GEOLOGY OF THE MIGUELS LAKE MAP AREA (2D/12), NEWFOUNDLAND

by

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INTRODUCTION

Preliminary mapping of the Miguels Lake area (Figure 1) at a scale of 1:50,000 was completed during 1981 (Colman-Sadd and Russell, 1981). Further work still needs to be done on the geology of the Devonian or younger subaerial volcanic rocks around Stony Lake in order to give the map uniform quality.

Access is from the Bay d'Espoir - Harbour Breton Highway which runs along the eastern edge of the area. A system of woods roads extends from the highway in the Grand Falls area (2D/13) almost to the west edge of the Miguels Lake area. Most of the roads shown on the NTS 1:50,000 maps are passable in a four-wheel drive vehicle. The northwest corner of the area can be reached from the woods road system that runs west and south from Grand Falls.

Previous work dates back to 1875 when Howley ascended the Northwest Gander River and made the first description of the Great Bend ultramafic rocks (Murray and Howley, 1881). In the early 1950's, exploration by the Buchans Mining Company (Swanson, 1952-1960) resulted in a report on the eastern part of the area by LeComte (1953), and a report and M.Sc. thesis on the western part by Peters (1953). At the same time, the Geological Survey of Newfoundland sponsored work by Grady (1953) on the southern part of the Gander River ultramafic belt, including the Great Bend complex on the Northwest Gander River. Nalco followed up Grady's work with exploration for chromite, asbestos and magnesite (Harrison, 1953; Coleman, 1954). Mapping by the Geological Survey of Canada at a scale of 1:250,000 was published in 1970 (Anderson and Williams, 1970). The Newfoundland Department of Mines and Energy has since conducted an assessment of the Great Bend ultramafic complex (Kean, 1974) and a regional lake sediment geochemistry survey (Butler and Davenport, 1978). Some of the samples collected by Kean were used in a study of the detailed mineralogy of the ultramafic rocks (Malpas and Strong, 1975). The sedimentology and petrology of the probable Silurian sediments around Great Rattling Brook have been studied by Wessel (1975). Recent industry exploration has been done by Amoco on the Devonian or younger volcanic rocks (Donovan, 1978), Minorex on the ultramafic rocks in the west of the area (Durocher, 1978) and Hudson Bay Oil and Gas on the mafic volcanic rocks of Unit 7 (Dean, 1977a; Lassila, 1979a, b, c, d).

The Miguels Lake area is cut by a major fault zone extending from the northeast tip of the Pipestone Pond ultramafic complex at Atlantic Lake through Miguels Lake in the east. The zone is marked by fault blocks of ophiolitic and Ordovician and Silurian sedimentary rocks. A similar fault zone, associated with the Great Bend ultramafic complex, occurs in the southeast of the area, and the two faults are linked, by way of the Coy Pond and Pipestone Pond Complexes, to form parts of an elliptical ophiolite belt (Figure 2).

Fossiliferous Lower to Middle Ordovician turbidites (2 and 3) occur south of the Atlantic Lake - Miguels Lake fault. Metamorphism in these sediments varies from greenschist to upper amphibolite facies (2 and 3). A

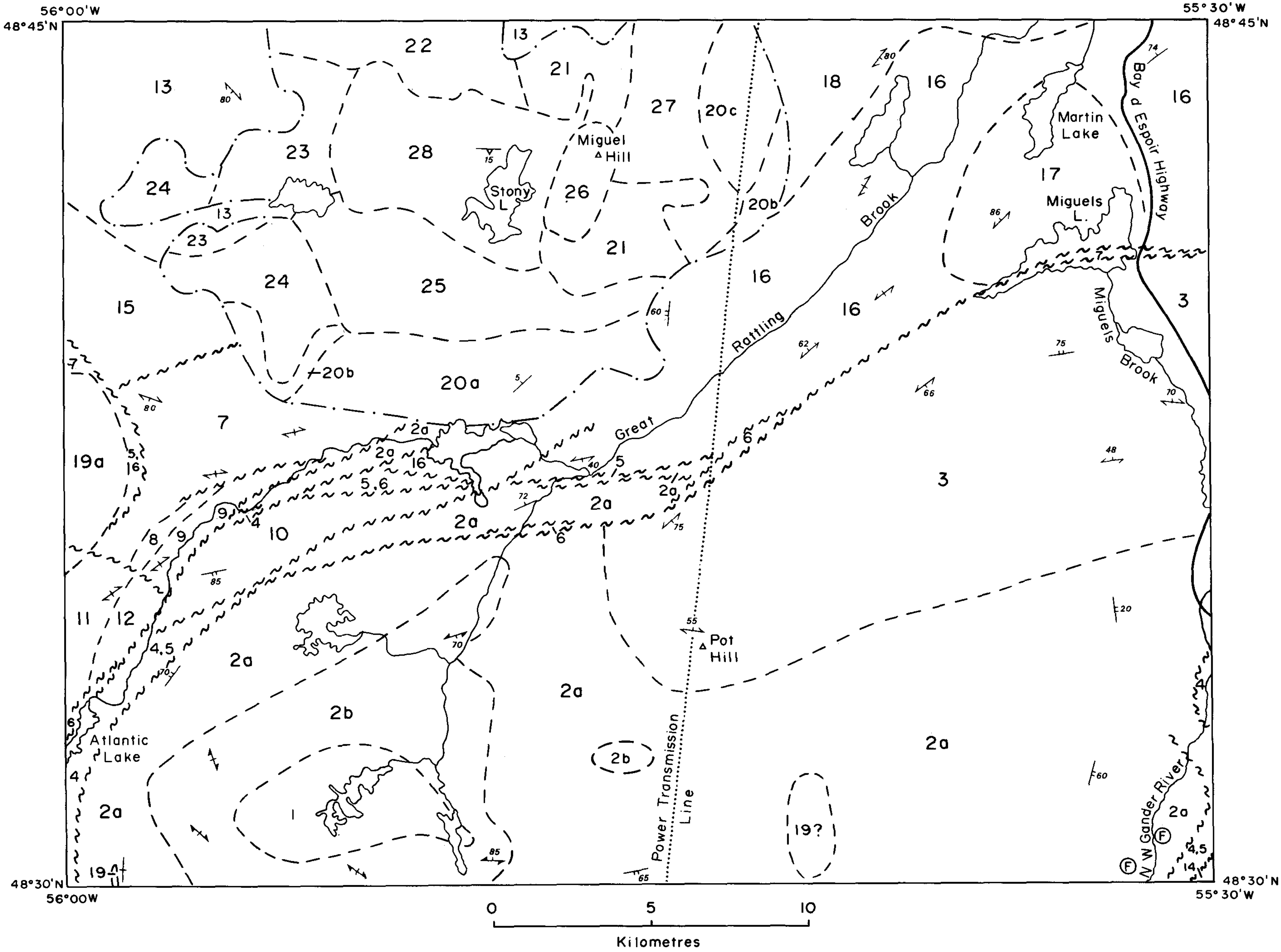

Figure I. Geological sketch map of the Miguels Lake Area

LEGEND

DEVONIAN OR YOUNGER

28	Dark gray to black feldsparphyric rhyodacite: Mainly pyroclastic, locally flow banded.
27	Dark gray to dark green feldsparphyric rhyodacitic lapilli tuff.
26	Gray and purple flow banded or brecciated rhyolite.
25	Purple and pink rhyolite: Mainly pyroclastic, locally flow banded.
24	Light purple, feldsparphyric rhyolite: Mainly pyroclastic, locally flow banded.
23	Gray rhyolite: Mainly lapilli tuff, locally flow banded.
22	Medium grained quartz and feldspar rhyolitic crystal tuff.
21	Mainly buff, but locally green and purple, feldsparphyric, pyritiferous rhyolite: Mainly flow banded, but locally pyroclastic.
20	Siltstone and sandstone: 20a, gray; 20b, red; 20c, gray and red with blocks of flow banded rhyolite and pyroclastic rocks.

DEVONIAN

19	Garnetiferous biotite/muscovite granite; 19a, Overflow Pond Granite.

SILURIAN

18	Botwood Group: Wigwam Formation: Red sandstone and siltstone.

UPPER ORDOVICIAN AND SILURIAN

17	Interbedded gray sandstone and siltstone and red siltstone.
16	Green-gray siltstone with minor sandstone beds.
15	Rogerson Lake Conglomerate: Unexposed, extrapolated from outcrop in Noel Paul's Brook area.

MIDDLE ORDOVICIAN AND OLDER - OUTSIDE AND INCLUDING THE OPHIOLITE BELT

Victoria Lake - Baie d'Espoir Groups

14 North Steady Pond Formation: Unexposed, extrapolated from outcrop in Burnt Hill area.

13 Tally Pond Formation: Interbedded felsic crystal tuff and lapilli tuff.

12 Felsic crystal tuff.

11 Semipelitic schist

10 Salmon River Dam Formation(?): Interbedded purple-gray sandstone, siltstone and minor shale.

Pipestone Pond - Great Bend Complexes, etc.

9 Black shale interbedded with fine grained sandstone.

8 Conglomerate: Composed mainly of mafic volcanic clasts.

7 Mafic pillow lava, breccia and tuff.

6 Gabbro, with minor trondhjemite.

5 Pyroxenite.

4 Peridotite.

MIDDLE ORDOVICIAN AND OLDER - INSIDE THE OPHIOLITE BELT

3 Green-gray siltstone and sandstone.

2 2a, Interbedded gray sandstone, siltstone and shale with minor conglomerate and limestone beds, metamorphosed in the greenschist and amphibolite facies; 2b, migmatite and granitoid gneiss thought to be derived from 2a.

1 Interbanded, migmatized, granitic, amphibolitic, semipelitic and psammitic gneisses

Eutaxitic foliation . . . . ⟋

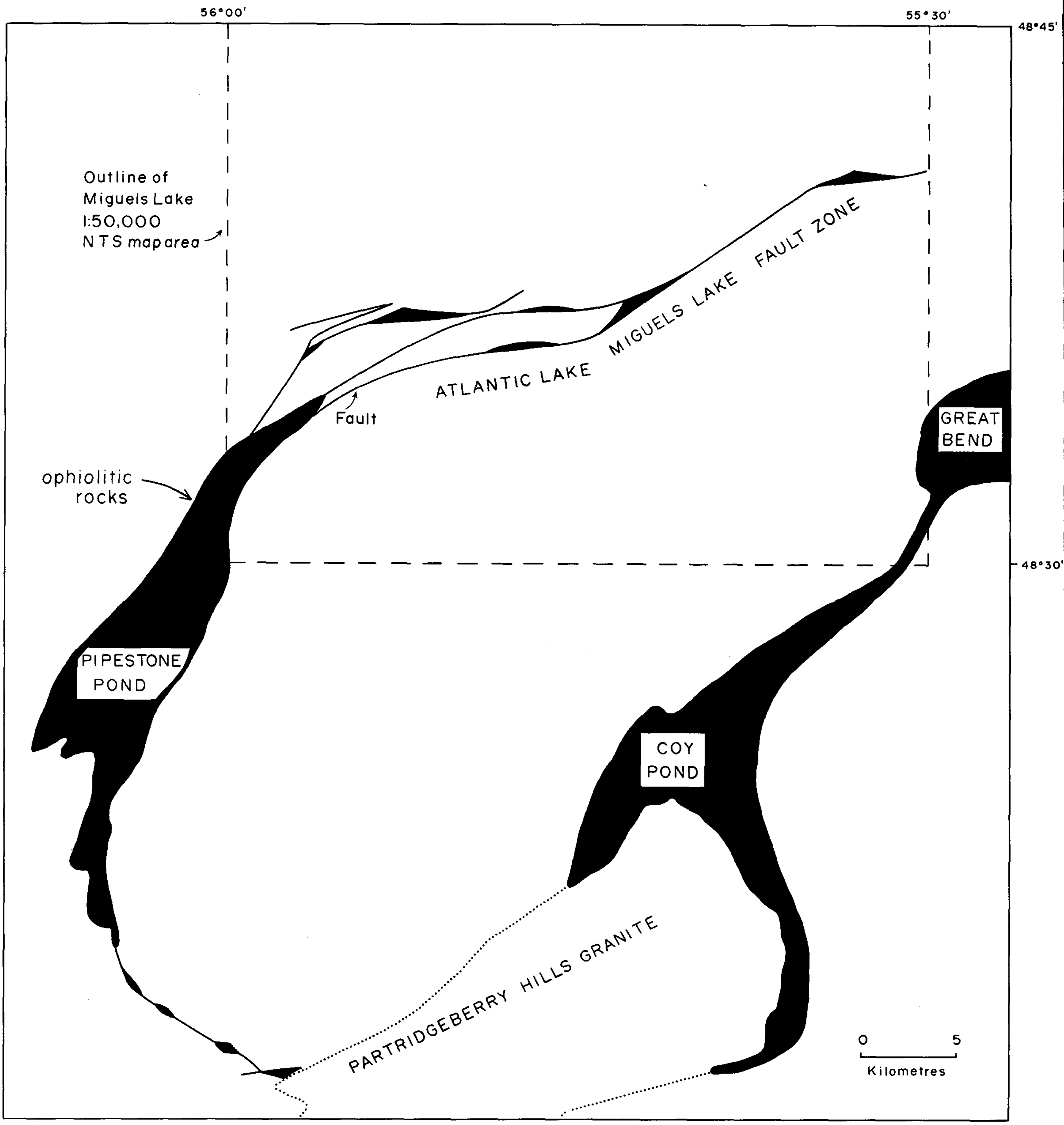

Figure 2: The Great Bend - Coy Pond - Pipestone Pond ophiolite belt. Outcrop pattern modified after Colman-Sadd and Swinden (1981).

migmatitic zone (2b) is cored by gneiss with a large amphibolite component (1). North of the fault zone are three groups of rocks. In the west are mainly Ordovician submarine felsic volcanics (12, 13) and associated sedimentary rocks (11, 15). The northernmost volcanics (13) can be directly correlated with the Tally Pond Formation of central Newfoundland (Kean and Jayasinghe, 1980). In the east are shallow marine clastic sediments (16, 17) and red beds (18); the latter are attributed to the Silurian Wigwam Formation of the Botwood Group (Dean, 1978). The central section is underlain by Devonian or younger subaerial felsic volcanic rocks (21-28) and associated shallow-water sediments (20). These overlie the other units unconformably.

Granitoid intrusions (19) include part of the Overflow Pond Granite (Kean and Jayasinghe, 1980) and a number of small bodies associated with the high grade metamorphic rocks in the south of the area. The age of the intrusions is probably Devonian.

MIDDLE ORDOVICIAN AND OLDER - INSIDE THE OPHIOLITE BELT (UNITS 1-3)

Amphibolite-bearing gneisses (Unit 1)

The gneisses of Unit 1 occur in the centre of the high grade metamorphic terrain in the southwest of the area. They differ from enclosing gneisses of Unit 2b in that they contain substantial amounts of amphibolite which is otherwise absent from rocks surrounded by the ophiolite belt.

The gneisses have a compositional banding on a scale of 5 cm to 1 m. The bands are composed of four principal rock types, which are in order of abundance: granite, amphibolite, sillimanite schist and biotite psammite. The granite is mostly fine grained and contains segregated foliae of biotite, some of which define complex folds within the bands; there are also segregations and bands of unfoliated pegmatite. The amphibolite has an internal banding reflecting variations in the amphibole to biotite and feldspar ratio; extreme compositions consist almost entirely of amphibole and have grain sizes of over 1 cm. The sillimanite schist is medium to coarse grained and has prominent white 'buttons' of fibrolite; it contains and is cut by segregations and veins of granite pegmatite. The psammite is fine to medium grained and contains varying amounts of biotite. All the rock types are involved in mesoscopic isoclinal folding which also folds the main foliations; some of the amphibolite, however, occurs as irregular blocks surrounded by granite gneiss and abruptly terminates the foliation in the gneiss.

Clastic sedimentary rocks and metamorphic derivatives (Units 2 and 3)

Unit 2 varies in degree of metamorphism from greenschist facies to migmatite as has previously been reported from the Burnt Hill map area (2D/5) to the south (Colman-Sadd, 1981). The character of the original sediments is best observed in the low grade terrain along the Northwest Gander River, where quartz-rich fine grained gray sandstone is interbedded with well laminated gray siltstone and dark gray to black shale. The sandstone beds are 10 cm to 2 m thick. Graded bedding, channelling, load casts, and ripple-drift lamination are common sedimentary structures, suggesting deposition by turbidity currents. Two occurrences of limestone conglomerate have been located close to the river and are thought to form a single horizon. They contain subangular, poorly sorted fragments that mainly consist of sandy limestone. The rock is supported by a matrix of slightly calcareous gray siltstone. It contains disseminations of pyrite and is cut by calcite-pyrite veins. Brachiopods that occur in both the clasts and the matrix indicate an age in the range Late Arenigian to early Caradocian and are most likely to be Llanvirnian (R.

Neuman, written communication, 1982).

An outcrop of conglomerate in the centre of the Miguels Lake area just west of the transmission line is tentatively included in Unit 2a. The clasts consist mainly of fine grained sandstone, are subangular, poorly sorted and up to 10 cm across. The rock is clast supported. The conglomerate is bounded to the south by a tectonically disturbed zone of sandstone, siltstone and shale similar to rock types that form the greater part of Unit 2a.

Metamorphic rocks included in Unit 2a in the southwest of the area are separated from the sedimentary rocks in the southeast by an area of no exposure. The correlation is made with reference to the Burnt Hill area to the south (Colman-Sadd, 1980b). The best exposure is seen in the west between the Pipestone Pond Complex (4) and the gneisses of Unit 1. A progression can be observed from biotite grade rocks close to the ophiolite, through an area where andalusite porphyroblasts are prominent, into rocks with white 'buttons' of fibrolitic sillimanite, and then into migmatite and granitoid gneiss (2b). Sillimanite-bearing metasediments reappear to the east of the migmatite. The characteristic sandstone beds interbedded with semipelite are present throughout Unit 2a. In the migmatitic terrain, fragments of bedded sediment are still recognizable, but in the granitoid gneiss no sedimentary structures are preserved.

Unit 2a has been subjected to one main period of deformation causing tight folds and a penetrative cleavage that in many places is subparallel to bedding. Exposures close to the Great Bend ultramafic complex in the southeast of the area show refolding during a second deformation and the local development of a strain-slip cleavage. The migmatitic rocks (2b) show complex fold patterns attributed to their high ductility during metamorphism.

Unit 3 consists of monotonous interbedded green-gray, very fine grained sandstone, siltstone and laminated siltstone and shale. In most places, the bedding is obscure because contacts are not sharply defined, but where it can be identified, the sandstone and siltstone beds are up to 1 m thick and the laminated siltstone and shale beds up to 10 cm. The sandstone and siltstone are well cleaved with a characteristic spacing of 2 to 5 mm between cleavage surfaces. In the exposures south of Miguels Lake, biotite of probable metamorphic origin is present. Farther west on the transmission line north of Pot Hill, where the metamorphic grade is much higher, the spaced cleavage surfaces are coated with mica, the siltstone and shale beds have become medium grained schists and a few originally calcareous beds contain garnet and actinolite. Quartz sweats and a few granitic segregations are present. The rocks on top of Pot Hill have also undergone further deformation and the spaced cleavage is folded into tight folds with a second axial planar crenulation cleavage.

MIDDLE ORDOVICIAN AND OLDER - OUTSIDE AND INCLUDING THE OPHIOLITE BELT (UNITS 4-14)

Ophiolitic rocks (Units 4-9)

Rocks representing all levels of the ophiolite suite outcrop in the western part of the area at the northeast end of the Pipestone Pond Complex. Likewise, most levels of the suite may occur in the Great Bend complex in the southeast, but only ultramafic rocks are exposed within the Miguels Lake area. Faulted slices of ophiolitic rocks in the Atlantic Lake - Miguels Lake fault zone variously include peridotite, pyroxenite, gabbro and pillow lava.

Peridotite of Unit 4 is a massive, brown weathering, black rock. The only observed internal structure is a local banding of chromite grains which are otherwise disseminated throughout the rock. Pyroxene crystals up to 5 mm across form a small percentage of the Great Bend peridotite, but at the Atlantic Lake outcrop they were only seen in loose boulders. All exposures show some degree of deformation. Where least deformed, the rock is cut by random fractures filled with talc, serpentine and asbestos. At the other extreme, the peridotite has been reduced to a well cleaved talc-serpentine schist. This intense deformation occurs locally in the main outcrop at Atlantic Lake and in the exposure just to the north near Great Rattling Brook; it seems to be associated with fault zones trending east-northeast, oblique to the main trend of the Pipestone Pond complex but parallel to the Atlantic Lake - Miguels Lake fault. In both the Pipestone Pond and Great Bend complexes, some exposures have been largely altered to magnesite, but can be recognized as having been originally peridotite by the characteristic disseminated chromite grains. In most cases, the magnesite-rich rock has the appearance of a tectonic breccia with large massive blocks enveloped in a foliated matrix.

Pyroxenite (5) has been found in four small outcrops, all of which are bounded by faults or granite. In the outcrop northeast of Atlantic Lake, the pyroxenite is medium grained and massive, it is cut by randomly-oriented fractures filled with magnesite and although the pyroxenite itself is only mildly sheared close to its contacts, the surrounding peridotite has been reduced to a talc-serpentine schist. The pyroxenite near the Overflow Pond Granite is also medium grained and massive; its contacts are unexposed. Farther east pyroxenite occurs with gabbro in a fault block; it is medium grained with thin layers of coarse crystals and in the northern part of the block it is interlayered with the gabbro. At the confluence of the two branches of Great Rattling Brook, a fault zone is defined by a narrow outcrop of sheared serpentinized pyroxenite, parts of which have been altered to magnesite.

Gabbro (6) occurs in close association with pyroxenite around the margin of the Overflow Pond Granite and in the fault block 5 km to the east. In each case, it is medium grained and indistinctly layered. The exposure near the granite is cut by diabase dikes and the gabbro is internally brecciated. Northwest of Atlantic Lake, massive gabbro grades into a slightly foliated, quartz-rich, plutonic rock that may be the edge of a trondhjemite body. The gabbro exposed in Great Rattling Brook in the central part of the area is fractured, but not foliated and is associated with a fine grained siliceous rock of uncertain origin. A single exposure of gabbro has been found in the outcrop on the transmission line; it has a slight penetrative lineation.

Unit 7 consists mainly of mafic pillow lava, breccia and fine grained mafic schist with pillow fragments. It also includes sheets of massive basalt or diabase that may be sills. Black shale and basalt-derived grit are locally interbedded with the lava. Pillows are up to 1 m across; they are generally variolitic and some of them are vesicular. Interpillow material, where present, consists of fine grained mafic schist or carbonate. Pyrite is disseminated in all the rock types of the unit and also occurs as segregations. The outcrop of Unit 7 at Miguels Lake contains mildly deformed pillow lava, as is found farther west, and also sheared lava and strongly mylonitized mafic schist. The latter has a banding with intrafolial folds, and has been brecciated along fracture zones that are parallel to the southern margin of the lake.

The mafic volcanic rocks (7) in the western part of the area are conformably overlain by, and to a small extent interbedded with, conglomerate and black shale and sandstone (8, 9). These sedimentary rocks are considered to form Layer 1 of the ophiolite sequence. They are similar to sediments that directly overlie the pillow lavas of the Coy Pond Complex in the Burnt Hill area (2D/5) to the south (Colman-Sadd, 1980b). The conglomerate (8) consists almost entirely of mafic volcanic clasts; a few clasts of carbonate, epidote and vein quartz also occur, and in one place pyrite forms a large part of the matrix. Sharp bed contacts are defined by changes in clast size, and bed thickness is not less than 30 cm. The rock is clast supported and the pebbles are slightly rounded and moderately sorted. Clasts are up to 10 cm across in the coarser beds; in the finer beds they are generally less than 5 cm and may be imbricated and graded. A fair cleavage is developed in the finer grained beds.

The conglomerate is in sharp, conformable contact to the southeast with black shale and sandstone of Unit 9. It is presumed that the shale and sandstone stratigraphically overlie the conglomerate, but this is not certain because isoclinal folding has made facing directions of the sediments variable. The shale is pyritiferous and well cleaved. It is interbedded with the sandstone on a scale of 5 mm to 12 cm, with most sandstone beds being about 3 cm thick. The sandstone is very fine grained and generally is massive and ungraded. Most bed contacts are sharp but the tops of the thickest beds grade into parallel laminated shale and sandstone. Sandstone beds commonly truncate shale beds and they themselves vary in thickness and terminate abruptly.

Victoria Lake - Baie d'Espoir Groups (Units 10-14)

Units 11, 12 and 14 are along strike and continuous with rocks included in the Baie d'Espoir Group (Colman-Sadd, 1980a, b; Kean and Jayasinghe, 1980; H.S. Swinden, personal communication, 1981). Unit 13 extends west and southwest into the Victoria Lake Group (Kean and Jayasinghe, 1980). Both groups are Middle Ordovician or older and are considered to be equivalent stratigraphic units belonging to the 'early arc' sequence of Dean (1977b) (Figure 3).

Unit 10 forms a fault block in the Atlantic Lake - Miguels Lake fault zone and is not directly correlatable with other rocks in the area. It is tentatively attributed to the Salmon River Dam Formation of the Baie d'Espoir Group (Colman-Sadd, 1976) on lithologic grounds. The unit consists of purplish gray, quartz-rich, fine grained sandstone interbedded with well laminated, purplish gray to black siltstone and shale. Thickness of the sandstone beds is generally about 30 cm and that of the siltstone and shale beds varies from 2 cm up to several metres. The more micaceous beds are well cleaved and metamorphism is at about biotite grade.

The semipelitic schist of Unit 11 is part of a much larger outcrop mapped by Kean and Jayasinghe (1980) in the Noel Paul's Brook map area. It consists of thinly bedded and laminated gray shale and siltstone that have been metamorphosed to phyllite. Metamorphism has caused the widespread growth of porphyroblasts, probably of andalusite. These have overgrown the first penetrative cleavage which is generally parallel to bedding, and form augen within the prominent second crenulation cleavage.

Unit 12 was observed at only two exposures. It consists of massive, felsic crystal tuff, which weathers rusty white. Most of the crystals are quartz, up to 3 mm across, and the matrix is fine grained and slightly pyritiferous. The rock resembles pyroclastic rocks observed elsewhere in the Baie d'Espoir Group (Colman-Sadd, 1976).

The Tally Pond Formation (13) consists of felsic pyroclastic rocks. In most exposures, these are fine grained, light gray and feldsparphyric, and contain a few lithic fragments of less than 3 cm in diameter; a poor, steeply

INSIDE THE OPHIOLITE BELT		AGE	OUTSIDE AND INCLUDING THE OPHIOLITE BELT			
Description	Unit		Unit	Description	Classification of Dean (1977b) etc.	Potential Mineral Deposits
		Devonian or younger	20-28	Unnamed subaerial volcanic rocks		Epithermal veins; precious metals, U, Sn, W, etc.
					Major un-unconformity	
Granite intrusion, metamorphism, deformation (?)	19	Devonian	19	Granite intrusion metamorphism, deformation	Acadian Orogeny	Vein and disseminated deposits, U, Sn, W, etc.
		Silurian Upper Ordovician	15-18	Wigwam Fm., etc. Rogerson Lake Conglomerate (?)	Post-Caradocian flysch	
Unnamed quartz-rich turbidites and metamorphosed equivalents	2, 3	Middle Ordovician	10-14	Victoria Lake Baie d'Espoir Groups	Pre-Caradocian island arc (early arc)	Kuroko-type massive sulphides Cu, Pb, Zn, Ag, Au
Unnamed amphibolite-bearing gneisses (?)	1	Lower Ordovician Cambrian	4-9	Pipestone Pond Great Bend Complexes	Oceanic crust	Cyprus-type massive sulphides Cu. Asbestos, magnesite, chromite in ultramafic rocks

Figure 3: Stratigraphic classification of units in the Miguels Lake area, with potential exploration targets.

dipping, anastomosing cleavage is generally present. Thick beds of lapilli tuff or tuff breccia occur locally and these generally have a well developed cleavage; they consist of fragments up to 6 cm across, that are dominated by aphanitic rhyolite but also include some mafic volcanic rocks. In some localities, it has been found difficult to distinguish the fine grained, poorly cleaved rocks of the Tally Pond Formation from fine grained undeformed Devonian or younger volcanic rocks (21 to 28) that unconformably overlie them.

The North Steady Pond Formation (14) is not exposed in the Miguels Lake area. Its outcrop is projected from the Burnt Hill area (2D/5) (Colman-Sadd, 1980b).

UPPER ORDOVICIAN AND SILURIAN (UNITS 15, 18)

The Rogerson Lake conglomerate (15) is projected into the map area from the Noel Paul's Brook area (12A/9) where Kean and Jayasinghe (1980) tentatively assigned it to the Silurian. Only one exposure has been found in the Miguels Lake area and that consists of massive, light gray siltstone. It is presumed to represent the finer grained sediments that are interbedded with the conglomerate farther west.

Units 16 and 17 appear to be conformable with the Wigwam Formation of the Botwood Group (18), which elsewhere contains Silurian fossils (Anderson and Williams, 1970; Dean, 1978). They are therefore assigned to the Upper Ordovician or Silurian. Most of Unit 16 consists of green-gray siltstone with interbeds of fine grained, brown-weathering, gray sandstone. The sandstone beds vary in thickness from 1 cm to 2 m and have ripple drift laminations and load casts. The siltstone is well cleaved and the thinner sandstone beds have been broken up and injected along the cleavage surfaces. At the most westerly exposures on the north branch of Great Rattling Brook, Unit 16 shows a gradation from mainly siltstone to mainly sandstone. Sandstone beds, which are between 10 cm and 1 m thick, have thin interbeds of siltstone. The siltstone is laminated and bioturbated and the sandstone has ripples and trough crossbedding.

Unit 16 grades into rocks of Unit 17 that are similar except that they include interbeds of light red siltstone 3 cm to 1 m thick. As in Unit 16, there are local concentrations of sandstone. Common sedimentary structures are ripples, load casts, and lenticular, flaser and graded bedding.

Rocks of the Wigwam Formation (18) consist of medium to thick bedded red siltstone and gray to grayish red sandstone. Asymmetric, bifurcating ripples occur throughout the unit, and lenticular and flaser bedding are common. Some of the sandstone beds contain mudclasts apparently derived from finer grained beds with mudcracks, and siltstone beds are extensively burrowed. A penetrative cleavage is present in the siltstone beds, but does not affect the sandstone beds.

DEVONIAN

The Overflow Pond Granite (19a) (Kean and Jayasinghe, 1980) is represented by a small area of exceptionally good exposure north of Atlantic Lake. The granite is medium to coarse grained and equigranular. Biotite is the only primary mica observed in the field and red garnet occurs as a common accessory mineral. There is no tectonic fabric and no pegmatite or aplite veins have been found.

Pegmatitic garnet-muscovite granite (19) occurs at two locations in the outcrop of Unit 2a near the southern edge of the map area. Only the more westerly of these occurrences has actually been observed *in situ;* the other is inferred from frost heaved boulders. These granite intrusions are small and resemble the Through Hill

Granite in the Burnt Hill area (Colman-Sadd, 1981), both lithologically and in their location close to the sillimanite isograd.

DEVONIAN OR YOUNGER

The youngest rocks in the Miguels Lake area consist of subaerial volcanics with shallow water sediments occurring around the southern and eastern edges of the outcrop. Eight different units of volcanic rocks have been separated in the field and most of these can be further subdivided into flows, breccias and tuffs. No subvolcanic intrusions have been observed.

There has been little deformation of these rocks. Dips are gentle and the most obvious fold structures are monoclinal flexures that occur in some of the sediments of Unit 20. Cleavage only occurs locally and is thought to be associated with fracture zones. The rocks are presumed to overlie the Ordovician and Silurian with angular unconformity, but the contact has not been observed. In the outcrop of Unit 27, however, a block of cleaved green-gray siltstone that probably belongs to the Botwood Group is surrounded and crosscut by undeformed volcanic breccia and lapilli tuff.

The most widespread sedimentary unit consists of gray sandstone and siltstone (20a). There are smaller outcrops of red siltstone (20b) and gray siltstone containing volcanic blocks (20c). The sandstone beds are all fine grained and in some cases are rich in mica. Bioturbation and asymmetric bifurcating ripples are common throughout Unit 20, but lenticular bedding and scours are restricted to the gray beds, whereas mud cracks and rib and furrow structures occur only in the red siltstones. The westerly outcrop of red siltstone is locally interbedded with tuff of Unit 24.

Brief lithologic descriptions of the volcanic rock types are given in the map legend (Figure 1). The following discussion emphasizes the mode of occurrence and probable age relationships of the rocks (Figure 4). Unit 21 consists mainly of buff flow banded rhyolite. Breccia, probably formed by autobrecciation during flow, is found in several localities in the central parts of the outcrop. Pyroclastic breccia occurs on the northeast and southwest edges of the more southerly outcrop and contains matrix supported fragments 2 to 10 cm across with alteration rims. The outcrop pattern and apparent overlapping relationships suggest that Unit 21 is older than Units 26, 27, and 28. Its relationship to Units 22 and 25 is unknown.

Rhyolitic crystal tuff of Unit 22 is medium grained and equigranular, and there is no variation across the outcrop. Slabbed samples from the same unit in the Grand Falls area (2D/13) show flattened pumice fragments on the cut surfaces (B.F. Kean, personal communication, 1981), but these are not visible on broken surfaces. The age relationships of Unit 22 to surrounding units is unclear.

Gray, flow banded rhyolite, lacking any kind of phenocrysts, occurs in the northwest corner of the outcrop of Unit 23. To the south, the outcrop consists of tuff and lapilli tuff, containing feldspar and quartz crystals in a fine grained gray matrix. The lapilli consist mainly of pink weathering rhyolite, but also include black feldsparphyric rhyodacite. Generally, the deposit is massive, but at one locality beds 2 to 10 cm thick are defined by changes in grain size. The relationship of Unit 23 to other units is uncertain.

Flow banded purple rhyolite of Unit 24 forms a hill at the southern edge of the outcrop, and this may mark the position of the original vent for the unit. Along the north edge of the hill is a breccia with fragments up to 50 cm across. This passes northwards into massive lapilli tuff, and then farther

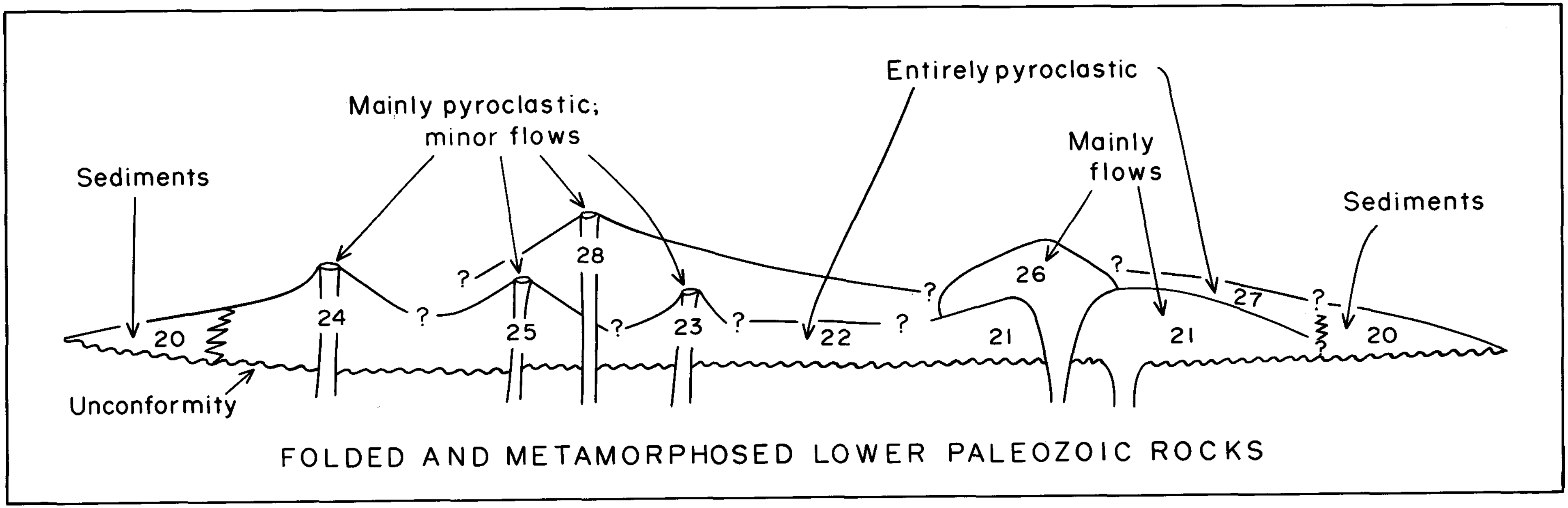

Figure 4: *Schematic representation of relationships in the Devonian and younger volcanic and sedimentary rocks (Units 20 to 28).*

north and isolated from the main outcrop is finer grained purple and pink tuff that may or may not be part of the same unit. Time relationships of Unit 24 are uncertain.

Unit 25 is formed of purple rhyolite that is lighter coloured and pinker than Unit 24. It appears to be centred at an outcrop of pink and purple flow banded and autobrecciated rhyolite southwest of Stony Lake. To the northwest of this outcrop, the same type of rhyolite occurs in massive lapilli tuff, whereas to the east it forms isolated blocks with alteration rims in a massive gray fine grained matrix.

The prominent topographic feature of Miguels Hill is formed of a roughly circular outcrop of flow banded aphanitic gray and purple rhyolite (26). Complicated flow folding is clearly visible in the excellent exposure. To the south the same rock type is found in a volcanic breccia, thought to be the result of autobrecciation, that forms a prominent south trending ridge. The elevated topography and overlapping outcrop of Unit 26 strongly suggest that it is younger than Unit 21. Its relationships to Units 28 and 27 are less clear, since it may have been extruded through them or it may have formed a pre-existing topographic high that deflected their respective pyroclastic flows.

Unit 27 consists entirely of lapilli tuff and tuff with minor breccia. It varies in colour from dark green, through black, to dark gray, but is everywhere characterized by white rectangular feldspar crystals and in most exposures contains abundant fragments of pink weathering rhyolite. The pink rhyolite fragments are generally equidimensional, but a few form gently undulating slabs with finely divided, 'frayed' edges. One fragment of pink rhyolite was found that, itself, contains a fragment of the same black feldsparphyric rhyodacite occurring in the matrix.

Dark gray to black rhyodacite(?) of Unit 28 forms a large flat lying sheet that appears to overlap onto neighbouring units, although the relationship with the rhyolite of Miguels Hill (26) is ambiguous. About 2 km west of Stony Lake the rhyodacite occurs as strongly flattened welded tuff and as probable flows with interbanded pumiceous and nonvesicular layers up to 50 cm thick. The eutaxitic foliation and flow banding in these rocks has steep dips and is tightly folded; the outcrop is roughly circular with a diameter of about 900 m. Surrounding this central zone is a circular outcrop of breccia and lapilli tuff between 500 m and 2 km in width. These rocks are massive without any measurable foliation. They consist of fragments up to 30 cm across, of flow banded and pyroclastic rhyodacite, pink feldsparphyric rhyolite, and a variety of other minor constituents; the fragments are angular and unsorted. The greater part of Unit 28 is formed of lapilli tuff which surrounds the central zone of breccia and intensely flattened or flow banded rhyodacite. The lapilli tuff is formed of angular fragments that are generally about 1 cm across but also include a few blocks up to 10 cm across. There are fewer accidental fragments than in the breccia, but flattened pumice is common and in many places allows measurement of a shallowly dipping eutaxitic foliation. In the promontory of Unit 28's outcrop north of Miguels Hill, the flattening of the pumice is extreme and the rock has been remobilized to form flow folds of the eutaxitic foliation. Rare occurrences of bedded and sorted tuff within the rhyodacite sheet suggest that it is formed of more than one cooling unit, but the scarcity of exposure and lack of topographic relief have prevented any detailed subdivision.

OTHER UNITS

Below are listed units that are too restricted to be shown on the sketch map, but which are separated on the 1:50,000 map by Colman-Sadd and Russell (1981).

1. Diabase dikes have intruded the sedimentary rocks of Unit 16. Their age is unknown.

2. Volcanic breccia, consisting of angular fragments of gray aphanitic rhyolite between 10 and 50 cm across, are exposed in a 30 m cliff face at the unconformable contact between Units 13 and 22. The breccia is thought to belong to the Devonian or younger volcanic sequence, but its relationship to individual units in this sequence is unknown.

3. Light to dark gray rhyodacite occurs in several exposures south and east of Miguels Hill. It contains scattered quartz phenocrysts in an aphanitic, structureless matrix and in one locality appears to be intrusive into an autobrecciated rhyolite flow of Unit 26.

4. Large conglomerate boulders form a small island in the central part of Miguels Lake. They are formed of clasts of gray and red siltstone, pink to red rhyolite, intensely sheared mafic volcanic rocks and fine grained limestone. Some of the siltstone and most of the limestone clasts have a cleavage. The sheared mafic volcanic rocks appear to be derived from Unit 7 as exposed on neighbouring islands in Miguels Lake. The conglomerate contains lenses of well sorted and locally graded sandstone, and there are beds of calcareous siltstone between 2 and 60 cm thick. The conglomerate itself is generally poorly sorted and clast supported; the clasts vary in size from 1 mm to 50 cm and are subangular to subrounded. The rock is undeformed and is appreciably less indurated than other conglomerates found in the map area (*i.e.* in Units 2a and 8). In view of this and because some of the clasts were most likely derived from the subaerial volcanic rocks to the west (Units 20-28), a Devonian or younger age is suggested.

STRATIGRAPHIC AND STRUCTURAL HISTORY

Most of the original geological relationships in the Miguels Lake area have been obscured by faulting and must be inferred from the regional geology of the Newfoundland Central Mobile Belt. A stratigraphic classification is presented in Figure 3 from which it is apparent that the units outside and including the ophiolite belt are easily reconcilable with the groupings of Dean (1977b). The units inside the belt, however, are lithologically distinct, although they seem to be about the same age as the pre-Caradocian island arc and possibly the oceanic crust. Their significance is discussed after the immediately obvious correlations of the rocks outside the belt have been made.

The dismembered pieces of the ophiolite suite (4-9) are comparable to the various levels of the structurally intact Coy Pond Complex to the south (Colman-Sadd, 1981). They can be considered as oceanic crust and, following the model of Strong *et al.* (1974), this crust is interpreted as the basement to a Middle Ordovician and older island-arc and back-arc basin. A minimum age for the oceanic crust is provided by Llanvirn-Llandeilo fossils in sediments that overlie the Gander River ultrabasic belt north of Gander Lake (Blackwood, 1978; Stouge, 1979).

The 'early arc' sequences of the Victoria Lake and Baie d'Espoir Groups (10-14) are dated as pre-Caradocian (Kean and Jayasinghe, 1980) and Caradocian or older (Colman-Sadd, 1976) respectively. Relationships in the western part of the Central Mobile Belt indicate that at least parts of the 'early arc' overlie the ophiolitic rocks conformably (Marten, 1971; Upadhyay *et al.*, 1971) and that formation of the arc began no later than the Arenigian (Snelgrove, 1931).

The original stratigraphic position of the Rogerson Lake conglomerate (15) cannot be conclusively determined in either the Miguels Lake or Noel Paul's Brook areas (Kean and Jayasinghe, 1980), but it may represent a facies similar to the Goldson Formation in the Upper Ordovician to Silurian post-Caradocian flysch. The transition to shallow marine sediments and red beds in the Silurian is represented by rocks of the Wigwam Formation (18) and associated units (16, 17). No 'mature island arc' volcanism of Silurian age has been recognized in the Miguels Lake area.

The presence of two sequences of Middle Ordovician and older rocks, one within the ophiolite belt and the other outside it presents serious stratigraphic and structural problems. The turbidites of Units 2 and 3 are rich in quartz and have no obvious volcanic detritus; they appear to be derived from a continental source. The Victoria Lake and Baie d'Espoir Groups (10-14), which are of equivalent age to Unit 2 and border about three quarters of the ophiolite belt on the outside, consist either of volcanic rocks or of detritus from a volcanic source. Although these rocks are everywhere faulted against the ophiolite and cannot be proved to lie directly on it, evidence from elsewhere in the Central Mobile Belt suggests that they may have once done so (Marten, 1971; Upadhyay *et al.*, 1971). There is no evidence that the rocks of Units 2 and 3 occur anywhere outside the ophiolite belt. This being so, there appear to be two contrasting sequences of the same age in the same area. The implication is that one of them is allochthonous.

The rocks of the ophiolite belt face outwards towards the Victoria Lake and Baie d'Espoir Groups, which are thought to have originally overlain them. This sequence is therefore thought to form the structurally higher, allochthonous sheet. If this interpretation is correct, the allochthonous sheet probably includes all of the Baie d'Espoir Group as far southeast as the Day Cove Thrust, and the Davidsville Group which appears to be contiguous with it (Colman-Sadd, 1980c). The minimum displacement on such an overthrust is about 80 km.

The Great Bend and Coy Pond Complexes are both near vertical and the Pipestone Pond Complex dips west at about 60° (Stuckless, 1975). If these rocks do in fact form the base of an overthrust sheet, there must have been much subsequent modification of the structure. This would also be indicated by the inconsistancy of the ophiolite outcrop (Figure 2); the thick continuous ophiolite complexes occur on the northerly trending sections of the belt, whereas the ophiolitic rocks on the more easterly trending sections occur in small isolated fault slices. Furthermore, where the contacts of the Great Bend and Coy Pond Complexes are exposed, the sediments of Unit 2 inside the ophiolite belt have been thrust or reverse faulted over the previously upturned ultramafic rocks.

If the major structure inferred from stratigraphic and paleontologic observations can be correlated with the minor structures observed in the field, the most likely time of overthrusting is Late Silurian or Early Devonian. All of the Lower Paleozoic rocks up to and including the Silurian Wigwam Formation have a single penetrative cleavage associated with isoclinal folds, on which are locally superimposed second deformation structures. Colman-Sadd (1980c) has suggested that this first penetrative deformation can be correlated through all the Lower Paleozoic rocks in the eastern part of the Central Mobile Belt so that all the deformation in these rocks can be considered as Acadian.

Metamorphism is also considered to be of Acadian age because of its relationship to the deformation. Outside of the ophiolite belt, where metamorphism is in the greenschist facies, it appears to have followed the onset of the main deformation, since structures formed by this deformation show evidence of having been imposed on poorly consolidated sediments. Within the ophiolite belt the metamorphic isograds have been superimposed across the major fold structures (Colman-Sadd, 1980d) so it is inferred that equilibrium was not reached until after the main period of deformation. The spatial conformity of the isograds with the ophiolite belt does however indicate a genetic link with the deformation that caused the updoming of the rocks inside the belt.

The Overflow Pond Granite (19a), which may place a younger limit on the main deformation because it postdates the major structures, has been dated at 389±6 Ma and 393±5 Ma using the ^{40}Ar/^{39}Ar method (Dallmeyer, 1980).

The Devonian or younger volcanic and sedimentary rocks (20 to 28) clearly postdate the deformation and metamorphism of the Lower Paleozoic rocks on which they lie unconformably, but further than that their age remains unknown.

MINERAL POTENTIAL

The Miguels Lake area contains units representing most of the major stratigraphic divisions of the Newfoundland Central Mobile Belt. Consequently, there are a variety of targets for mineral exploration (Figure 3), but only two of these have been prospected in any detail.

The ultramafic rocks (4, 5) have showings of asbestos and magnesite, and chromite is disseminated throughout the peridotite. Minorex currently holds claims around the asbestos showings near Atlantic Lake, where cross-fibre veinlets 1 to 3 mm wide are common but not abundant in exposures of peridotite (4). Asbestos fibres 1 to 4 mm long were reported by Coleman (1954) from the Great Bend complex. Magnesite occurs in fault zones near Atlantic Lake, along Great Rattling Brook and on the Northwest Gander River; literature on the magnesite occurrences in the Great Bend complex has been reviewed by Colman-Sadd and Swinden (1981). No chromite concentrations comparable to those present in the Pipestone Pond and Coy Pond Complexes (Snelgrove, 1934) have been found in the Miguels Lake area.

The mafic lavas and tuffs of Unit 7 form the upper part of the ophiolite sequence and as such have potential for Cyprus-type massive sulphide deposits. Disseminated pyrite is a common constituent of the rocks and Dean (1977a) reported a locally derived boulder of basalt containing stringers of pyrrhotite and chalcopyrite and assaying 0.78 percent copper.

Felsic volcanic rocks belonging to Dean's (1977b) 'early arc' sequences are represented by Units 12 and 13. The former is along strike from the Great Burnt Lake belt where mafic volcanic rocks are host to two significant volcanogenic massive sulphide deposits (Colman-Sadd and Swinden, 1981). Unit 13 is part of the Tally Pond Formation which contains pyrite, sphalerite, galena, and chalcopyrite mineralization near Burnt Pond in the neighbouring Noel Paul's Brook area (Dimmell, 1974; Kean and Jayasinghe, 1980).

The Middle Ordovician and older rocks inside the ophiolite belt (1-3), together with the Upper Ordovician and Silurian sediments outside the belt (15-18) seem to have little economic potential. The potential of the granitic rocks (19) may be higher since the two small intrusions in Unit 2 are similar to the Through Hill Granite, which has been rated as one of the more favourable granites for tin and tungsten mineralization in south-central Newfoundland (Colman-Sadd and Swinden, 1981).

The Devonian or younger volcanic rocks (20-28) have been the subject of several reconnaissance studies, but only Amoco have done any detailed work, and then only in a very restricted area

(Donovan, 1978). Possible targets are epithermal veins carrying precious metals, uranium or other mineralization, and tin-tungsten deposits similar to those at Mount Pleasent in New Brunswick (Dagger, 1972). The likelihood of an economic deposit of the latter type may have been significantly reduced by the present mapping project, because no subvolcanic intrusions have been found outcropping at the surface. The apparent absence of significant veining or alteration, however, can easily be explained by poor exposure, especially since altered zones may be less resistant to erosion and so might be more likely to occur in drift-filled valleys. The possibility of uranium mineralization is suggested by an exposure in the northern outcrop of Unit 24 which gave a radioactivity reading of 700 cps against a background of 150 cps.

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