite is the common accessory; it may reach two per cent, but is usually sparse. About 15 per cent of the amphibolite is a coarse grained, gabbroic-looking phase, containing 60 to 70 per cent hornblende. This has a rough "pimply" weathered surface. Possibly this represents basaltic flows.

A heavy hematite alteration is characteristic in certain places, notably in the lower part of Leonard McLeod Brook. The hematite occurs as a bright red mm coating some joints; others have an iridescent black-blue film, and some have both forms. In some cases, epidote develops on the joints and forms hairline joint fillings. Sparse disseminated pyrite is not uncommon.

In thin section, an amphibolite from Middle River shows 80 to 85 per cent hornblende in grains 0.5 to 4 mm long and 5 to 10 per cent of plagioclase (Abao). Quartz is normally in small amounts but may be as much as 10 per cent in fine grains. There are accessory amounts of epidote, sphene, calcite, and-large amounts of opaque minerals. It should be noted that on Middle River the amphibolites are at a much higher metamorphic grade than at Leonard MacLeod Brook. where epidote and carbonate are normal components.

An amphibolite very high in epidote occurs in a few places, of which the valley of Gillis Brook is the most notable. Fletcher commented that "in Gillis Brook the abundance of epidote is remarkable ... sometimes half the rock". This alteration is chiefly in patches, suggesting derivation of the epidote from feldspar phenocrysts. Many of the patches are composed of aggregates of radiating epidote needles, and have a marked effect upon the colour of the outcrop surface. Epidote veins, nodules, laminae, stringers, and irregular patches high in epidote and up to 4 or 5 inches in diameter occur in many other places also; of these the amphibolites of North Baddeck River, northeast of the airstrip, probably have the most extensive alteration.

Variations within the amphibolite are relatively minor in amount. Porphyritic phases occur, and in a few places where there are good exposures, as on North Baddeck River, one seems to be able to recognize irregular boundaries between the porphyritic and non-porphyritic flows. The phenocrysts are feldspar.

Thinly-layered amphibolite, suggestive of air-laid tuff, occurs in small amounts in a number of places. In one case, in the large northwest tributary of Leonard McLeod Brook, the regular laminae are up to 5mm thick; within this, one zone 10 feet thick, has nodules up to 2 cm in diameter mixed in with laminae less than I mm thick, and the whole high in epidote. This is rather suggestive of lapilli or small bombs in tuff. On McRae Brook also, near Mason's lumber camp on Crowdis Mountain, there is a rock with layers 1 mm to 5 cm thick, suggestive of a tuff. In some layers feldspar and biotite are recognizable; such layers probably are of the normal "greenstone" composition. Other layers are very high in feldspar and have sparse quartz "eyes". In the same brook, near the sharp northerly bend about a mile east of the main haulage road, amygdaloid was found in boulders along the bank, but was not seen in outcrop. Possible pyroclastic fragments and amygdaloid were also noted in a small exposure in the brook immediately north of the Crowdis Mountain landing strip.

At the northeastern extremity of exploration of Sarach Brook, there is an outcrop of schistose, fine-grained, chloritic "greenstone" which has at least a superficial resemblance to the ignimbrites of the east end of the Sudbury basin.

Included with the amphibolite is a rock which differs from the typical in having a high feldspar content. Though it occurs elsewhere, it is most abundant in the narrow band of amphibolite on North Baddeck River north of the Crowdis Mountain landing strip. There are three main phases, all fine grained and various shades of dark grey on the weathered surface. At first glance, one resembles the feldspathic quartzite; but is massive and has IS to 20 per cent plagioclase as phenocrysts, some of which suggest angular fragments. Under the hand lens it shows an igneous texture, with patches of red and grey feldspar, and is reminiscent of the diorite seen further downstream. The second phase is probably about the same as the first, but finer grained. The third phase appears to be a normal fine-grained chloritic greenstone, but is abnormally high in feldspar - up to 70 per cent or more. In many places these phases seem to be completely mixed up on a single outcrop.

This rock and its relationships are not at all clearly understood. Faulting may be the explanation of the intermixing in some cases. It is probable, however, that there are various phases of feldspathic flows, some porphyritic and some not, which have been fractured and cut by granite, with feldspathization adjacent to the fractures and granite dykes. (Haloes of red feldspar extend up to 12 inches on either side of some fractures. Epidote stringers are numerous and widespread, and epidote alteration of the feldspars very common.) The great irregularity and intermixing of phases, and the apparent "inclusions" of normal greenstone in the "dioritic" first phase, would then be due to normal variations between flows on which was superimposed feldspathizanon controlled by the random distribution of fractures.

In the *Boisdale Hills,* no amphibolite is reported on the accompanying map. It should be pointed out, however, that the body of gabbro and diorite west of the church at Upper Leitches Creek includes some material originally described as "prophyritic greenstone with 20 per cent feldspar phenocrysts I mm in diameter". There is no question about the intrusive nature of the gabbro: on its western edge it cuts metamorphosed George River sedimentary rocks, which also occur as xenoliths. There is a distinct possiblity.however, that amphibolite also was engulfed by the gabbro, though it is thought that such inclusions are a small part of the whole.

Relationship to Other Units

The amphibolites are interbedded with the slates and feldspathic quartzites beneath, and with the limestones above them, in the transition zones between one type and the other. This statement is perhaps most particularly applicable to the Craignish Hills; in the Crowdis Mountain area the relations are much less definite. In the former area the bulk of the amphibolite occurs as a single more or less discrete mass, and, though chopped up by faults, the general relations are reasonably apparent. On the border between one unit and another, there is a certain amount of interbedding.

In the Crowdis Mountain and Middle River areas, however, the situation is by no means clear. In the first place, the limestones are missing, unless they are represented by the "carbonate zone" on Fionnar Brook, the band of dolomite and Limestone running along Middle River nearby. and a few exposures of marble in Sarach Brook just above its confluence with Middle River. Secondly, the arnphibolites are scattered over the whole Crowdis Mountain area, and are apparently mainly remnants, large and small, in a very extensive intrusive mass. North of the Gold Brooks, the amphibolites are apparently not present, except on North Baddeck River, and the gneisses there are considered equivalent to the feldspathic quartzites and greywackes. Finally, at the Gold Brooks, and to the south in McLean's Brook, it would appear that the amphibolites are interbedded in the slates and quartzites, but farther south still, between the Garry Brook and McLeod Brook, or on Muskrat Brook, the sedimentary rocks are interbedded in an extensive mass of amphibolite which apparently once extended as far south as MacMiIlan Mountain and Harris Brook.

It has proven to be exceptionaJly difficult to make any structural sense out of these remnants more or less isolated in the intrusive rocks. But it is obvious that there was here a much greater thickness of volcanic rocks than the 3,000 feet, more or less, of the Craignish area, unless there has been much greater structural repetition than seems to be indicated.

Gabbro and Diorite

Skye Mountain

The main intrusive body of diorite is about 2½ miles along by I mile wide, underlying the summit area of Skye Mountain. The eastern part of the mass is chiefly diorite, the western part is granitic. This peculiar situation in a single body may not he real: between the eastern, or dioritic, part and the western, or granitic, part, there is a zone half a mile wide devoid of any outcrop of any kind. Two smaller masses occur south of Bridgend Brook, east of Kewstoke. A third body of diorite and quartz-diorite lies between East MacPhail Brook and River Denys.

The diorite at Skye Mountain is typical, and can be seen along a former road and a brook which join Bridgend Brook at the "Iron Bridge" near Churchview. It is coarse grained and contains fragments of the George River rocks which it has invaded. In many places it appears that there has been absorption of blocks of the roof rocks into the diorite, with accompanying changes in its composition. The quartzite blocks, of course, have not been absorbed, though the feldspathic quartzites apparently have been.

The diorite is a dark greenish-grey rock mottled with black hornblende, and weathers to a very dark grey or brown. It is composed of 25 to 40 per cent hornblende, in prisms up to 2 or 3 mm long, in a matrix of greenish-grey feldspar. Epidote alteration is commonly visible, and locally there is 10 to 20 per cent salmon-pink feldspar, especially in the vicinity of fractures or of a reddish diorite phase, described below. Some local phases are more rnafic and approach gabbro in composition. Still others are finer grained and with a higher proportion of feldspar than the main mass; the weathered surface is then light grey.

The rock is extensively altered. Hornblende and biotite are altered to magnetite and chlorite, the latter giving a greenish colour to the rock. The feldspar is saussuritized. There are accessory amounts of apatite and calcite.

In this same area are a few dykes of spessartite larnprophyre. This rock has a characteristic brown weathered surface with angular to prismatic white spots about 5 mm across. Black hornblende laths up to 3 mm long, form about 20 per cent of the rock, but are clearly visible only on the dark brownish-grey fresh surface, where they too look like phenocrysts. Finer-grained phases occur. The phenocrysts are zoned plagioclase (30 per cent) and hornblende with lesser amounts of biotite. The ground mass is plagioclase, potash feldspar and biotite, with accessory amounts of calcite, magnetite, apatite, and epidote. The biotite is altered to chlorite. A fine-grained phase contains both augite and hornblende in the groundmass, and serpentinized olivine as phenocrysts.

This rock is not abundant and is usually not well exposed. It is probably younger than the diorite, and it is cut by the red diorite phase now described:

There is a reddish rock which was described in the field as syenite. It is fine grained and porphyritic, with 3 mm feldspar phenocrysts in a brick-red matrix of feldspar and 15 per cent of chloritized biotite. Other phases appear to be contaminated by absorbed wall rock and are severely altered, while the coarsest and most massive phases resemble a red granite, lacking only quartz.

Microscopic examination shows, however, that the feldspar is all plagioclase, and, in the case of some of the darker "contaminated" varieties, is a calcic andesine. The dark minerals in this case are pyroxene and hornblende altered to biotite, magnetite, and chlorite.

The feldspar owes its red colour to finely-disseminated hematite. In the vicinity of bodies of this red diorite there is usually red feldspar disseminated in wall rock. It appeared in the field that this was due to feldspathization from the diorite.

The hematite alteration, however, raises the question of *the* control of its formation. The red diorite was apparently separated from the more usual variety of diorite by an interval during which the spessartite dykes were emplaced. If the "feldspathization" of the wall rocks is related to the introduction of the red diorite, then the hematite must have been an integral part of the feldspars of that rock. Otherwise there is the problem of why a subsequent hernatite alteration is restricted to certain feldspars in, and adjacent to, the red diorite, Presumably, then, the hematite was in some way, carried in with the feldspar.

The diorite phase of the intrusive body between East MacPhail Brook and River Denys is as described above for the typical diorite. It contains quartz diorite and granodiorite phases as well.

Upper Glencoe - Glendale

A very extensive area of diorite bounds the George River rocks to the west, between Upper Glencoe and Glendale. This occupies the height of land, but the relief on it is low, there is considerable swamp. and considerable float but few outcrops. The boulders appear to be almost completely diorite.

Here, too, there are a number of places where there is red hernatite alteration in the feldspars. The alteration is obviously fracture controlled, and extends for an inch or more on either side of fractures in the diorite. The rock differs little from diorite described above: It weathers dark grey to brownish-grey, is massive. and contains 30 to 40 per cent black hornblende, 2 mm long, in a matrix of bluish-grey feldspar, so that the fresh surface is speckled black and white. There is a very little biotite and epidote. There may be some gabbro in the northwest corner of the intrusive.

At Lime Hill there are dioritic phases in the granodicrite, but they are probably only local patches.

North Baddeck River

On North Baddeck River, near New Glen, there are fairly numerous outcrops of diorite and diorite porphyry. This rock has about 70 per cent feldspar, is massive, coarse to medium grained, and greenish-grey on the fresh surface because of chlorite and biotite alteration of the hornblende. It therefore differs little from the diorite elsewhere. Locally there are quartz diorite phases with 2 to 5 per cent bluish quartz.

Its chief interest is for the age relations which it reveals. It cuts. and includes, a fine-grained greenstone which generally looks like a fine-grained phase of the diorite, but the dykes are definite. The diorite is cut by dykes of red granite, and was found as inclusions in the granite which is, in turn, cut by diabase. The latter dykes have ophitic texture and chilled margins; there is some epidote alteration. These relations can be seen in a number of places, but they are all visible in a single outcrop about ¼ mile upstream from the Horton contact.

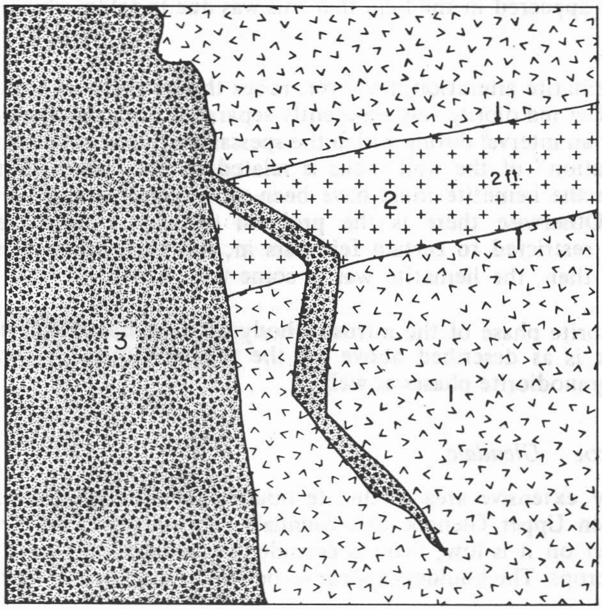


FIGURE 5 *Age relations in an outcrop on North Baddeck River.*

Similar relations between diorite and greenstone are visible in Leonard McLeod Brook. As mentioned above, there is a suspicion that some of the amphibolite there may be diorite, but only thick dykes have been recognized.

BoisdaleHills

Diorite is present in a few places in an irregular area which extends from Highway 23, near the crossing of George River, to the Guthro Road near Upper Leitches Creek. Gabbro and a fine-grained phase are also present.

The diorite here is more mafic than is the usual material. It is dark grey, medium grained, with 40 to 60 per cent black hornblende in a matrix of grey feldspar. In one place, a porphyritic phase was found, with 30 per cent feldspar phenocrysts in a matrix dominantly hornblende. The diorite cuts the metamorphosed George River sediments, which also occur as inclusions, and is cut by grey granodiorite and by grey aplite dykes. Quartz diorite also occurs. The gabbroic phase is dark brownish-black, coarse grained, massive, and has 30 to 60 per cent feldspar. It contains inclusions of the George River rocks.

There is no doubt about the presence of intrusive rocks in this area; there is some doubt about their extent. Of the rocks shown on the map as diorite, those south of the quartzite quarries on George River are dominantly a fine-grained amphibolite. Inspection of the map will show that there are actually only eight outcrops and some boulders shown. All are fine-grained, composed of hornblende and plagioclase, and faintly schistose, and were initially mapped as "greenstone", It is possible that the eight outcrops are actually indicative only of dykes, such as those near Highway 23 at George River, though it is difftcult to find a reasonable explanation of the faint schistosity, Alternatively they may, in fact, be greenstone.

Aeromagnetic data are not of much help. There is a considerable magnetic disturbance associated with the intrusives to the west, (see G.S.C. Map 360 A) but this immediate area has a local high only about 100 gamma above the general "background".

Relations to Other Rock Units

The age relations of the diorite, and its gabbroic and quartz dioritic phases, can now be summarized:

The diorite is intrusive into, and contains xenoliths of, the George River sedimentary and volcanic rocks in all areas here discussed. It grades into gabbro and quartz diorite, which are apparently local phases of the same intrusive unit. In the Skye Mountain area only, spessartite lamprophyres have been recognized. They are probably later than the main diorite but are older than an unusual reddish diorite resembling syenite. The diorite, elsewhere is cut by grey granodiorite, by granite, and by later igneous rocks.

Diorite and its associated gabbro, therefore, are the oldest intrusive rocks recognized in the region. They were followed by the grey granodiorite,

Granodiorite

Craignish

Granodiorite is a minor part of the intrusives in the Craignish Hills. Some is present in the southeastern part of the large area of diorite between Glendale and Upper Glencoe. There is also some in the eastern end of the plug which lies between the headwaters of River Denys and East MacPhail Brook.

Boisdale

A grey biotite or biotite-hornblende granodiorite is found in a number of widely scattered localities. Both north and south of Highway 23, outcrops are numerous enough to indicate a small area of the granodiorite.At Upper Leitches Creek a few more outcrops suggest another such area; there are a few widely scatted outcrops at Frenchvale Brook and Steele's Crossing.

The whole distribution suggests a border zone of granodiorite between the George River rocks and the granite to the northwest. The two areas first mentioned have been joined on the map, but, in truth, no outcrop of any kind was found in the space between them.

If the granodiorite is a marginal phase of the main intrusive body, it was cut, after its consolidation, by dykes from the main mass of the parent magma.

The granodiorite is grey with 15 to 20 per cent biotite in a matrix of white or light grey teldspar, though a phase with a brownish colour occurs in the southwest. Quartz may be minor in amount, or reach as much as 25 to 30 per cent. A characteristic surface results when this abundant quartz weathers up in relief. It might be possible to find gradations berween the granodiorite and the feldspathic phases of the diorite and quartz diorite, but dykes of the granodiorite have been found cutting the other rock.

North Mountain

In the North Mountain area there is a body of granodiorite forming the height of land. In this area explorations were restricted, essentially, to the areas outside the granitic rocks, and, in consequence, the extent of the granodiorite is not known. It does extend for several miles southwest from the headwaters of MacKenzie's Brook. East of Mill Brook, it lies to the north of the diorite body above described. The boundary is very irregular, but passes, in general, along the line of the lakes locally called McAskill's, Black Charlie's, and the Steel Company Lake to MacPhail's Lakes. There is a large tongue of granodiorite south from the Steel Company's Lake at least as far as the former road across the mountain, and probably into the village of Marble Mountain; a few outcrops of it were found on Sydenham (McRae's) Brook. The contact apparently swings west or northwest beyond MacPhail's Lakes. It does not occur in the upper ends of either Lime Hill Church Brook or of the tributaries of Campbell Brook.

The granodiorite here is devoid of foliation and is porphyritic in many places, giving a spoiled pallern to the light grey weathered surface. As in the Boisdale area, the quartz weathers up in relief and, in some places, this quartz may be in masses up to I cm in diameter. In porphyritic phases, feldspar also may be as much as 1 cm diameter. The usual mineral proportions are: quartz 10 to 15 per cent, grey feldspar 70 to 75 per cent, and hornblende, altered to biotite, 10 to 15 per cent. There is a red feldspar present in many places, associated with fractures and with dykes of a later red granite, from which presumably it is derived.

Crowdis Mountain - Middle River

Though granodiorite is widespread as small bodies and dykes, the only substantial mass appears to extend eastward from the upper end of North Baddeck River, where, for a mile or more, the tributaries on the eastern side all cross granodiorite. Whereas the granodiorite bodies in the Craignish Hills grade into quartz diorite and diorite, this mass appears to grade into granite.

Compositionally, the granodiorite here does not differ significantly from that described above. As elsewhere, the biotite is in clusters of grains, apparently pseudomorphic after hornblende, and there are epidote stringers, as well as epidote alteration on the feldspars. In general, however, the rock has a fresh appearance.

Relation to Other Units

West of Morrison Lake, in the Boisdale Hills, dykes of granodiorite were found cutting the diorite there. In other areas the age relationship is not so clearly defined, but no contradictory evidence was recorded. It is probable that in all these areas the granodiorite is later than the diorite, though it may be only a later phase of the same igneous activity.

Diabase

In several places, of which Leonard McLeod Brook is the chief, there is an amphibolitic rock which has caused considerable difficulty and uncertainty. In the field *it* was generally described as "greenstone", and "dioritic" or "gabbroic" greenstone. The latter name refers to a coarse-grained phase resembling gabbro in appearance. Microscopic examination has shown relics of ophitic texture in several cases.

It has also been found that rocks, which in the field appear to be the same, occur as dykes cutting .the normal amphibolite of the area. Such dykes, of course, are normally fine to medium grained, and can be distinguished from the normal greenstone only on good outcrops and by a slight difference in the weathered surface. That there are such dykes, cutting the greenstones and the sedimentary rocks, there can be no doubt; they have been found in a number of places where the relations are clear and definite. As discussed below, there are also lamprophyre dykes which cut the later granite in many places.

The practical problem has been to distinguish the dykes from the normal greenstone, to establish an age for them, and to find a basis for correlation. For this problem there is no satisfactory solution. In large part this is because of the difficulty of recognizing the diabase, There must be some method, short of the impractical procedure of making a thin section from every outcrop of greenstone, but it has not been found. Uncertainty results, as is illustrated below:

On the west side of Leonard :McLeodl Brook, upstream from its junction with Gillis Brook, there are syenite dykes cutting greenstone described in the field as "gabbroic" or "dioritic". (This is the area where Fletcher described the rock as diorite, but without giving the evidence for intrusive character.) In the next outcrop, also described as "dioritic", the rock has an ophitic texture. If these similar neighbouring outcrops are, in fact, all the same, a pre-syenite diabase intrudes the greenstones, and this pre-syenite diabase must be distinguished from a later post-granite series of lamprophyre dykes as well.

A somewhat similar situation occurs on the second tributary of North Baddeck River north of the Crowdis Mountain landing strip. Here a "diorite" with ophitic texture is cut by dykes which are fairly certainly derivatives of the syenite. In this case the "diorite" could not be found cutting anything, however.

In short, it appears to be possible, if not probable, that there is an ophitic dolerite or diabase, older than the syenite, and closely resembling some of the amphibolite. Its age can be placed only as later than greenstones; if it cuts the diorite or granodiorite, this has not been recognized, unless the diabases are the equivalent of the spessartite lamprophyres of the Craignish Hills. The diabase might even be related to the diorite, but it has not been recognized as pre-granodiorite at any place. Pre-granite mafic dykes at George River have been serpentinized,

Syenite

Syenite occurs in small amounts in all areas, but is most abundant and most extensive in Crowdis Mountain. There the plateau is underlain chiefly by syenite and, though the streams running off the mountain are on George River rocks, their headwaters cut into syenite in most cases.

The syenite weathers reddish to light reddish brown. Where much frost fractured rock is present, as on the wood roads of the Crowdis Mountain area, the whole surface of the ground has a light reddish cast from the syenite fragments. The fresh surface is light reddish brown, with a few flecks of dark minerals. The rock is fine grained; though good feldspar prisms up to 2mm across are surrounded by a finer matrix, the rock does not have a noticeable porphyritic texture. Quartz is normally present in amounts less than 5 per cent, and this in only a few places. The bulk of the rock is feldspar and most of it is reddish brown. Ferromagnesian minerals are less than 5 per cent of the rock, and in many places less than 2 per cent; they are about equally magnetite and small grains of biotite.

In thin section, a sample from Crowdis Mountain shows: 50 per cent oligoclase feldspar (Ab_{S0}), ranging in grain size from 0.5 to 6 mm; about 45 per cent orthoclase, in'grains about the same size and slightly sericitized. Quartz is about 5 per cent; it is all finer grained than the feldspar and forms lenticular grains less than 0.5 mm. Some feldspar shows perthitic intergrowth. The **accessory minerals are biotite, muscovite,** epidote, sericite, **magnetite. and** pyrite, together totalling less than I per cent. This sample is more accurately described as quartz monzonite.

In the North Mountain area, only one or two outcrops of syenite were found. These may very well be, in fact, a low-silica, contaminated phase of the red granite which is abundant there.

In the Craignish Hills, syenite was identified in the field in a few places. One of these, at Kewstoke, has been discussed above as the "red diorite" phase. The most important syenite occurence is a small area north of River Denys Road, at the headwaters of Diogenes Brook. It is in no significant way different from the typical syenite of Crowdis Mountain, though locally the quartz content is as much as 25 per cent and it must then be called a granite.

Two phenomena related to the syenite deserve mention. A phase of the syenite which is fine-grained and resembles quartzite, has been described already in connection with the sedimentary rocks. In essence, a narrow sill or dyke of the syenite is very fme grained, because of chilling, and resembles some of the quartzites.

The second feature is feldspathization apparently associated with the syenite, and perhaps to a lesser degree with the granite. Around many fractures, as well as adjacent to syenite, there is a halo of pink 01 reddish feldspar. This may be a band a quarter of an inch thick, with a tiny fracture in its centre, or it may be a dyke 01 fracture, with a halo extending 12 inches 01 more into the wall rock from the edges. The efTect also appears in many shear zones in the George River rocks, especially the amplubolites, where numerous porphyroblasts of feldspar appear in the schist of the shear zone. The presence of the feldspathization is generally indicative of syenite dykes on the surface nearby; the exceptions may well indicate comparable dykes not far below the surface. The dykes, in turn, are more abundant c1ose to a larger body of the syenite. On Leonard McLeod Brook, as an example, one section of about 200 feet exhibits feldspathization fOI ¼ inch on either side of joints. In the centre of this zone are several dykes of syenite, up to 18 inches thick, cutting the greenstones. At about this point a tributary has cut a small gorge in which there are syenite dykes, from I inch to 3 feet thick, in the greenstone which forms the walls of the gorge. Though these syenite stringers and dykes are restricted to the 10weI portion, feldspathization adjacent to joints is notable for at least a hundred yards up the tributary.

Age Relations

North of the Crowdis Mountain landing strip, syenite occurs as veins in quartz diorite, and also contains inclusions of quartz diorite. The syenite also cuts the "diabase" of Leonard McLeod Brook.

The relationship of the granodiorite is obscure: If the granodiorite is a late phase of the diorite and quartz diorite, then it also is older than the syenite. If the granodiorite is an intrusive distinct from the diorite, as is indicated by the dykes found cutting the diorite in the Boisdale area, there really are no data on its relative age, other than that it is later than the main diorite mass. lt has not been recognized as cut by the syenite, nor vice versa.

At present then, the syenite is known to be later than the diorite, and later tban the "diabase", but its relation to the granodiorite is not known, if that rock is other than a late phase of the diorite.

In a number of places on the west side of Crowdis Mountain, the syenite appears to grade into the granite by an increase in quartz. But near the top of Skye Mountain, the fine-grained marginal phase of the syenite is cut by a dyke of red granite; the normal syenite is exposed about 100 feet away.

The syenite of River Denys Road deserves special mention. Fletcher described the limestone there as sitting upon the syenite - which would make the syenite pre-George River, and unconformable beneath the limestone. There is no doubt whatever that Fletcher was a sharp-eyed observer, and his statement must be taken seriously when assessing relative ages.

The outcrop described by Fletcher, so far as one can locate it, is about ¼ mile north of the crossroads. A tiny stream, tributary to Diogenes Brook, and following along the west side of the road to Glencoe, crosses the road and passes an old saw mill site on the east side of the road, About 100 feet downstream from the mill the brook plunges into a cavern in limestone, and emerges again as a large spring 500 feet further along.

The limestone is probably not unconformable on the syenite. It is faulted against the syenite at the place where the brook disappears, but twenty feet upstream there is a small exposure of limestone with syenite on both sides. At the next small bend a further twenty feet upstream, the "syenite" is very severely altered in the brook, and most of it is disintegrated almost to clay. The contact at the small exposure is not faulted and the outcrop looks as if the limestone were sitting upon the syenile. However, the contact appears to be vertical in the few inches that are visible, and the limestone is altered for a few inches from the contact. Similarly, near the spring where the brook emerges from the limestone, the syenite is contaminated and the calcium content of the feldspars increases toward the contact. It appears probable, therefore, that the syenite is intrusive into the limestone. Locally this syenite body becomes a granite with up to 20 percent quartz.

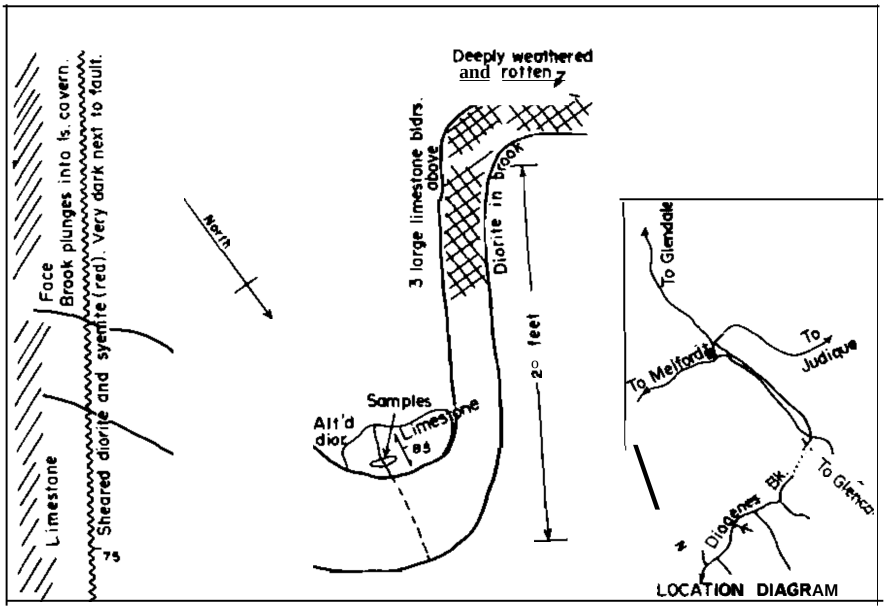


FIGURE 6 *Relations **of limestone to** syenite. Fletcher considered **this an unconformity.***

Granite and Alaskite

Granite is not an abundant rock in any of the areas here considered. It is essentially absent from the Craignish Hills, and is minor within the area mapped in the Boisdale Hills, though there is a considerable body of granite to the west of that area. As pointed out above, the summit area of North Mountain probably has extensive granite, though only the edges of it were examined. The greatest volume of granite and closely related rocks is in the', Crowdis Mountain-Middle **River section.**

In field appearance, the granite is essentially syenite with more than five per cent quartz, and it characteristically has the same low content of ferro-magnesian minerals. The proportions of the minerals do vary considerably: quartz may reach 25 or even 35 per cent, but generally is about 10 to 15; biotite is usually about 5 per cent or less, but may reach 15, especially close to the contact with wall rocks; feldspar is generally dominantly red and relatively fine grained, but porphyritic phases with feldspar phenocrysts up to I cm do occur. Grey or white feldspar appears to be very rrunor, but amounts up to 35 per cent are reported from North Mountain and from north of George River quarry. In these cases the rock is reddish-brown, speckled with white, like suet in a pudding.

Microscopic examination of a sample from the upper end of Second Gold **Brook, considered to be representative of the granite, shows: 45 per cent quartz, which shows some signs of** brecciation **and varies in grain size from less than I mm to over 5 mm; about 40 per cent orthoclase, which has minor sericite** alteration, and 15 per cent plagioclase (Ab_{95}), both very coarse grained (5 to 8 mm). The accessory minerals are biotite and muscovite.

There is a phase of the granite which resembles rhyolite, and which has caused much difficulty in consequence. Though it occurs elsewhere, it is best exposed north and west of the George River quarry at Scotch Lake, and this area may be considered typical.

The "rhyolite" is red to brownish-red on the weathered surface, which generally has small rounded to angular white spots about 2mm across. These look like phenocrysts; but some of them, at least, appear to be aggregates of mineral grains. The fresh surface is slightly darker in colour, and shows the same feldspar prisms and fragments (?) in a red matrix. The matrix has, in some cases, a vitreous lustre and sub-conchoidal fracture, and breaks very readily into irregular flat slabs, almost as if it were "pre-stressed" and fracture imminent. In other places the matrix is duller, and the rock is perhaps a little coarser grained. Some outcrops are intermediate in appearance between this type and the granite. Lithologically, this rock resembles the rhyolites of Lake Ainslie.

The gradation from "rhyolite" to granite is visible in a dry stream channel which crosses the MacKinnon farm, one mile south of the George River quarry, just south of the farm driveway. In the channel, south of about 150 feet of limestone is the very glassy-looking brown phase. North of the limestone, this is repeated but the material changes to granite over a distance of 800 feet. The change to granite is primarily a change of grain size: In the finest phase, within a few feet of the contact, the rock appears almost glassy and has few, or no, phenocrysts. Next appear white feldspar phenocrysts, with or without quartz, in a fine-grained red to reddish-brown matrix. This is followed by increase in size and abundance of phenocrysts, accompanied by the appearance of small streaks and patches of chloritized biotite in the matrix. Finally the rock is recognizably granite. By contrast, to the north and west of the George River quarry the fine-grained phase, resembling a flow, is 400 to 600 feet thick.

It is possible that there may be a similar rhyolite as well. In the George River area some of the "rhyolite" appears to have a flow banding, and a boulder of such banded material was found containing a 4-inch red aplite dyke. Until it can be shown clearly that both flows and the intrusive are present, all this rock is mapped as a single type.

Alaskite appears when the ferromagnesian content goes below two per cent. The grain size increases. A few outcrops of alaskite .are reported elsewhere, but the major occurrence is a large dyke which extends from McLean's Brook, at Finlayson, to the limit of explorations on Sarach Brook – an airline distance of about six miles. Its maximum width is probably about three quarters of a mile, the minimum, 100 yards, and over most of its length it is about half a mile wide. Bothan Brook has cut a gorge across it and the cliffs provide very spectacular exposures.

The alaskite consists almost exclusively of quartz and red feldspar. The proportions vary from about 25 to 60 per cent quartz. The feldspars range from I to about 10 cm, the larger crystals occuring as prisms; the quartz is generally in irregular patches of much smaller grains and, in many places, is trapped as irregular aggregates inside the large feldspar crystals, but rarely in graphic intergrowth. In most places biotite and magnetite are negligible.

Age Relations

The alaskite appears to be a derivative of the granite and, in the rare places where the ferromagnesian content is appreciable, the rock becomes a coarse-grained granite, in appearance as well as by definition. Yet, if this is so, the alaskite must have developed sufficiently late for the grarute, as well as the surrounding rocks, to have been solid enough to rupture. Though the main alaskite mass does not map as a typical dyke with parallel walls, it is equally atypical of a segregation within the granitic or syerutic intrusive. The small exposures of alaskite in the upper parts of Nile Brook are mapped as dykes, but could be interpreted as segregations.

The alaskite, then, is slightly younger than the granite from which derived and except for pegrnatites and late lamprophyre dykes, is the youngest intrusive rock in the areas here considered.

The granite, on the other hand, is younger than the granodiorite, though the age of that rock, in turn, is uncertain. In the North Mountain area, a coarse-grained grey granodiorite on Morrison's Brook is cut by a dyke of red granite. The same thing is indicated at a number of other places in that area. The most definite of these is on the extreme upper end of the second brook east of the Valley Mills school. At that place the brook itself flows for 100 feet on red granite, though the walls of the brook are grey granodiorite with 10 to 15 per cent red feldspar.

The granite cuts the diorite in a number of places, but its age with respect to the syenite is uncertain: If the syenite and granite grade into one another as they appear to do on the west side of Crowdis Mountain, and are, in effect, different phases of a single intrusive body, then the problem vanishes; if they represent distinct episodes, there is, apparently, at present no reliable objective information on their relative ages.

The granite cuts lamprophyre dykes which intrude the dolomite in the George River quarry.

Late Lamprophyre Dykes.

Lamprophyre dykes, which cut the granite, are especially numerous in the Boisdale Hills, and to a lesser degree on the upper part of North Baddeck River.

The dykes are unlike the late diabases found in many areas in the Canadian Shield. They are fine to medium grained, many with chilled margins, and are from a few feet up to 80 feet or more in thickness. In a few of the wider dykes, increased grain size permits recognition of the feldspars, and an occasional dyke is porphyritic. In general, they resemble the ordinary arnphibolite very closely, with about 60 per cent feldspar. They appear to be fresh and unaltered. The lamprophyre dykes are possibly related in space to major fault zones such as that in George River, or in North Baddeck River. There is also a suggestion, in the George River area, of spatial relationship to the diorite, though the dykes cut the granite and are therefore later than the diorite.

The pre-granite mafic dykes, such as those around the George River quarry, are generally schistose, often severely fractured and slickensided, and serpentinized. They must antedate the deformation and metamorphism which produced the serpentinization, and are, presumably, the equivalent of the "diabase" discussed on page 43.

Unless a dyke were found cutting the granite, it would be essentially impossible to recognize it as belonging to this later group in the Craignish and other areas where the granite is absent. Therefore, there is no way of assigning an age to a dyke from its field relations.

Pegmatite

Pegrnatite dykes, masses, and stringers are common in the gneisses west of the upper part of Middle River, but are less abundant elsewhere. Much of the pegrnatitic and aplitic material in the gneisses is probably of metamorphic origin and locally derived. There are larger dykes and masses, however, and some of these appear to be spatially related to granitic intrusives. On Nile Brook, for example, there is an increase in the abundance of pegrnatite with proximity to the granite. This relationship is not so clear near the confluence of Sarach Brook and Middle River, another area where pegmatite is common.

The pegrnatites vary considerably in size. The smallest are little more than thick stringers, with feldspar grains little more than an inch across. The largest noted is probably over 40 feet thick.

Compositionally, the pegrnatites also vary. An average composition would be about 60 per cent or more, of feldspar. which is generally pink to reddish. No beryl, spodumene, or amblygonite were noted.

On Ryan Brook, a IS·foot dyke conformable to the surrounding gneisses is composed mainly of pink to reddish feldspar, and contains scarce muscovite in books about ½-inch in diameter.

In Fionnar Brook a 20·foot pegmatite contain. white and pink feldspar and about 30 per cent quartz.

The largest dyke noted is on "Back" Brook about ½ mile upstream from its confluence with Ryan Brook, 70 feet above brook level on the south bank. The outcrop is about IS by 40 feet. If conformable with the wall rocks, a. are the other dykes in the area, it is over 40 feet thick. At the northwest end the feldspar is brownish; elsewhere, it is deep pink. There is no other evidence of zoning. There are numerous small books of muscovite. If the time ever came when this was more easily accessible, it might be considered as a source of ceramic feldspar.

The pegrnatites are assumed to be slightly younger than the granite, to which they appear to be spatially related. The only contra- indication is from the upper part of Middle River, a short distance below its junction with Sarach Brook, where a 4·foot pegrnatite in the gneisses is cut by a 4·foot fine-grained granite dyke.

SUMMARY OF RELATIONS BETWEEN UNITS

It is perhaps appropriate, at this point, to summarize the relations between the various units, so far as they are now understood, and between the George River rocks and their bounding formations. For the George River rocks themselves, the Craignish Hills are used as a standard, largely because a more complete representation is there exposed than in the type area at George River.

In the Craignish Hills, a sequence of sedimentary rocks has been recognized, and Iithologically similar units are recognized in the other areas. It is important to note, however, that the order of deposition of these units has been derived from their position in large folds and that the character of such folds has been deduced from the evidence of minor structures, such as drag folds. Mis-reading of the significance of such minor structures has the practical result of inverting the whole sequence of deposition.

Primary depositional features of the sediments, such as cross-bedding, scour and fill, sole markings, and similar criteria of attitude, have not been found - or where found, have been of very doubtful quality at best.

The George River sedimentary rocks were derived from, and deposited upon, an unknown basement. Conglomerate is essentially missing. The few exposures indicate a variety of conditions: At Second Gold Brook the pebbles present are of the most resistant rock types (mainly quartz and quartzite) and they are well-rounded, indicating maturity and much milling action before deposition. At Whycocomagh, on the other hand, the pebbles and cobbles are angular and little worn and indicate not only slight modification prior to deposition but, with the exception of the limestone, are not unlike the George River rocks themselves. At Iron Mines, the conditions were somewhat intermediate - with more modification of rock fragments than at Whycocomagh.

There is apparently no continuous conglomerate horizon and, so far as our present information goes, these isolated occurences are just that. One could postulate deposition in stream channels, but such is scarcely compatible with the uniform character of the surrounding rocks.

The oldest major unit is dominantly dark quartzites with only minor amounts of more feldspathic material. In detail, it is difficult or impossible to follow individual horizons from one exposure to the next, but the dominant quartzitic character can be recognized over considerable areas. Upward, the proportion of "impure feldspathic quartzite" and greywacke increases and, through a transition zone, they become the dominant rock types, with some interbedded dark quartzite and slate.

The "impure feldspathic quartzties" and greywackes show considerable variation especially from one layer to another in the sequence. They obviously represent sands with different amounts of clays and other "contaminants". If they ever contained rock fragments, as in typical greywackes, none have been recognized; it is perhaps too much to expect that such should have survived the deformation and the development of cleavage in these rocks.

Unfortunately, lack of outcrops prevents tracing individual horizons laterally. It is impossible, therefore, to know if individual layers of sediments were uniform over wide areas, or if they were lenticular and as variable laterally as they were vertically. The alternation of quartzites with slaty rocks must represent rapid changes from deposition of pure sands to muddy sands, or even rnuds, and back again many times. This suggests deposition in an extensive basin, as by turbidity currents, but the apparently large variation in thickness between areas now only a few miles apart rather suggests that conditions were far short of uniform within that basin. There is recognizable, at least in the Craignish Hills, a gradual change to sediments predominantly mud.

The slates are generally much more uniform than the older sandy rocks. The transition from one to the other occurs over a great thickness in which the proportion of sandy beds gradually decreases.

Though the character of the slate bands themselves is apparently remarkably uniform, indicating uniformity of those sediments, the changes from sandy to dominantly muddy conditions must have been very gradual. It has been possible to follow certain zones within the slates for short distances, but there does appear to be considerable lateral variation of thickness within them, and from one area to another. For example, no other area so far examined has a section of slates as thick as that exposed in the Craignish Hills.

Overlying the slates are volcanic rocks, predominantly andesite. In the Craignish area, these may have been originally lenticular with a maximum thickness of about 3,000 feet. In the Crowdis Mountain area, amphibolite, considered to be the same horizon, is much more extensive and, unless duplicated by folding to a greater degree than recognized, is considerably thicker. The widespread amphibolite at Crowdis Mountain, in no clearly recognizable relationship to the slates and other units, raises the possibility that the volcanic outburst in that area is not the same as that recorded in the Craignish region.

Overlying the volcanic rocks in the Craignish area, is a thick section of marbles of considerable variety. Though "greenstones" are interbedded with the marbles, the change from vulcanism to deposition of limestones and dolomite was relatively rapid.

Some sandy beds occur within the marbles and some of the marbles owe their dark colour to fine mud contained within them. One horizon contains oolites and doubtful algal features.

The deposition of carbonate was succeeded by that of very clean quartz sands, and again the change was relatively abrupt. The accompanying map suggests that, in the Craignish region, there was some vulcanism contemporaneous with the sand deposition, for minor bands of "greenstone" appear to be interlayered in the quartzites. There is also some indication, north of Glendale, that carbonate deposition began again after deposition of the clean quartzites. The relevant area is limited and the structure is not clear; reappearance of the carbonate may be due to folding.

The whole sequence of sedimentary and volcanic rocks was deformed and then invaded by plutonic rocks.

The oldest of the intrusive rocks is a diorite which locally has gabbroic and quartz dioritic phases. The diorite in some places, as in the Boisdale Hills, is cut by dykes of granodiorite, but in other places the diorite appears to grade into granodiorite.

A group of early diabase dykes is recognized in some areas. Metamorphism has rendered them very similar in appearance to some phases of the amphibolites, which are probably of volcanic origin, and it is very probable that much early diabase has been grouped with the amphibolite because of lack of criteria for separation in the field. The diabases are probably older than the syenite.

Syenite is extensive in the Crowdis Mountain area, but is relatively minor in other places. Its position in the sequence is somewhat doubtful. It is certainly younger than the diorite and quartz diorite; it is probably younger than the early diabase; but its relation to the granodiorite is not known. Nor is its relation to the granite clear, though dykes at Skye Mountain indicate that the syenite is older.

Granite and alaskite are probably the youngest major intrusives in the area. Some doubt comes because of uncertainty as to relations with the syenite, and because of the peculiar position of the granodiorite. At present, it appears probable that the intrusive mass underlying Crowdis Mountain is essentially a single unit representing a single period of plutonic activity, and that the syenite and granite are simply phases of the intrusive, differing in the amount of silica they contain. The a1askite appears to be a later derivative of the same magmatic event, and to have been emplaced as an irregular dyke cutting the previously consolidated margin of its own parent body as well as part of its roof.

Late lamprophyre dykes cut the granite. They appear to be especially common in two areas, but this may be a false impression. The only way a late dyke can be recognized positively is by its relation to the granite; in areas where the granite is absent, the dykes may well be mis-identified.

Quartz veins and pegmatites are fairly common. Some, at least, antedate the late lamprophyres.

The absolute age of the granite, near Sandy McLeod Lake at Upper Leitches Creek, has recently been determined for Kelley by the laboratory of the Geological Survey, as 493 million years by the K/Ar method. This granite is later than the other intrusive rocks which, in turn, post-date the deformation of the rocks of the George River group. This age is a bit younger than might have been expected from the field evidence, for non-metamorphosed sediments which, according to Bell, contain Middle Cambrian fossils, overlie the granite. The current estimate of the absolute age of the Cambrian seems to be 500 to 600 million years.

Dykes cutting the George River rocks at McAskill Brook. Skye Mountain have recently been dated by Cormier. Two samples give Rb/Sr ages of 505 and 515 million years with a probable error of 5 per cent. This would make them about middle to upper Cambrian. The material used is probably from a late phase of the igneous activity and would, therefore, be the youngest age assignable to the intrusive sequence.

Here we run into an anomaly. The George River rocks of the type area were invaded and severely metamorphosed by a granite abut 490 million years old. The same thing has happened, at least to the limestones, at North Mountain. In the Craignish Hills, rocks of similar lithology also have in their midst, intrusive rocks of about the same age. However, in the Craignish, the metamorphic grade is low; in all the slates there, no garnet or other high grade metamorphic minerals have been found. The only notable change is an increase in grain size which was mentioned above (page 17). Now an interesting relationship appears. Within this recrystallized quartz-feldspar-biotite rock of slightly increased metamorphic **grade, and within the lower quartzites, granitic dykes are common, to the extent** of several dykes of thickness up to 2 or 3 feet in some individual outcrops. However, though common to the east, not a single granite or syenite dyke has been recorded west of the road from the Iron Bridge to McAskill Brook and all the way to River Denys Crossroads on the Melford-Judique road. That is to say, through all the sequence of slates, andesites, limestones, and upper quartzites, there is not a single granitic dyke reported.

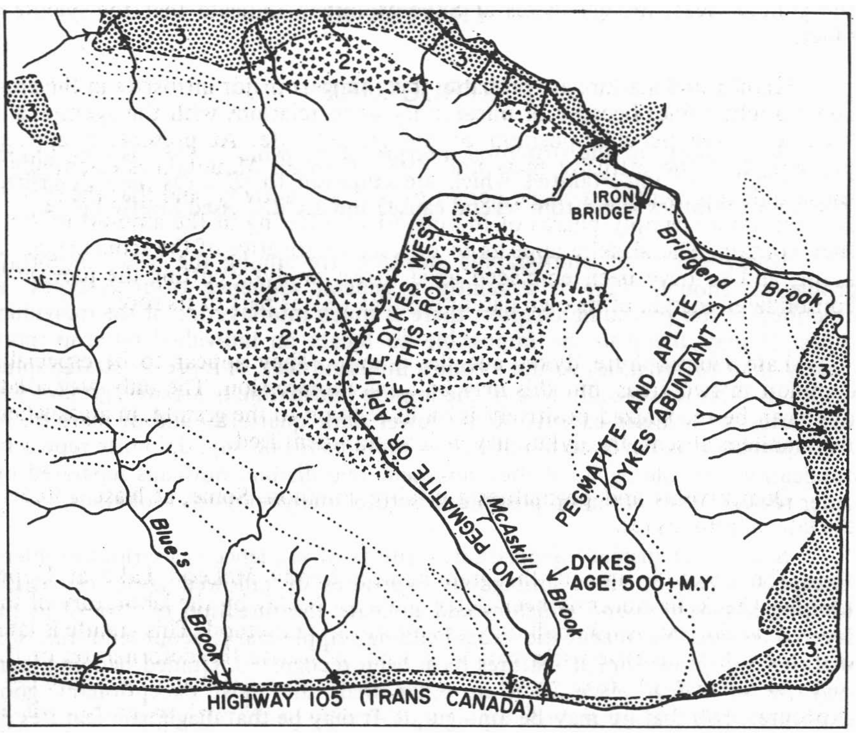


FIGURE 7 *Siliceous dykes are abundant at Skye Mountain, but none were found to the west. Dykes at McAskill Brook were recently dated by Connier. No. 2 indicates intrusive rocks;* 3 ***is*** *Horton sandstones.*

There is no obvious explanation for this remarkable distribution. It suggests that there is some profound change more or less along the line of the road near McAskill Brook, and it is the more remarkable when one recalls that the granitic portion of the Skye Mountain intrusive body itself lies to the west. It is almost as if the part to the west had been, in some way, completely separated from the remainder at the time when the granitic dykes were introduced.

Until there is an explanation for the above remarkable distribution, perhaps one should be cautious about assigning an age to the intrusive mass on Skye Mountain.

CHAPTER III

STRUCTURE

The validity of the structural interpretations which follow is conditioned by a number of uncertainties which are common to all areas here described. These uncertainties stem from several causes and are discussed briefly below.

Uncertainties of stratigraphic position are among the more important problems. Though there is evidently a general sequence of rock types, as described in the preceding chapter, there is much interlayering of the individual types. It may therefore be impossible to locate an individual outcrop more closely than to say it lies within a zone a thousand feet, or more, in stratigraphic thickness. This is especially true of the impure feldspathic quartzites, greywackes and slates; to a lesser extent, of the lower dark quartzites and of marbles. In consequence, it is never certain if two or more bands of, say. dolomite represent duplication by folding, or if they represent two distinct horizons separated by other rocks. The effect upon possible structural interpretations is obvious.

Scarcity of primary depositional criteria of sequence is a serious problem. Except for two or three ambiguous exposures of pillowed lavas, essentially nothing has been found which would indicate the direction of "tops" in the layered rocks. No diagnostic cross-bedding, ripple-mark, scour and fill, sole markings, or other similar features have been recognized. Graded bedding there may be in a few places, but in other than the most exceptionally good exposures, this feature may be ambiguous. It may be that diagnostic features do exist, but, within the limits of the necessary speed of traversing, careful search did not find them. The obvious consequence, as pointed out in Chapter 11, is that one cannot be confident even of the overall sequence of deposition.

Minor structural features, such as drag folds, have been used as indicators of attitude. It is assumed that a drag fold is related to the major fold in a definite way; directions of movement and character of major folds are then deduced. However when most exposures are in brooks, many of which can be shown to be fault-controlled, the validity of the observation becomes suspect; a "drag-fold" may be due to an adjacent but invisible fault, and have only the most indirect relationship to the major fold.

In the fo11owing sections, the structure is described for individual areas, starting with the least complex.

BOISDALE HILLS

The George River rocks, in this type locality, are composed, from north to south, of carbonate, quartzite, and feldspathic quartzite as a narrow zone between the granite and carbonate on the west side, and the Palaeozoic rocks on the east. The width is never more than a mile, and the average is about half that. The zone is over ten miles long.

Intrusive rocks, mainly granitic types, form the western boundary. In detail, the contact is very irregular, with long dykes and tongues of granite and syenite cutting into the George River rocks. Though not everywhere true, there is generally a zone of granodiorite between the George River and granitic rocks to the west.

The eastern boundary with the Palaeozoic rocks is nowhere actually exposed; it is, in part at least. a fault contact.

Stratigraphic Correlations

Within the George River rocks, it has been impossible, so far, to follow individual rock units for any distance. In the field, the carbonates were carefully subdivided according to composition, texture, and colour, in an attempt to follow individual members from traverse to traverse. Although the traverses are only a thousand feet apart, it was found. in fact, that correlation was possible only over very restricted areas, and then with only very limited confidence. It is probable that by "walking out" the individual layers, they could be followed, especially in the valley of George River.

Bedding in the George River rocks is steeply inclined almost everywhere. Essentially none is recorded with a dip less than 40 degrees and, in most places, the dip is greater than 55 degrees.

Repetition of the carbonate at either end of this narrow zone suggests duplication by folding. Bell and Goranson considered the quartzitic central part to be older than the carbonate, and the overall structure an anticline. They did not detail their evidence, stating simply that "field evidence, not entirely satisfactory, suggests that the carbonate member overlies the quartzite-schist-gneiss member" (G.S.C. Map 360A and Memoir 215).

The quartzites are here considered to be the equivalent of the "Upper" quartzites of the Craignish Hills. This correlation is based primarily upon lithological similarity, though it will be noted that the quartzites are closely associated with the carbonates in the upper part of George River valley. If the quartzites were the equivalent of the lower "dark" quartzites, there should be a thick section of greywacke, impure quartzites and slate intervening between them and the carbonate.

Such a correlation with the "Upper" quartzites makes the remainder of Bell's quartzite member anomalous. It consists of quartzite, feldspathic quartzites with ID to 20 per cent feldspar, and a recrystallized layered rock with the mineralogical composition of a metamorphased slate or very impure sandstone. This latter rock is what Bell and Goranson called "schist and gneiss" in the quotation above. (It should be noted that though it is a gneiss, it in no way resembles the granitic gneisses common in the Canadian Shield.) Such an assemblage would correspond to the interbedded slates, greywackes, and impure quartzites which in the Craignish Hills *underlie* the carbonate horizon.

Folding

There are then four possibilities, at least:

(a) The structure is basically anticlinal. The siliceous unit then corresponds to the slate, with interbedded feldspathic quartzites and greywacke, which underlies the carbonates in the Craignish area. Though dominantly quartzitlc, especially in the northern part, there is enough greywacke, etc.. present to make this a possibility at least. A white, clean, quartzite, which "overlies" the slate zone near George River and Highway 23, (fig. 8) is absent at Frenchvale and Sandy McLeod Lake. It would require the sudden disappearance of a substantial thickness of quartzite, on the one hand, or, on the other, it would require that the fault in Frenchvale Brook have a substantial

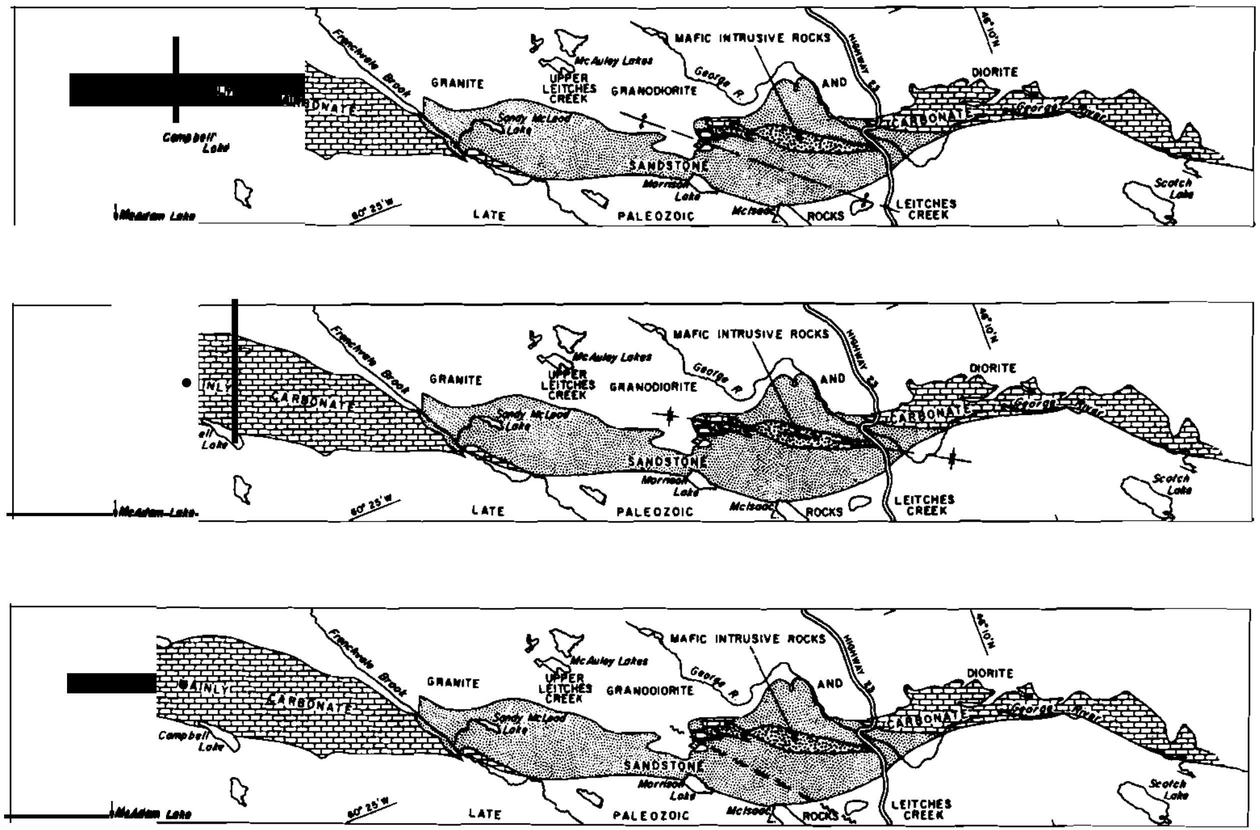


FIGURE 8 **Alternative interpretation of the structure of Boisdale Area.**

displacement and that it be rejuvenated with only slight displacement in post-Wtndsor time. One further complication arises from the scanty bedding attitudes, which suggest that limestone once extended from west of Morrison Lake across to George River. This is the area which, on the anticlinal hypothesis, should be siliceous rocks.

(b) The structure is basically synclinal (Fig. 8). This has fundamentally the same objections as the anticlinal structure, and assumes that the siliceous unit is the equivalent of the "Upper" quartzites. The data can be interpreted to show a synclinal fold with a dioritic body (between Leitches Creek and George River) in its axial part. In this case, the whole mass of impure quartzites between Mclsaac Lake and Frenchvale Brook should go between the northern carbonate zone and George River - and this it obviously cannot do. If the axial zone of a synclinal fold is further south, say near Morrison Lake, then the white quartzites are missing near FrenchvaJe Brook. and there is the same problem as with the anticlinal idea.

(c) There is a major fault break, with a large stratigraphic throw. This assumes that the quartzites at George River are, in fact, "Upper" quartzite (stratigraphically above the carbonates) and that the remainder of the siliceous unit is stratigraphical\y beneath the carbonate. There is then a unit, the quartzite, from above the carbonate placed alongside a unit from below the carbonate. The break would have to pass, more or less, through Mdsaac Lake, and trend about southwest. This would solve most difficulties with correlation and stratigraphy, The chief objection is that, although outcrop is scarce in the critical area, not the slightest evidence of such a break was recognized on the ground. The aeromagnetic map does show that the magnetic disturbance associated with the Boisdale Hills'is cut off abruptly, as required, but the change comes about a mile north of the appropriate position and is probably more closely related to the mafie intrusive rocks than to any structural disruption.

(d) There is no major fold at all. This hypothesis requires that a single carbonate zone once extended from Scotch Lake, along the west side of George River and, with minor folds and distortions, through Upper Leitches Creek to Frenchvale Brook and almost to McAdam Lake. It is now missing where cut out by later intrusive rocks. For this to make sense requires that the two carbonate zones be at different stratigraphic levels, and that the siliceous rocks represent an intertonguing zone. That is, the present exposures cut across a zone of facies change.

This is not an impossible solution of the problem. Small folds of considerable complexity certainly exist. They are an order of magnitude smaller than the structures here being discussed, and might readily explain bedding altitudes oblique to the general trend. The chief objection is that it introduces into the carbonate portion of the series a section of both impure and clean sands, and muds, much thicker than anything recognized elsewhere within the carbonates. To rule out the hypothesis for this reason is to deny the possibility of contemporaneous facies differences in the depositional basin, yet the available evidence of such differences is by no means compelling. On the other hand, on a relatively small scale, it is a fact that limy bands are interbedded with quartzite, and vice versa, within outcrops two or three hundred feet long, north of Frenchvale Brook.

At present, none of these alternatives is satisfactory. For the stratigraphic reasons detailed in (a) and (b), above, there appears to be no way of interpreting

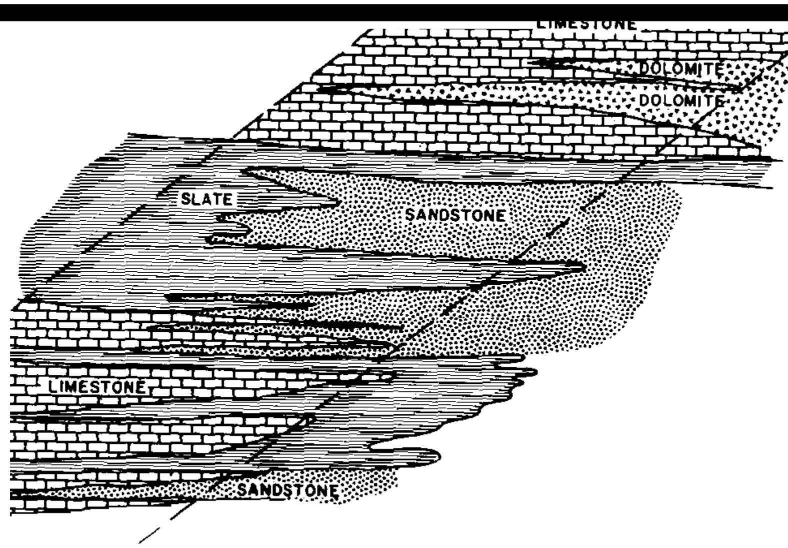


FIGURE 9 *Diagram of a fourth possible interpretation of Boisdale structure. For explanation see text.*

the structure as either an anticline or a syncline. There is no evidence of the major fault required by (c), even though, by this mechanism, the units can be made to fit the same stratigraphy found elsewhere. By default, then, the idea of a narrow zone which has cut "diagonally" across an area of facies change may be the least objectionable hypothesis.

Minor folds do occur within the larger structure considered above. The fold shown east of Sandy McLeod Lake, is of this kind. Though complicated by minor faulting, this is a fold about 1000 feet across, on which there are smaller folds, of the dimension of single outcrops and too small to show on the map. These are the best exposed folds, and are probably reasonably typical of the minor folds; they are discussed below at some length.

The larger fold is an antiform and plunges about 40 degrees to the west. Faulting complicates the picture, but on Frenchvale Brook, just upstream from the tributary draining Sandy McLeod Lake, there is a small syncline marked by a folded limestone. This can only be suggested on the main map, but the adjacent diagram, figure . has been made by enlarging the appropriate portion of that map. One can see that, to accommodate both the 65 degree westerly dip and the vertical beds, the fold must be nearly isoclinal and plunging west. The least dip recorded on the western limb of this fold is 40 degrees, which should approximate the plunge. This is, in turn, in approximate agreement with the plunge of the larger fold nearer Sandy McLeod Lake. To the west of the fault the brook runs on limestone to the next tributary, though only a very small stratigraphic thickness is exposed.

Two small folds appear on the tributary; an anticline on the north is followed to the south by a very narrow syncline. Drag folds on Frenchvale Brook, near the junction, confirm the syncline to the north and again indicate a westerly plunge, this time at 50 degrees.

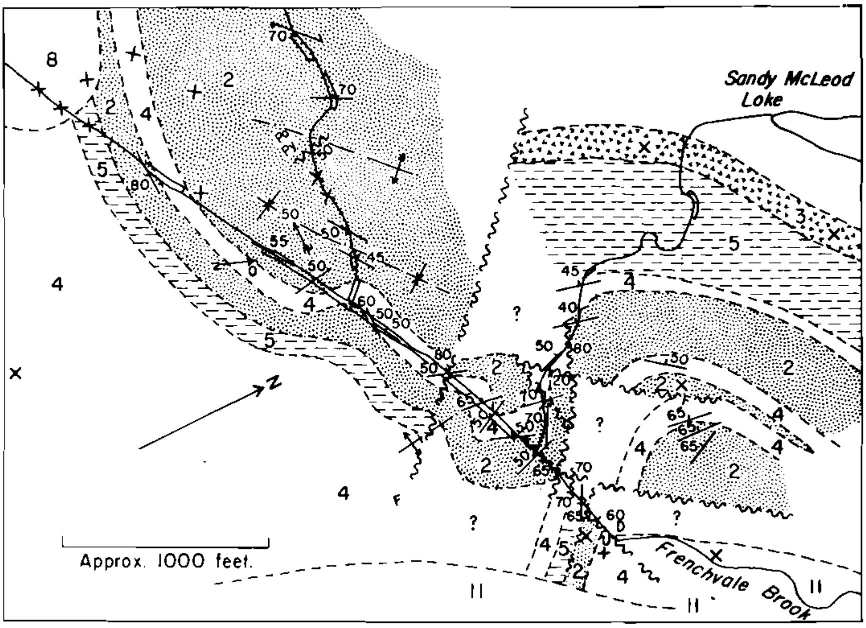


FIGURE 10 Enlargement of map of an area on Frenchvale Brook. Numbers identify units as on Boisdal« map.

Still another fold direction is indicated in the main brook. In the greywacke and quartz-feldspar-biotite rock, two rolls about IS feet across, which are essentially two drag folds, have horizontal axes trending north 20 degrees east. The diagram, figure 11, was prepared from a notebook sketch of the cross-section of these two folds as they are exposed in the wall of the brook. It is evident that they represent minor crumpling on the flank of the syncline which has its axial plane a couple of hundred feet north in the tributary brook.

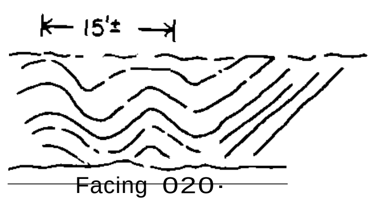


FIGURE 11 Notebook sketch of crass-section of folds: Plunge is 00.

In summary, we have here at least three structures of different orders of magnitude. The major one, probably some miles across, is represented by the steeply dipping zones of the whole series. According to the hypothesis outlined on page , the portion of the George River series found in the Boisdale Hills is a zone of facies change now turned up on edge on one limb of a fold; the balance of the fold has been lost under the Palaeozoics to the east, or destroyed by the intrusive to the west. Superimposed upon this more or less vertical flank of the major fold, are minor folds, a thousand feet or so in outcrop width, and plunging about west by north at 40 to 50 degrees. Superimposed upon these, in turn, are still smaller folds, with dimensions of tens of feet, or less, and nearly horizontal. Because of their horizontality they must trend nearly parallel to the main George River zone.

It is tempting to assign such folds to three different .tectonic events. Suitable major deformations are, of course, known here. Without knowing the attitude of the major fold, however, one does not know the relationship to it of the intermediate folds. It would be premature, therefore, to try to relate the fold directions here discussed to any regional tectonic history.

Faulting

Many faults and shear zones are reported on the map, but few have been extended beyond the point of observation. Partly this is because of lack of contours on the base map, but primarily it is because of scarcity of outcrop. In many places it is difficult to say, even for outcrops only a few tens of feet apart, whether or not two faults are related.

The faults here reported are based on three main field criteria. Most frequently used is the presence of a slickensided surface, or a zone of shattering containing many such surfaces. The next most common criterion is a zone of mica schist in rock otherwise massive, or. if the outcrop is small, schist derived from a rock which is massive on other outcrops in the vicinity. Finally, the least common and the most difficult to demonstrate in the field, is observed displacement of marker horizons. In individual cases, other factors were no doubt considered in evaluating the outcrop, but the above are the chief features actually represented by the fault symbol on the map.

Post-Mississippian movements are, of course, represented by such faults as that in Frenchvale Brook, which apparently deflects the Palaeozoic boundary, and by that in George River, which separates the George River from the Windsor rocks near the quarry. The direction in both cases is about west-southwest. It will be noted that some other fractures have a similar direction, but, within the George River rocks, it is, of course, impossible to tell if they too are of post-Windsor age. A parallel fault probably controls a brook draining into an unnamed lake north of Sandy McLeod Lake (near Gouthro Road).

The displacement shown for the granodiorite west of George River quarry may be more apparent than real. At the upstream end, the fault is visible in the brook as a schist and breccia lone, the latter containing fragments of the granodiorite. It also cuts off dykes of granite. The south bank shows outcrops of white dolomite along this section. On the map, this fault has been extended downstream to join it to a heavily serpentized fault zone in dolomite in the brook below the quarry. This leaves three outcrops of the granodiorite in the brook south of the fault, and the boundary has been drawn to include them. The requirements of draughting make necessary some exaggeration of the extent of the granodionte and limestone between the fault and the Windsor contact.

A probable post-Mississippian fault is also present on the north side of the isolated triangular mass of limestone north of, the George River quarry. This fault is exposed at the northeastern corner; it probably forms the northern boundary because the metamorphic grade of the limestone is much too low to be consistent with an intrusive boundary with the granite.

What appear to be minor faults trend in a variety of directions, of which northwest and northeast are common. On the basis of slickensiding on the individual exposures, there is no obvious systematic sense of motion on these breaks.

Where outcrops are good, as in Frenchvale Brook, considerable complexity of faulting can be seen. Good exposures elsewhere would presumably show similar numbers and complexity.

CHRISTOPHER McLEOD BROOK TO ST. ANN'S

This small area is the southern extremity of a narrow band of George River rocks which extends as a high, flat-topped ridge from just north of Baddeck Forks to west of Tarbotvale,

The area of immediate concern lies between North Baddeck River and the coast at SI. Ann's. The northern limit of the present exploration is a short distance up North River beyond McDonald Brook, which also was included. (There was some difficulty with both navigation and geology at the limit of the work, and the edge of the surveyed area is not shown on the accompanying rnap.) The centre of the area is drained southward by Christopher McLeod Brook, which has two branches. Between the two branches is a high ridge marked by a cliff of white quartzite, which is the southern extremity of the flat-topped ridge mentioned above, and a landmark visible for many miles.

It is suggested that this ridge, and the high land to the east and west of it are due to a sheet of George River rocks thrust over the Horton and Windsor. If true, the displacement must be at least two miles. The evidence for this is discussed below.

The exposed rock, except for the quartzite ridge, is limited almost entirely to the brook bottoms, or the steep walls of the valleys.

For the critical portions of Christopher McLeod Brook, the positions of outcrops, and their elevations, were determined by stadia survey. The datum for elevations is the level of the east branch of the brook where crossed by a main lumber road near a sawmill site, assumed to be 425 feet, as shown on the topographic map.

Distn1lution of Horton Rock.

Basic to any understanding of the structural history of the area is an understanding of the behavior of the Horton unconformity. This is now considered, working westward from Quarry St. Ann's.

Not only Horton rocks, but Windsor gypsum as well, outcrop at *Quarry St. Ann's* especially in Goose Cove Brook and in the quarry. To the westward, in Goose Cove Brook, the Windsor rocks are succeeded by syenite, granite, and George River quartzite. To the northward, the Horton unconforrnity, with the Horton to the east, is visible in a tributary of McDonald Brook, near Meadow.

The east branch of Christopher McLeod Brook shows the Horton unconformity in a number of places. These are all in the tributary brooks on the east side of the branch, and all are near the road which runs along the east side of the valley. The observed dip in the Horton, at or near the unconformity, varies from 15 to 30 degrees west. In conglomerate and sandstones, such variability is not surprising. The average dip, determined geometrically from three exposures of the unconformity, is 22 degrees west, and the strike is almost due north. Simple projection of this plane surface gives a trace for the unconformity which fits all field data with considerable accuracy to a point about one mile north of Peter's Brook. Further southward, the dip averages II degrees. The present work did not extend much beyond Peter's Brook, but simple projection of this II degree surface fits all of Kelley's published data, except one outcrop north of Rear Big Hill, and the Horton which he shows between that place and North Gut, St. Ann's.

The east side of this valley is almost a dip slope. Therefore, very slight changes in elevation or in the dip of the unconformity result in wide swings of its outcrop. It is possible that some such small variation is the reason for the distribution of the Horton between Rear Big Hill and St. Ann's.

The dip of the unconforrnity, **of course, carries it downward and westward** under the east branch of Christopher McLeod Brook. The bottom and the west side of the valley have outcrops of Horton sandstones, as would be expected.

In the west branch of Christopher MeLeod Brook the Horton unconformity again appears. From an old logging dam roughly a quarter of a mile north of the last abandoned farm on the west side, George River rocks are exposed in the bottom of the brook for a further distance of about 3,000 feet to the north. Horton outcrops occur in the hrook for another 1,000 feet northward beyond that.The west wall of the valley has considerable Horton float and, even **in the part where** George **River rocks are exposed in the brook, Horton rocks** outcrop at, or just above, the water level. It is evident that the brook is running **on, or very near. the unconformity, which dips about 25 degrees west.**

In summary, then, the Horton unconformity, with a constant westerly dip of about 20 degrees, appears at St. Ann's and Meadow in the east; some miles westward it appears in the east branch of Christopber McLeod Brook and again, about. a further mile westward, it reappears in the west branch of the same brook.

In the east branch of Christopher McLeod Brook, outcrops of Horton sandstones occur in the bottom of the valley as far north as the logging roads at the base of the great quartzite cliff which forms the west wall of the valley at its northern end. A spur from the ridge forms the northern end of the valley, and the logging operations stopped on its bottom part. Careful search produced no trace of Horton, or of Horton float, on the main part of the spur ridge; sandstone fragments, totalling 7 pieces only, were found near the base of the ridge, but none was more than 100 feet north of the northernmost logging road. Horton rocks outcrop beneath the George River in the bottom of the brook at the eastern extremity of the logging clearing. The contact strikes north 65 degrees east, and dips 24 degrees northwest.

On the ridge between the branches of Christopher MeLeod Brook, Horton **outcrops are common at the south end and along the base on the eastern side.** Near the summit, and towards the south end on the eastern side, a large boulder of Horton sandstone was found about 50 feet from an outcrop of brecciated George River quartzite, and 35 feet below it. The upper limit of Horton rocks on the east side of the ridge must lie between this boulder and the quartzite outcrop, with the quartzite above.

In the same general area, but on the western side of the ridge, Horton sandstone outcrops in three places in the uppermost of the old logging roads there. The outcrops are at elevations of 777, 770 and 755 feet, and are respectively 13, 20, and 35 feet below the level of the quartzite outcrop just mentioned; though they are on the opposite side of the ridge, they are only 600 feet distant from it. It seems very probable that the Horton rocks extend completely through this narrow ridge, with their top at an elevation of 750 to 780 feet.

On the west side of the ridge, below the outcrops just mentioned, good undoubted outcrops of Horton are very scarce. Small amounts of float fragments are not uncommon beneath overturned trees and in the brooks tributary to the west branch. Because experience has shown that fragments of the Horton rocks disintegrate into sand in the brooks within a few hundred feet of their source, it is possible to trace an approximate upper level of Horton fragments, from the outcrops just discussed northward to the most northerly exposures of Horton in the valley bottom. One positive outcrop of Horton conglomerate was found 700 feet east of the stream and at an elevation of 937 feet.

In the west branch of Christopher McLeod Brook, outcrops of Horton rocks and considerable amounts of Horton float occur on the steep parts of the west bank, as would be expected above the unconformity in the brook. As would not be expected, however, none is found on the upper part of the valley side, nor on the plateau above. Very scarce outcrops of greenstone, granitic rocks, and slates have been found at elevations above the Horton. The upper contact of the Horton rocks is nowhere exposed. As on the eastern side, however, a general line of the upper limit of Horton fragments can be followed along the west side of the valley and southward onto the farmland there.

Summarizing this, we have:

(a) Horton rocks occupy the bottom of the valley of the east branch of Christopher McLeod Brook, but are cut off against a ridge of George River rocks at the north end of that valley, and George River rocks, locally at least, overlie the Horton there.

(b) White quartzite of the George River is found at elevations above the Horton on the ridge between the two branches of the brook.

(c) George River rocks, and granite, occur at elevations above HOftOD sandstone and conglomerate on both the east and west walls of the valley of the west branch of the brook, but with a narrow strip of George River rocks exposed in the valley bottom, where the stream has just cut through the Horton unconformity.

interpretation

The presence of the Horton unconformity to the east at St. Ann's and at Meadow, its reappearance, dipping 22 degrees west, in the east branch of Christopher McLeod Brook, and yet again, dipping 25 degrees west, in the west branch of the brook requires that there be either,

(a) a very marked relief on the pre-Horton erosion surface, or,

(b) folding of the unconformity, or,
(c) faulting with vertical displacement of several thousand feet.

Postulating pre-Horton relief to explain the distribution of the unconformity, requires a valley floor which was nearly a plane surface over a length of several miles, north and south from Peter's Brook, lying between hills with a relief of at least 1500 feet and (immediately west of St. Ann's) probably in excess of several thousand feet. In effect, an intermontane valley, or even a canyon is necessary. We must further suppose that, whatever the direction of sediment source and transport, the general dip of the resulting deposits was uniformly westward.

Folding of the unconformity is a possible explanation of the appearance of the George River rocks in the west branch of Christopher McLeod Brook. But folding of the unconformity is not indicated by any of the observed strikes and dips near the contact.

It is most probable that the repetition of the Horton unconformity is due to faulting. Such faults, themselves, have not been recognized, though strongly fractured, and locally schistose, George River rocks in the western branch of McLeod Brook suggest that a fault may be nearby. If so, the schistosity indicates that any fault plane must be steep or nearly vertical. There is nothing to suggest the location of the eastern fault; it could be anywhere between Christopher McLeod Brook and Quarry SI. Ann's. The natural place to suggest, of course, is just west of the quarry.

The occurrence of George River and granitic rocks at elevations above the Horton is a separate problem, but also implies faulting. The great question is the number and attitude of the faults involved.

In Christopher McLeod Brook, it is possible to explain the presence of pre-Horton rocks to the west of the west branch by means of a steeply dipping fault trending about north, perhaps with some minor cross-faulting. For the latter, there is some evidence in the brook. Here the uncertainties and inaccuracies in our base maps become important, as does the paucity of outcrop. The contact cannot be defined more closely than ± 200 feet at any point, and in most cases not within 1000 feet. In consequence, a horizontal fault would equally well explain the observed data.

Starting with such a fault, of indeterminate dip, on the west side, it is possible to imagine a whole series of faults to the eastward. There would then be, in succession, a steep fault bringing the Horton unconformity to the surface in the west branch of the brook; then the Horton,lying above the unconformity, which must outcrop again near the summit of the quartzite ridge; the quartzite, in turn, brought up by a fault on the east side of the ridge near the summit; finally, far to the east, another fault near Quarry SI. Ann's brings the unconformity back down below the present surface.

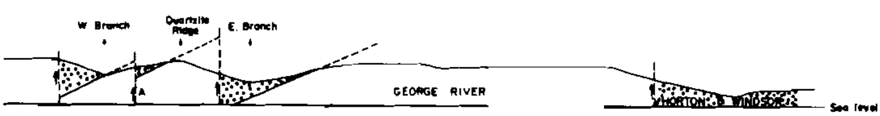


FIGURE tz *Possible cross-section at Christopher McLeod Brook. Except at A. attitude of faults is diagrammatic only.*

It is implied also that the Horton rocks on the west side of the quartzite ridge should be the conglomerates usually found just above the unconformity. Three of the four positive outcrops found are shaly sandstone.

The fault on the east side of the quartzite ridge must be cut off at the north end by a cross-fault. This is necessary to explain the termination of the Horton against the spur ridge at the north end of the valley. Such a cross-fault has not been recognized on the west side of the ridge, and would, in fact, introduce considerable complication there.

Finally, if the fault on the east side of the ridge is steep, there should be a long wedge of George River rocks extending south from the south end of the ridge, not just the 600-foot width described above. If, to avoid this, one assumes that the Horton rocks on the west side of the quartzite ridge are continuous, under the ridge, with those on the east side, the fault must pass above all the Horton.ln this case, the dip must be very shallow.

It is, in fact, possible to explain all the data in terms of a single, nearly horizontal, thrust sheet. Two steep faults are necessary, as was indicated above:

(1) The Horton unconformity is visible in the east branch ofChristopher McLeod Brook, because of a steep fault between there and Quarry St. Ann's.

(2) The unconformity is repeated again in the west branch of the brook by another steep fault with a vertical displacement of about 1,500 feet. This whole issue, including the two faults just mentioned, was then over-ridden by a thrust sheet which carried granite and George River rocks over both Horton and George River. Such a fault would have to have a maximum dip of about la degrees to the west, in the western part; the dip would change to a maximum of 5 degrees east under the quartzite ridge, and is probably about 3 degrees.

This would fit the probable upper limit of Horton, would require no cross-fault at the upper end of the eastern valley of Christopher McLeod Brook, would explain the peculiar southward termination of the quartzite ridge, and would explain why the Horton boundaries approximate the topographic contours . It would thrust George River rocks over George River between Christopher McLeod Brook and Quarry St. Ann's.

It is possible that the granite is a sheet or sill, but this does not provide an explanation of greenstones and quartzite at higher elevations than the Horton on the sides of the western valley.

The observed contact of George River rocks over Horton is probably a fault. This has a dip of 24 degrees northwest where seen in the upper end of the east branch of Christopher McLeod Brook. This is certainly not the postulated dip of three degrees east. It is possible, jf not probable, that the measurement was actually made on a surface subsidiary to the main fault plane.

The minimum displacement on such a thrust sheet would be about two miles: from the west branch of Christopher McLeod Brook to a zone of faults on Goose Cove Brook which may mark the bottom of the sheet there. The direction of motion of this postulated fault is not known. Orientation of other features suggests movement from either east or west.

The two steep faults which repeat the unconformity are something of a problem. Obviously they are older than the overthrust, which rode across them; presumably they belong to the same post-Mississippian tectonic event. Their general direction indicates an east-west major stress. It is possible to make an argument that the nearly horizontal main thrust and the nearly vertical faults are conjugate movements parallel to the directions of maximum shearing stress in a field where the principal compressional stress is inclined upward to the east or west. Such an argument is probably a gross over-simplification, and is none too satisfying.

If the overthrust exists, it must change to a southwesterly dip near Meadow. Such would not be unexpected for it is common to find that the bottom of a generally horizontal thrust sheet is, in fact, a gently rolling surface. There may be complications near the junction of MacDonald Brook and North River, but the data are there very scanty at present.

CRAIGNISH HILLS

A preliminary study of the structure of the Craignish Hills was made by R.C. Parsons, as an M.Sc. thesis, in 1964. The following differs in no essential part from the conclusions reached by Parsons but, at the end, there is some discussion of inconsistencies and ambiguities in the evidence, and of points that require further clarification for a satisfactory preliminary understanding of structural events in this area.

Description of Data

Structural Blocks

There are a number of sub-areas which appear to be internally consistent structural units. At the same time, some of these structural blocks appear to be unrelated to those immediately adjacent, and there is a natural inclination to explain this disjunction by faulting. The major faults shown on the map are basically of this type, and are fairly obvious by inspection. Exceptions are those few where one small block of rock is apparently completely surrounded by another type (e.g. a limestone in an area of andesite) and, of course, the faults bounding the areas of Palaeozoic rocks. Each of the sub-areas is now considered briefly.

From Iron Mines to East MacPhail Brook, on the south side of the hills, the attitude of the rocks is fairly constant. The general trend is westerly; the northerly dip increases with fair regularity from about 20 degrees near Blue', Mills to 6S to 70 degrees near the top of the mountain. In general also, in the westward part, along the extension of the strike of the formation, there is a comparable increase in the dip as one proceeds from south to north. It is not clear-cut, however, and especially between River Denys and East MacPhail Brook, the dip is uniformly steep and there is more variation in strike direction than there is to the east; locally there are some southerly dips.

From west of Churchview to Kewstoke, the strata on the north side of the mountain are also reasonably uniform in attitude. They bend in a great arc so that the strike changes from about west to about southwest, and the dip is fairly consistently north at 60 to 70 degrees. There are local disturbances of this regularity near the Iron Bridge at Churchview, and south of the Soapstone road. The latter is almost certainly associated with post-Palaeozoic faulting; the former may be related to a fault in the brook at the Iron Bridge. There is a very distinct and abrupt change in orientation of the strata west of Kewstoke Brook.

Between Kewstoke Brook and Upper Glencoe the prevailing direction of strike is northerly. The change of direction occurs somewhere between the two branches at the upper end of Kewstoke Brook, and the new direction applies to the slates and andesites between there and Upper Glencoe, as well as to the limestones to the north of Dunakym. The dip generally is 55 to 75 degrees to the east, though there is considerable variation in dip near the andesite contact in the vicinity of the Maple Hills-Blue's Mills road. The exceptions to this generalization are in the andesites on the height of land between River Denys and Mull River, where the general trend is easterly and the dip steep to the north.

In the limestones southwest of the uppermost part of Mull River and adjacent to the road along East MacPhail Brook, there is considerable variation in bedding attitude. The variation has no obvious general system, and some imagination has been used in interpreting the data. The real problem is to reconcile the bedding attitudes with the distribution of the outcrops of dark blue and black limestone. Though it is plain to see in many places on the ground that small scale "plastic" flow is common in the limestones, it must be admitted that the interpretation shown on the map indicates a style of folding completely different from the remainder of the area. Here one is particularly impressed by the need for some method of positive correlation of individual limestone units.

Between East MacPhail Brook, and Diogenes Brook, on the south side of the hills, the general strike direction is westerly. Some of the quartzites are massive and bedding layers do not show clearly, especially near Diogenes Brook. There are a few places, near East MacPhail Brook, where local variations of lithology and attitude indicate small scale folding. Though this area was systematically covered by traverses between the brooks, there has been little real success in following the different, apparently thin, rock units, such as the greenstones and black slates.

The area between Diogenes Brook and the Trans-Canada Highway, and extending west from Melford to beyond River Inhabitants north of Glendale, seems to be almost a detached unit. The general trend of the George River strata is northward over most of this area, but with a northwesterly direction near Diogenes Brook. Dips are steep and generally eastward or northeastward, though there are exceptionally gentle dips near the road from Melford to River Denys Road.

On the Indian land at Whycocomagh the strike is generally westerly, but is variable on the hill top overlooking Churchview. There is some recognizable small-scale folding on McAskill Brook and possibly also on the next brook to the east.

Plunge of Structure

Few reliable criteria are available to indicate the plunge of major structures. Such as they are they indicate some variability.

In the eastern part of the Craignish Hills, the strike and dip of bedding near the nose of a small fold on McAskill Brook indicate a fold plunging northwest at about 15 degrees. Actual measurement on an axis of this small fold gives a plunge of 10 degrees northwest. In the next brook to the east, estimation from intersecting strike and dip measurements indicates a plunge of 60 to 65 degrees northwest, and this appears to be representative of the general situation in the eastern part of the Craignish Hills.

In the upper part of River Denys, drag folds indicate steep fold axes in a variety of directions. Some of these are probably dragging related to nearby faults, as in the extreme upper end of the valley, but others are probably valid. Considering all the evidence available to him, Parsons concluded that the drag folds indicated a general plunge of about 50 degrees to the northwest.

The Proposed Fold System

Parsons' explanation proposed a major anticlinal fold, somewhat distorted by cross-folding, overturned from the north and plunging 50 to 60 degrees to the northwest. The axial trace of this fold follows generally the top of the mountain from Highway 5 on the Whycocomagh Indian land, through Skye Mountain, the upper end of Blue's Brook and of River Denys, to near Upper Glencoe. The northward-trending rocks of the Melford-Glendale section were considered the crest region of a parallel anticline to the south, and the upper quartzites, south of East MacPhail Brook, represented the intervening syncline. Similarly the limestone at Kewstoke represents the syncline to the north. The whole southeastern side, of course, was cut off diagonally by the down-faulted Mississippian rocks. Though local faulting is recognized on the north side of the mountain, and there are isolated patches of Horton rocks, the Horton in that area was considered to have been deposited as a sequence overlapping on the George River rocks and in depositional rather than fault contact.

In locating the west end of the northern, and most complete, fold, very considerable weight was attached to a fold found in one of the uppermost tributaries of River Denys. The beds swing from a westerly to a northeasterly strike in a width of 300 feet, and this was considered to mark the apex of the major fold. The plunge of the fold at that point appears to be about 50 degrees west. Considerable weight was also assigned to a few outcrops of black slate in a nearby tributary. This is considered to represent the thick band of black slate found between Blue's Brook and McAskill Brook, to the east.

At least two things are implicit in this interpretation. The first is that the major units do not repeat in the stratigraphic column. That is, the grey slates east of Kewstoke Brook are the same slates as those between River Denys and Blue's Brook. The second is that the stratigraphic sequence is correctly interpreted. If not, the anticlines become synclines. What is more, because of the plunge, the fold on Skye Mountain is an antiform, and, if the stratigraphic sequence is reversed, that fold becomes a completely inverted syncline.

If one grants both the assumption of correct stratigraphic sequence and non-repetition of units, the above interpretation is not impossible. In fact, if the slates on the north and south sides of Skye Mountain are the same unit, it is difficult to picture any structure which does not include an antiformal fold under that mountain. The dark quartzites west of Whycocomagh also fit reasonably well into such a picture. It will be obvious to the reader that this picture of Skye Mountain has dominated all the preceding presentation of stratigraphlc units and sequence.

Difficulties and Inconsistencies

There are certain very obvious difficulties with the above hypothesis. First, the small patch of quartzite north of Bridgend Brook at Churchview is white quartzite and apparently identical with the "upper" quartzite from north of Diogenes Brook. Thus, the uppermost units, and the associated limestones, are alongside the feldspathic quartzites and greywackes, almost the lowermost part of the sequence. The volcanic rocks and the Jimestones are missing. Second, the great thiekness of volcanic rocks between Maple Hills (Dunakym] and Upper Glencoe is not represented between the slates and the limestones on the uppermost parts of River Denys. It is possible to explain this, qualitatively at least, if the intervening fault is a thrust dipping northwestward and, in fact, such appears to be the only way of explaining the apparently contradictory displacements on the fault. However, it would be more convincing if some quantitative check could be made. Third, many marvelous things may, no doubt, be hidden beneath the adjacent Horton, but the ridge of limestone north of Dunakym appears to be completely unrelated to the nearby George River rocks. Fourth. a somewhat similar isolation is suggested for the patch of slates west of Melford. Further, the slates are separated from the andesite to the west by a band of feldspathic quartzite which should be, if anywhere, to the east. Finally, there is the peculiar distribution of metamorphism and granitic dykes described above. Though there is an intrusive mass on Skye Mountain, the metamorphic grade of the slates is only the biotite zone and the dykes are all east of McAskill Brook.

The Mississippian on Diogenes Brook includes Windsor gypsum, which is assumed to have been faulted into place. The dip of the sandstones and conglomerates between Melford and Chisholm's Mill is about 40 degrees east - not an unreasonable value for deposits overlapping onto the George River slates. However. there is an unusual isolated patch of Mississippian rock on the first and second tributaries south of the mill. It was obvious in the field that this did not fit, but in the time then available no explanation could be found. With the situation at Christopher McLeod Brook in mind, one wonders about this ridge, about the gypsum on Diogenes Brook, and about the possibility that the slates are overlying the Mississippian. It should be stressed, however, that this possiblity was not recognized in the field, that accordingly no critical observations were made, and that no positive information so indicating has, in fact, been recognized.

The Horton, on the Whycocomagh Indian land, appears to overlie the George River with a normal unconformity dipping about 20 degrees east.

It is because of the uncertainties indicated above, and the obvious need for reconsideration, that the accompanying map is printed as a preliminary map in only one colour.

CROWDIS MOUNTAIN - MIDDLE RIVER

General Relations

In a very general way, the George River rocks in this area may be described as large irregular masses, probably disconnected from one another, and penetrated by large dykes and masses of the intrusive rocks in which they are engulfed. The plateau which forms the flat top of Crowdis Mountain is underlain by granite, syenite and related igneous rocks. However, exposures are visible on the top of Crowdis Mountain only because of the logging roads there. To the north, where such roads are absent, although no information is available outside the brook bottoms, it appears that between Middle River and Nile Brook the plateau is underlain mainly by gneisses derived from the George River rocks, with granite more abundant at the northern end.

There are post-Mississippian faults. The three most prominent are those in Middle River at Finlayson, to the north of the upper end of Garry Brook, and in Leonard McLeod Brook near Middle River village. These faults are all deduced to explain displacements of the Mississippian rocks, but the fault in Leonard McLeod Brook has an associated magnetic disturbance and can be traced by means of shear zones (with a minimal amount of imagination) through Muskrat Brook to a fault in North Baddeck River near the landing strip. The evidence for these faults and their displacements is treated in greater detail below.

Northward the grade of metamorphism is increased. The rocks contain minerals which are obviously not equilibrium assemblages (chlorite and epidote in the amphibolites, for example) but there is a clearly visible trend from chlorite zone equivalents in the vicinity of Gillis Brook and the lower part of Leonard McLeod Brook, to high grade gneisses north of Fortune Brook, and gneisses of distinctly granitic aspect north of Ryan Brook. The recrystallized feldspathic quartzites and greywackes are represented on the maps by "quartz-feldspar-biotite rock", and by its still higher grade equivalent, the gneisses. The boundary of the gneisses, as shown on the map, coincides with the garnet isograd; the garnet first appears in the area of the Gold brooks. The gneisses at Ryan Brook and to the northward have a distinctly granitic aspect in hand specimen. but have in most outcrops a distinct coarse layering obviously derived from sedimentary layers a few inches to a few feet thick. The granite shown on the map for that part of the area is massive and was probably truly /luid when emplaced. There is some reason to suspect that small patches- of gneisses encountered in some of the brooks are large detached fragments of the gneisses engulfed in the invading granite.

Limited outcrops in the northern half of the area make it difficult to follow structural trends. Though a regular and uniform easterly strike direction is indicated on the map from Ryan and "Back" brooks to the limit of exploration on Middle River, it is obvious that this is based upon most inadequate outcrop.

There is the further generalization that there is a notable localization of the stream valleys to the areas of George River rocks. There are, of course, exceptions. but it is the general rule that most streams are underlain by George River rocks, and so are their tributaries. It is also the general rule that the headwall of each valley - main or tributary - lies on syenite, granite, or other siliceous intrusive rock, though the stream may not have cut far into it. It is assumed that this localization of the drainage to the George River rocks is but another manifestation of the youthful stage of development of the streams and of the landscape, of which there is abundant other evidence in the area.

Folding

In the Gneisses

Few folds have been recognized in the gneisses. As mentioned above. exposures are almost non-existent on the plateau. and many elsewhere are small. Recognition in the gneisses of folds larger than a single outcrop accordingly depends heavily upon the presence of a stream at the critical point. Generally, within the limits of a single outcrop the layering of the gneisses is quite regular.

A large open fold in the gneisses occurs east of Lake O'Law. It plunges northward at about 60 degrees. There is no obvious reason why there should be only a single fold, and it is probably fair to consider it as a sample of the style of folding existing in the hidden parts of the gnersses ID that area. In fact, there IS a suggestion of the axis of a somewhat similar fold in the lower part of Duncan Brook. Such a sample, however, does not permit of detailed connection with other folds in adjacent parts of the area.

Only the broadest trends have been indicated in the gneisses in the remainder of the upper part of Middle River.

West Side of Crowdis Mountain

On the west side of Crowdis Mountain a band of George River slates and related rocks can be traced from Gillis Brook along the face of the mountain to the upper part of the Garry Brook. There is disruption by a post-Mississippian fault in Leonard McLeod Brook, and locally there is confusion in some of the details, but the general trend and continuity of the units seem to be reasonably well established. There is a deflection of the strike of the units to the north of Garry Brook, and it seems probable that the slaty horizon again appears in McLean Brook, the next to the north, and continues into the upper part of Second Gold Brook.

It is tempting to think that McLean Brook and the adjacent Gold brooks represent the crest area of an anticlinal-shaped fold. If so, the slate zone probably continues to the east across the upper part of Leonard McLeod Brook and Muskrat Brook to the vicinity of the landing strip. The structure plunges northward at about 40 degrees. Another anticline, with similar plunge, is just north of Fortune Brook.

There is an inconsistency in this interpretation. Immediately north of Middle River, at Finlayson, the trend of the rocks changes from southwest to northwest, toward the east side of the fold near Fortune Brook. Even allowing for displacement by the post-Mississippian fault, the strata south of the river should conform to this, in a general way at least, instead of swinging away to the southeast. It is possible, however, that the Fortune Brook fold (most of which is necessarily buried beneath the Mississippian rocks) may die out southward and that its hinge area is represented by the change in strike on the upper part of Garry Brook. Otherwise it would be difficult to account for the volume of rock which must underlie the Mississippian.

There is the further problem of repetition of beds. On the above interpretation, the rather thin slaty band on Gillis Brook is the equivalent of a thicker band on, and near, McLean Brook, and of a still wider zone on Muskrat Brook. This involves a strike distance of over 16 miles, and considerable variation in thickness of beds is possible. On the other hand, in Leonard McLeod Brook itself, which has good outcrops, there is no concrete evidence of such folding, although there is some obscurity due to intrusive rocks.

On the east side of Crowdis Mountain, between McRae Brook and Falls Brook, the George River rocks appear to be completely detached structurally from the above fold system. The lithology is different (including rhyolite and pyroclastics), and the general trend is northeast instead of northwest.

Faulting

General

Slickensided surfaces and schistose zones have been noted in very many places in these areas. Certainly all indicate movement, but it is not at all evident how many represent significantly large movements. Nor is it always evident whether the plane or zone of movement is extensive; that is to say, there are many such isolated observations of movement surfaces which can neither be extrapolated nor connected up to other observations. Such are simply reported on the map as observed data.

Many streams are fault controlled. This point was mentioned above (p. 7) and is again emphasized. The simplest case is that of a fault surface exposed in a brook at one place, or perhaps at only a few points. Under the conditions of limited visibility in most brooks, the relations are usually not recognized in the field, and it is not until the fault plane is traced on a contour map that the situation becomes clear. Probably, in most cases, the fault surface is actually just inside the bank of the brook, and may be visible at only a few points, which are apparently not related to one another.

The more complex case of fault control is the more common. The actual field evidence is slickensided surfaces, or schist zones, which at first glance seem to represent all possible directions. An example is where McRae Brook turns sharply east near the Crowdis Mountain lumber camp; there, every fragment in the outcrop is slickensided on at least three sides. Exploration along such a stream usually shows that there are many movement surfaces, and that they have two common attitudes, one of which is at an acute angle to the stream while the other is crudely parallel to it. It may take some time to realize that this probably represents a fault zone with a set of fractures conjugate to the main movement.

Two or more such zones crossing one another become exceedingly complex in detail. Because the geologist is constrained by the brook to follow the shattered zones, and does not see any marker horizons outside such zones, the proper correlation and interpretation of the faults becomes as much a matter of hope as of deduction. The upper branches of McLean Brook are a case in point.

The interpretations and correlations shown on the map appear to be a reasonable fit of all data, but are subject to all the complications and qualifications outlined above. Though horizontal displacements are indicated in many cases, the net slip has not been determined for any fault.

The general trends of the faults have not been investigated statistically. Inspection of the maps suggests that faults with a northwesterly trend are more abundant and more general than those with a northeasterly strike. Though only a few faults of northerly trend are recognized, they may be more persistent - at least it seems to be possible to follow them for considerable distances. Faults of almost any orientation can be tound on the map, but the above appear to be the chief directions.

This would suggest a situation in which the principal stresses were oriented eastward and northward. Until the directions of motion, and the correlation of the faults is better understood, anything more than this mere suggestion is probably premature.

Post-Mississippian Faults

Three main post-Mississippian faults have been recognized. They are all indicated by an inferred displacement of the Mississippian unconformity and are located in Leonard McLeod and Muskrat brooks, in McLean Brook, and in Middle River at Finlayson.

The Mcl.eod fault trends northeast, is assumed to have a very steep dip **and nearly vertical movement, and has been traced across the area to North** Baddeck River north of New Glen. Careful consideration of all the information available, including distribution of float, indicates that the base of the Mississippian rocks, at MacMillan Mountain, probably strikes 155 degrees and has an average dip of 21 degrees westward. This fits all known outcrops, including the peculiar "near window" on Rice Brook at MacMillan Mountain. (Projection of the contact indicates that Horton sandstones should outcrop high up the south bank of McDonald Brook. This has not been checked in the field.) Such a contact should continue across the bottom of the valley of Middle River after crossing the Old Crowdis Mountain Road. Instead, it crosses Leonard Mcl.eod Brook and continues to the east of the Garry farms. In this part the average strike is almost the same as at MacMillan Mountain, and the dip, 17 degrees. Again this fits all the available data, including the disappearance of the tributaries of Garry Brook into the Windsor limestone and gypsum. The contact has a right-handed displacement of one mile due to the fault. A coincident disturbance of the magnetic field is shown on the aerornagnetic maps. In Leonard Mcl.eod Brook, north of Gillis Brook, the right-hand displacements of the greenstones and of the granite contacts are smaller, but are those appropriate to such steepIy-dipping formations and a minimum movement on the fault of about 1,500 feet. The fault has been shown as extending along Muskrat Brook, mainly on the evidence of schist zones observed in the tributaries on the south side of that brook. The fault probably branches near the confluence of Muskrat and Mcl.eod brooks, but the northern branch could not be followed. There is no **concrete evidence of this fault on the hill top near the airstrip. However,** projection on its last observed strike and dip suggests that it should cross North **Baddeck River as shown, and there is a shear zone in the river at the appropria-te** place.

The fault in Middle River is inferred from a similar displacement of the **Mississippian contact. The minimum movement is about 800 feet. Between** McLean Brook and Middle River, the average dip of the contact is 13 degrees, and the strike is slightly more northerly than at MacMillan Mountain. The contact should therefore pass near the last farmhouse on the south side of the **river and continue across the river; the north bank, of course, is formed by** George River rocks. The contact must be displaced to the southwest beyond the last George River outcrop, and it is placed, somewhat arbitrarily, through the largest island. The contact could continue from there, with the same 13 degree **dip and the same strike as before, across Fortune Brook without conflicting with** any observations. The Mississippian rocks would then overlap on the side of the mountain there. This possiblity was not recognized in the field and therefore has not yet been checked.

Between Garry and Mcl.ean brooks there is also a right-handed *dis*-placement of the same contact. At this place the movement appears to be much less than in the other two just described. Although the fault is recognizableas a schist zone in the lower-most tributary of Mcl.ean Brook it was not recogruzed further to the northeast. It may be that it is a "scissors" fault, with the north side relatively lowered. The average dip of the Mississippian contact appears to be about 30 degrees - 15 degrees steeper than in the adjacent blocks. Such an increase in dip would be appropriate to a downward movement of a fault block rotated about a hinge line to the northeast.

Possible Overthrusting

The presence of an overthrust at Christopher Mcl.eod Brook, a short distance east of this area, suggests the possibility that the same thrust sheet, or a similar one, may be present also at Crowdis Mountain. This suggestion has certain obvious attractions.

Some problems could be solved by this theory. The contact of Mississippian rocks with the George River outcrops approximately along contour lines, thus suggesting that it may be a nearly horizontal plane. Such a sheet of George River rocks thrust over Horton would easily explain the distribution of the Horton on the south end of Crowdis Mountain. (The standard explanation is that the Horton sediments were deposited on the flanks of hills carved from George River rocks.) The overthrust hypothesis would also explain the anomalous metamorphic grade (biotite zone) in slates within three hundred feet of an intrusive, at Second Gold Brook.

There are certain other problems and consequences however. George River rocks should occur on certain hill tops, where they have not been reported. An especially obvious consequence is that the thrust plane, and possibly Horton rocks, should be found for some distance up both Middle River and Leonard McLeod Brook. If such a fault is present is has not been recognized in either stream.

Though this fascinating idea must be considered, there are still too many gaps, uncertainties, and contradictions for it to be held as anything more than a possibility at present.

NEW CAMPBELLTON

At New Campbellton, the George River limestones and dolomite form a narrow zone between granite to the north, and the fault marking the edge of the Sydney coalfield, to the south. This carbonate band probably extends along the south slope of Kelly Mountain from Kelly's Cove to Cape Dauphin. Though it certainly occurs at a number of intervening places, it is not known if the band is continuous over the complete distance.

Over the area mapped, the band appears to be essentially a strip with a regular steep dip to the north. lt is cut by a number of small thrust faults. Pods of granite occur in the central part of the zone at its southwest end, and, in the former quarry, a very irregular mass of limestone occurs at the same horizon. This limestone mass has been interpreted as a replacement residual left when a limestone band was dolomitized, as a piece of the limestone to the north, faulted into place, and as a severely contorted limestone band in the core of an anticlinal fold in the dolomite.

The dolomite is probably isoclinally folded. The limestone may be a replacement residual, but the other limestone contacts of the immediate area do not appear to have such great irregularity. lt is improbable that one limestone band would be almost completely dolomitized, leaving only a ragged remnant, without there being some attack on other adjacent limestones. Though there are faults within the dolomite zone, they do not appear to be so located as to give a satisfactory explanation for the position and shape of the limestone mass, and faulting does not appear to be an adequate explanation. The dolomite is massive, coarsely-crystalline and does not show bedding layers, so folding cannot be recognized within it. However, photographs of the east wall of the quarry, taken 28 years ago, show a light band which appears to be folded. This band is now somewhat obscured by subsequent slumping of the quarry face, but the general outline of the fold is still visible. It appears probable, therefore, that the very **irregular limestone mass is a thin,** much-contorted **bed** forming **the core of an** isoclinal fold in the dolomite.

NORTH MOUNTAIN

General

The structure of the North Mountain area is not at all well understood. The accompanying map, being the result of about three weeks work in 1962, is of a most preliminary character. It has been included primarily because of a number of references to that area in the preceding descriptions of the lithology of the George River rocks.

Since this work was done, Professor B. J. Keating has made a very exhaustive study of the North Mountain area. He has found that there is much more outcrop than is shown here, that there is very complex folding on both a large and small scale, and that many structures are not in steeply inclined attitudes, as they here appear to be. Publication of Keating's data should go a long way toward unravelling the structure of this complex area.

In general, the George River rocks can be described as a narrow strip extending across the mountain from Lime Hill to River Denys. The top of the mountain is underlain by granite and granodiorite intruded into the George River rocks, of which there are patches and remnants to the southwest and to the northeast of the narrow strip just mentioned. These probably represent roof pendants in the intrusive and extend along the south side or the mountain towards Malagawatch. On the north flank of the mountain, east of Campbell Brook, Horton conglomerates overlie the George River unconformably. The contact dips northwestward at 20 degrees. On the south side of the mountain, therefore, the Mississippian rocks, which now underlie the lake and are faulted against the George River, must have been dropped downward.

Folding

Marble Mountain

A quarry was operated at Marble Mountain for a number of years and faces up to 230 feet high provide good exposures.

Mapping of this quarry showed a fold of synclinal shape plunging southward at about 40 degrees. There probably is an anticlinal fold adjacent in the west wall, but a longitudinal fault must also be present there as well. This work also showed that, within the limestones at least, there is much small scale minor folding - from a few inches to a few tens of feet across. (These folds are, in fact, of small amplitude, though the beds wander about in a most spectacular way because the slope of the quarry walls approaches the plunge of the folds.)

Dallas Brook

Limestone and dolomite occur on most of the farms on the south side of the moutain from north of the Marble Mountain quarry to Lime **Hill** church. There are further exposures of carbonates to the north of Dallas Brook and Campbell Brook. This suggests that, though disrupted by a mile-wide tongue of intrusive rock, there was, in general, a limestone horizon or zone which extended from north of Marble Mountain to Lime Hill and then across the mountain almost to River Denys Station.

Further carbonate *is* found interbedded with metamorphosed clastic sediments on the upper part of McCuish Brook. This occurrence (which contains the Lime Hill zinc prospect) is separated from that just described by a mile, more or less, of slates. intrusive rocks, and minor greenstones.

Minor amounts of quartzite and greywacke are found to the north of the Marble Mountain quarry (Le. structurally below the carbonates). Still further to the north and east are the doubtful volcanic rocks described on page

Slate, with only very minor amounts of carbonate, underlies most of the valley of Dallas Brook and the upper half of Campbell Brook. In the lower (western) part of the Valley of Campbell Brook the carbonate dips steeply northward (65 degrees or more); the slates and minor quartzite apparently conform. In the upper part of that valley, and in Dallas Brook, there is greater variability of altitude. Though dips generally are greater than 45 degrees, they are in a variety of directions, and minor folds indicate plunge of the structure at 25 to 45 degreees southwest. From the present maps, it has not been possible to follow individual bands. It appears, however, that the slates are nearly isoclinally folded, that the folds plunge southwestwards, as does that at Marble Mountain, and that to the westward these merge into a rnonoclinal block, or the limb of a very large fold, which disappears beneath the Mississippian unconformity in the lower part of Campbell Brook.

Stratigraphic problems now appear. The steep northerly dip of the monoclinal block of Campbell Brook, puts the carbonate above the slates – where it should be, according to the stratigraphy deduced in the Craignish Hills. If the foregoing generalizations are correct, and the carbonate band extends from Lime Hill church to Campbell Brook, then the plunge of the structure indicates the slate of Dallas Brook must overlie the carbonate - where it should not be.

The explanation is not yet apparent. In 1964 consideration was given to the possibility that the Whole sequence is, in fact, upside down and represents the overturned lower limb of a large recumbent fold, the upper part of which was eroded away. This seems to be a gratuitous complication of the structure, for which there is no confirmatory evidence. Certain other possibilities have been considered.

The possibility of a cross-fold, or depression, more or less in the area of Dallas Brook, is suggested by reappearance of the carbonate to the west at McCuish Brook, but again this requires that the slates overlie the carbonate. The steep plunge of the structure, while not impossible, also does not fit well with the concept of such a depression. It should be pointed out that Professor Keating, in conversation, has indicated that he found the folds, in general, to be much nearer horizontal than is indicated on the accompanying map. On the whole, however, it appears probable that the repetition of the carbonate is due to a fault, of which there is some concrete evidence in CampbeU Brook.

There is a possibility that the carbonate is, in fact, overlying the slates of Dallas Brook as would be expected from the regional stratigraphy. All the foregoing discussion assumed a carbonate band from Lime Hill church, through

MacInnis Brook and the upper ends of Campbell Brook. It further assumes that **the small exposures of carbonate scattered over the mountain top are narrow** interbands within the slates. However, it might just be possible that these **apparently minor and scattered carbonate exposures represent a continuous** band repeated many times by folding. This hypothesis would require that a band of limestone a few hundred feet thick, representing the bottom of the carbonate zone, be involved in a number of nearly isoclinal folds. A relatively shallow plunge, such as Keating has suggested, would probably be necessary. Such folds would be not more than about a thousand feet across, and it appears probable that some would have to be only a few hundred feet across, and locally overturned. With the data available on this map, it is premature to attempt to follow this possibility further.

Faulting

The dominant fault in this area, of course, lies along the north edge of the Bras d'Or Lake, at the foot of North Mountain. Its position is indicated by small patches of Palaeozoic rocks which appear on projecting points. Simple extrapolation southward and upward of the 20 degree dip of the Mississippian unconfonnity, for the 18,000 feet distance from Campbell Brook, indicates that the unconformity should pass over the north edge of the lake at an altitude of more than 6,000 feet. This then is a measure of the minimum throw on the fault - **assuming that the unconforrnity is a nearly planar surface.**

This large normal fault, it may be noted, is approximately parallel to a similar fault with substantial throw on the south side of the Craignish Hills. This leads to the suggestion that North Mountain and the Palaeozoic lowland of the River Denys valley are underlain by a fault block rotated so that the north side went down. lt follows also that a similar block underlies West Bay.

The present work was not concerned with the Palaeozoic **and this obvious** fault is the only one recognized as of definitely post-George River age.

There is probably a fault along the general line of Carnpbell Brook to Cameron Point. Such a fault is suggested by the repetition of carbonates (as mentioned on page 105), by schist and shear zones in a number of places in Campbell Brook and its tributaries, and by termination of the George River rocks along this general line. Shearing is evident in the most southerly branch of Campbell Brook but was not recognized in McLean Brook which is approximately on the line of the fault. The fault must be younger than the intrusive **rocks.**

There is probably a branch fault, striking eastward, in the brook south of the MacMillan farm buildings, and a parallel fault was found in limestone outcrops to the north of those buildings.

A fault probably bounds the west side of the lower Marble Mountain quarry, though it is unlikely to be the same fault which cuts across the upper (McAskill) quarry there. Such a fault is inferred because there appears to be an anticline in the west wall of the quarry. (In fact, the wall is almost on the axial plane of such a fold.) The upper edge of that wall is quartzite, whereas the anticline should have repeated one of the marble bands from the excavated portion of the quarry on this upper edge.

The marble band east of Carnpbell Brook has faults on both north and south sides. These were both found by drilling. The altitude of the northern fault is not known. There is some suggestion in the tributary brooks that the southern may mark the flank of the limestone ridge, and so strike slightly south of east. One is tempted to consider this as another of the faults branching eastward from that in Carnpbell Brook.

As elsewhere in the George River rocks, during field work, a number of schist and shear zones were found which could not be correlated with others. Such are less numerous here than in the other areas, but this may reflect only an initial unfamiliarity with the rocks and their variations.

CHAPTER IV

MINERALIZATION: ASSOCIATED WALL ROCK ALTERATION

(By A.K. Chatterjee)

The following is an interim report on an investigation of metallic mineralization in the George River rocks commenced in 1966. The main effort, to date, has been to determine the mineralogy of the known deposits and of their wall rocks. The wall rocks have, of course, been subjected to regional metamorphism of various grades and should have developed an appropriate assemblage of minerals. A considerable part of this investigation, therefore. has been a concurrent comparison of the minerals actually present in the wall rocks with those to be expected. For this, comparison has been made with the minerals developed during regional metamorphism of the George River rocks outside the influence of metallic mineralization, as well as with those to be expected theoretically, as reported in the literature. Departures from the regional metamorphic mineral assemblage which are found adjacent to sulphide bodies must be due to the mineralization process - whatever its nature - and recognition of such departures may produce a useful guide to ore.

It has been observed that the sulphide minerals occur in areas where a low grade has been superimposed upon a high grade of metamorphism. It has also been observed that the ore minerals are concentrated in certain compositional units. If these two observations are accepted, we have two "intersecting loci", suitable composition and appropriate metamorphic grade, which can be used as guides in the search for ore.

One must stress, however, that the use of alteration as a guide to ore requires the recognition of a mineral assemblage. Individual minerals are not reliable guides; a specific mineral may alter in a variety of ways, or may be derived from a variety of parents. Feldspar, for example. may alter to sericite/paragonite, epidote, or muscovite; antigorite, by the same token, may be derived from forsterite, periclase, or dolomite, depending upon the conditions. A single mineral species may, therefore, be the product of regional metamorphism, or of alteration associated with mineralization. In short, the alteration is a metamorphic reaction in which water, at all times, and silica and carbon dioxide, sometimes, are present. Any valid comparison of changes must consider all changes, i.e.; the total assemblages before and after.

KINDS OF MINERALIZATION PRESENT

No deposits which are commercial under present conditions have yet been recognized. At Lime Hill, drilling gave some encouragement about 10 years ago, but did not show a cornmerical deposit. At Meat Cove, a substantial tonnage is present, but its isolated location has so far prevented development. The other prospects and occurrences here discussed have received varying amounts of geophysical and geochemical work and some have had exploratory drilling.

Two main groups of deposit are recognized:

The first is characterized by an essentially argillaceous wall rock, and includes:

(1) Gold-silver prospect at Second Gold Brook, from which there was limited production between 1902 and 1915;

(2) Copper showing at Nile Brook;
(3) Silver-zinc-lead-copper prospect at Dauphinee Brook ("Silver Cliff' showing), and the ("Core Shack") showing on the opposite side of the same mountain, above Faribault Brook;
(4) Copper-zinc prospect at "Mountain Top", Faribault Brook; and the former Iron Top and Grandin Brook prospects on Faribault Brook. There was considerable expenditure on these about 1903.

. The wall rocks are mainly sericite-chlorite schist, garnetiferous muscovite-biotite schist, quartz-feldspar-biotite schist, hornblende schist, and granite gneiss.

The second group is characterized by an essentially calcareous host rock, and includes:

(5) Zinc prospect at Lime Hill;
(6) Zinc prospect at Meat Cove;
(7) Copper-magnetite prospect at Whycocomagh (Mullach).

Representative wall rock types are limestone, argillaceous limestone, and dolomitic limestone with variable amounts of quartz. Distinctive skarn minerals are common but are not always present.

The calcareous rocks of parts of the Glencoe and Glendale areas in the Craignish Hills; parts ofthe George River section, in the Boisdale Hills, and the section exposed in the New CampbeUton quarry have also been examined.

MINERALIZATION IN CALCAREOUS ROCKS

BOISDALE HILLS

The mineral assemblages found in the calcareous rocks of the Boisdale Hills were compared with the mineralogy to be expected from such rocks when regionally metamorphosed. Comparison with other areas (especially Skye, Scotland), as reported in the literature, shows that the mineralogy of the rocks of Boisdale is normal for the appropriate compositions and grades.

There are Local exceptions. Later pegrnatite, greenstone, and lamprophyre dykes have had an effect in modifying the mineral assemblages in the surrounding rocks.

The mineral assemblages to be found in metamorphosed carbonate rocks are rather varied, and the details are summarized below because they are ordinarily not familiar to those not constantly working with them. The assemblages obviously vary with the grade and composition of the rocks. The compositional units found here may be considered in terms of combinations of: (1) siliceous limestone, (2) argillaceous limestone, (3) argillaceous dolomitic limestone, and (4) siliceous dolomitic limestone. For each of these the appropriate metamorphic products, at high and low grades, are shown in the following table, which also shows the effects of the later dykes mentioned in the preceding paragraph,

TABLE 3

Mineral Assemblages in Metamorphosed Carbonate Rocks

Compositional Units	High grade mineral assemblages near the granite contact	Low grade mineral assemblages away from the granite	Effects of later dykes	
			Near the dyke	Away from the dyke
(I)Siliceous limestone,	Wollastonite bearing limestone, + muscovite, jf some potassium and alumina are available.	No reaction; simple recrystallization.	Development of idocrase.	
(2)Argiliaceous limestone	Wollastonite-scapolite-muscovite-bearing limestone, + cordierite, + antigorite when minor Mg. is available.	Muscovite-talc-plagioclase (Ab9S) assemblage	Development of idocrase, and antigorite from dolomite.	Development of phlogopite.
(3)Argiliaceous dolomitic limestone	Spinel-potassium feldspar-tremolite-bearing assemblages + plagioclase (Ab6S) and diopside.	Muscovite-talc-chlorite-phlogopite-antigorite assemblage.	Development of idocrase, and garnet.	Development of talc, muscovite, and phlogopite.
(4)Siliceous dolomitic limestone	I. Forsterite-diopside-tremolite-bearing assemblages. n. Larnite-merwinite-forsterite assemblages at extreme grade	Antigorite-talc assemblage.	Development of chondrodite, forsterite and lizardite.·	Development of antigorite, and tremolite.

'Uzardite is a platy variety of serpentine.

Generalization from a few observations in any part of the area may be dangerous. From the above table it is not difficult to find the high grade mineral assemblages adjacent to the granite contact, but there are low grade mineral assemblages near the granite contact as well. From the study of the mineral assemblages it can be shown that the contact between granite and sediments is intrusive in some places, faulted in others. The faulted contact between carbonate and syenite immediatly north of the George River quarry is an example of such.

MEAT COVE

This prospect was discovered in 1953 and received extensive exploration. It can be considered more or less typical of a sulphide body in a calcareous host rock. In 1968, three long trenches were excavated by the owners. The samples used in this work came chiefly from these new trenches; others were from the dump and old drill core. The samples chosen were those showing sulphide mineralization and associated alteration.

The general geological situation may be summarized:

I. The host rock is a sequence of interbedded dolomitic limestone and garnetiferous quartz-feldspar-biotite schist. Regional mapping indicates that it is a large pendant in granite.

2. The strike appears to be east and the dip varies from 45 to 70 degrees north.

3. The sequence has been intruded by granite, and later greenstone and aplite dykes cut the dolornitic limestone and the granite.

4. Sulphide mineralization is essentially sphalerite-pyrite, with some chalcopyrite and galena, and occurs as massive bands, as veins, and also as dissemination. Thin stringers of chalcopyrite and pyrite occur in quartz-feldspar-biotite schist. In many places the presence of sulphides is indicated by gossan at the surface.

5. Alteration is very distinct; the two major products are antigorite and brucite. The color of the antigorite varies from pale greenish-yellow to dark greenish-black. Brucite occurs as spotted white dots and, on weathered surfaces, the resulting pitted clayey grains showing onion-skin structure are common.

6. Sillimanite zone appears to be the regional grade of metamorphism, reflected in the dolomitic limestone by the presence of periclase and monticellite.

High Grade Regional Metamorphism

The metamorphic grade at Meat Cove is somewhat higher than that represented in the Boisdale Hills, though the general geological situation is very similar. Of the mineral assemblages shown in Table 4, units 3 and 4, at high grade, are the ones relevant for comparison: In each case dolomite is the chief constituentin the rock and therefore a part of each assemblage.

TABLE 4

Comparison of Metamorphic Mineral Assemblages

Boisdale Hills	Meat Cove
Forsterite-diopside-tremolite	I. Monncelhte-periclase-forsterite
	2. Monticellite- forsterite
	3. periclase-forsterite
Diopside-tremolite-spinel	4. Penclase-forstente-spinel
	5. Periclase·forsterite-wollanstonite

At first glance these assemblages do not appear at all comparable, though one *is,* **in** fact, **derived from the other. TremoLite, in the presence of excess dolomite** reacts with it to give forsterite and diopside. But at higher temperature these, in turn, react to produce monticellite. At this extreme grade the dolomite itself begins to break down to form periclase (MgO). The absence of periclase in assemblage 2, therefore, simply means the dolomite has not decomposed.

The absence of monticellite in assemblage 3 may reflect a slight variation in bedding composition. The formation of monticellite is due to:

$$\text{Diopside} + \text{Forsterite} + \text{Calcite} \rightarrow \text{Monticellite} + CO2$$

which requires available calcite. In this situation the calcite is itself the product of a reaction between diopside and dolomite:

$$\text{Diopside} + \text{Dolomite} \rightarrow \text{Forsterite} + \text{Calcite} + C02.$$

The availability of calcite and the formation of monticellite, therefore, depend upon the equilibrium between these six phases. Slight variation in the amounts of silica will then control the amounts of diopside and forsterite, and thus of the whole equilibrium.

In a similar way, the periclase-forsterite-spinel of assemblage 4, is the **equivalent in the sanidinite facies of a silica-bearing dolomite containing some** alurnina, which goes to form the spine!. The periclase-forsterite-wollastonite **assemblage appears to be anomalous, however.**

Low Grade Alteration

In addition to the above assemblages, which indicate very high metamorphic **grade,** brucite, antigorite , **and minor talc are present at Meat Cove in all the samples from the dumps, outcrops, and drill cores. These minerals are indicative** of a very low grade of metamorphism, and the textural relations indicate that they were formed as an alteration from the minerals of high grade.

The formation of talc occurs at very low grade in the metamorphism of **siliceous dolomitic limestones:**

$$3 \text{ Dolomite} + 4 \text{ Quartz} + \text{water} \rightarrow \text{talc} + 3 \text{ calcite} + 3\ C02$$

Turner, on thermodynamic grounds, indicates that

$$2 \text{ Talc} + 3 \text{ calcite} \rightarrow \text{Tremolite} + \text{Dolomite} + CO_2 + H20$$

at a temperature of 170^0 C at I atmosphere. The equilibrium temperature probably rises rapidly with pressure. This implies that the talc is stable only at low metamorphic grade.

Antigorite and brucite occur in close association with the talc and are therefore also considered to be a product of low intensity alteration. Equations comparable to those above have not been found in the literature and this conclusion therefore is based entirely upon the observed textural relations. There is an experimentally determined reaction which produces antigorite below $400\,^oC$:

$$\text{Forsterite} + H20 \rightarrow \text{antigorite} + \text{brucite}$$

but in the present case, the antigorite has been derived from other materials as well.

Low Grade Minerals Derived From Metamorphic Rocks

The equation above quoted shows that talc could have formed by the addition of silica and water to the dolomite host rock. Because of the textural relations, it appears that such was generally not the case. Summarized below are observations which indicate that the talc, antigorite, and brucite were all derived largely from pre-existing high grade minerals:

Brucite:
(I) has resulted from the action of water on forsterite; antigorite is an additional product (Fig. 13B).
(2) has resulted from the alteration of antigorite (Fig. 13C).

Antigorite:
(I) has been derived from tremolite; in this type the amphibole cleavage is preserved (Fig. 13£).
(2) has been derived from periclase; in this the antigorite grains are rounded and show relics of a periclase core (Fig. I3F).
(3) has been derived from forsterite; the antigorite grains show relics of forsterite and the fracture pattern is also preserved (Fig. 13G.)

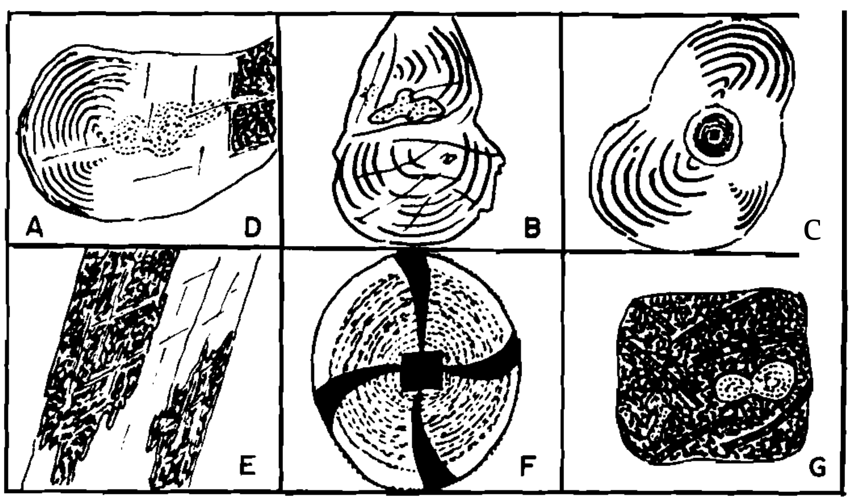


FIGURE 13 Sketches of textural relations seen in thin sections For explanation see text.

Brucite and antigorite were both derived directly from dolomite as well; the formation of antigorite releases calcite (Fig. 13A and D). The direct alteration of periclase to form brucite has apparently 'not occurred; instead the periclase formed antigorite.

Brucite and antigorite invariably have talc intergrown, and no talc has been found at Meat Cove that is not associated with these two minerals. However, in the Boisdale Hills talc as an alteration product of forsterite, cordierite, and antigorite has been found adjacent to calcite veins containing sparse sulphides.

From the preceding, it appears that some brucite and antigorite might have been formed directly from dolomite by the agency of a mineralizing solution containing water and silica. The bulk, however, was derived from pre-existing minerals which formed during high grade metamorphism and must therefore represent a retrogressive change.

Low Grade Alteration Associated With Sulphides

It has been shown above that the development of a low grade mineral assemblage must have been later than the formation of the high grade minerals from which it was derived. This demonstrates only that it was later – not that it was due to sulphide mineralization. The textural relations indicate that, in some cases at least, sulphides replace antigorite, but the connection between mineralization and low grade alteration is necessarily a problem of space rather than time.

The low grade mineral assemblages are present only in the vicinity of sulphide mineralization. In the Boisdale area, no brucite has been found. Sulphide mineralization is ubiquitous in trace amounts, but the only concentrations of sulphides examined are in a few calcite-pyrite-pyrrhotite veins and these have associated antigorite and talc. Furthermore, antigorite and talc alteration has been found only in association with such veins. At Meat Cove, where sulphides are present in important amounts, brucite, antigorite and talc are present in all samples. For samples from the dumps, the original position is, of course, unknown. They came from the adit and from core, and some must originally have been a considerable distance from sulphide. For samples from the trenches, where the exact position is known, it can be shown that brucite, antigorite, and talc occur up to 30 feet from sulphide veins. Lack of exposures makes it impossible to see how much farther alteration extends.

Whatever may be the genetic relationship, the association of brucite, antigorite, and talc characterizes proximity to the ore.

LIME HILL

The general geological setting for this deposit is summarized on p. 97. It is generally similar to that at Meat Cove and the Boisdale Hills, and the regional metamorphic grade in the dolomitic limestones is again high. It is marked by the presence of forsterite and monticellite assemblages, as in the other two, but has larnite-merwinile-forsterite as well. The latter indicates a slightly higher grade of metamorphism, with magnesium somewhat less than at Meat Cove. The rock at Lime Hill is more strongly banded than at Meat Cove, and contains interbanded quartz-feldspar-biotite schist.

Comparison With Meat Cove

At Lime Hill, as at Meat Cove, the siliceous dolomitic limestone is characterized by development of forsterite, and by its alteration to antigorite and talc in the vicinity of sulphides and adjacent to fractures. Chondrodite $(Mg(OH,F)_2 . 2\,Mg_2\,Si0_2)$ is characteristic of certain thin bands, and probably reflects the presence of fluorine.

The quartz-feldspar-biotite bands represent impure sand layers in the carbonates. They contain garnet and a very calcic plagioclase, and show alteration of the potassium feldspar to sericite, and of garnet to biotite and chlorite. This is confirmative of the same low grade of alteration as that shown by the carbonates. Sulphides occur only as thin disseminations and stringers.

Argillaceous and calcareous bands also occur in the carbonates and contain only minor disseminations and stringers of sulphide. In the argillaceous layers, the feldspar is altered to sericite/paragonite, and diopside to tremolite. In the calcareous bands, the plagioclase produced calcite as an additional alteration product, and diopside altered to epidote. Such bands are too calcareous to produce antigorite and talc.

Dolomitic bands are the most important host for sulphides, which occur as massive bands and as heavy dissemination. In hand specimen, antigorite and talc are closely associated with the sulphides as a waxy-yellow to green alteration. The mineral associations actually present are, in addition to dolomite and calcite:

1. antigorite-talc-cordierite
2. antigorite-talc-phlogopite

In one case, assemblage 1 has muscovite and scapolite in addition and, in another case, spinel. Textural relations show that both cordierite and antigorite alter to talc, and antigorite also alters to chrysotile.

Neither metamorphic assemblages reported elsewhere, nor experimental data, coincide with these observations, and a satisfactory explanation of the mineralogy is not yet available.

The situation here is similar to that at Meat Cove and, on the basis of this comparison, it seems probable that the low grade alteration minerals are also a product of the mineralizing episode. Again, this is based especially upon the close association with sulphides,

The presence of talc is probably an indicator of the presence of sulphides, and in our specimens no sulphides have been found without associated talc.

MINERALIZATION IN ARGILLACEOUS ROCKS

The deposits here considered are those at Faribault Brook (see p. 92-94) Nile Brook (p.95) and Middle River (p.91). They all occur in interbanded quartzo-feldspathic rocks of a considerable range of composition. In every case the host rock is a metamorphosed shale or sandy shale.

The products of regional metamorphism of such rocks are well known, and it is not necessary to review them here. The present investigation has, so far, revealed nothing abnormal about the regional metamorphism and its products.

FARIBAULT BROOK

"Silver Cliff" and "Core Shack"

In the "Silver Cliff" and "Core Shack" showings, the sulphides are concentrated chiefly in a very crenulated schist, interbanded with more massive layers.

The silicate mineral assemblages found are shown in table 5.

TABLES

MINERAL ASSEMBLAGES

No.		Regional									AJteration			
		Kyanite	Garnet	Muscovite	Quartz	K-Feldspar	Plagioclase	Biotite	Sulphides	Chlorite	Sericite/ Paragonite	Epidote	Calcite	Tremolite
M3157					P		P	P			P		P	
M3159			P	P	P		P	P	P	P	P			
M3161			P		P	P	P	P	P	P	P			
M3163			P	P	P	P			P		P		P	
M3166	(a)			P					p		P			
M3166	(b)		P	P	P			P	P	P	P			
M3170					P			P	P	P	P	P		
M3171			P		P	P	P	P		P	P			
M3172			P		P			P	P	P	P			
M3174			P		P			P	P	P				
M3177			P		P		P	P	P	P	P			
M3179			P		P				P		P			
M3180			P		P			P	P	P	P			
M3181		P	P	P	P			P	P	P	P			
M3182		P	P	P	P	P	P	P	P	P		P		P
M3183					P	P			P		P			
K66-2			P		P		P	P		P			P	
K66-5	(a)		p		p			P						
K66-5	(b)		P	P	P			P		P		P		P
K67-1		P	P	P	P		P	P	P	P	P			P
K67-2		P		P	P	P	P	P	P	P	P			
K67-3					P		P	P	P		p	p		P
K68-2			P	P	P		P			P				
K684			P		P		P	P	P		P			
K69-2			P	P	P		P	P	P	P	P			
K69-3		P	P	P	P		P	P	P		P			
K694				P	P	P	P	P	P	P	P	P		P
K70-1					P		P				P	P		P
K70-3			P		P		P		P		P	P		
K71-1			P	P	P		P				P	P		

Regional Metamorphic Grade

In the **above** table, the mineralngy **indicates some variation** in the **composition of the original rocks and a regional metamorphic grade equivalent** to the kyanite zone (or kyanite-almandine sub-facies), The absence of staurolite probably reflects an original lnw iron content, and the presence of biotite **indicates a content of magnesium too high to be accommodated in garnet. The** epidote is here considered to be an alteration product, as it is at "Mountain Top" on the opposite side of Faribault Brook (see below).

The mineral associations shown in the table are obviously not in equilibrium. This complex association is readily understood if one will accept the idea, as at Meat Cove, that the first part represents the high regional grade and the second is the result of the mineralizing process and was superimposed upon the first.

Alteration

The alteration minerals are later than those formed during regional metamorphism. This is shown by such textural evidence as: biotite altered to chlorite, plagioclase altered 10 epidote, and Kfeldspar altered to sericite ,

The alteration has a close spatial relation to the sulphides. No sulphides have been found without accompanying alteration. The alteration does occur at distances up to 94 feet from sulphides in one of the drill cores at the "Core Shack" showing, but present information does not show how much farther it may extend.

The distribution of the valuable metals is indicated by the observed sulphide minerals, as shown below:

TABLE 6

Sulphide Mineral Assemblages

Group	Assemblage
A	Pyrite-pyrrhotite.
B	Pyrite-arsenopyrite.pyrrhotite.
C	Pyrite-chalcopyrite-pyrrhotite. Pyrite-chalcopyrite-pyrrhotite-galena.
D	Pyrite-chalcopyrite-galena-bornite-covellite-sphalerite. Pyrite-chalcopyrite-sphalerite-bornite-chalcocite-pyrrhotite. Pyrite-chalcopyrite-sphalerite-galena-chalcocite.

These groups represent minerals found co-existing in the same samples. From laboratory study of sulphide systems, it appears that Groups C and D represent combination of both high and low temperature sulphide assemblages, and that the minerals are not in equilibrium with one another. This is similar to the way the silicates just discussed represent reaction to two sets of conditions. This probably indicates complex relations within the sulphides, and between sulphides and silicate alteration. The details of this have not yet been resolved.

Abundant garnet occurs in patches in the mineralized zone at Dauphinee Brook. As can be seen from Table S, the garnet is a product of regional metamorphism. Though it is present in the sulphide zone, it was not formed as a result of the mineralizing process, and is therefore not a guide to sulphides.

Proximity to sulphides is shown by the presence of chlorite, epidote and sericite. Of these a peculiar, and characteristic, bluish-green chlorite is the most abundant and distinctive. In massive quartz-feldspar-biotite rock adjacent to, but not within, the mineralized zone, careful search with a hand lens will reveal corroded garnets.

"Mountain Top"

The situation at "Mountain Top"(p.95)is similar to that at the two showings just described, except that there is sulphide mineralization in hornblende schist. This rock now contains up to 85 per cent hornblende, which is altered to chlorite to greater or lesser degree. The plagioclase is remarkably sparse.

The regional grade of metamorphism is the same as that across the valley at the "Core Shack" and "Silver Cliff' showings, with variations in mineralogy appropriate to variations in bulk chemical composition of the rocks concerned. As in those showings also, sulphides are accompanied by low grade assemblages of minerals: chlorite-epidote-sericite in the siliceous rocks, and chlorite-epidote-calcite-rnagnetite in the hornblende schist.

The alteration is zoned. In the siliceous rocks, four zones have been recognized, of which the outermost probably extends at least 40 feet from the sulphides. (In a core, two samples taken from within an interval of 80 feet between two veins both show the characteristic chlorite alteration.) In the hornblende schist, similar alteration extends at least 60 feet from sulphide veins. Chlorite is characteristic of the outermost zone and increases to 80 per cent adjacent to the vein. Epidote is as much as 50 per cent in an intermediate zone, but decreases in abundance close to the sulphides.

NILE BROOK

The sulphide occurrence at Nile Brook is described on page 95.

The host rock here is in the siJlimanite zone of regional metamorphism (sillimanite-almandine sub-facies) and the extensive recrystallization has generated a granitoid gneiss. In many places, the gneiss has the look of a sheared granite, but original compositional banding is preserved. The recrystallation to a gneiss is essentially the only difference between this and the showings at Faribault Brook,just described.

The characteristic feature. here again, is the occurrence of minerals of the greenschist facies in this high grade assemblage. Sulphide mineralization is confined in a shear zone, and there is a halo of low grade minerals around it. The zone is complex and, under the microscope. it has been found that there are numerous minor fractures characterized by biotite, chlorite, epidote, and limonite. In hand specimens. these fractures appear as thin greenish-blue streaks.

The alteration halo around the mineralized zone is shown diagrammatically in Fig.14. This diagram is based upon samples of the gossan, mineralized zone and wall rock. The mineralogy of the zones is shown in Table 7.

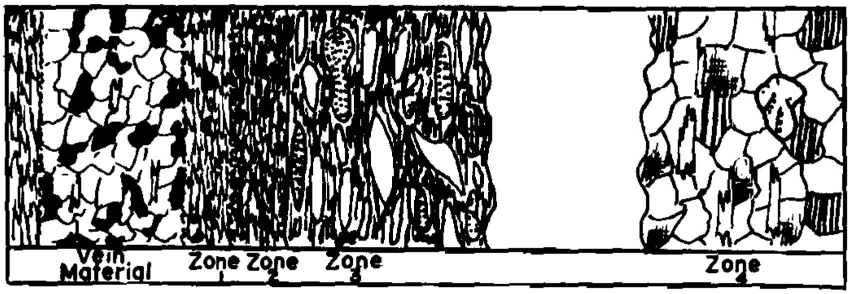


*FIGURE 14 Diagram of alteration halo, Nile Brook. Zone 4 extends at least 150 feet **from vein.***

TABLE 7

Mineralogy Of The Alteration Zones

(percentage as Visual Estimates)

Minerals	Mineralized Zone	Zone 1	Zone 2	Zone 3	Zone 4
Quartz	40	4-5	0	40	40-45
Feldspar	0	0	0	35	50
Biotite	2-3	85	0	5	2-3
Chlorite	tr	4-5	tr	tr	tr
Sericite	6-7	tr	99	15	tr
Epidote	0	tr	0	0	0
Garnet	0	0	0	tr	0
Kyanite	0	0	0	tr	1-2
Sulphides	50	3-4	0	tr	tr

It will be noted that the mineralogy is essentially the same as that described from Faribault 'Brook. In the present case, Zone 1 is the shear zone. Samples show mineralogy of Zone 4 up to 157 feet from the shear. In the mineralized zone within the shear, chalcopyrite (up to 50 per cent) and pyrite are associated with quartz, biotite, sericite, and chlorite.

MIDDLE RIVER (SECOND GOLD BROOK)

The general geological setting of this former gold mine is described on p. 91. It will be noted that, unlike all the other showings previously described, this mine was in a zone of low grade regional metamorphism. Such low grade metamorphism in proximity to granite (p. 92) is itself anomalous, and probably indicates considerable fault movement. It is not considered to be due to the mineralization.

It may be possible that the emplacement of the quartz had some effect upon the wall rocks. It has been possible to recognize some changes in proportions of biotite and chlorite, and the development of sericite/paragonite on the plagioclase feldspar. The effect, however, is noticeable only for about two inches from the vein, and is, therefore, no useful guide in prospecting.

CHAPTER V

ECONOMIC GEOLOGY

There has been sporadic exploration activity in the George River rocks for over a century, but only very minor production therefrom. The exception to this is the quarrying of dolomite and limestone, of which substantial tonnages have been produced.

GOLD

MIDDLE RIVER (SECOND GOLD BROOK)

Gold was reported by Fletcher, in 1877, as having been "obtained by washing the sands of the brooks which flow from the hills in the vicinity of Middle River above the Margarie road". A small washing operation was later attempted on Middle River, but the return was insufficient and it collapsed after a few months. Fletcher also reported gold from vein quartz in McLean Brook at Middle River. According to a local man, Mr. Fortune, a nugget (or two ?) was found years ago in the brook draining into Lake O'Law on the east side.

Later a small mine and mill were operated. on Second Gold Brook, but little **concrete information concerning this operation is now available. The site can be** reached by a road which branches from the Cabot Trail where it crosses Middle River at Ivera, though one must walk the last few hundred feet from where the road crosses Second Gold Brook. An inclined shaft was sunk in the brook bottom and a level driven both ways from the shaft on the Lizard vein. In addition, there was an adit on the west side just above the brook. In 1909, Woodman reported the vein exposed for a length of 350 feet. The mill foundations and a part of the flume are all that remain. Average recovery was reported to be only 70 per cent, attributed to arsenic in the ore, but figures for 1908 and 1909 indicate production of 1,298 ounces from 4,583 tons (0.284 oz. per ton). Total production was 1,670 ounces, from 6,093 tons.

Operations had ceased by 1915.

Chalcopyrite, pyrite, and pyrrhotite containing nickel can be found on the dump by the former blacksmith shop. On the assumption that this came from the mine, Cape Breton Metals made an electromagnetic survey and did about 1,500 feet of drilling in 1955. Again, in 1962, Mareast Explorations, under the direction of A.G. MacKenzie, drilled 5 holes near the shaft to intersect the vein on either side of it. Several other holes were drilled on the supposed extension up the hill on the west side of the brook. Quartz stringers and thin veins were found in the holes near the shaft, but nothing sufficiently thick to be minable.

The vein occurs in shale (chlorite schist) interbedded with impure quartzite, and apparently conforms to the bedding. Conglomerate, 60 feet wide, outcrops in the brook just below the old mill site. The rocks dip northward at about 40 degrees in the immediate mine area, but the dip is as little as 25 degrees at some places in the neighbourhood. The conglomerate band can be followed up the east side of the valley without any obvious offset, so transverse faulting is apparently negligible there. It has been supposed that the western part of the Lizard vein was cut off by a transverse fault. Though' exposures are poor, it is probable that the conglomerate band is not displaced on the west side of the valley either, and the fault, if it exists, must have a minor horizontal movement.

In 1962, one of the holes drilled from the bottom of the brook intersected "quartz porphyry" at a vertical depth of 170 feet. Despite the presence of an intrusive rock so close to the surface, and of granitic rocks about half a mile away at the head of the brook, the metamorphic grade is very low and chlorite is abundant. It seems probable, therefore, that the vein and its enclosing rock must have been faulted into the present position in contact with the intrusive.

Alteration adjacent to the vein is characterized by sericite, chloritized biotite, and paragonite, as described on page 90, but is not at all apparent on the outcrops.

The massive sulphides containing nickel and copper were not found in the drill cores. Sulphides have been found in the adit on the south side of the brook (February, 19.70). The adit is being cleaned out and re-timbered, so very little information is as yet available, but the sulphide vein appears to be about two feet thick in the drift, and to be cut by several faults of small displacement.

BASE METALS

FARIBAULT BROOK (NEAR CHETICAMP)

"Silver Cliff" showing, Dauphinee Brook
"Core Shack" showing, Faribault Brook

Though outside the area formally covered by the accompanying maps, prospects in the vicinity of Faribault Brook were examined in 1967 and 1968. This is an area which received considerable attention years ago. A wagon road was built and a considerable expenditure made to develop several copper and lead showings in the area, particularly the so-called "Mountain Top" mine. Since 1960 geochemical and geophysical work, trenching, and diamond drilling has been undertaken by a number of companies. The larger efforts were by Noranda Exploration Company, Limited, and by A.C.A. Howe for Barrington Exploration Corp., Ltd.

The two prospects here considered are about 5 miles from Petit Etang, and are on opposite sides of a ridge between Faribault Brook and Dauphinee Brook, both tributaries of Cheticamp River. The showings can be reached by a bulldozed "jeep" road which branches off the wagon road to the old "mine" and climbs eastward up the north side of the valley of Faribault Brook. This road goes just beneath the "Core Shack" showing, and continues to the top of the mountain, where it swings north to Dauphinee Brook. A bulldozed road, no longer passable, leads down the north side of the ridge to the "Silver Cliff" showing, which is a few hundred feet lower on a tributary of Dauphinee Brook.

The "Core Shack" showing was discovered by John Skotynsky during the recent exploration activity and has been cleaned off by bulldozing. Old reports in the files of the Department of Mines, dating from the period of previous activity (1903), show an occurrence of galena on Dauphinee Brook, but it was apparently re-discovered in recent years, and is now known as the "Silver Cliff." It should not be confused with a "Silver Cliff' shown on some old maps.

The mineralization consists of argentiferous galena, sphalerite, and chalcopyrite, with pyrite, pyrrhotite, and arsenopyrite. It has been exposed over a length of 120 feet at Dauphinee Brook and 300 feet at the "Core Shack." The

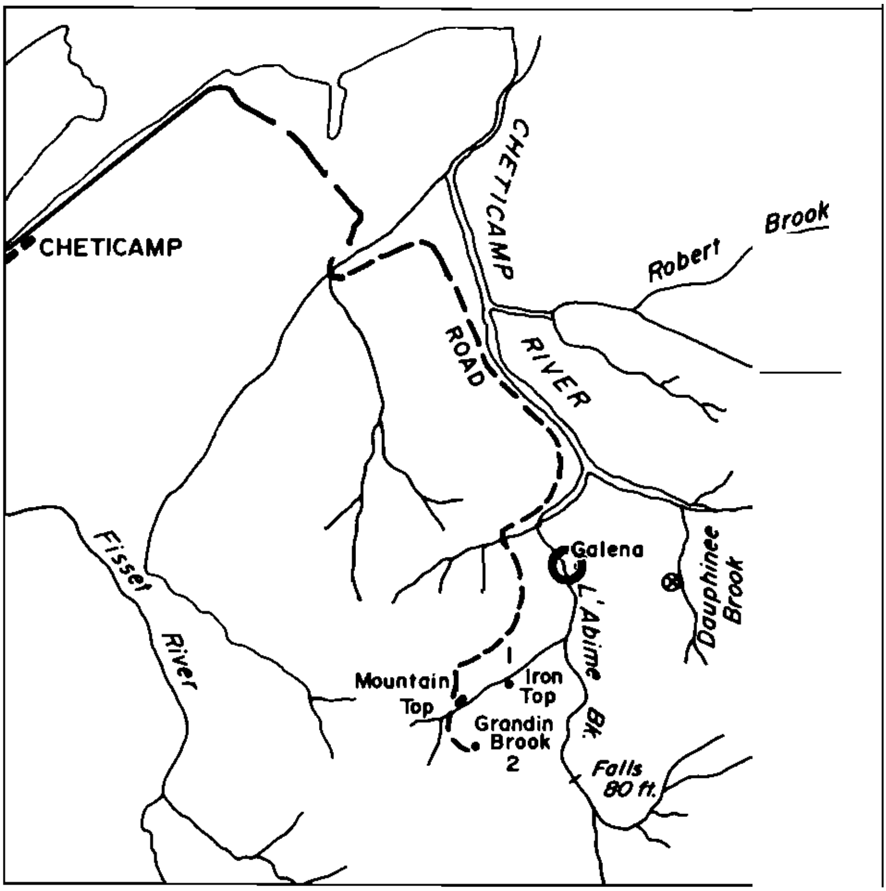


FIGURE 15 ***Location of former prospects, Faribault (L'Abime) Brook, 1903.***

exposed thickness is very variable: at "Silver Cliff," up to about 6 feet, and at the "Core Shack," in irregular areas through a thickness of about 30 feet. The attitude is discussed below. The two showings are of very similar character.

The host rock is a plicated schistose member in a sequence of interbedded garnetiferous quartz-feldspar-biotite schist and arkose. At the "Core Shack," amphibolite has been faulted against the west end of the mineralized zone, but similar amphibolite is known near "Silver Cliff' only at the very beginning of the brook on the top of the mountain. Massive igneous rocks, reported to be granite, are visible in cliffs on the opposite side of Dauphinee Brook and on Cheticamp River. They are assumed to be intrusive into the George River rocks.

Chlorite and sericite alteration is abundant and closely associated with the sulphides. The pale greenish-blue chlorite which is especially abundant at "Silver Cliff" is so distinctive that it cannot be overlooked in the field. It accompanies the highest-grade mineralization, and has been variously identified in the field as **fuchsite,** mariposite, **and perhaps other micas. Garnets are abundant in the** mineralized rock but are also found elsewhere.

The "Silver Cliff" is shown on the accompanying map, which is a composite showing the rocks visible in August, 1967, and September, 1968. Mr. Skotynsky has stripped away large volumes of overburden with an ingenious hydraulic device of his own invention which he calls a "splash-dozer." This device automatically dumps about 2½ tons of water onto the steep hillside at intervals of a minute or less. The resulting erosion is a most effective method of exposing rock. "Splash-dozer" No. 2, in operation in 1968, had buried under its debris some of the mineralized zone exposed in 1967 - hence the composite map. The section shown was made by *projecting* from the outcrops to a vertical plane along the line indicated. It is, therefore, not a true section, and does not correct for the plunge of the structure, which varies from 5 to 14 degrees north, nor does it correct for the displacement in position of faults between the outcrop and the plane of the section. Excepting the arkose, essentially only two units are shown; massive and schistose quartz-feldspar-biotite rock, the latter with or without hernatite. Especially in the lower half of the exposures, the hematite occurs in very schistose and limonitic rods about half an inch in diameter, and up to a foot long, parallel to the plunge of the fold.

The showing is on the east flank of an anticlinal fold, and near its crest. The strike of bedding is nearly north and its dip up to 4S degrees east. The dip flattens toward the top of the exposures and there is some indication that the beds should be nearly horizontal just west of the map limits. Similar nearly horizontal beds occur higher up the mountain, on a switchback just west of, and well above, "Splash-dozer" No. 2. The schistose layer is very contorted in detail and on a small scale; the more massive members, less so. It appears that an incompetent layer, probably originally shale, between more massive siliceous layers, absorbed most of the interlayer movement during folding and became very schistose and contorted. The mineralization seems to be restricted to this layer.

Mineralization, therefore, does not appear to be restricted to a vein or vein-system, but to be essentially a dissemination within a single sedimentary horizon. Locally, the concentration approaches massive sulphides. It follows, then, that the mineralized zone, and an ore body if it exists, has the shape of a folded sheet of variable thickness, and that the fold has a shallow northward plunge. For purposes of exploration by drilling, the problem becomes a matter of finding a body shaped vaguely like a piece of pipe split longitudinally and sticking nearly horizontally out of the mountain side.

In addition to the major SUlphides mentioned above, Chatterjee has found minor amounts of bomite, covellite, and chalcocite.

Sampling by the present owners has shown up to 14.15 per cent zinc, 7.92 per cent lead, 0.22 per cent copper, and 50.30 ounces of silver per ton. Systematic sampling has not been done, so an average grade and thickness are not available.

The "Core Shack" showing is on the other side of the mountain, directly above the access road, and has been exposed for about 300 feet by bulldozing. The mineralogy and general relations are as at the "Silver Cliff' showing, though here more than one schistose layer is exposed. The dip is 2 or 3 degrees to the east. This flat attitude suggests that this may be the top of the same fold, and be the same mineralized zone, as the "Silver Cliff" abowing. Relative elevations, however, are not accurately known and without them correlation cannot be made with any confidence.

This showing is terminated at its west end by a fault of unknown displacement.

"Mountain Top" showing, Faribault Brook

This occurrence is near the source of one of the tributaries of Faribault Brook and is about three quarters of a mile southwest across that valley from the "Core Shack" deposit. This was explored prior to 1903, at the same time as the other prospects in Faribault Brook. It is accessible by the old wagon road built at that time from Petit Etang. There has been some drilling in recent years to test geophysical and geochemical anomalies, but surface exposures are rather scanty.

Drill cores show interbedded garnetiferous quartz-feldspar-biotite schist, hornblende schist, chlorite schist and arnphibolite. The host rock is, therefore, very similar to that on the other side of the valley at the "Core Shack," and has been intruded by granite and later basic dykes.

Mineralization occurs as thin bands, stringers, and disseminations of chat-copyrite, pyrite, pyrrhotite, and arsenopyrite both along and across the foliation in hornblende schist and quartz-feldspar-mica schist.

Two other occurrences in Faribauit Brook are discussed in the old reports, but nothing is known about them.

NILE-BROOK

This showing is at the bottom of the deep valley of the north branch of Nile Brook. It is actually not far from the Fielding Road, but is accessible only on foot. It was discovered by John Skotynsky in 1954. There is only a small surface exposure, on which some blasting and shallow drilling have been done. The exposure has more gossan than would be expected in this area.

The host rock is the quartz-feldspar-biotite gneiss common all along Nile Brook; this is generally strongly-banded paragneiss, which has a granitoid texture in many places. It has been intruded by granite, and by larnprophyre dykes which probably followed shear zones. There are a number of faults and shear zones in the gneiss, and a substantial part of Nile Brook is probably controlled by such a zone.

Mineralization occurs in a shear zone. which is marked by biotite schist, strikes N IOOW, and dips 70 to 80 degrees east. The shear is exposed for a length of 15 feet and the width varies from 3 to 6 feet. The sulphides are confined to the shear and are essentially pyrite and chalcopyrite. Sericite and chloritic alteration are distinct in the wall rock, and minor epidote also occurs as thin stringers. Such alteration is obviously a retrogression superimposed upon the high grade of regional metamorphism and associated with the sulphides. It could be an important guide to mineralization, but does not appear to extend sufficiently far from the sulphides to be of any practical use.

MEA TCOVE

This prospect is located about half a mile off the road from Meat Cove to Lowland Cove, and is practically at the extreme northern end of Cape Breton Island. The property is accessible from Meat Cove, but the former road to Lowland Cove is no longer passable much beyond the turn-off to the prospect. The road would require complete rebuilding to carry heavy trucks. The nearest practical harbour is at Dingwall, 13 miles away.

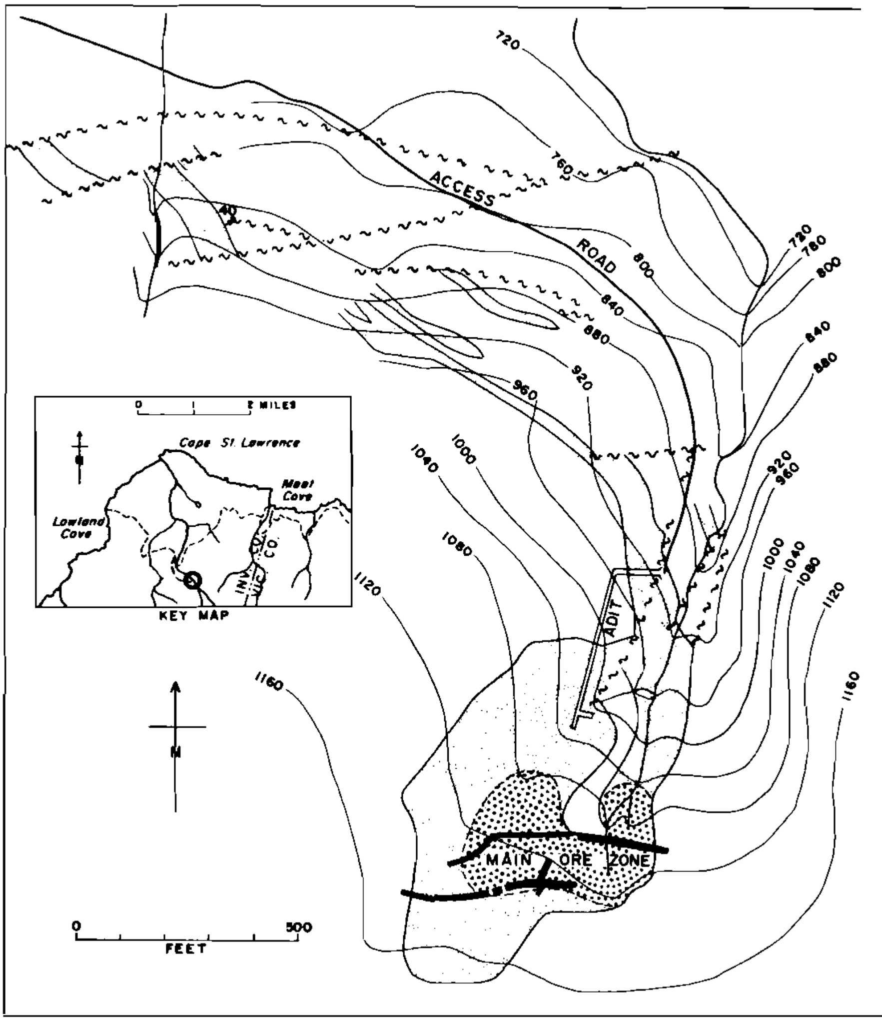


FIGURE 16 *Meat Cove Prospect, from a 1954 map by Mineral Exploration Corp., Ltd., based upon surface pits and diamond drilling. Surface trenching* (1968) *shown in solid black.*

It was discovered in 1953 and there was extensive exploration during 1954 and 1955. This included a large number of surface pits, diamond drilling, and the driving of an adit. In 1962 practically nothing could be seen in the surface pits, and in 1968 three long surface trenches were excavated by the current owners. The accompanying plans show these recent trenches together with the general distribution of mineralization as found in the earlier work and reported to the Department of Mines at that time.

The important sulphide mineral is sphalerite but there are very minor amounts of chalcopyrite and galena, in addition to pyrite. It occurs as thin massive bands, as veins, and as disseminations. In the trenches there are a few inches of gossan over the sulphides; in some cases this is rather hard and massive. In some other places the gossan has colour bands of various combinations of pale yellow to dark reddish-brown, with distinct pink patches randomly distributed. Presumably, the colours reflect various amounts of different sulphides. The pink colour is not due to erythrite. The host rock is dolomitic limestone with some interbanded garnetiferous quartz-feldspar-biotite schist. The present work did not include any mapping but, according to Neale, the whole appears as a roof pendant in a large area of syenite. The general strike is east and the dip 45 to 70 degrees north. The further controls, which localized the sulphides within the mass of carbonate, have not been recognized from the data available.

The mineralogy and the characteristic alteration associated with the sulphides have been discussed at length by Challerjee on pages 82 to 85. For our present purposes it is sufficient to say that invasion by the granite produced high grade metamorphism of the host rocks, and that the mineralizing process superimposed an assemblage of minerals characteristic of low metamorphic grade. Of the latter, antigorite and brucite are the most important, and their presence indicates proximity to the ore body. The round white grains of brucite are sufficiently large to be recognized in the field, and are sufficiently wide-spread to suggest that they could be used elsewhere in the George River carbonates as a guide to similar sulphide mineralization.

The average grade of the deposit, according to the initial investigations of 1954 and 1955, is 3.5 per cent zinc, and a tonnage in excess of 4 million tons was indicated, available for open pit mining. Minor germanium values were found near surface but not in the adit.

The crucial problem in developing this property is its isolated location and the cost of transporting concentrate to a shipping point.

LIME HILL

This prospect is on the plateau of North Mountain, near the head of McCuish Brook, West Bay Marshes, and is accessible via "jeep" road from the highway at Cameron Point. It was discovered in 1957 by Professor B.J. Keating, who found a geochemical anomaly in the brook. Surface mapping and diamond drilling were done shortly thereafter by Consolidated Mining and Smelting Co. Ltd., and by others. The present owner is The Patina Mining Corporation, which did some further diamond drilling in 1967 and 1968. The early work found interesting amounts of zinc, but no ore body.

The accompanying surface plan is based upon detailed surface mapping done by Cominco, The present work has involved only a re-examination of selected outcrops, amounting to perhaps 20 per cent of the total, and an examination of such core as could be identified as to source.

The general geological setting is very similar to that at Meat Cove. The host rock is mainly dolomitic limestone and dolomite, with interbedded garnetiferous quartz-feldspar-biotite schist. The George River rocks occur as a roof pendant (or a number of pendants) in a siliceous intrusive. The whole has been cut by later aplite and lamprophyre dykes. The regional metamorphic grade is high (equivalent to the sillimanite zone) and a low grade mineral assemblage has been superimposed on it in association with the sulphides, which are most abundant in the dolomitic beds.

There are some differences, apart from the amount of sulphide found: Argillaceous and siliceous dolomitic limestone bands are both present at Lime

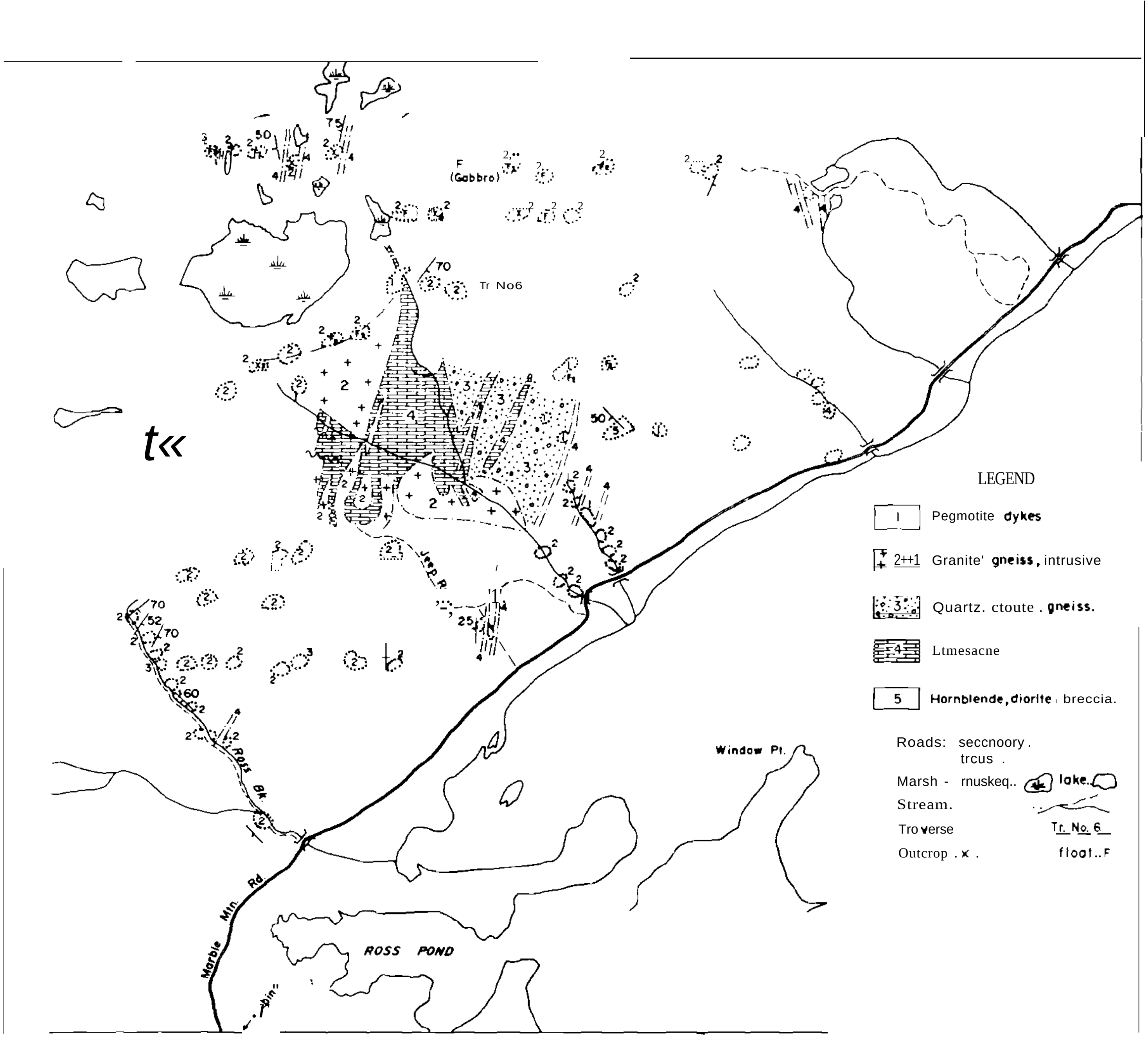


FIGURE 17 Surface plan, Lime Hill prospect,

Hill, suggestive of slightly different conditions during carbonate deposition and therefore of somewhat different carbonate character. The alteration at Lime Hill does not include the brucite which is characteristic at Meat Cove; instead, talc formed by alteration of cordierite and antigorite is associated with the sulphides. Mineralization is within fractures and shears in the carbonate. This may be the case at Meat Cove also, but is not nearly as apparent from the evidence now available.

Mineralization occurs in dolomitic limestone as massive bands, thin veins, and disseminated. It is dominantly sphalerite, as at Meat Cove, but also includes chalcopyrite, pyrite, pyrrhotite and arsenopyrite. Thin stringers of calcite, chalcopyrite and pyrite occur in the quartz-feldspar-biotite schist and are larger and more abundant than at Meat Cove. The serpentine and talc alteration which extends several feet from the associated sulphides is bright greenish-yellow to dark greenish-black in colour, and gives the rock a very fine-grained, almost waxy, appearance.

Control of sulphide deposition by the dolomitic limestone as the favourable host rock is apparent in the drill core. Information from the previous drilling is now scarce, but the general distribution of the sulphides in zones suggests a further control by large fractures cutting the limestone.

Figures on tonnage and average grade found are no longer available.

WHYCOCOMAGH

This prospect is on the edge of the plateau, north of the village of Whycocomagh, in the area shown on Fletcher's maps as "Mullach." There has been some prospecting at intervals for at least 60 years. This involved trenching and sinking of a shaft; an old adit was reported by local people, but was not found.

Additional trenching and several hundred feet of drilling were done in 1960, on the basis of magnetic data. The resulting core has since been destroyed. A road made at that time provides access to the area from a dirt road on the mountain top, which in turn joins the Trans-Canada highway at Whycocomagh.

The general geology in the vicinity is not at all clear. Exposures are limited to the trenches and to small outcrops in the brooks. These show, in the George River, amphibolite, quartzite. conglomerate, garnetiferous quartz-feldspar-biotite schist and a rather weakly foliated gneiss, in addition to the dolomite and dolomitic limestone which appear to be the chief host rock for the mineralization. The general strike is north easterly and the dip steep to the northwest, but the structure is obscure.

This immediate area has rocks of the highest metamorphic grade found in the Craignish Hills. Nowhere else does garnet occur, and the nearest approach to gneiss is near the Iron Bridge, on Bridgend Brook, about a mile away across the valley. The nearest amphibolite appears to be that on the Glencoe – Blue's Mills road, several miles to the southwest.

The mineralization is best seen in the dump adjacent to the old shaft and in trenches near it. It consists of chalcopyrite and pyrite, with a surprising amount of magnetite, in an altered dolomitic limestone. The dump has large chunks of massive sulphides and magnetite but there is no indication whether or not this is

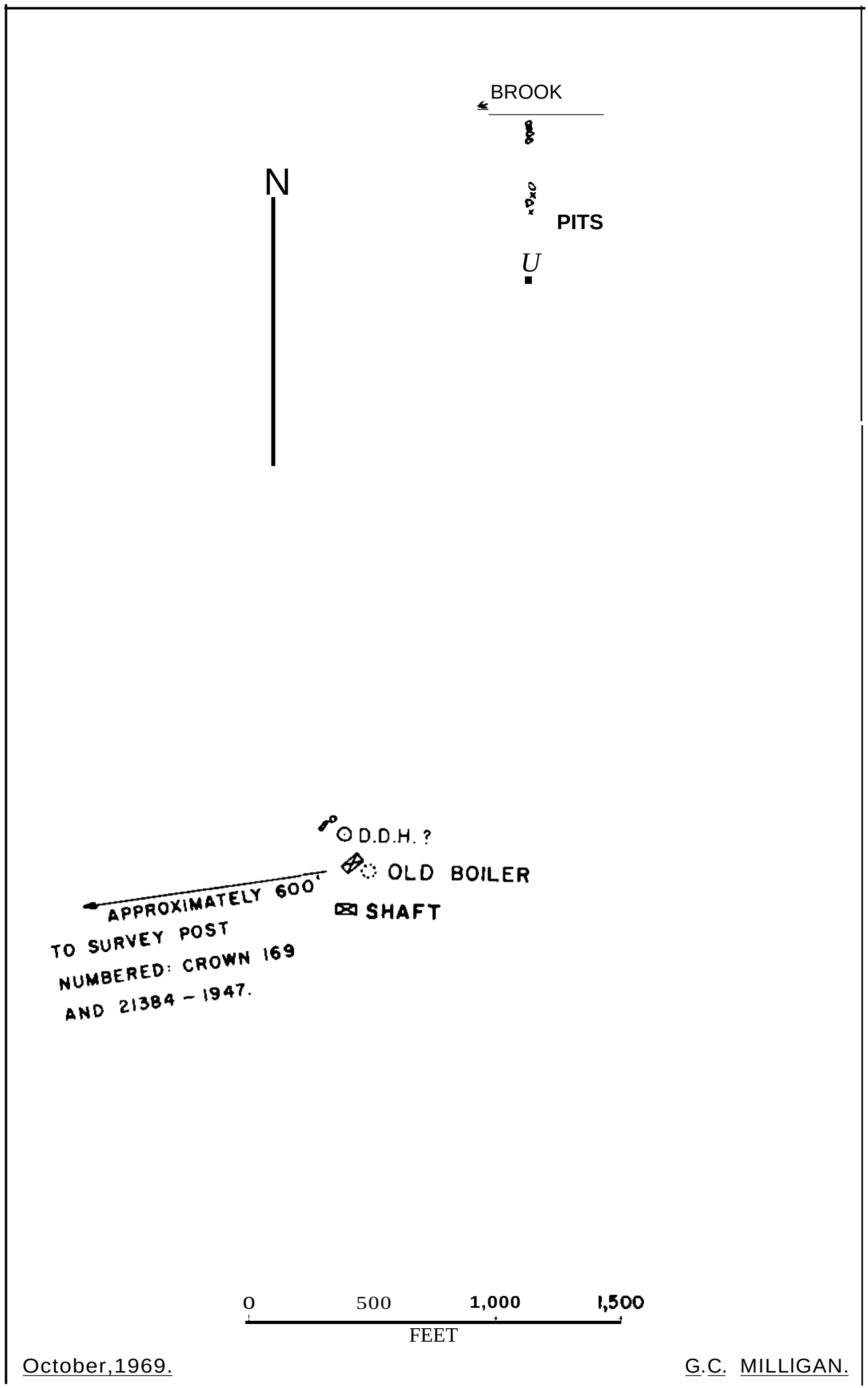


FIGURE 18 Location of test pits, magnetite showing, Upper Glencoe.

representative of the material as a whole. Nor is there any indication of the thickness or attitude. The old shaft appears to have been steeply inclined; if the practice of the times was followed, this would indicate a steeply-dipping, and probably thin, vein or group of veins more or less following the limestone.

UPPER GLENCOE

This prospect is about 4 miles north of River Denys Road on the road to Upper GLencoe, and about 250 yards east of that road. Under stress of wartime conditions, in 1941, it was considered as a possible supplementary source of magnetite for the steel plant at Sydney, but its previous history is not known. On the site at present is an old boiler adjacent to a collapsed shaft, a few test pits nearby, and another line of very old pits over half a mile away near a tributary of Mull River.

The mineralization is essentially massive magnetite stained with malachite. Nothing is now visible in the pits, but the dump suggests that the magnetite occurs as a zone of narrow veins, a few inches to perhaps a foot thick. The wall rock is a massive light grey diorite, which is part of the large intrusive mass forming the western margin of the George River rocks in this area. Grab samples of dump material, taken by Barry Jones of the Department of Mines, carried 0.50 per cent copper. Similar copper-stained float from a brook at Upper Glencoe, some two miles to the northeast, carried 2.05 per cent copper.

The location of the pits is shown on the adjacent sketch. Those near the brook are assumed to indicate the trend of a similar magnetite zone but, in truth, little is visible and there is little to indicate the presence of magnetite except a slight deflection of the compass needle.

McDONALD BROOK, NORTH RIVER

This prospect is near McDonald Brook, a large tributary of North River. There is no longer a road near it, but a footpath follows a former farm road westwards from Meadow.

Considerable trenching was done in 1967 by The Patino Mining Corporation. A sketch map of the trenches is shown as figure 19. The mineralization is essentially massive pyrite in quartzite and feldspathic quartzite of the George River.

STEELE'S CROSSING - BOISDALE

This occurrence is a few yards from the house of a Mr. Currie between Steele's Crossing and McAdam Lake, and shows a few hundred tons of massive hematite alongside a pit. According to Mr. Currie, the hematite was mined from the pit in 1903. The mineralization was known long before, however, for Fletcher mentions it in his report for 1875, at which time it was already described as on the Currie farm. Fletcher also mentioned pits of similar material 2½ miles to the northward on the Frenchvale road, but these were not found.

The pit, now filled with water, and other test pits nearby, are shown on the adjacent sketch map, figure 20.

In 1962, five holes were drilled from a short distance northwest. The nearest was 300 feet from the pit, and would have passed underneath the Pit at about that depth. The others were apparently designed to test beneath the extension of

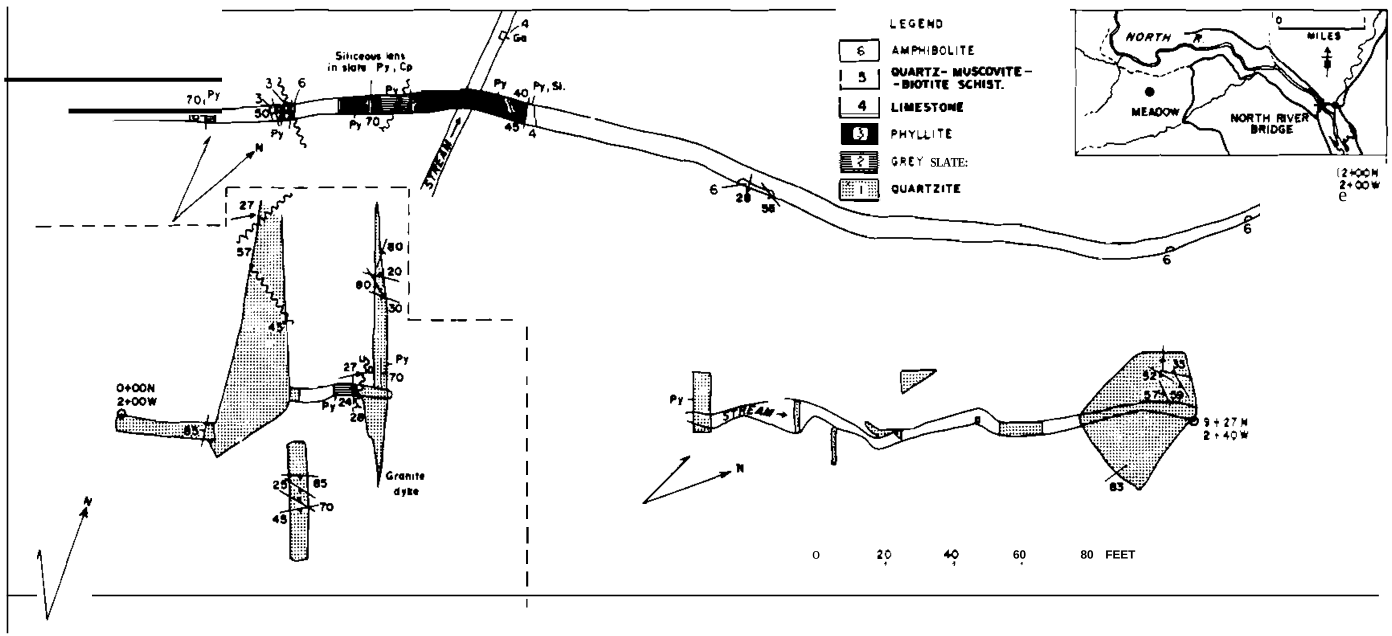


FIGURE 19 *Trenching near Meadow.*

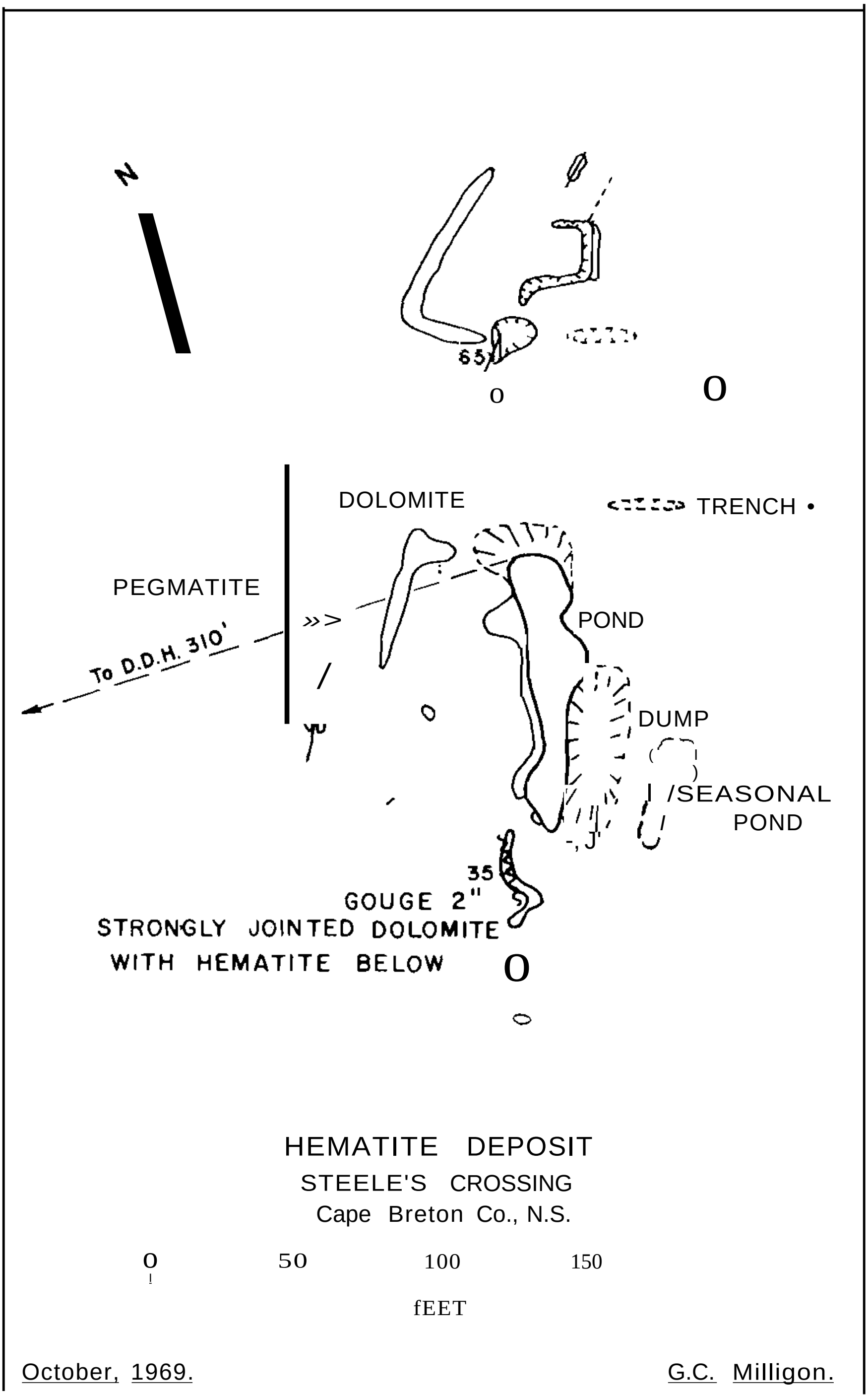


FIGURE 20 Hematite deposit, Steele's Crossing.

the strike of the hematite to the southwest. Small amounts of zinc were reported. The mineralization in the pit is essentially massive hernatite, in a band less than 10 feet wide, with white dolomite and limestone on both walls. There is little or no visible alteration of the dolomite, save a sparse dissemination of pyrite, but some hematite alteration was noted below the fault at the southwest corner of the pit. There is, however, an unusual amount of sparse sulphides in the rocks within about a mile of this deposit.

An analysis of the material is quoted by Fletcher, on p. 449 of the GeologicaL Survey Report of Progress for 1876-7. Fletcher also reports that some pyrite was observed filling small cavities, and was also found "between the ore and a layer of chlorite rock which sometimes occurs intermixed, and at other times forms the wall rock. He adds that patches of white siLvery talc and mica in large flakes occur in the limestone.

This hernatite is distinctly odd. The obvious suggestion from its position is that it probably represents the result of secondary enrichment, by some process, of an originally iron-rich layer in the carbonates. Nowhere else in the George River rocks has a similar layer been noted, nor any extensive layer of iron carbonate. Nor does the hematite show any oolitic or similar texture, such as is characteristic of Wabana and other ores of the Clinton type. Fletcher, who saw it when the pit walls were fresh, considered the second occurrence, on the Frenchvale road, to be indicative of a possible bed in the George River limestone, but was evidently doubtful and concluded that this "cannot yet be consideredas conclusively established."

Some fragments, found jm the north end of the pit, have a few cavities suggestive of a boxwork derived from sulphides. Even though the wall rocks would represent a reactive gangue, to produce "indigenous limonite" would require both abundant carbonate and abundant sulphide, and the result could hardly have the present massive form. Even some form of "transported Iimonite" would appear to be out of the question, in view of the lack of alteration in the adjacent dolomite.

UMESTONE AND DOLOMITE

MARBLE MOUNTAIN

This quarry was initially opened in the 1870's for dimension stone and for the production of quicklime. It was subsequently a producer of flux for the Sydney steel pLant as well. It was closed in the 1920's. There appear to have been several contributing reasons, of which the chief were a slight increase in the silica content of the product, and a disagreement over new terms of the lease under which the steel company operated the quarry. The "Upper," "Number 2," or "McAskill' quarry was operated for dolomite.

The accompanying map was made in 1962. Since then the quarry has been re-opened and several thousand tons have been produced for aggregate, especially for exposed aggregate precast concrete.

Contrary to the impression conveyed by the map, the quarry was not started at the south end and advanced northward. Fletcher, writing in the Geological Survey Report of Progress for 1877-78, (p. 318) describes a quarry about 450 feet above the lake, and with a face then 60 feet high. The northern part of the lower quarry, above the third bench, corresponds to his descriptions.

The marble is folded into a syncline which plunges southward. There is some indication that the plunge changes from about 30 degrees on the east side to nearly 50 degrees on the west side, but an average plunge of 40 degrees appears to be most consistent with all the present data. The section is drawn normal to this; and was obtained by projecting from the surveyed position of the contacts.

The stone is available in a variety of colours, of which white, bluish-grey and dark blue are the chief. It weathers well, as indicated by monuments now over 70 years old, and polishes well. Initially, according to Fletcher, "immense blocks" could be removed; no doubt the blasting attendant upon flux production has fractured everything in the area. The Los Angeles abrasion test showed 27.3 per cent wear (6 per cent after 100 revolutions), and the soundness test with sodium sulphate (A.S.T.M. Standard C88) showed a loss of 0.7 per cent after 5 cycles. Boulders immersed in the sea at the former piers show little weathering effect after 60 years.

Chemical analyses are tabulated below. The location of the samples is shown on a map available as a white-print from the Department of Mines.

Sample No.	SiO_2	R_2O_3	CaO	MgO	Loss
M113-62	4.60	1.52	50.76	1.80	41.14
M114	0.92	0.54	53.67	1.60	43.18
M115	1.20	0.86	54.24	1.80	42.80
M116	0.64	0.60	53.67	1.57	43.42
M117	1.26	0.46	51.81	3.00	43.34
M118	4.46	1.34	51.49	1.50	41.12
M119	3.36	0.70	52.70	1.25	41.88
M120	7.42	2.26	49.71	1.15	39.38
M121	2.66	0.78	53.55	0.90	42.24
M122	3.42	1.14	52.86	0.56	41.92
M123	8.18	1.72	50.72	0.30	39.24
M124	2.18	1.12	53.68	0.24	42.68
M125	2.58	0.70	53.13	1.27	42.22
M126	3.58	1.04	52.38	1.22	41.68
M127	3.00	0.86	52.60	1.56	41.88
M128	2.96	0.70	52.54	1.88	41.82
M129	3.64	0.92	50.60	3.00	41.82

About 3.6 millions tons are available above a level permitting natural drainage.

The old waste dumps are all that separates the quarry from deep water. The gravelled road from the quarry to the paved highway at Cleveland (14 miles) has recently been improved to carry heavy trucks.

CAMPBELL BROOK

The band of limestone which extends along the north side of the valley of Campbell Brook is well situated as a potential limestone quarry where rail shipment is intended. For this reason, a horizontal hole was drilled across it in 1963 to provide a sample of the material.

The steeply-dipping limestone outcrops on the crest of a ridge which extends from the northward bend of Campbell Brook near Cummings Siding to the MacMillan farm at the top of the mountain. The valley of Campbell Brook is to the south, and a parallel tributary valley to the north. Quarrying is therefore possible along the ridge from its end, which is also the west end of the limestone, without involving large amounts of waste removal on either side. A former siding from the Canadian National line to Sydney came to within a few hundred feet of the brook.

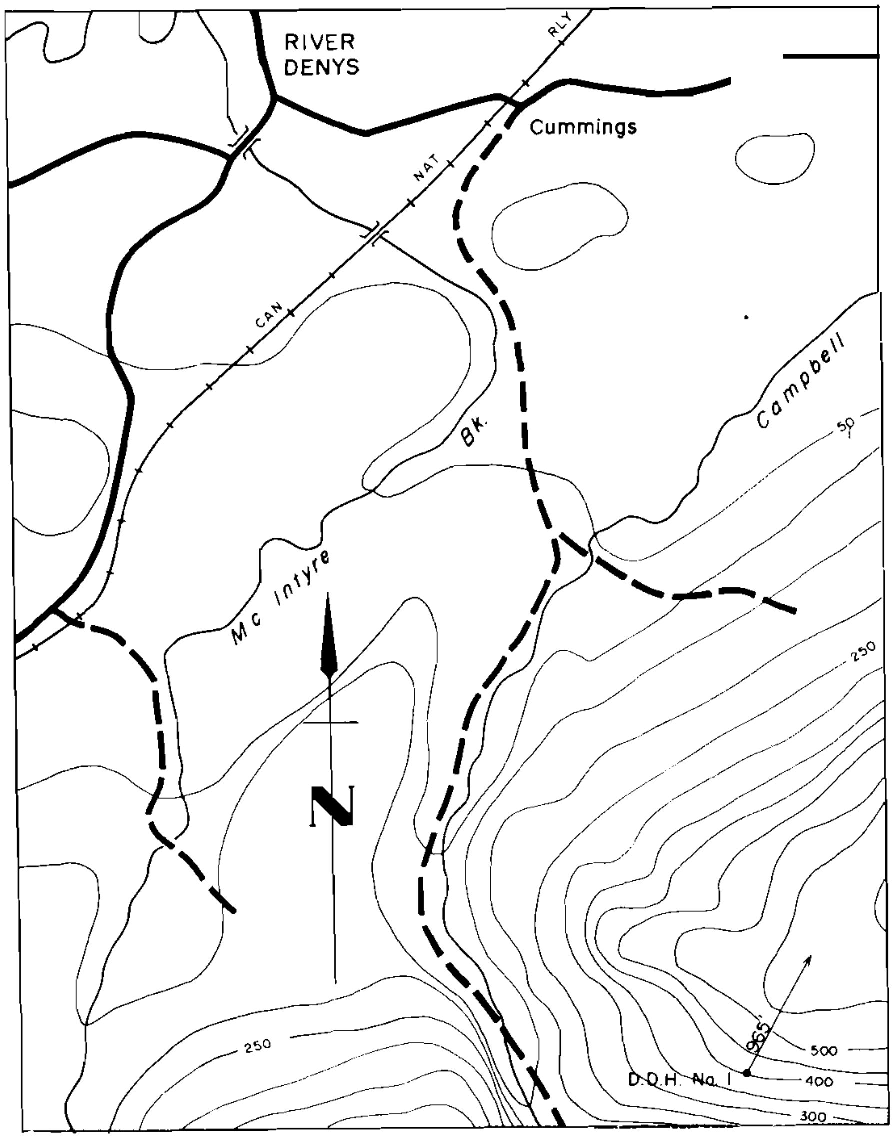


FIGURE 21 Location of drill hole, Campbell Brook.

The diamond drill hole was driven horizontally, on a bearing 030 degrees true, from a point 150 feet vertically below the summit of the ridge. To locate the hole, proceed on a bearing of 030 degrees for 700 feet from a point on the road to the MacMillan farm 1900 feet above the lowest bridge on the brook.

In general, the hole passed through dark severely-fractured quartzites followed by 100 feet of limestone. A fault repeated the quartzites, which were then followed by 457 feet of limestone and then more quartzites. The repetition of the quartzite is not visible in the surface outcrops. A generalized log of the hole has been published by the Department of Mines in the Annual Report for 1963, p.54. A detailed log is also on file with the department.

Samples from the outcrops on the top of the ridge showed:

Sample No.	Loss on Ignition	SiO_2	R_2O_3	CaO	MgO
M451	42.30	2.28	1.50	52.46	1.36
M453	42.10	3.22	1.26	52.70	0.62
M456	42.18	3.20	1.00	52.05	1.46
M462	42.04	3.02	1.02	53.05	0.77
M471	38.20	9.20	3.06	47.60	1.80

Analyses from the drill core are tabulated on p. 57 of the Mines Report for 1964. Silica content in the main limestone band averages slightly over 4 per cent, with MgO about 1 per cent.

Such material is obviously not suitable for fluxing purposes, but falls within the general limits for limestone for manufacture of portland cement.

NEW CAMPBELLTON

The characteristics of this deposit were reported at some length by G.V. Douglas, in the Annual Report of the Department of Mines for 1941. The map which accompanied that report was on a rather small scale, but is available from the Department of Mines in its original size.

The mapping and sampling by Douglas showed an estimated one million tons of dolomite within the area covered by his map. This is of very good quality, some of it approaching the theoretical composition of pure dolomite. It is clean, white, and coarsely crystalline. The band of dolomite extends to Cape Dauphin, but continuity throughout is not established.

Some faulting has since been recognized within the dolomite, and the low metamorphic grade of the adjacent limestone indicates a fault contact between it and the granite. Traces of sulphide were found near the contact.

In 1941, the deposit was being considered as a possible source of magnesium metal, to be produced by the Pidgeon process, which had just been developed. Samples of several hundred pounds were tested, and the material found to be satisfactory.

Mr. Chatterjce has pointed out that this dolomite is, in appearance and texture, identical with that used for the construction of the raj Mahal. Depending upon the fracturing caused by the previous limited quarrying, it might be possible to get dimension stone. Judging from the changes in the quarry in 30 years, the stone, though very white on the fresh surface, would probably weather a light russet brown in this climate.

For ease of reference. a selection of the analysis is here reproduced from the report by Douglas:

Sample	Inset	FeO	Al_2O_3	CaCO}	MgCO}	Total	CaO	MgO
PlO	1.7	0.9	0.2	52.5	45.5	100.9	29.4	21.7
P 15	0.6	0.4	0.8	54.2	44.2	100.2	30.4	21.1
P 16	0.1	1.18	0.2	53.0	44.3	98.8	29.8	20.8
P 19	0.5	0.33	0.1	55.0	43.8	99.7	30.8	20.9
P 21	0.4	0.5	0.1	55.8	46.0	102.8	31.3	22.0
P22	0.5	0.6	0.1	53.7	45.7	100.6	30.1	21.8
P23	2.8	0.8	0.7	52.3	45.3	100.9	29.3	21.7
P 26	0.4	0.3		55.1	44.7	100.5	30.9	21.4
P 27	0.9	0.36		54.4	43.5	99.1	30.5	20.8
P 28	1.3	0.48	0.4	54.1	44.9	100.2	30.3	21.4
P 30	5.5	1.16		49.9	39.1	95.6	28.0	18.7
P 32	1.7	0.48	0.1	57.9	40.3	100.4	32.4	19.3
P 33	1.1	0.52	0.7	57.1	41.6	101.0	32.0	19.8
P43	lA	0.36		54.0	43.5	99.2	30.2	20.8
M38	2.0	0.76	0.7	53.4	46.7	103.5	29.9	22.4
M39	1.4	0.91	1.2	53.9	45.7	103.1	30.2	22.0
M50	2.0	0.76	1.0	53.9	44.1	101.7	30.3	21.1
M53	1.2	0.48	0.2	54.0	43.7	99.6	30.3	21.8

The former tramway grade from the wharf at Kelly Cove (2 miles) is still passable by automobile to within about 300 yards of the quarry.

GEORGE RIVER (SCOTCH LAKE)

This operation is on the west side of George River, near Scotch Lake. A quarry has been operated here at intervals for nearly 100 years. An initial operation was northeast of the present quarry and produced quicklime. The major production, discontinued only a few years ago, was of dolomite for the Sydney steel plant, transport being by C.N.R. Recently there has been limited production of crushed rock for ballast for the Trans-Canada Highway, and of large blocks for piers and breakwaters.

The dolomite is fractured, and there is much alteration adjacent to the fractures. This alteration has been discussed by Chatterjee in Chapter IV. The general effect is to produce a characteristic waxy yellowish colour where alteration is slight, and a dark greenish-black colour where alteration is most intense adjacent to larger fractures. An intermediate greenish phase has been worked by local lapidaries as "jade." and a variety of small articles could probably be produced. Though 20-ton blocks are produced, the variations of colour probably preclude any use for dimension stone.

A substantial tonnage still remains.

WHYCOCOMAGH'

A small quarry was operated by Brandram-Henderson Paint Company at Churchview, near Whycocomagh. This white dolomite was used as a paint filler. The company still owns the quarry, from which perhaps 2000 tons were produced. but there has been no production since the 1920's.

KEWSTOKE

The large area of carbonates at Kewstoke has been explored as a possible source of dolomite. Details of this have been reported in Bulletin No. 2, Limestone and Dolomites of Nova Scotia, Part I, p. 263, 1967.

SILICA

Diogenes ***Brook***

Silica sand was produced about 40 years ago from the upper part of Diogenes Brook. It was trucked to Melford on a road which runs along the bank of the brook, and thence shipped to Montreal. The pits suggest that production was not large.

The sand is fine grained, somewhat reddish stained, and can be cleaned to a well-sorted white sand by washing in weak hydrochloric acid solution. It appears to have been deposited on a meander when Diogenes Brook was at a higher level; the quantity available is small.

White quartzites (the Upper Quartzites) occur on a number of tributaries of Diogenes Brook. Grab samples of those that appear to be the cleanest contain 92.58 per cent SiO_2.

Christopher McLeod Brook

The high ridge between the east and west branches of Christopher McLeod Brook is composed of quartzite, some of which is very white. Samples from the top of this ridge were, unfortunately. not taken in such a way as to show the mining possibilities; they showed 91.30 per cent SiO_2. It is probable that there is no suitable quality of silica available.

TALC

In view of the conclusions by Mr. Chatterjee in Chapter IV, the following may be relevant.

Old reports state that several tons of talc were produced in 1896 from shafts near Bridgend Brook. The area is about 2½ miles northwest of Whycocomagh and is still known in the district as "Soapstone" or "Soapstone Road". At present, nothing is visible except small depressions where the former openings have collapsed or been filled for safety reasons.

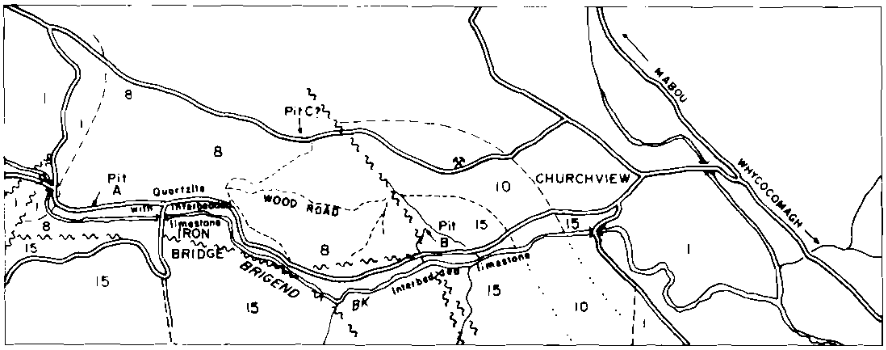


FIGURE 22 Location of talc pits at Soapstone, near Whycocomagh.

In 1943, the locations were examined by M.G. Goudge of the N.S. Department of Mines, and H.S. Spence, of the Bureau of Mines, Ottawa, in the hope that talc of strategic value might be present. The following is extracted trom their reports, which are available at the Department of Mines office in Halifax.

The position of the pits is indicated in Fig. II derived from Goudge's report. Accurding to information he obtained from older inhabitants of the district:

"A" was a shaft 50 to 70 feet deep
"B" was a shaft 40 to 50 feet deep
"C" was a shaft 18 feet deep, and no talc was found.

From Pit A (Spence's No. I Pit) some waste was then visible on the steep bank between the pit and Bridgend Brook, about 20 feet below. Spence's samples consisted of banded, greyish-white to buff, medium- to fine-grained dolomitic limestone. Some samples contained quartz and some contained limonite probably derived from oxidation of pyrite. Calcite was present in nearly every piece (Effervescence in cold HCI). A few small pieces, up to 2 inches across, consisted entirely of a compact aggregate of fine flakes. Some pieces had thin layers or seams of talc, or talc surrounding a core of dolomitic limestone.

From Pit B (Spence's No. 3), the samples were composed of dolomitic limestone, with talc in flakes averaging ½ to I mm. The talc is concentrated as thin layers on bedding or "squeeze planes and seams". Though all the rock contains some disseminated talc, Spence estimated the average talc content to be less than lO per cent. In one piece he found "considerable" pyrite as minute scattered crystals, and "small nests of green chlorite flakes" in other samples.

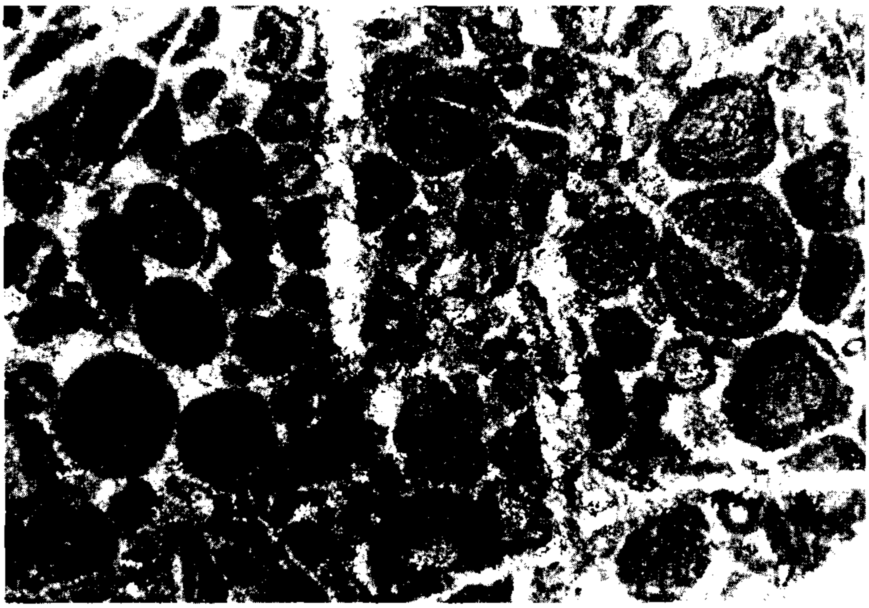


Photo by F. Barbieri

PLATEI: Oolites and possible algal forms in limestone. (See text p. 26.)

PROVINCE OF NOVA SCOTIA
DEPARTMENT OF MINES

To accompany N.S. Department of Mines Memoir No. T.

LEGEND

PALEOZOIC (after BELL a GDRANSON,1931)

PENNSYLVANIAN

12 MORIEN AND CANSO SERIES

MISSISSIPPIAN

11 WINDSOR SERIES

DEVONIAN

MCADAM LAKE FDRMAT/ON

PRE- ORDOVICAN

Late lamprophyre dykes of unknown age ·posf - granite; possibly pre-McAdam Lake Fmn.

9 *Granite; syenite; fine-grained dyke Dnd border phases 01 ba/h. Minor aplite and pegmatite.*

Granodiorite; minor small bodies dlorl!".

Diorite; quartz diorite.

Gabbro. May include some basal!.

PRE- CAMBRIAN (P)

GEORGE RIVER SERIES

5 *Ouortzlte*

4 *Limestone*

3 *Dolomite; Dolomltic /lmutone.*

Impure feldspathic quartzite; minor, latej metamorphic equivalents.

SYMBOLS

Strike and dip of b.dding (inclined, vertical).

Strike and dip of fault (visible, assumed).

Strik. and dip of foliation (1l."lcol, inclined).

Outcrop; Area of abundant "float" boulders.

Qtz, Py, Po *Quartz vein; Pyrite; Pyrrhotite.*

Conloal (approx,,,,t"_, assumed).

Topographic omissions and irregularities of the base mop have no! been corrected.

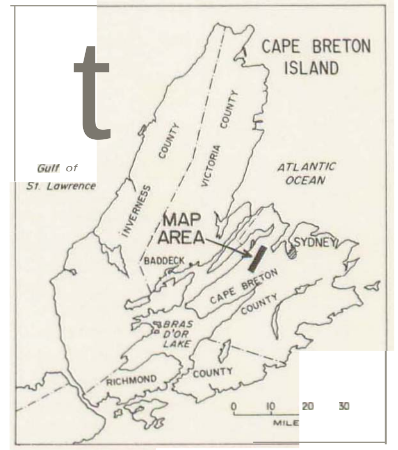
GEOLOGY

BOISDALE HILLS

SCOTCH LAKE TO STEELE'S CROSSING
Cape Breton County., N.S.

Gedogy by: G.C.Milligon & R.C.Porsons, Aug.,1963.

¼ ¾
1000 2000 3000 4000



KEY MAP

PROVINCE OF NOVA SCOTIA
DEPARTMENT OF MINES

LEGEND

MISSISSIPPIAN

Windsor and Horton

Conglomerate and coarse sandstone; minor limestone and gypsum.

DEVONIAN or earlier

Granite

Granodiorite

Diorite, quartz diorite; minor gabbro. Includes minor early and late lamprophyre dykes.

PRECAMBRIAN

George River Group

Quartzite

Limestone

Dolomite

Amphibolite. Probably mainly volcanic rocks, but much is of uncertain origin; includes minor undifferentiated gabbro and diorite. Some tuff.

Feldspathic quartzite. Interbedded slate and quartzite.

Slate; minor interbedded quartzite and feldspathic quartzite.

Geology by G. C. Milligan, with the assistance of Brion White, R. M. Creed and A. K. Chatterjee, 1967.

SYMBOLS

Strike and dip of bedding: vertical, inclined

Strike and dip of cleavage or foliation: vertical, inclined

Strike and dip of fault (observed, approximate, assumed), with plunge of lineation and sense of motion

Contact: observed, approximate, assumed

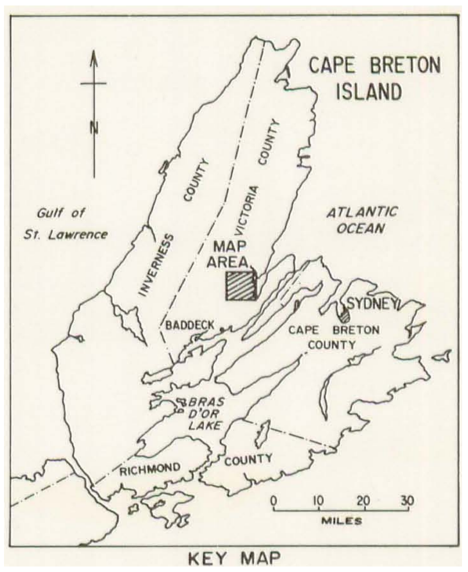
Anticline, syncline

Drag fold, with plunge and sense of motion

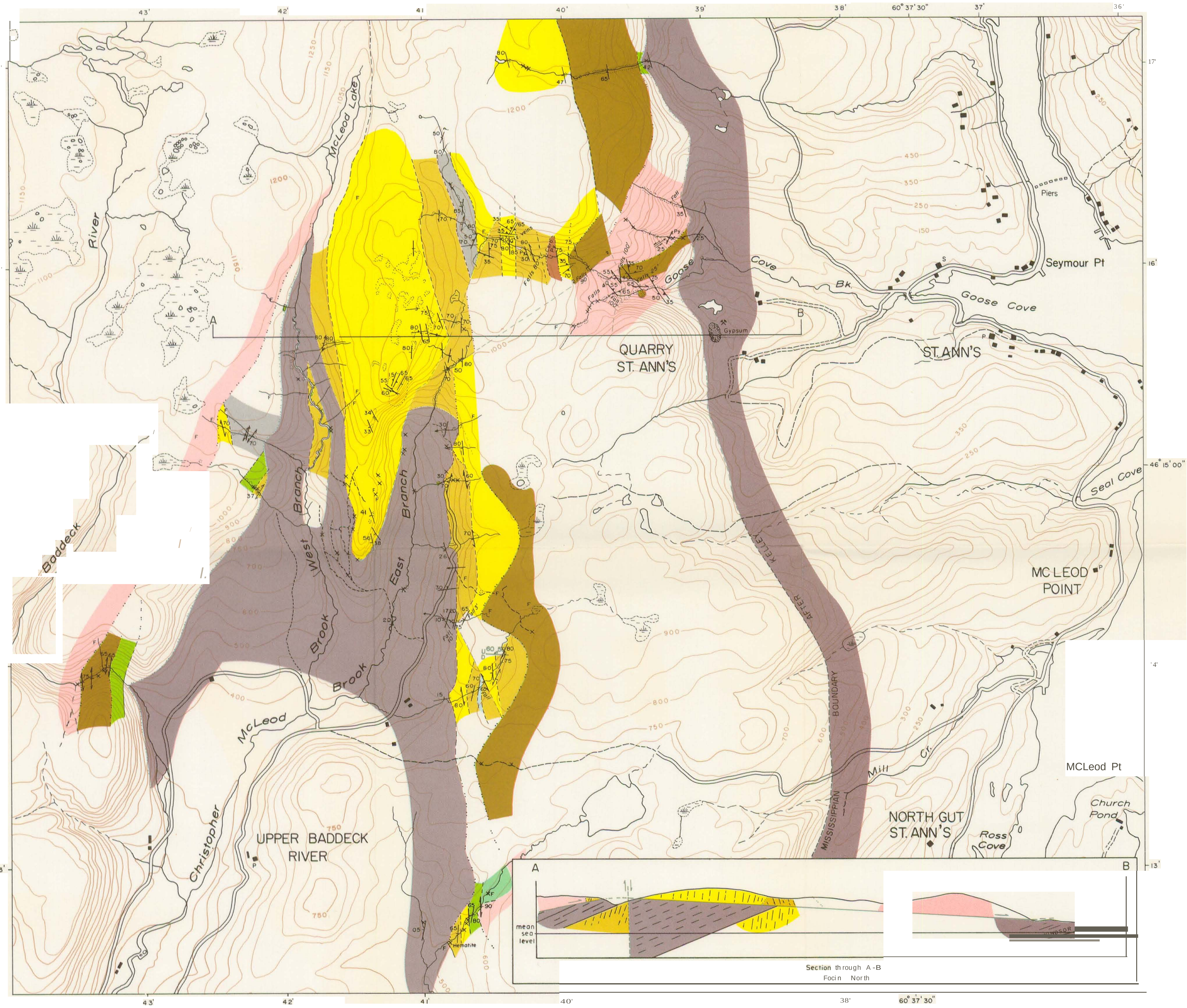
Outcrop: Isolated, adjacent to stream crest of outcrops

Loose fragments and boulders of "float", dominantly of one rock type

Roads: metalled, unmetalled, woods road



KEY MAP



To accompany Nova Scotia Department of Mines Memoir No. 7.

GEOLOGY
AREA OF
CHRISTOPHER MC LEOD BROOK
Victoria County, N.S.

0

Scale in miles

To accompany N.S. Department of Mines Memoir No. 7.

Copies may be obtained from the Nova Scotia Department of Mines, Halifax, Nova Scotia, at $ 1.00 per copy.

PROVINCE OF NOVA SCOTIA
DEPARTMENT OF MINES

11 K 2 / NW

LEGEND

MISSISSIPPIAN

Windsor and Horton

- Conglomerate and coarse sandstone; minor limestone and gypsum.

DEVONIAN or earlier

- Alaskite; minor pegmatite.
- Granite
- Granodiorite
- Syenite and quartz syenite
- Diorite, quartz diorite; minor gabbro. Includes minor early and late lamprophyre dykes.

PRECAMBRIAN

George River Group

- Quartzite
- Limestone
- Dolomite
- Amphibolite. Probably mainly volcanic rocks, but much is of uncertain origin; includes minor undifferentiated gabbro and diorite. Some tuff.
- Feldspathic quartzite. Interbedded slate and quartzite.
  - Derived quartz-feldspar-biotite rocks
  - Derived quartz-feldspar-biotite gneisses, above the garnet isograd.
- Grey slate; minor interbedded quartzite and feldspathic quartzite.
- Brown and grey slate; minor interbedded quartzite and grey slate.
- Conglomerate
- Rhyolite, trachyte; minor tuff.

Geology by G. C. Milligan, with the assistance of Brian White, R. M. Creed and A. K. Chatterjee, 1966 and 1967.

To accompany Nova Scotia Department of Mines Memoir No.7.

SYMBOLS

Strike and dip of bedding: vertical, inclined

Strike and dip of cleavage or foliation: vertical, inclined

Strike and dip of fault (observed, approximate, assumed), with plunge of lineation and sense of motion

Contact: observed, approximate, assumed

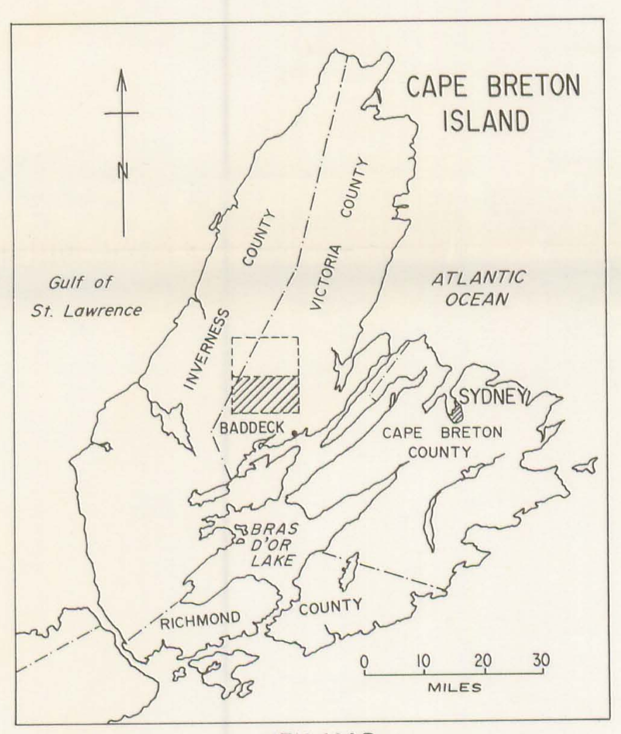
Anticline, syncline

Drag fold, with plunge and sense of motion

Outcrop: isolated; adjacent to stream; area of outcrops

Loose fragments and boulders of "float", dominantly of one rock type

Roads: metalled, unmetalled, woods road



KEY MAP

GEOLOGY

CROWDIS MOUNTAIN AREA

VICTORIA COUNTY, NOVA SCOTIA.

Miles
Kilometres
1000 500 0 1000 2000 3000 Yards

PROVINCE OF NOVA SCOTIA
DEPARTMENT OF MINES

LEGEND

MISSISSIPPIAN

Windsor and Horton

- Conglomerate and coarse sandstone; minor limestone and gypsum.

DEVONIAN or earlier

- Alaskite; minor pegmatite.
- Granite
- Granodiorite
- Syenite and quartz syenite
- Diorite, quartz diorite; minor gabbro. Includes minor early and late lamprophyre dykes.

PRECAMBRIAN

George River Group

- Quartzite
- Limestone
- Dolomite
- Amphibolite. Probably mainly volcanic rocks, but much is of uncertain origin; includes minor undifferentiated gabbro and diorite. Some tuff.
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  - Derived quartz-feldspar-biotite rocks
  - Derived quartz-feldspar-biotite gneisses, above the garnet isograd.
- Grey slate; minor interbedded quartzite and feldspathic quartzite.
- Brown and grey slate; minor interbedded quartzite and grey slate.
- Conglomerate
- Rhyolite, trachyte; minor tuff.

Geology by G. C. Milligan, with the assistance of Brian White, R. M. Creed and A. K. Chatterjee, 1966 and 1967.

To accompany Nova Scotia Department of Mines Memoir No.7.

SYMBOLS

Strike and dip of bedding: vertical, inclined

Strike and dip of cleavage or foliation: vertical, inclined

Strike and dip of fault (observed, approximate, assumed), with plunge of lineation and sense of motion

Contact: observed, approximate, assumed

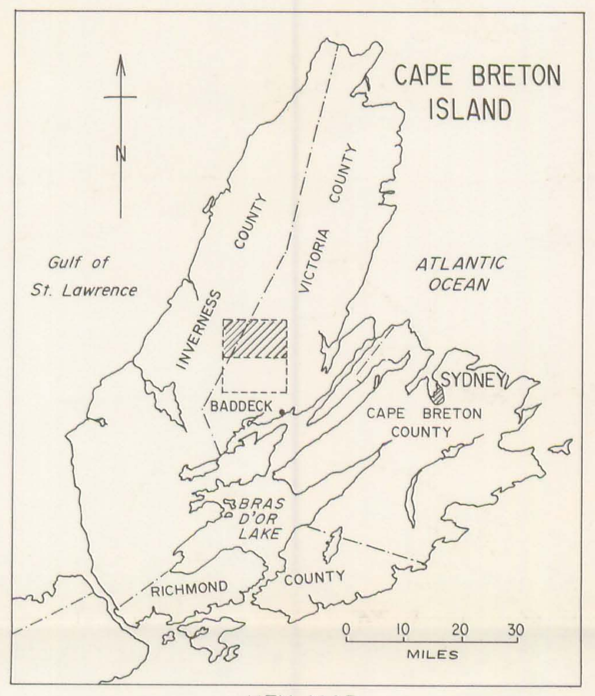
Anticline, syncline

Drag fold, with plunge and sense of motion

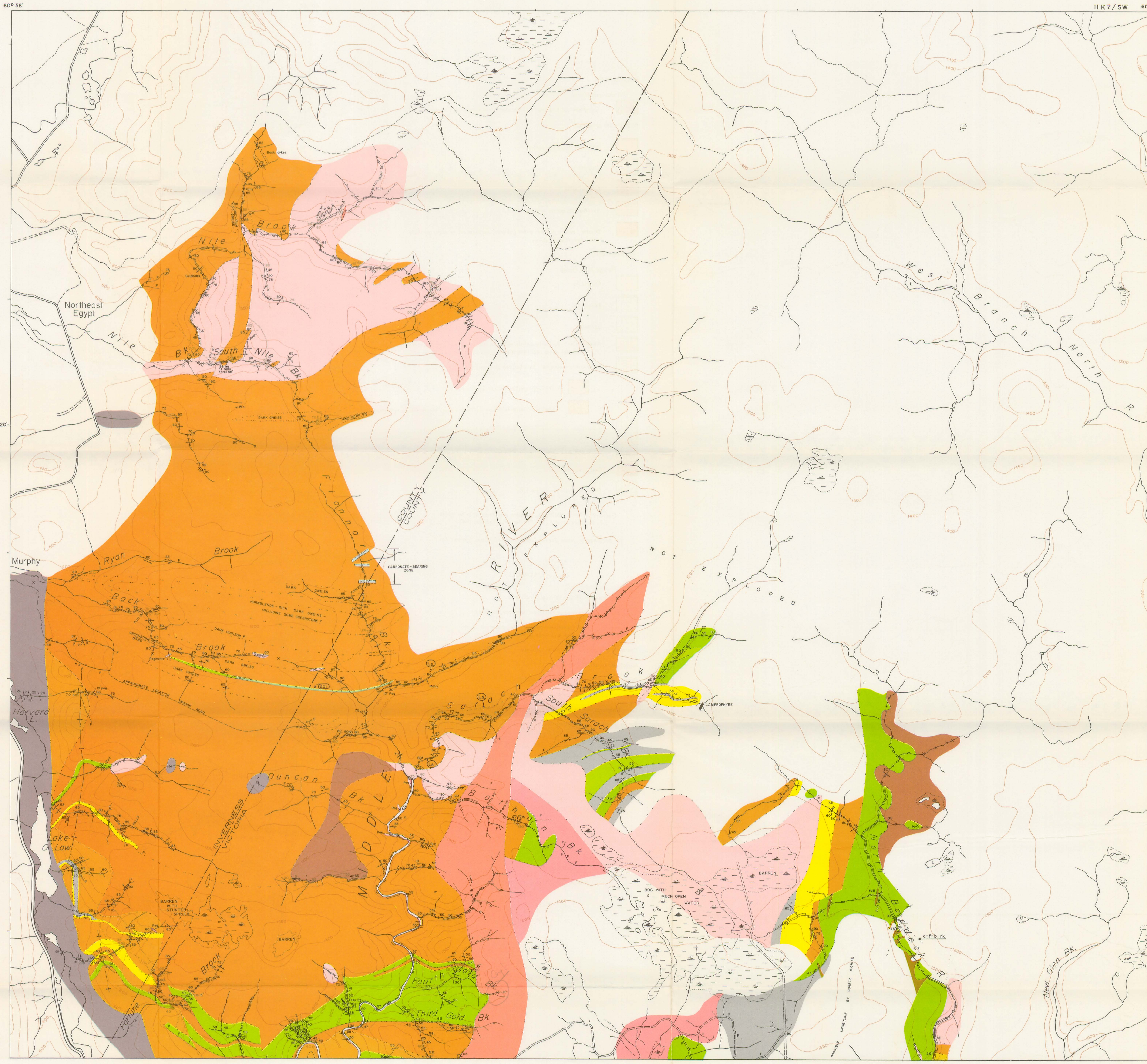
Outcrop: isolated; adjacent to stream; area of outcrops

Loose fragments and boulders of "float", dominantly of one rock type ... F

Roads: metalled, unmetalled, woods road



KEY MAP



GEOLOGY
MIDDLE RIVER AREA
INVERNESS AND VICTORIA COUNTIES, NOVA SCOTIA.

Scales: 1 ½ 0 1 2 Miles; 1 ½ 0 1 2 3 Kilometres; 1000 500 0 1000 2000 3000 Yards

DEPARTMENT OF MINES

PROVINCE OF NOVA SCOTIA

LEGEND

MISSISSIPPIAN

WINDSOR AND HORTON

12

DEVONIAN OR EARLIER

PALAEOZOIC

11 Diorite and quartz diorite, minor granite

10 Gneiss

9 Granite

8 Granodiorite

7 Syenite

GEORGE RIVER GROUP

ARCHAEAN

6 Quartzite

5 White to blue-white limestone

4 Blue to blue-black limestone

3 Dolomite

2 Slate

1 Feldspathic quartzite

(GEORGE RIVER: LITHOLOGICAL UNITS ONLY; NOT IN STRATIGRAPHIC ORDER)

Geological boundary (defined, ...)

Fold axis (anticline, syncline) with plunge 25

Bedding (inclined, vertical, dip unknown)

Schistosity (inclined, vertical, dip unknown)

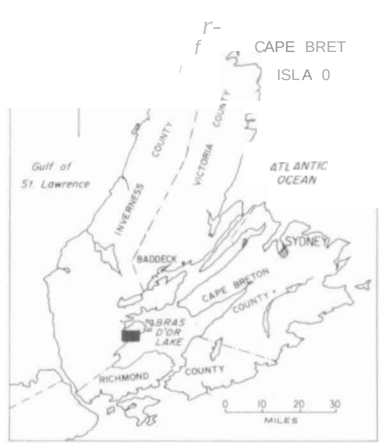
Joints (inclined, vertical)

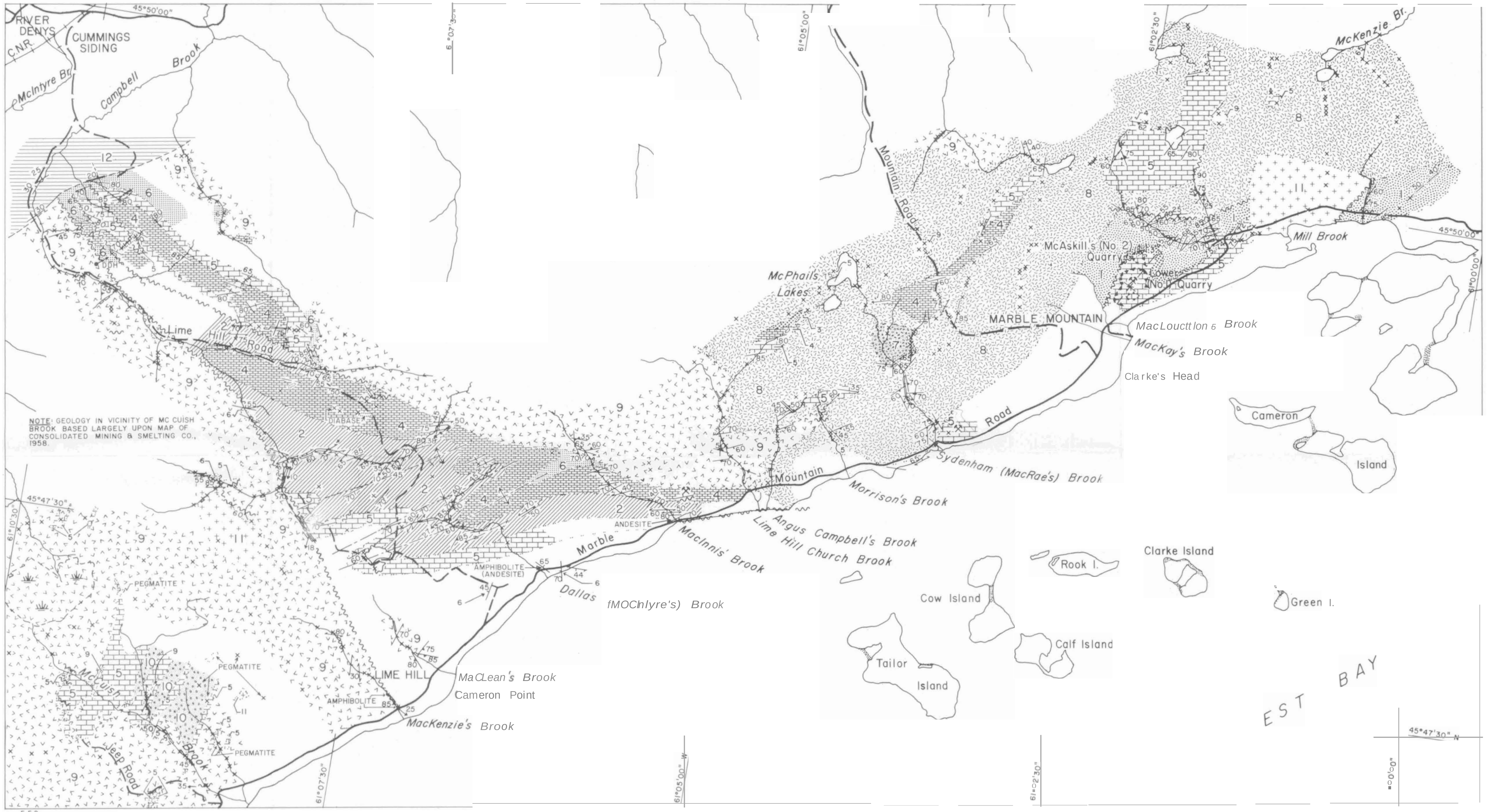
Faults (defined, approximate, assumed, with plunge of line or feature)

Drag fold, showing plunge and motion

Quarry

Outcrop x





GEOLOGY

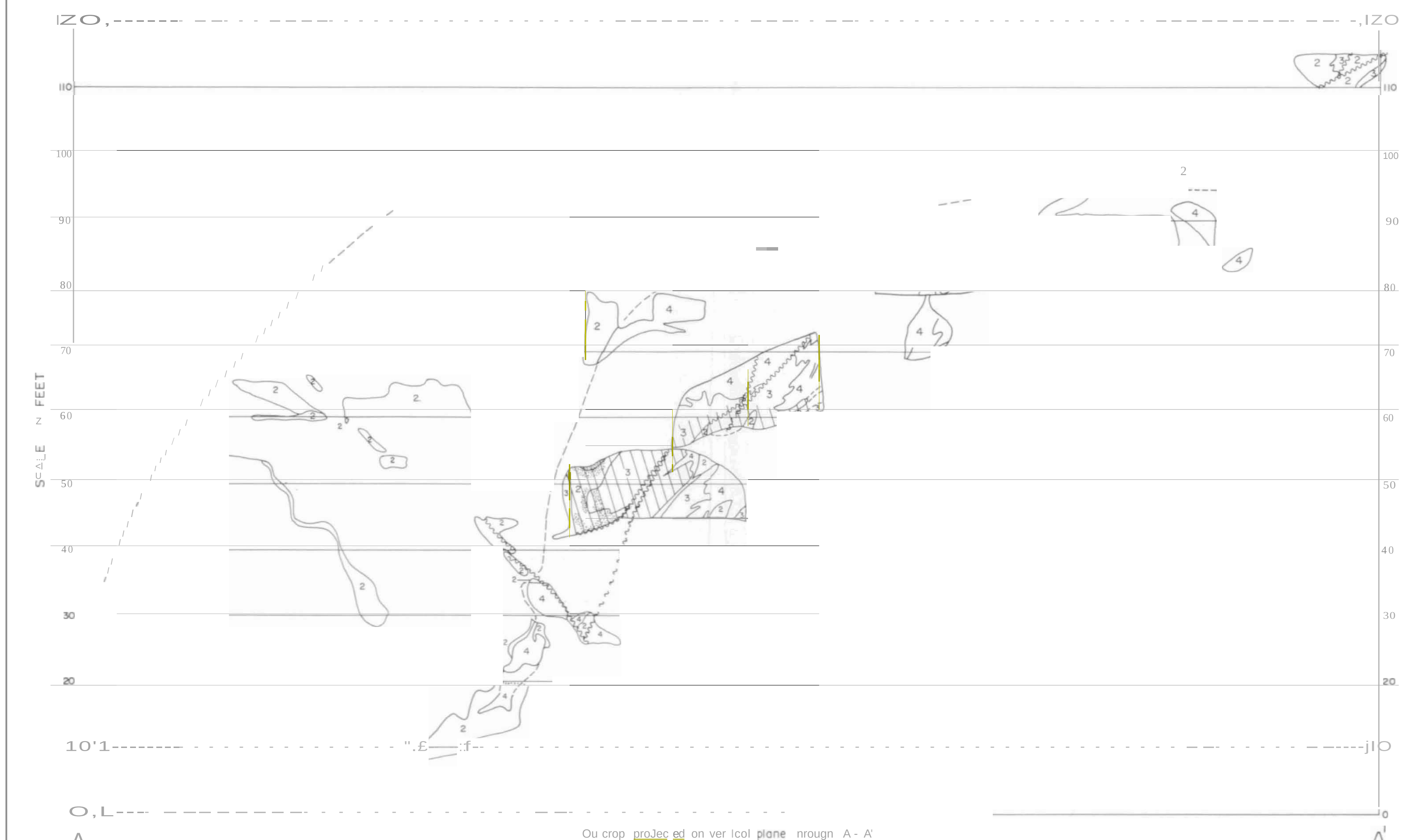
NORTH MOUNTAIN

INVERNESS COUNTY, NOVA SCOTIA

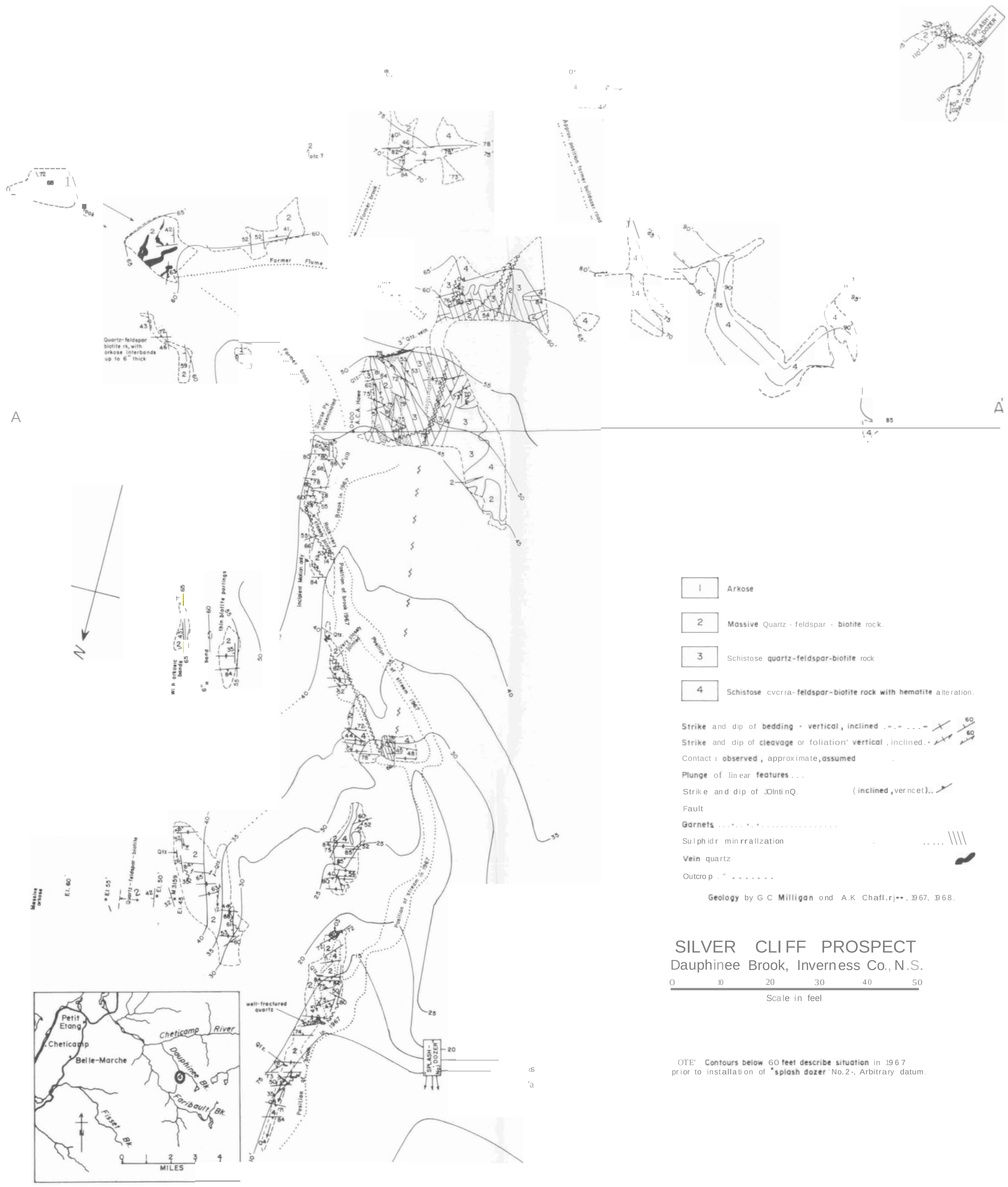
0 — 2

SCALE IN MILES

Geology by G.C. Milligan and R.C. Parsons, 1962.



Outcrop projected on vertical plane through A - A'



1	Arkose
2	Massive Quartz - feldspar - biotite rock.
3	Schistose quartz-feldspar-biotite rock
4	Schistose quartz-feldspar-biotite rock with hematite alteration.

Strike and dip of bedding - vertical, inclined
Strike and dip of cleavage or foliation: vertical, inclined
Contact : observed, approximate, assumed
Plunge of linear features
Strike and dip of jointing (inclined, vertical)
Fault
Garnets
Sulphide mineralization
Vein quartz
Outcrop

Geology by G.C. Milligan and A.K. Chatterjee, 1967, 1968.

SILVER CLIFF PROSPECT

Dauphinee Brook, Inverness Co., N.S.

0 10 20 30 40 50

Scale in feet

NOTE: Contours below 60 feet describe situation in 1967 prior to installation of "splash dozer" No. 2. Arbitrary datum.