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GEOLOGY OF THE HODGES HILL (NTS 2E/04) MAP AREA, NORTH–CENTRAL NEWFOUNDLAND

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ABSTRACT

The Hodges Hill map area (NTS 2E/4) was mapped at a scale of 1:50 000. The northwestern part is underlain by Early to Middle Ordovician island-arc and non-arc volcanic rocks and turbiditic sandstones of the Wild Bight Group. The Wild Bight Group is conformably overlain by the Caradocian Shoal Arm Formation, which is in gradational contact with the Late Ordovician–Early Silurian turbidites of the Point Leamington Formation of the Badger group. The Point Leamington Formation was overthrust by a portion of the Wild Bight Group.

The Late Ordovician–Early Silurian turbiditic pebble conglomerates and interbedded sandstones of the Badger group, in the southwest form a recumbent fold that has been openly re-folded. The probable Silurian Charles Lake sequence, comprising subaerial bimodal volcanic rocks and minor sandstone, may be a correlative of the subaerial bimodal volcanic rocks of the Lawrenceton Formation of the Botwood Group. The overlying Wigwam Formation of the Botwood Group is a sequence of mainly fluvial red sandstone.

The Hodges Hill intrusive suite contains an early foliated granite, later pyroxene gabbros followed by granodiorite and granite and finally a one-feldspar hornblende granite, locally containing sodic amphibole indicating a peralkaline affinity.

Diabase dykes are common and major concentrations of northeast-trending dykes occur in the New Bay Pond and Mary Ann Lake areas.

The Wild Bight Group west of New Bay Pond, has potential for base-metal mineralization similar to that found on the Point Leamington deposit. Several areas of the Hodges Hill intrusive suite have potential for dimension stone usage. Test quarries in granite have been developed south of Hodges Hill.

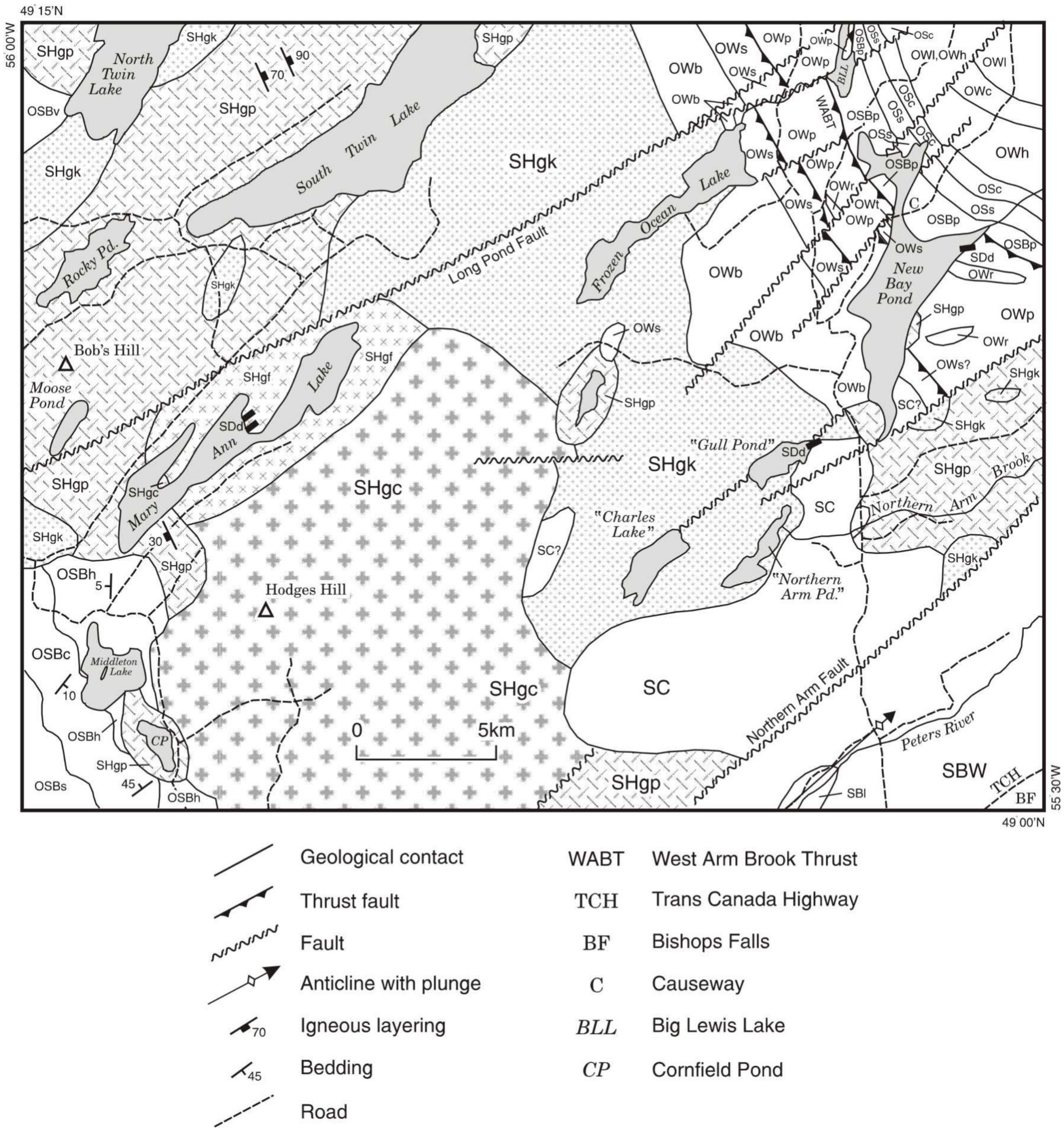
INTRODUCTION

Geological mapping and lithogeochemical sampling of the Hodges Hill area was carried out during 1998, and most of the area was covered at a scale of 1:50 000. The west half had been previously mapped (1 inch to one mile) during the late 1940s by Hayes (1947, 1951a,b) and the New Bay Pond area was mapped by various exploration companies during the late 1970s and 1980s. The "Charles Lake"[1], Rocky Pond and West Arm Brook areas still require further mapping that will be done in 1999.

GEOLOGICAL SETTING

The Hodges Hill map area lies within the Exploits Subzone of the Dunnage Zone defined by Williams *et al.* (1988). The Exploits Subzone is dominated by Early to Middle Ordovician island-arc volcanic and turbiditic sedimentary rocks that are intruded by various Silurian gabbros and granites. Within the survey area (Figure 1), Early to Middle Ordovician island-arc volcanic rocks of the Wild Bight Group are locally overlain by a thick unit of Caradocian chert and shale of the Shoal Arm Formation. This formation is conformably overlain by Late Ordovician to Early Silurian turbidites of the Badger group. Probable later Silurian units include the Charles Lake sequence, which is dominated by felsic and mafic volcanic rocks, and the Botwood Group, which contains subaerial mafic volcanic rocks overlain by fluviatile to lacustrine sedimentary rocks. Apart from the Botwood Group and possibly the Charles Lake sequence, all strata have been intruded by the extensive Silurian Hodges Hill intrusive suite (informal, new name) that contains various gabbroic and granitic

[1] Name in quotation marks is local name for pond or lake not named on the topographic map.



LEGEND

SILURIAN TO DEVONIAN?

SDd Fine- to medium-grained, equigranular to coarsely plagioclase-porphyritic diabase dykes

MIDDLE TO LATE SILURIAN

HODGES HILL INTRUSIVE SUITE (SH)

SHgc Coarse- to medium-grained, equigranular, one-feldspar (perthite), hornblende ± pyroxene ± biotite granite

SHgk Medium-grained, equigranular to K-feldspar-porphyritic, two-feldspar biotite ± hornblende granodiorite and granite

SHgp Fine- to medium-grained, pyroxene ± hornblende gabbro commonly net-veined by granite; minor layered gabbro and pyroxene-rich gabbro

SHgf Weakly to strongly foliated, medium-grained, equigranular, two-feldspar, biotite granite commonly containing psammite, semipelite and amphibolite xenoliths

Figure 1. *Simplified geology of the Hodges Hill map area (NTS 2E/4).*

LEGEND *(Continued)*

BOTWOOD GROUP (SB)

SBw Wigwam Formation: Massive to weakly cleaved, medium- to thick-bedded red sandstone and minor siltstone and conglomerate

SBl Lawrenceton Formation: Massive, equigranular to coarsely plagioclase-porphyritic, locally amygdaloidal basalt flows and fine-grained, grey to pink felsic tuff and quartz–feldspar crystal-lithic tuff; minor grey sandstone

?SILURIAN

CHARLES LAKE VOLCANICS (SC)

SC Quartz–feldspar-porphyritic, flow-layered ignimbrite, quartz-porphyritic rhyolite, and felsic tuff interbedded with massive fine-grained basalt; minor grey sandstone, pillow lava and cobble conglomerate

MIDDLE ORDOVICIAN (CARADOCIAN) TO EARLY SILURIAN

BADGER GROUP (OSB)

OSBh Contact metamorphosed and locally migmatized, thin- to medium-bedded, cleaved sandstone and siltstone locally interbedded with chert-pebble conglomerate and coarse-grained sandstone

OSBc Massive to weakly cleaved, very thick-bedded, pebble conglomerate and coarse-grained sandstone

OSBs Massive, medium- to thick-bedded, medium-grained, sandstone

OSBv Schistose, medium- to thin-bedded, grey biotite psammite, semipelite, migmatite and minor felsic tuff

OSBp Point Leamington Formation: Massive to weakly cleaved, medium to very-thick bedded, fine- to very coarse-grained feldspathic sandstone, pebbly sandstone and pebble conglomerate

MIDDLE ORDOVICIAN - CARADOCIAN

SHOAL HARBOUR FORMATION (OS)

OSs Strongly cleaved, thin- to medium-bedded, commonly pyritic, locally graptolitic slate and siltstone; minor interbedded grey sandstone; thick olistostromal horizons

OSc Massive, thin- to medium-bedded, laminated chert containing slate partings

EARLY TO MIDDLE ORDOVICIAN?

Og Massive, medium- to coarse-grained, equigranular, grey pyroxene gabbro dykes and sills

EARLY TO MIDDLE ORDOVICIAN

WILD BIGHT GROUP (OW)

OWb Massive to weakly cleaved, extremely thick-bedded, mafic agglomerate containing assorted basalt fragments; rare massive basalt flows and mafic tuff horizons

OWh Massive, very thick-bedded, fine-grained, green basalt flows, pillow lava, pillow breccia, hyaloclastite; minor coarse-grained poorly sorted, polymict conglomerate at the top of the succession

OWs Massive to cleaved, thick-bedded, sandstone and pebble conglomerate, thin- to medium-bedded siltstone and chert; minor chert-clast breccia and slumped chert units

OWc Massive to weakly cleaved, coarse-grained, tuffaceous sandstone and angular pebble conglomerate; minor laminated, thick-bedded sandstone

OWt Massive to weakly cleaved, fine-grained, pink, quartz–feldspar porphyritic rhyolite and coarse-grained felsic lapilli tuff

OWr Massive, very fine-grained, equigranular or feldspar-porphyritic rhyolite

OWl Massive, very thick-bedded, fine-grained, green basalt flows and pillow lava

OWp Massive to locally sheared, very thick-bedded, fine-grained, equigranular to plagioclase-porphyritic basalt, pillow lava, basalt breccia and pillow breccia rocks. An interesting, generally northeast-trending, diabase dyke swarm cuts all the units with a particularly intense dyking in the Mary Ann Lake, "Gull Pond"[1] and New Bay Pond areas.

Major structural features include the northwest-trending thrust contact between a southern belt of Wild Bight Group volcanic rocks and the Badger group in the Big Lewis Lake to New Bay Pond area. The northeast-trending Northern Arm Fault in the Peters River area separates the Botwood Group from the Hodges Hill intrusive suite and the Charles Lake sequence. The Four Mile Lake and Long Pond faults (*see* Swinden and Jenner, 1992), which coalesce north of Frozen Ocean Lake, extend across the survey area from beyond the northeast corner of Big Lewis Lake to west of Mary Ann Lake, in the west. These faults show considerable dextral movement within the Wild Bight Group, Shoal Arm and Point Leamington formations but appear to show only minor displacement within the Hodges Hill intrusive suite.

LOCATION AND ACCESS

The survey area lies to the northwest of Bishops Falls and about 5 km north of Grand Falls–Windsor. Only part of Bishops Falls lies within the survey area. Several cabins lie within the region mainly in the New Bay Pond and the Middleton Lake–Cornfield Pond areas.

The Trans-Canada Highway (TCH) cuts across the southeast corner of the map area for about 3 km. Much of the area is accessible by two major networks of gravel forest-access roads that cover the eastern and western parts of the area. The eastern network is accessible from the TCH east of Grand Falls. A small area of the southern portion of the map area is accessible from Grand Falls–Windsor (*see* NTS Map 2D/13). The western road network is accessed from the TCH at Aspen Brook, approximately 18 km west of Grand Falls–Windsor, and 2 km north of Catamaran Park (or 11 km north of Badger), and also from the TCH, 16 km north of Badger. There are numerous branch roads representing several generations of roads many of which are passable only with difficulty and by use of an ATV. Several major roads shown on the published topographic map are in poor shape.

Most of the woods-roads are not shown on the topographic map but are available from the 1:12 500 colour aerial photographs. However, there has been significant woods-road construction since 1983 in the areas to the southeast of Mary Ann Lake, west of Mary Ann Lake, west of Middleton Lake, west of Moose Pond, northwest of South Twin Lake, and in the several areas between Bishops Falls and Northern Arm Brook.

Several of the larger ponds and lakes in the area are navigable by boat and provide access to large areas and also numerous exposures. These include New Bay Pond, Big Lewis Lake, Frozen Ocean Lake, Cornfield Pond, Middleton Lake, Mary Ann Lake, South Twin Lake and North Twin Lake. Boats are not permitted on "Gull Pond" and "Northern Arm Pond" as they are part of the water supply system for the Grand Falls–Windsor–Bishops Falls region. No rivers are suitable for boat use apart from the 1 km of the Exploits River within the survey area.

Several areas are quite rugged, e.g., Hodges Hill, and immediately south and east of Frozen Ocean Lake. Extensive stands of closely spaced, burned trees southwest of Northern Arm Pond make traversing difficult. Access to the more isolated parts may be gained with difficulty on foot or by helicopters available at Glenwood and Gander, 45 km and 60 km to the east, respectively. Extensive areas of bog with only isolated bedrock exposures lie to the north and east of Hodges Hill. A veneer of till covers much of the area and bedrock has been exposed by woods-access road construction and subsequent erosion along ditches and hill-crests along the roads.

PREVIOUS INVESTIGATIONS

The earliest geological excursion into the Hodges Hill area was by James P. Howley in 1875 who ascended Hodges Hill starting from Badger. The bearings from the hilltop to other known hills were measured (Murray and Howley, 1881, page 416) as part of a triangulation survey; however, there is no mention of any rock type. Subsequent surveys along the Exploits River by Howley in 1882 and 1886 did not include any excursions into the study area (Murray and Howley, 1918). The geological map of Newfoundland by Howley (1907) indicates that Hodges Hill is composed of "trap greenstone" (i.e., diabase or other fine-grained, dark-coloured igneous rock) with granite to the east, both having intruded Silurian rocks that underlay the southern part of the survey area. The northern part is underlain by various mafic igneous rocks including diorite.

John Jesse Hayes and assistants mapped the west half of the Hodges Hill map area, the west half of the Roberts Arm map area (formerly called the Marks Lake area; NTS 2E/5), the eastern part of the Dawes Pond map area (formerly Gull Pond; NTS map area 12H/1) as far west as the Badger–Halls Bay road (now the TCH), and the northern part of the Grand Falls map area southward to the Exploits River. This work commenced in 1947 with the Geological Survey of Newfoundland and continued in 1949 with the Geological

[1] Name in quotation marks is local name for pond or lake not named on the topographic map.

Survey of Canada. The reports, map and thesis by Hayes (1947, 1951a,b) and a report and map by one assistant B.G. Craig (1949) are the first known geological reports and maps on the area. Hayes (1947) described in some detail the various rock units and their relationships in the Hodges Hill area noting the folding in the rocks southwest of Middleton Lake. The sedimentary and volcanic rocks were assumed to be Middle Ordovician and the intrusive rocks, *viz.*, gabbro, the Hodges Hill granite, and mafic dykes were all of post-Middle Ordovician age. Hayes (1951b) indicated that there was evidence of interaction between the diorite and granite. The glacial features indicated movement toward the northeast.

Craig (1949) produced the first geological map of the area and repeated much of the information given by Hayes (1947). Hayes (1951a) provided the first published map of the Hodges Hill area. The stratigraphic nomenclature of Heyl (1936) was adopted by Hayes (*op. cit.*) and the sedimentary rocks were considered to be equivalent to the Sivier, Sansom and Hornet formations of the Ordovician Exploits Group. The intrusive rocks were generally considered to be of Devonian age. In his thesis, Hayes (1951b) described the sedimentary rocks and the northeast-plunging folds in the Middleton Lake area, the extensive, high-grade, contact metamorphism of the sedimentary units immediately south of Mary Ann Lake, and the mineralogy and textures of the diorite and gabbro of the Twin Lakes diorite, Hodges Hill granite and mafic dykes, noting in particular that the Hodges Hill granite was locally granophyric and possibly contained riebeckite. The mineral potential of the area was considered poor due to the lack of sulphide mineralization but the potential for granite dimension stone at Hodges Hill was noted.

An aeromagnetic survey done for the Newfoundland and Labrador Corporation Ltd. (Nalco), which included the Hodges Hill map area (Aeromagnetic Surveys Ltd., 1950), outlined several anomalous areas. Two "aeromagnetic low closures" noted from the survey were investigated by Parks (1952). One anomaly was located in the Cornfield Pond area and Parks (*op. cit.*) deduced that this was due to negatively polarized magnetite in the host diorite. He was also able to deduce the western contact of the diorite with the adjacent sedimentary rocks using his dip-needle instrument.

The other anomaly was located on the west side of New Bay Pond. Parks (1952) determined that the negative anomaly was due to the presence of a dacite band within the sedimentary and mafic volcanic sequence. He also noted the presence of chert and slate at the northern end of New Bay Pond, which were cut by a north–northeast-trending fault zone. The map accompanying his report is the first known geological map of the New Bay Pond area.

Falconbridge Mines Ltd. (1954) produced a compilation map that included the North and South Twin lakes area. The map appears to be based on Hayes (1951a) but, in error, their legend indicates that the gabbro of Hayes (*op. cit.*) is shales and slates.

Williams (1962, 1964a) published the first geological map of the entire Hodges Hill map area (at a scale of one inch to four miles), and compiled the work of Hayes (1951a) with new work in the eastern half of the map area. The 1962 map and report show a generalized stratigraphy for the map area with the older sedimentary and dominantly mafic volcanic rock units, (including the "Wild Bight volcanics"; Unit 6 of Williams, 1962) being assigned to the Middle Ordovician Exploits Group. The Wild Bight volcanics was the oldest unit as it was overlain by Middle Ordovician rocks in the New Bay area. The presence of sandstone, fossiliferous shale and chert within the Wild Bight volcanic rocks created a problem. It was interpreted to be either an infolded sequence or an intercalation with the volcanic rocks. The younger stratified units were assigned to the Silurian Botwood Group. All the units are intruded by granites and gabbro of probable Devonian age.

Williams (1964a) showed a modified stratigraphy and proposed that the Wild Bight Group be separated from the Exploits Group. The fossiliferous New Bay Pond sedimentary sequence was tentatively included within the Wild Bight Group and Williams (1964b) reported a 415 Ma age (recalculated to 423 Ma using modern decay constants) from granodiorite southwest of North Twin Lake.

Wanless *et al.* (1965, 1967) reported the details of three K/Ar (biotite) ages from granitic rocks in the North Twin Lake and South Twin Lake areas. A recalculated age of 423 ± 20 Ma was obtained from granodiorite located 1.2 km southwest of North Twin Lake. A recalculated age of 383 ± 12 Ma was obtained from granodiorite located on the largest island at the southern end of South Twin Lake. A suspect (recalculated) age of 292 ± 58 Ma was obtained from another sample of granodiorite from the island.

Williams (1972) provided a comprehensive review of the stratigraphy and petrology of the stratified units of the Botwood (NTS 2E) map area. The graptolitic sedimentary units at New Bay Pond were of Caradocian–Trentonian (Ashgill) age and therefore younger than the generally accepted pre-Middle Ordovician age of the surrounding volcanic rocks of the Wild Bight Group. An overturned syncline of these fossiliferous units was proposed to resolve the problem of their consistent parallelism with the units of the Wild Bight Group. The Exploits Group comprised the post-Wild Bight Group units including the graptolitic Caradocian shale and chert (Shoal Arm Formation), overlying greywacke and conglomerate (Sansom Formation). The sedimentary rocks of the Exploits Group at Middleton Lake were interpreted to be younger than the Caradocian shales based on relationships exposed along the Exploits River to the south, and were correlated with the Late Ordovician–Early Silurian Sansom Formation. The Botwood Group in the Hodges Hill area was divided into a lower volcanic unit termed the Lawrenceton Formation and the overlying Wigwam Formation, which is dominated by red sandstone and conglomerate.

Questor Surveys carried out airborne electromagnetic surveys in the area around Gull Pond (NTS 12H/1), which included the western part of the map area (Questor Surveys Ltd., 1972a), and in the Point Leamington area (NTS 2E/5), which included much of the eastern part of the New Bay Pond area (Questor Surveys Ltd., 1972b). The former survey did not indicate any significant anomalies within the Hodges Hill map area, however, the latter survey highlighted two long conductive horizons, one of which coincided with the shale and chert exposed along the north shore of New Bay Pond. This unit extends from outside the northeastern margin of the area at New Bay River northwestward to beyond Big Lewis Lake. A clear offset in the anomaly pattern was identified east of Big Lewis Lake. Numerous isolated EM anomalies were also noted within the mafic volcanic units in the New Bay Pond area.

Wessel (1975) included the area northwest of Bishop's Falls as part of a doctoral study of the sedimentology of the Springdale and Botwood groups. He concluded that the Wigwam Formation (his Botwood Formation) was composed of a narrow (approximately 25 km wide) northwestern fluvial facies that extended from Grand Falls northeastward to Botwood, a narrow central transitional fluvial–marine zone about 30 km wide, and an extensive southeastern shallow-marine sequence that extended southeastward for over 150 km, as far as the Northwest Gander River (*see* Anderson and Williams, 1970; Dickson, 1992).

Dean (1977, 1978a) produced a compilation map of the Hodges Hill survey area based on the work of Hayes (1951a), Williams (1964a), and unpublished Noranda Exploration Co. Ltd. maps. In particular, this work revised the stratigraphy in the New Bay Pond area and provided a solution to the problem of Wild Bight Group volcanic rocks apparently overlying the Caradocian Shoal Arm Formation by proposing that the overlying volcanic units are a separate group, *viz*., the Frozen Ocean Group. Details of the revised stratigraphy were presented in Dean (1977, 1978a) and detailed descriptions of the various units were presented in Dean (1978a). The Frozen Ocean Group contained a lower unit dominated by pillow lava, pillow breccia and massive basalt, overlain by various tuff, agglomerate, sandstone, chert, and minor basaltic units. A possible upper succession of felsic subaerial volcanic flows and pyroclastic rocks, tuffaceous sandstone and tuff located to the southwest, in the "Charles Lake" area, was included in the Frozen Ocean Group but its relationship to the other units was unknown.

Dean (1978b) produced an amended map of the New Bay Pond area in a report on the mineral potential of the area. No significant mineralization was noted although several weak geophysical anomalies were thought to indicate a potential for Buchans-type (Cu–Pb–Zn) mineralization.

Clark (1979) followed up on some of the recommendations in Dean (1978b) and reported on an extensive stream-sediment geochemical survey and scattered geological observations in the area described in Dean (1978b). He noted that rhyolitic rocks occurred in several places at the base of the Frozen Ocean Group apparently in contact with the Sansom Formation. Rhyolitic rocks were also found within the dominantly mafic volcanic sequence. The rhyolitic rocks at the top of the Frozen Ocean Group were noted to be distinctly different from those near the base of the group. Clarke (*op. cit.*) noted that jasper–magnetite iron formation occurred over a limited area, near the top of the lower basaltic unit of the Frozen Ocean Group (2 km east of Frozen Ocean Lake), and it contained 10 to 20 percent pyrite and assayed 0.19 % Cu. Most geochemical anomalies in the study area occurred along the same stratigraphic location.

Fenton (1980) provided a comprehensive report on the work of Dean (1978b) and Clark (1979) and gave details of the results of the geochemical survey. Several anomalous areas were described in detail and further work was recommended. Fenton (1981) reviewed the further investigations of nineteen anomalous areas by Hudson's Bay Oil and Gas in the New Bay Pond–Frozen Ocean Lake–Peter's River area. The work included drilling six shallow holes in five different areas between Frozen Ocean Lake and New Bay Pond. The drill logs indicate some of the variation over relatively short distances. The results of the drilling explained most of conductors. The conductors included graphite and pyrite, disseminated pyrite + pyrrhotite + chalcopyrite, and pyrite in siliceous argillite. Metal values were generally low. Further work was recommended on some of the drill targets and others which had not been drilled.

The Department of Mines and Energy (Butler and Davenport, 1981; Davenport and Nolan, 1986) reported on the results of lake-sediment geochemistry. Within the Hodges Hill area, some economically significant elements displayed anomalous values. These included copper (Cu > 20 g/t) in South Twin Lake and the northern New Bay Pond area; nickel (Ni > 15 g/t) in South Twin Lake, Middleton Lake area, Big Lewis Lake and Northern New Bay Pond area; cobalt (Co > 20 g/t) in the Moose Pond, Big Lewis Lake, southwestern Frozen Ocean Lake, and northern New

Bay Pond area; uranium (U > 10 g/t) in the South Twin Lake and Big Lewis Lake area; and gold (Au > 2 mg/t) in the New Bay Pond–Frozen Ocean Lake area. Manganese in lake sediments was highest in Big Lewis Lake and Middleton Lake (Mn > 10 000 g/t), and the area southeast of Hodges Hill (up to 10 000 g/t). Because of the known scavenging properties of manganese, it is interesting to note that most of the anomalies are not associated with high manganese.

Getty Mines Ltd. (Coll, 1981) reported on two airborne surveys in the Hodges Hill and New Bay Pond areas. Minor anomalies were reported from the Hodges Hill area but to the south of the actual Hodges Hill map area. (These may reflect the Caradocian shale exposed along the TCH west of Grand Falls; *see* Kean and Mercer, 1981). The New Bay Pond area contained several anomalies, some of which could be explained by the known presence of graphitic shale. The others were interpreted to possibly reflect faults or potential mineralized horizons. Getty Minerals staked some ground that included the northeast corner of the Hodges Hill map area. Werniuk (1982, 1983) carried out follow-up ground exploration in the northeastern part of the New Bay Pond area as part of a more extensive survey to the east and north. A few outcrops of amygdaloidal basalt were mapped within the map area and the soil geochemistry and geophysics did not indicate any anomalies within the map area.

Swinden (1984) provided a brief description of the mafic volcanic rocks of the Wild Bight Group northeast of New Bay Pond noting that the sequence was conformably overlain by Caradocian chert and shale.

Noranda (Graves, 1984) carried out a stream-silt and till geochemical and ground geophysical survey in the area west of Big Lewis Lake as part of a more extensive survey carried out mainly to the north of Big Lewis Lake. The results did not warrant any further work.

Moore (1984) reported on a limited petrographic, geochemical and isotopic study of part of the Twin Lakes Diorite and Hodges Hill Granite and concluded that magma mixing of a country-rock contaminated diorite and a later granite produced the intermediate-composition rocks. Of particular note, is the Rb/Sr isochron age of 415.6 ± 2.1 Ma and an initial $^{87}Sr/^{86}Sr$ ratio of 0.70453 determined for the granitic rocks in the Hodges Hill area.

Utah Mines Ltd. (Legein, 1985) carried out geological mapping, rock and soil geochemistry in the area northwest of New Bay Pond mainly to determine the extent of felsic volcanism in the area. Legein (1986) reported on further detailed exploration by Utah Mines Ltd. in an area 600 m west of the causeway on New Bay Pond previously drilled by Hudson's Bay Oil and Gas in 1980. The results showed only minor base-metal anomalies.

Kusky (1985) did detailed mapping of the New Bay Pond area and showed that thrusting was a significant component to be considered in structural models of the area. Of particular significance was the observation that the Frozen Ocean Group of Dean (1977) was in thrust contact with the post-Caradocian Point Leamington Formation along the Frozen Ocean Group Fault (FOG Fault), which extends from the Big Lewis Lake area to New Bay Pond. He further proposed that the Frozen Ocean Group was the stratigraphic equivalent of the Wild Bight Group. The contact between the Shoal Arm Formation and the Point Leamington Formation, on New Bay Pond, was also interpreted to be a fault.

Swinden (1987a) and Swinden *et al.* (1989, 1990) showed that the Wild Bight Group, northeast of New Bay Pond, was comprised of mafic volcanic rocks that showed a progressive sequence from early primitive island-arc volcanism to back-arc basin volcanism.

Swinden (1987b, 1988) proposed that the term "Frozen Ocean Group" should be dropped as it was probably composed of two unrelated components, *viz.*, the "Charles Lake sequence" comprising the uppermost unit of the Frozen Ocean Group (*see* Dean, 1978a and Kusky, 1985) and located to the southwest of New Bay Pond, and the "New Bay Pond sequence" comprising the remaining lower units of the Frozen Ocean Group. The upper agglomeratic unit of the New Bay Pond sequence was considered to be equivalent to the Big Lewis Lake basalt of Swinden (1984), which is conformably overlain by the Caradocian Shoal Arm Formation. The Charles Lake sequence was considered to be comparable with the subaerial Silurian Springdale Group.

Noranda (Collins, 1987) returned to the New Bay Pond–Point Leamington area and compiled a comprehensive detailed review of all previous work, however, no new ground work was carried out. Later, Noranda (Basha, 1989) did further prospecting in the New Bay Pond–Point Leamington area. In the vicinity of West Arm Brook, within the lower unit of the "Frozen Ocean Group", several mineralized boulders and an anomalous lake-sediment assay of 4 mg/t Au were obtained.

Detailed airborne, total-field magnetic, gradiometer and VLF-EM surveys were done by the Geological Survey of Canada in the Hodges Hill area as part of a larger survey (*see* Geological Survey of Canada, 1988a,b; Tod and Ready, 1989a,b). These data highlighted many of the lithological and structural features in the area. Faults and conductive horizons such as the Shoal Arm Formation are quite apparent. A digital presentation of the geophysical data from this survey is available (*see* Davenport *et al.*, 1996).

MacRee Resources Inc. (Frew, 1989) examined the mineral potential of the Northern Arm Fault (*see* Figure 1) in the area where the felsic volcanic rocks of the Charles Lake sequence are juxtaposed with the Botwood Group. An airborne geophysical survey carried out over the property (Konings, 1989) clearly indicated the Northern Arm Fault and possible fault splays. Some electromagnetic anomalies were considered worthy of a geological investigation but no anomalies with mineral potential were noted.

St. Croix and Taylor (1992) reported that striation data in the map area indicate four glacial events. The earliest ice-flow was northeastward; the second was northward; the third (and most commonly preserved) was also northeastward; the last ice flow, identified mainly in the New Bay Pond area, had an eastward trend.

Swinden and Jenner (1992) showed that the upper portion of the New Bay Pond sequence could be correlated, along strike to the northwest, with the upper non-arc units of the Wild Bight Group. This correlation also showed that the Point Leamington massive sulphide deposit would lie in the lower unit of the New Bay Pond sequence. The FOG Fault of Kusky (1985) was formally renamed as the West Arm Brook Thrust (Swinden and Jenner, 1992).

Williams and O'Brien (1994) reported on graptolite biostratigraphy of the Shoal Arm Formation and included collections made at three sites on New Bay Pond. The graptolites indicated that the Shoal Arm Formation, including the uppermost chert units, are of Caradoc–Ashgill age. This study indicated that the Wild Bight Group–Shoal Arm Formation contact, northeast of New Bay Pond, had been modified by thrusting.

Mercer (1994) and Kerr (1995) carried out a detailed assessment of the dimension-stone potential of the varieties of granite exposed in the Hodges Hill area. Blocks submitted by Mercer (*op. cit.*) for testing returned encouraging results. Kerr (1995) assessed twelve sites that had good potential for development. He also noted that high-level, hypersolvus (one-feldspar), alkali–feldspar, locally miarolitic, coarse-grained granite dominated the area and that a subsolvus (two-feldspar), fine-grained granite occurred along a portion of the outer margin of the batholith.

The sedimentary sequence that conformably overlies the upper Caradocian Shoal Arm Formation, i.e., the Point Leamington Formation at New Bay Pond and the sequence southwest of Middleton Lake, were assigned by Williams *et al*. (1995) to the post-Caradocian–Llandovery Badger group (informal term introduced by Williams, 1993).

MacLachlan and O'Brien (1998) compiled the available geological maps of the Wild Bight Group and included the area east and northeast of Frozen Ocean Lake. They indicated that several northwest-trending thrusts bound some of the major units.

Dickson (1998) provided a summary and sketch map of the map area and indicated some new units within the plutonic terrain and revised contacts between the Ordovician stratified units and the Hodges Hill intrusive suite.

The adjacent NTS map areas have been mapped at scales of 1:50 000 or greater. These are the Botwood map area (NTS 2E/3) by Dickson *et al.* (1993) and O'Brien (1993), Grand Falls map area (NTS 2D/13) by Kean and Mercer (1981), Dawes Pond map area (NTS 12H/1) by Kalliokoski (1955) and Swinden and Sacks (1996), and the Roberts Arm map area (NTS 2E/5) by O'Brien and MacDonald (1996) and O'Brien (1997, 1998).

STRATIFIED UNITS

Stratified rocks in the map area have been assigned to the Early and Middle Ordovician Wild Bight Group, the Middle Ordovician Shoal Arm Formation, the Late Ordovician to Early Silurian Badger group and the Point Leamington Formation of the Badger group, the Silurian Botwood Group, and the Charles Lake sequence of probable Silurian age.

The Wild Bight Group

The Wild Bight Group has been described as an island-arc sequence (e.g., Dean, 1977) and subsequently the model was refined by Swinden and co-workers (e.g., Swinden *et al*., 1989, 1990; Swinden and Jenner, 1992) to show that the Wild Bight Group contained several distinctive components comprising a lower island-arc volcanic sequence, overlain by turbiditic deposits, and an upper non-arc volcanic sequence. These sequences are represented in the Hodges Hill area.

Within the Hodges Hill area, the Wild Bight Group is structurally divided by the West Arm Brook Thrust into two separate northwest-striking zones. The northeastern portion of the Wild Bight Group forms a steeply dipping, northwest-striking zone composed of a lower sequence of basaltic flows, pillow lava and pillow breccia (OWl), conformably overlain by thick-bedded, coarse-grained epiclastic sedimentary rocks (Unit OWc) and sandstone, and an upper sequence of very thick-bedded mafic volcanic rocks (Unit OWh) including pillow lava, massive basalt, hyaloclastite breccia and basalt breccia, and thick-bedded sedimentary rocks including sandstone, pebble conglomerate and minor cobble conglomerate. These three units form part of the Penny's Brook Formation of Dean (1977, 1978a). The northeastern zone of the Wild Bight Group is overlain by

Caradocian Shoal Arm Formation chert (Unit OSc) and shale (Unit OSs) and the Point Leamington Formation sandstone (Unit OSBp).

Along the West Arm Brook Thrust (Swinden and Jenner, 1992), the upper portion of the Point Leamington Formation is juxtaposed with the southwestern zone of the Wild Bight Group. This zone contains a sequence (Unit OWp) of very thick-bedded pillow breccia (Plate 1), basalt flows and pillow lava locally containing lenses of rhyolitic flows and tuff (Unit OWr), a central sequence (Unit OWs) composed of medium-bedded sandstone, thin-bedded yellow, red, green and black chert (Plate 2), very thick-bedded pebble conglomerate and thin-bedded siltstone, and an upper sequence (Unit OWb) of very thick-bedded coarse-grained basaltic agglomerate and basalt flows. Swinden (1988) indicated that the sequence dips to the northeast and therefore the youngest rocks occurred toward the northeast. Subsequently, Swinden and Jenner (1992) said that the geochemical data showed that the sequence should young to the southwest and suggested that internal faulting had produced the northeast-dipping sequence. The present study indicates that nearly all of the sequence dips steeply and faces to the southwest. Younging directions are indicated by numerous sedimentary structures in Unit OWs. The western package is openly folded south of Frozen Ocean Lake and the sedimentary sequence (Unit OWs) reappears to the west of the upper agglomerate unit (Unit OWb).

Plate 1. *Pillow breccia from Unit OWp of the Wild Bight Group, 2 km west of Big Lewis Lake; lens cap is 5 cm in diameter. Site LD980527.*

The oldest unit of the Wild Bight Group, based on the geochemical criteria of Swinden and Jenner (1992) and also the structural interpretation of MacLachlan and O'Brien (1998), is Unit OWp, which is exposed immediately to the west of the thrust contact with the Point Leamington Formation (Unit OSBl). Unit OWp is dominated by dark green, massive basalt flows containing interbedded pillow lava flows and minor, thick-bedded pillow breccia horizons

Plate 2. *Massive sandstone containing ripped-up clasts of thin-bedded red chert; Unit OWs of the Wild Bight Group, 1 km east of Frozen Ocean Lake; lens cap is 5 cm in diameter. Site LD980487.*

(Plate 1). Locally, thin units of chert and sandstone occur within the mafic volcanic rocks and graphitic pelite was noted in sheared basalt, in an exploration trench, 2 km west of the New Bay Pond causeway.

The northeastern margin of the unit is highly deformed along the West Arm Brook Thrust and includes brecciated as well as mylonitized basalt. As previously described in Kusky (1985), the thrust fault is exposed in several small coves along the southwest shore of the northern portion of New Bay Pond and on the main woods-road west of New Bay Pond. In the Big Lewis Lake area, the north-trending channel between the two halves of the lake contains several exposures of brecciated and mylonitic basalt. In other poorly exposed areas, the contact is marked by a prominent scarp face where the basalt forms the higher ground. The fabric in the rocks along the thrust is generally steeply dipping to the west and displays steeply plunging lineations. Kusky (1985) interpreted these structures to indicate that the Wild Bight Group had been overthrust from the northeast and subsequently folded into its present configuration.

The western margin of Unit OWp, 2 km east of Frozen Ocean Lake, is generally marked by a prominent break in slope and elongate lakes parallel the contact between the basalt and the sedimentary rocks of Unit OWs. In this area, isolated exposures of sheared basalt are locally cut by quartz veins. In one area, possibly the site of drilling by Hudson's Bay Oil and Gas, a basalt flow is veined by quartz and contains angular fragments of jasper and rusty layers. North of West Arm Brook, the two units are locally separated by a medium-grained, massive gabbro dyke which is over 200 m wide. However, to the north of this dyke, the pillow lava and grey sandstone and chert appear to be interbedded. One kilometre west of the lower part of New Bay Pond, a sequence of thin sandstone and chert beds is clearly overlain by fine-grained mafic agglomerate. The shearing of the basalt, along with apparently stratigraphic contacts, suggest that the original depositional contact has been modified by faulting. MacLachlan and O'Brien (1998) have interpreted this contact to be a thrust with the sediments of Unit OWs having overthrust Unit OWp.

Various massive rhyolite (OWr) and rhyolitic tuff zones (Unit OWt) occur along the western contact of Unit OWp. A northeast-trending fault to the west of New Bay Pond is interpreted to truncate Unit OWp and appears to have a sinistral displacement of about 2 km such that the upper contact of Unit OWp is almost adjacent to its lower contact along the West Arm Brook Thrust. However, the displacement of the Shoal Harbour Formation 1.5 km to the north is less than 300 m, as indicated by the aeromagnetic anomaly pattern (e.g., Questor Surveys Ltd., 1972a; Coll, 1981; Geological Survey of Canada, 1988a,b). This suggests that the possible juxtaposition of the upper and lower contacts may mainly be due to early thrusting that was subsequently modified by sinistral strike-slip movement along a vertical fault. The rhyolite (Unit OWr) and rhyolitic tuff (Unit OWt) map out as lenses at the top of Unit OWp. However, east of New Bay Pond, elongate belts of pale yellow rhyolitic rocks appear to lie within Unit OWp.

The rhyolite of Unit OWr is very fine grained, aphanitic to locally plagioclase–porphyritic, pale yellow to grey, and does not display any layering or flow features. Alteration is rare but west of New Bay Pond, 1-m-wide bands, rich in epidote and chlorite, cut the rhyolite. A possible correlative of the rhyolite is exposed on the eastern shore of New Bay Pond 2 km southwest of New Bay River. The rock is a buff, fine-grained, leucocratic microgranite.

The felsic tuffs of Unit OWt are best exposed to the northwest of the New Bay Pond causeway. The tuffs are grey to purple, fine grained and are fractured, variably porphyritic containing 1 to 3 mm quartz ± feldspar ± hornblende? phenocrysts. Along the west shore of New Bay Pond, the highly jointed rhyolite contains numerous joints coated with 1 mm pyrite cubes.

Overlying the Units OWb, OWr and OWt, is a thick sequence of sedimentary rocks (Unit OWs) that is dominated by light grey, thick-bedded medium-grained sandstone, pebbly sandstone, pebble and granule conglomerate, medium- to thin-bedded siltstone, thin-bedded pale green, red, black and grey chert, and locally slumped, disrupted sequences of siltstone and chert (Plate 2). Numerous sedimentary structures indicate that the sequence is turbiditic, possibly a submarine fan deposit, and these include normal and reverse grading bedding, scours, parallel- and crosslamination, rip-ups, load casts, interbedding of thick-bedded, coarse-grained sandstone and thin-bedded, fine-grained sandstone and siltstone. The thicker, coarse-grained sediments are concentrated in the lower (eastern) part of the sequence whereas the thinner, fine-grained units dominate the upper (western) part of the sequence.

The conglomerate and pebbly sandstone units contain clasts of vein quartz, mafic volcanic rocks, and chert, in a coarse sand matrix containing abundant quartz and plagioclase clasts; these beds commonly exceed 3 m in thickness. The sandstone units contain conspicuous plagioclase clasts in a quartz-rich matrix and beds generally range in thickness from 50 cm to 2 m. Thin-bedded (1 to 5 cm thick), light green, yellow or black chert and grey siltstone generally form sequences up to 4 m thick, and about 500 m southwest of the New Bay Pond causeway, black chert separates two basalt flows. Olistostromes comprising large blocks of contorted, interbedded grey chert and siltstone sequences set in a sandstone matrix occur 1 km east of Frozen Ocean Lake. Slabs and small fragments of chert are common in the sandstone. The upper sequence is dominated by thin- to medium-bedded siltstone and sandstone and locally contains thin chert beds. Locally, the black siltstone contains white spots that may reflect contact metamorphism by diabase dykes.

An isolated sequence of very thick-bedded, massive sandstone, located 2 km south of the western end of Frozen Ocean Lake is tentatively included in Unit OWs. This sequence appears to form an enclave within gabbro of the Hodges Hill intrusive suite. The sandstone contains locally abundant disseminated pyrite. An assay of a chip sample gave a background Au value of 6 mg/t.

The upper sequence of mafic volcanic rocks (Unit OWb) is dominated by very thick-bedded, (probably tens of metres thick), basaltic agglomerate containing minor medium- to thick-bedded mafic tuff, hyaloclastite breccia and massive basalt flows and rarely pillow basalt and flow-layered rhyolite. The agglomerate contains angular to subrounded clasts of equigranular to plagioclase-porphyritic, fine-grained basalt generally varying in size from 1 to 10 cm, set in a coarse sand matrix of basalt fragments; pillow breccia was not found and epidote alteration of the fragments is common. Bedding is apparent only where laminated mafic tuff occurs within the agglomerate. The basalt flows are generally featureless but locally contain chlorite- or quartz-filled amygdules and some flows contain plagioclase ± pyroxene phenocrysts; the pillow basalt is probably interbedded with the agglomerate. The rhyolite is grey, aphanitic and equigranular, and contains contorted thin layers. It forms a thin horizon within the mafic agglomerate 5 km southeast of Frozen Ocean Lake.

In the area east of Frozen Ocean Lake, northwest-trending, medium-grained diabase and coarse-grained, pyroxene gabbro dykes have intruded the upper agglomerate unit (Unit OWb) and the sedimentary unit (Unit OWs). The dykes are over 200 m wide and have a distinctive aeromagnetic pattern (*see* Geological Survey of Canada, 1988b). They have been dextrally displaced along a northeast-trending fault. The length of the dykes, as indicated by the aeromagnetic anomaly, is possibly 7 km but only a small portion of each dyke is exposed. Comparable dykes have been assigned to the Ordovician or Silurian Gummy Brook Gabbro by O'Brien (1998) and they appear to be restricted to the Wild Bight Group.

The northeastern zone of the Wild Bight Group comprises a lower sequence of pillow lava and massive basalt (Unit OWl), conformably overlain to the southwest by a sequence of grey to green, coarse-grained pebbly sandstone, feldspathic sandstone and minor massive basalt (Unit OWc), and an upper sequence of pillow lava and mafic breccia (Unit OWh). The proposed contact between Units OWl and OWc is exposed 3 km northeast of New Bay Pond where pillow lava is stratigraphically overlain by coarse-grained pebbly sandstone and granule conglomerate.

Unit OWl is very poorly exposed in the survey area and only the pillow lava at the contact with Unit OWc was observed during this study, but Getty Minerals (Werniuk, 1982, 1983) noted the presence of amydaloidal basalt flows 2 km to the northeast. The pillows are perfectly shaped and indicate younging to the southwest.

The overlying sedimentary sequence (Unit OWc) comprises a sequence at least 1 km thick that forms a northwest-trending belt. The western end is probably terminated by a northeast-trending fault and the unit extends beyond the eastern margin of the survey area. The lowest part of Unit OWc is a pebbly sandstone that fills in the gaps between the pillows and is undeformed. Pebbles include angular fragments of chert and basalt set in a coarse sand matrix that grades upward into medium- to thin-bedded, laminated sandstone. The most common rock type is a coarse-grained epiclastic unit containing 1- to 3-cm-long pale green clasts that may include fragments of pillow margins as well as fine-grained basalt and chert, set in a coarse sandy matrix containing fragments of quartz and plagioclase. Other components include thick-bedded, medium- and coarse-grained sandstone rich in quartz and feldspar, and laminated, thin- to medium-bedded, locally scoured, laminated and graded sandstone and rarely basalt flows that have disrupted the laminae in the sandstones.

The lower portion of Unit OWh is interpreted to conformably overlie Unit OWc but no contacts were found. Very thick beds of coarse-grained, mafic breccia dominate the unit and include highly altered, yellow to light-green mafic breccia, interpreted to be hyaloclastic basalt breccia, polymict agglomerate containing a variety of basalt fragments, and pillow breccia. Minor components include pillow lava, massive basalt flows and minor sequences of coarse-grained sandstone, pebble and cobble conglomerate that occur within the mafic volcanic sequence and immediately below the red chert and siltstone of the Shoal Arm Formation.

The lower part of Unit OWh is dominated by coarse-grained, basalt breccia having clasts of grey, green and rarely purple basalt clasts. The breccia is locally interbedded with massive pillow lava and, rarely, mafic tuff and quartz-rich sandstone. The central portion of the unit contains extensive exposures of hyaloclastite (Plate 3) which is best exposed in old gravel pits along several woods-roads, 2 km north of New Bay Pond. The rock type is dominated by light green, brecciated basalt containing very poorly sorted clasts ranging in size from a few centimetres to 1 m set in a fine-grained, green, altered matrix. Some laminated mafic tuffaceous rocks also occur within the breccia. The hyaloclastite is overlain by an extensive sequence of basalt breccia, pillow lava, pillow breccia and massive basalt flows (Plate 4). The breccia clasts are commonly angular, about 4 to 8 cm in size, variably vesicular or amygdaloidal, plagioclase-porphyritic or equigranular, fine-grained basalts.

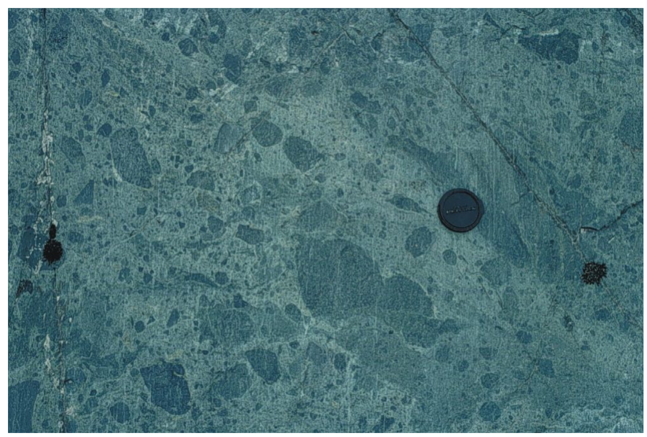


Plate 3. *Poorly sorted hyaloclastite breccia of Unit OWh of the Wild Bight Group, 2.5 km east of Big Lewis Lake; lens cap is 5 cm in diameter. Site LD980138.*

The top of Unit OWh is marked by a variety of clastic sediments. About 2 km east of Big Lewis Lake, thin- to medium-bedded sandstone, interbedded with thin-bedded siltstone and a thick-bedded boulder conglomerate occur between the upper basaltic horizon and the chert of the Shoal Harbour Formation. The boulders comprise equigranular and plagioclase-porphyritic basalt set in a feldspathic sandstone matrix. Similarly, along the main road 2 km north of New Bay Pond, within 10 m of the basalt breccia, medium-bedded, grey, pebbly sandstone is interbedded with maroon, laminated siltstone. Sedimentary features also include crosslamination and scours. The pebbles include various types of basalt and siltstone and sandstone. This

Plate 4. *Pillow breccia of Unit OWh of the Wild Bight Group, 1.75 km north of New Bay Pond; lens cap is 5 cm in diameter. Site LD 980114.*

sequence may extend to the west for about 50 m where maroon, siliceous siltstone may form the lowest exposed portion of the Shoal Arm Formation. In the northeastern corner of New Bay Pond, north of the causeway, medium- bedded, fine-grained, black, laminated sandstone and grey, medium-bedded, sandstone and pebble conglomerate outcrop between grey chert of the Shoal Arm Formation and basalt breccia of the Wild Bight Group. The sandstone displays scoured surfaces and crosslamination. The sequence of sandstone and pebbly sandstone, which is estimated to be at least 300 m thick on New Bay Pond, does not have its upper and lower contacts exposed. The pebbles include various types of basalt, and some larger slabs of sandstone occur within some sandstone beds. In an adjacent cove, 100 m to the southeast, the sandstone is not exposed and an outcrop of fine-grained, buff, quartz-porphyritic rhyolite lies between the basalt breccia and the Shoal Arm Formation.

The upper contact of the Wild Bight Group with the Shoal Arm Formation is probably a stratigraphic contact. There is no indication of either ductile or brittle deformation in either unit in the contact areas. The variations in strike of bedding may reflect open folding of both units although an angular unconformity is a possibility based on the observations in this area.

The various units of the Wild Bight Group, in both zones, dip steeply to the southwest or west. Only rarely does bedding vary from this trend. Cleavage is weak to absent in most of the volcanic rocks and is strongest in the sediments of Unit OWs where it generally trends to the southwest, dipping steeply (65 to 80°) to the northwest.

The Shoal Arm Formation

The Shoal Arm Formation forms a distinctive northwest-trending belt of steeply dipping rocks. It is approximately 500 m thick, and consists of a lower sequence of thin- to medium-bedded, variably grey, red, and maroon chert and siltstone and minor sandstone (Unit OSc), and an upper, approximately 500 m thick sequence of thin-bedded black and grey, commonly pyritic shale, siltstone and sandstone (Unit OSs). At New Bay Pond, a highly disrupted olistrostromal sequence of shale, siltstone and chert forms the equivalent upper portion of the unit.

The shale, within the olistostrome, contains graptolites indicating an upper Caradocian–lower Ashgill (Kusky, 1985) or Caradocian (Williams and O'Brien, 1994) age for the shale. During fieldwork, a new fossil locality was discovered and several graptolites were obtained from cleaved, black shale in a shallow pit within a disused aggregate quarry 2 km north of New Bay Pond (UTM coordinates 603750E 5453125N). Some of the graptolites have been provisionally identified by W.D. Boyce (Newfoundland and Labrador Geological Survey), as *Climacograptus bicornis* and *Pseudoclimacograptus scharenbergi* and are interpreted to indicate the presence of the Middle Caradoc *C. bicornis* Zone (*see* Table 1 in O'Brien *et al*., 1997).

The lower contact of the Shoal Arm Formation with the Wild Bight Group is described in the preceding section. The upper contact of the formation with the Point Leamington Formation is perfectly exposed along the main east–northeast-trending woods-road, 1.5 km north of New Bay Pond. The contact is clearly gradational as thin 1- to 4-m-thick sequences of thin-bedded black pyritic shale, and are interbedded with 1- to 2-m-thick grey feldspathic sandstone beds over a distance of 50 m. Graded beds indicate that the sequence youngs to the west. The contact between the lower chert sequence (Unit OSc) and the upper black shale sequence (OSs), on New Bay Pond, is described by Kusky (1985) as gradational over 2 m. The contact is not exposed elsewhere in the map area.

The most complete section through the chert and siltstone (Unit OSc) of the Shoal Arm Formation is exposed in narrow inlets along the north shore of New Bay Pond. Elsewhere, only parts of the section are exposed but the stratigraphic succession is consistent. The composite stratigraphy and dominant lithology from bottom to top, is as follows: 1) dark grey, medium-bedded chert and siltstone, 2) medium-bedded, maroon chert and siltstone, 3) bright red chert (jasper) and siltstone (Plate 5), 4) pink chert and siltstone, grading over a few metres, to 5) thin- to medium-bedded black (light grey-weathering) chert and minor siltstone and sandstone. Within sequence 5, just north of the main woods-road 2 km north of New Bay Pond, a >30-m-thick sequence of medium-bedded, dark blue to black, manganese-rich, black chert and siltstone is exposed in a disused aggregate quarry.

Plate 5. *Steeply dipping, medium-bedded red chert of the Shoal Arm Formation (Unit OSc), north shore of New Bay Pond; lens cap is 5 cm in diameter. Site LD980224.*

The chert and siltstone are commonly interbedded, and parallel-bedded or parallel-laminated. Graded bedding is locally present and the laminae in the chert are commonly bioturbated. Kusky (1985) has suggested that the white spots, which give a speckled appearance to the chert beds, are recrystallized radiolaria. The sandstone and siltstone beds are also quite siliceous. The sedimentary structures and petrography indicate that Unit OSc is turbiditic (Kusky, 1985).

Unit OSs of the Shoal Arm Formation is best exposed on New Bay Pond and along the main woods-road 2.5 km to the north. Thin- to medium-bedded, parallel-bedded, pyritic, black to dark grey, locally graphitic, commonly siliceous shale and siltstone and minor interbedded, medium-bedded, medium-grained, dark grey sandstone characterize the unit. Some of the thin-bedded shale sequences are siliceous and beds are separated by siltstone laminae. The interbedded sandstone locally forms 1-m-thick beds, and feldspar clasts are conspicuous. Other sedimentary features noted in the sandstone and siltstone include graded bedding, parallel- and crosslamination, and scoured bases, indicating a turbiditic origin.

At New Bay Pond, the unit is highly deformed and tight isoclinal folds have been noted. Bedding is disrupted and large blocks of parallel-bedded, folded sequences are set in a chaotic matrix (Plate 6). The cleavage within this sequence is not axial planar to any of the folds. The sequence is interpreted to be an olistostrome and Kusky (1985) has determined that the sequence slumped to the southeast.

The Shoal Arm Formation possess a strong cleavage that generally trends to the southwest and dips steeply to the southeast or northwest at about 80°. The cleavage is nearly at right angles to bedding and the West Arm Brook Thrust. A few open folds were noted and these have nearly vertical axes.

Plate 6. *Tightly folded, interbedded grey chert and siltstone in an olistostrome horizon within the upper portion (Unit OSs) of the Shoal Arm Formation, north shore of New Bay Pond; hammer head is 18 cm in length. Site LD980219.*

A sample of pyrite-rich sandstone from Unit OSs was assayed and returned no detectable Au. The Cr value of 370 g/t and Ni value of 180 g/t indicate that the source rocks could be mafic volcanic rocks from the upper portion of the Wild Bight Group (*see* Table 1 in Swinden and Jenner, 1992).

Badger Group (Unit OSB)

The sedimentary rocks (Unit OSBp) overlying the Shoal Arm Formation at New Bay Pond were originally assigned to the Exploits Group by Williams (1964a) and correlated with the Sansom greywacke of the Exploits Group by Dean (1977). The sedimentary rocks (Units OSBs, OSBc, OSBh), located in the southwestern portion of the survey area, were originally assigned to the Sansom Formation, and Unit OSBv to the north, which contains minor felsic volcanic rocks, was assigned to the Sivier Formation, both of the Exploits Group, by Hayes (1951a). These units have been reassigned to the informally proposed Late Ordovician to Early Silurian Badger group by Williams *et al.* (1995) as they also overlie the Caradocian Shoal Arm Formation to the south of the Hodges Hill area (*see* Kean and Mercer, 1981). These units have not been given new formation names within the Badger group and await further study.

The Point Leamington Formation

The Point Leamington Formation (Unit OSBp) conformably overlies the Caradoc to possibly lower Ashgill Shoal Arm Formation and follows the stratigraphic nomenclature of Williams (1991). The top of the sequence is not exposed as it is in thrust contact with the Wild Bight Group. The Point Leamington Formation (Unit OSBp), in the survey area, is a sequence of southwest-dipping, interbedded, thick-bedded sandstone, very thick-bedded, coarse-grained, pebbly sandstone and granule conglomerate, and rare medium-bedded, medium-grained sandstone and siltstone. No fossils were found in the map area but, in other areas, the formation contains Late Ordovician to Early Silurian fossils (e.g., Williams, 1991; Williams and O'Brien, 1991). Near the base of the formation, on the main road north of New Bay Pond, a >5-m-thick unit of buff, cleaved, quartz–feldspar porphyry outcrops within a series of thick sandstone beds. The contacts are not exposed and there is no indication that the rock is volcanic. It is interpreted to be a small intrusive plug. The Point Leamington Formation is estimated to have a maximum exposed thickness of 1.5 km.

The Point Leamington Formation is dominated by thick- (about 1 m) to locally very thick-bedded (locally exceeding 5 m), parallel-bedded, buff to grey, sandstone and pebbly sandstone. The pebbly sandstone horizons are concentrated near the top of the sequence. The sandstone is quartz-rich and clasts of plagioclase are conspicuous. In the pebbly sandstone and granule conglomerate, the lithic fragments commonly include mafic and felsic volcanic rocks, vein quartz, and chert. Sedimentary features, commonly in various combinations, include normal- and reverse-graded bedding, cross- and parallel-lamination, scours, rip-ups, and flame structures. These features, along with the bed thickness, are indicative of proximal turbidite deposition. Kusky (1985) proposed that deposition was toward the present-day southeast on the basis of slump folds and crosslamination.

The formation generally dips steeply to the southwest and south-southwest at 60 to 80°. Toward the thrust contact with the Wild Bight Group, bedding is locally overturned to the northeast. The sandstone displays a variably developed, steeply northwest-dipping cleavage displayed as widely spaced (approximately 10 cm apart) fractures. The thicker bedded and coarser grained units rarely display cleavage.

Pyrite mineralization was noted 1 km southeast of Big Lewis Lake where a 50-cm-wide and 10-m-long rusty zone in sandstone contains several 1-cm-thick pyrite veins. A chip sample of the sandstone and the veins was assayed but gold was not detected.

Unnamed Badger Group Units

Unit OSBv is a poorly exposed unit located southwest of North Twin Lake. Hayes (1951a,b) indicated that the unit was exposed along the western shore of the lake but dam construction has raised the former shoreline so that the unit is now only visible in extensive glacial erratics. The stratigraphic position of the unit is uncertain other than that it is older than the Hodges Hill intrusive suite. Hayes (1951a,b) shows the unit to be in fault contact with the other stratified units exposed in the adjacent map areas. The few outcrops exposed inland include thin- to medium-bedded, migmatized biotite semipelite and psammite and rarely medium- to thick-bedded, lithic felsic tuff. Bedding is highly contorted and disrupted by granitic migmatite veins. The well-developed cleavage is gently dipping at about 20° and is shallower than right-way-up bedding, which dips at around 50° indicating that the sequence is downward facing. The extensive metamorphic biotite development and migmatization of the unit is probably related to contact metamorphism by gabbro and granodiorite of the Hodges Hill intrusive suite.

Units OSBs, OSBc, OSBh are exposed to the south and west of Middleton Lake and Cornfield Pond. The three units comprise a generally very gently dipping, open-folded sequence comprising a lower unit (Unit OSBs) of thick-bedded grey sandstone, overlain by very thick-bedded pebble and cobble conglomerate and sandstone (Unit OSBc), and an upper unit of thin- to medium-bedded sandstone (Unit OSBh).

Unit OSBs is a poorly exposed unit that outcrops 2 km southwest of Middleton Lake and is comprised of thick- to very thick-bedded, coarse- to very coarse-grained sandstone.

Unit OSBc is an extensive unit that extends across the southwest corner of the survey area. The unit is characterized by very thick-bedded, generally parallel-bedded, coarse-grained pebble conglomerate containing interbedded, thick-bedded, coarse-grained sandstone and pebbly sandstone (Plate 7). The conglomerate beds range in thickness from about 1 m to over 5 m; the sandstone beds vary in thickness from about 30 cm to 2 m. Clasts in the conglomerate are rounded to subrounded and are commonly 2 to 10 cm in diameter. The clast rock types are dominantly white-weathering, black chert, and minor vein quartz, siltstone, limestone, felsic volcanic rocks, and medium-grained granite set in a matrix rich in plagioclase, quartz, and chert fragments. The limestone clasts are deeply weathered. Sedimentary structures are particularly well developed and include graded-bedding, cross- and parallel-lamination, scours, conglomerate and sandstone lenses, and large rip-up clasts of sandstone in the conglomerate beds. These features are possibly indicative of submarine fan deposition.

In gradational contact with the conglomerate is a sequence (Unit OSBh) of thin- to medium-bedded, fine- to medium-grained, parallel-bedded sandstone containing, toward the base of the sequence, thin interbedded pebble conglomerate and very coarse-grained sandstone beds. The sandstone is generally dark grey to black and has rusty horizons. Feldspar and chert fragments are locally conspicuous in the sandstone. The coarser grained units contain chert pebbles. Sedimentary features include cross- and parallel-lamination, graded beds, and scours. The sequence youngs toward the north and is generally right-way-up although in a

Plate 7. *Thick-bedded, chert-pebble conglomerate and overlying thick-bedded sandstone (Unit OSBc) of the Badger group, southwest corner of Middleton Lake; lower conglomerate bed is about 1.25 m thick. Site LD980680.*

Plate 8. *Highly disrupted and migmatized sandstone (Unit OSBh) of the Badger group near the contact with gabbro of the Hodges Hill intrusive suite, 1 km southwest of Mary Ann Lake; lens cap is 5 cm in diameter. Site LD980397.*

few places the beds are overturned with dips varying from 10 to 70°. The sedimentary features could also indicate submarine fan deposition.

The beds are gently dipping and possess a cleavage that is commonly subparallel to bedding. In the overturned beds, cleavage is more steeply dipping than bedding and is hence downward facing. Metamorphic biotite is apparent on the cleavage planes and is probably mimetic resulting from contact metamorphism. Biotite is more abundant where the rusty horizons occur. Toward Mary Ann Lake, the grade of metamorphism increases and migmatization of the thin-bedded sandstones occurs in proximity to the gabbro of the Hodges Hill intrusive suite, resulting in disruption of the beds by granitic veins (Plate 8).

Unit OSBh is complexly deformed on the large island in Middleton Lake. Bedding attitudes are highly variable but cleavage is generally gently dipping. Where less deformed, bedding and the sub-parallel cleavage are openly folded and define a series of gently northeast-plunging folds. The parallelism of the gently dipping cleavage and bedding indicates that the early deformation of the Badger group produced recumbent folds (F_1) and the later open folds are therefore F_2 structures. Similar structures are described from the Roberts Arm Group in the Gullbridge area, 15 km northwest of Middleton Lake, by Pope *et al*. (1990) and Pudifin (1993). In the Gullbridge area, the Roberts Arm Group is recumbently folded and has overthrust the Sansom Greywacke (now part of the Badger group). The migmatization and hornfelsing of the polydeformed sandstones indicate that regional deformation occurred prior to intrusion of gabbro of the Hodges Hill intrusive suite and is therefore older than the recalculated 423 ± 20 Ma age obtained by Wanless *et al*. (1965) from granodiorite in the North Twin Lake area and younger than the Caradocian age (*D. Clingani* Zone, Williams, 1988; approximately 450 Ma, *see* O'Brien *et al*., 1997; Tucker and McKerrow, 1995) of the Shoal Arm Formation, which underlies the Badger group.

Charles Lake Sequence

The Charles Lake sequence (Unit SC) comprises a bimodal rhyolitic–basaltic volcanic suite associated with minor sedimentary rocks including conglomerate, sandstone and siltstone. The area underlain by the unit occurs to the northwest of the Northern Arm Fault and to the southeast of "Charles Lake". The unit has not been mapped in detail but its extent is not as great as shown by Swinden (1987b, 1988) as the unit is terminated by granite southeast of "Charles Lake". The rhyolites are most abundant 2 km southeast of "Charles Lake" where they are the only exposed rock. In other areas, the rhyolite appears to be interbedded with the more extensive, massive basalt flows.

The northern extent of the unit in the southern New Bay Pond area is complicated by a diabase dyke swarm that generally forms the only exposures in the area and the host rock is a featureless basalt that could possibly be part of the Wild Bight Formation. However, the lack of the basaltic breccia, that is so characteristic of the Wild Bight Group, indicates that the basalts are probably part of the Charles Lake sequence. A few isolated exposures of felsic tuff and basalt outcrop about 3 km west of "Charles Lake". The extensive bog in the area masks the relationship of the presumed Charles Lake sequence rocks to the main zone, but a ridge of granite intervenes between the two areas.

The most characteristic component of the Charles Lake sequence is red to purple, massive, very fine-grained (Plate 9) rhyolitic ash-flow tuff that has a eutaxitic layering and locally contains quartz and feldspar phenocrysts and flat-

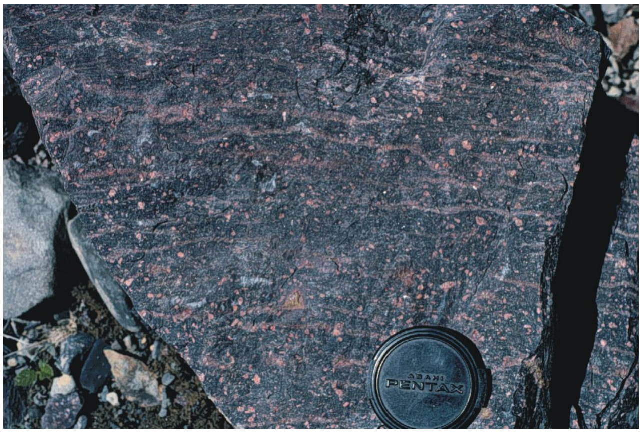


Plate 9. *Flow-layered, quart–feldspar-porphyritic ignimbrite of the Charles Lake sequence (Unit SC), road to Northern Arm Pond; lens cap is 5 cm in diameter. Site LD980047.*

tened fiammé. The layers are about 3 mm thick, discontinuous and highly contorted. Other felsic rock types include fine-grained tuffaceous rocks containing 30 cm blocks of layered tuff, and massive, pale grey tuff with 1 cm tuffaceous fragments, and massive feldspar-porphyritic very fine-grained glassy tuff.

The basalt is generally very fine grained and locally contains small plagioclase phenocrysts. Flows are very thick and only rarely were flow tops observed. At one locality a 10-cm-thick tuff bed occurs within the basalt. One flow of basalt pillow lava was discovered 1.5 km southeast of "Gull Pond" within a sequence of massive flows. Minor epidote ± quartz alteration and veining are quite common. In a few places, feldspar-porphyry dykes and possible plugs of quartz –feldspar porphyry have intruded the massive basalt flows.

Several types of sedimentary rock also occur within the sequence and include spectacular cobble conglomerate on the road to Northern Arm Pond. The clasts are dominated by volcanic rocks and include rhyolitic ash-flow tuff, plagioclase-porphyritic and equigranular, fine-grained basalt, laminated felsic tuff, and massive rhyolite. The conglomerate may be in fault contact with the Charles Lake sequence and is possibly an outlier of the Wigwam Formation of the Botwood Group (*see below*). At one locality, medium-grained, grey sandstone overlies the reddened top of a basalt flow. The only extensive area of sedimentary rock is an approximately 5-m-thick sequence of fine-grained, medium-bedded sandstone and siltstone that appears to lie within the basalt flows. The few bedding planes observed indicate that the Charles Lake sequence forms a northeast-plunging open syncline with the limbs dipping at up to 70°.

The Charles Lake sequence is quite distinct from the Wild Bight Group in that it is mainly a terrestrial sequence of volcanic flows and the few sedimentary horizons could also have formed in this environment. The age of the sequence is assumed to be Silurian and is possibly a correlative of the Lawrenceton Formation (*see below*), which does contain similar felsic and mafic flows. The Lawrenceton Formation in the Botwood area (NTS 2E/3) also contains elongate belts and lenses of interbedded felsic and mafic subaerial volcanic rocks and spectacular cobble conglomerates (Colman-Sadd, 1994).

Botwood Group–Lawrenceton and Wigwam Formations

The Lawrenceton Formation (Unit SBl) and the overlying Wigwam Formation (Unit OSw) of the Botwood Group (Williams, 1972) underlie the southeast corner of the map area, southeast of the Northern Arm Fault. The Lawrenceton Formation is exposed along Peters River where it forms the core of a northeast-plunging anticline. The extent of the formation below the Wigwam Formation is indicated by the aeromagnetic anomaly pattern (Geological Survey of Canada, 1988a,b) which shows a magnetic anomaly extending from the start of Peters River (in the survey area) northeast for 11 km. Only the first 2 km of the anomaly are exposed within the survey area. The main rock types are black, massive, coarsely plagioclase-porphyritic, very thick-layered basalt and pink to grey felsic tuff locally containing an abundance of flow-banded rhyolite clasts, and minor interbedded grey medium- to thick-bedded sandstone. The felsic tuff forms beds up to 50 m thick. Layering in the beds is locally flow-folded. The various features of the volcanic rocks are consistent with terrestrial volcanism.

The Wigwam Formation (Unit SBw) is very poorly exposed and only in Bishop's Falls is there any extensive exposure. The few bedding measurements obtained indicate that the formation forms a series of northeast-plunging folds with steep limbs. The dominant rock type is very thick- to thick-bedded, large-scale parallel- or crosslaminated, locally ripple-drift laminated, red medium-grained sandstone and minor thin- to medium-bedded siltstone. Graded bedding and rippled surfaces are common in the Bishops Falls area. The sandstone also occurs as featureless massive rock displaying no indication of bedding, but it commonly has a well-developed subhorizontal fissility that may indicate bedding attitudes. Along with quartz and feldspar, the sandstone commonly contains white mica and opaque fragments. Isolated outcrops of matrix-supported, pebble conglomerate occur within the sandstone sequence. They are composed mainly of volcanic fragments clearly derived from the Lawrenceton Formation.

The Wigwam Formation in the survey area was interpreted by Wessel (1975) to have been deposited in a mainly fluvial environment and is a transitional facies with the shallow-marine environment that lay to the southeast. This interpretation is supported by the structures in some rock-cuts along the TCH that may not have been available to Wessel (*op. cit.*). The poorly sorted conglomerate within the cross-laminated sandstone, exposed north of Peters River, would lie within the fluvial facies whereas the rock-cuts on the TCH containing ripple-drift lamination, rippled surfaces and large-scale crosslamination would be indicative of both fluvial and marine components.

INTRUSIVE ROCKS

Hodges Hill Intrusive Suite

The name, Hodges Hill intrusive suite, is informally introduced here for the plutonic rocks that extend throughout the survey area and extend to all adjacent areas (*see* Colman-Sadd *et al*., 1990). Various names have been used for components of the suite such as Twin Lakes Diorite, Twin Lakes complex, Twin Lakes diorite complex, Twin Lakes intrusive suite, Hodges Hill granite or Granite, Hodges Hill Complex, Hodges Hill Intrusive Complex, Hodges Hill igneous suite, and Hodges Hill–Twin Lakes igneous suite.

The suite contains a wide variety of rock types ranging in composition from mesocratic clinopyroxene-rich gabbro to leucocratic alkali-feldspar granite. Within the suite, intrusive relationships indicate a general sequence from mafic to felsic intrusive activity. The only radiometric dates are from the granite in the Hodges Hill area, which gave a Rb/Sr isochron age of 415.6 ± 2.1 Ma (Moore, 1984), granodiorite from the southern end of North Twin Lake, which gave a recalculated age of 423 ± 20 Ma, and granodiorite from South Twin Lake, which gave a recalculated age of 383 ± 12 Ma (Wanless *et al*., 1965, 1967).

The gabbroic rocks have not been radiometrically dated. However, they are cut by the dated Silurian granite. Intrusive relationships and contact metamorphism of the Late Ordovician to probable Early Silurian Badger group at Cornfield Pond, the North Twin Lake area, and south of Mary Ann Pond indicate that the gabbroic rocks are also Silurian in age.

The granitic rocks are known to have intruded the Late Ordovician to Early Silurian Badger group (e.g., Kean and Mercer, 1981), and the Wild Bight Group is intruded by granite at the eastern end of Frozen Ocean Lake and by granite dykes east of New Bay Pond and west of North Twin Lake. Thin granite dykes are common within massive, fine-grained basalt flows of the Charles Lake sequence northeast of Northern Arm Pond. The dykes are similar to the nearby granite and are almost certainly related. The Botwood Group and the Hodges Hill intrusive suite are only in fault contact. There is no indication of an intrusive relationship.

Contacts between the gabbro and the larger granitic intrusions within the suite are rarely exposed and transitional contacts are the norm in the South Twin Lake area. The transition zones vary in width from about 100 to 300 m, and the rock type grades from dark grey, pyroxene gabbro through lighter grey hornblende ± biotite granodiorite to pink or buff, biotite ± hornblende granite and granodiorite. In a few places, magma mixing with partial assimilation of the gabbro inclusions appears to have taken place, e.g., east of Cornfield Pond. In some areas, the granite contains abundant angular gabbro inclusions that appear to be chemically unmodified. Contacts with large granite dykes and some of the smaller granite intrusions vary from sharp, e.g., along the north shore of South Twin Lake, to zones with gabbro invaded by several medium-grained granite dykes, e.g., along the roads north and south of Rocky Pond.

Foliated Biotite Granite (Unit SHgf)

Within the suite, there is evidence that a variably foliated, medium- to coarse-grained leucocratic biotite granite, exposed in and around Mary Ann Lake, may be the oldest intrusive unit. The granite (Unit SHgf) is a weakly to strongly foliated, biotite granite that is intruded by undeformed granite (Unit SHgc) on the peninsula in the southern portion of Mary Ann Lake. To the southeast of the lake, strongly foliated granite is in close contact with the typical undeformed medium-grained gabbro (Unit SHgp). The foliated granite contains an abundance of metasedimentary and metaigneous inclusions including large coarse-grained pyroxene-rich screens, and biotite-rich psammitic schist, orthoquartzite, massive amphibolite, layered amphibolite, and banded ?gneiss (Plate 10). The inclusions vary in size from a few centimetres to several metres. The local abundance of the biotite psammite has produced a rusty appearance in the granite. The pyroxenite screens are net-veined by the granite. However, this could also be the result of remobilization of the granite during the later intrusion of a pyroxenite dyke rather than veining of a xenolith.

The fabric in the granite is strongest toward its present-day margins north and south of Mary Ann Lake. Within the granite, the fabric is displayed by a variably developed mineral alignment and fractures that parallel this alignment.

Massive Equigranular Gabbro (Unit SHgp)

Massive, grey, equigranular, medium-grained, pyroxene gabbro (Unit SHgp; Plate 11) is the dominant rock type in the northwest portion of the survey area and extends from south of Mary Ann Lake to beyond the northern and western

Plate 10. *Rust-coloured, weakly foliated granite, Unit SHgf of the Hodges Hill intrusive suite, containing elongate quartzite (white) and amphibolite (black) xenoliths; central portion of Mary Ann Lake; lens cap is 5 cm in diameter. Site LD980602.*

margins. Smaller areas of gabbro occur south of Frozen Ocean Lake and south and east of New Bay Pond. In the South Twin Lake–Rocky Pond area, the gabbro is intensely net-veined by thin, fine-grained granitic veins (Plate 12). In other areas, the gabbro is cut by a few isolated, fine-grained granitic veins and granite pegmatites. Southeast of New Bay Pond, the gabbro is medium grained and contains varying proportions of pyroxene, hornblende and biotite.

Other varieties of gabbro included within Unit SHgp are pyroxene-rich gabbro and layered gabbro. The pyroxene gabbro occupies small areas within the medium-grained gabbro, e.g., south and east of Rocky Pond. The gabbro contains only a small amount of plagioclase (possibly <10 percent) and is cut by a few thin veins. Three kilometres southwest of Frozen Ocean Lake, melanocratic to mesocratic, medium- to coarse-grained, pyroxene gabbro locally contains pods of spectacular pyroxene–plagioclase pegmatite with some pyroxene crystals approaching 10 cm in length.

Layered, pyroxene gabbro outcrops along the shore southeast of the peninsula in Mary Ann Lake, and also 1.5 km north of the central part of South Twin Lake. The layered gabbro is associated with ophitic gabbro that contains 1- to 2-cm-diameter concentrations of pyroxene crystals in a plagioclase-rich matrix. The ophitic gabbro occurs above and below the layered gabbro. At Mary Ann Lake, the layered gabbro occurs on a small island and in a small area (<1 km^2) to the southeast. The layers are about 10 to 30 cm thick and reflect alternating variations in the pyroxene:plagioclase ratio. The layers dip to the southwest at 30 to 60°.

Northwest of South Twin Lake, the layered gabbro occupies a more extensive area (>3 km^2) but the northeastern extent is unknown. The aeromagnetic anomaly (Geological Survey of Canada, 1988a,b), which coincides with the layered gabbro, forms a north-trending zone that extends to the north and southward to the shore of South Twin Lake. The eastern margin of the anomaly is quite abrupt and may indicate a sharp contact with magnetically different rocks. The layers dip to the northeast at 70 to 90° and are commonly 5 to 30 cm thick and rarely some exceed 3 m in thickness. The layers again reflect the variations in the plagioclase:pyroxene ratio.

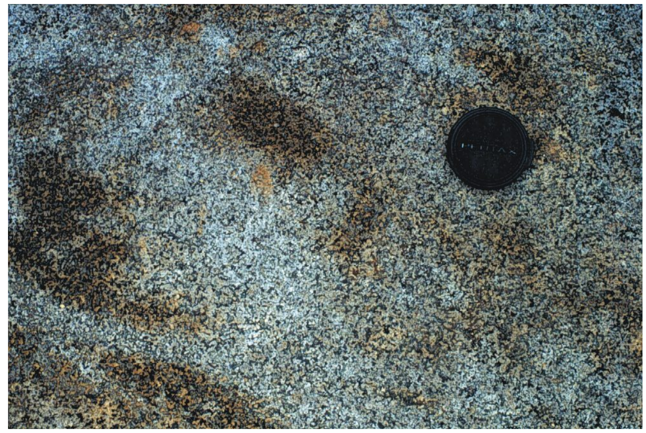


Plate 11. *Massive, medium-grained, equigranular pyroxene gabbro, Unit SHgp of the Hodges Hill intrusive suite, 4 km south of Frozen Ocean Lake; lens cap is 5 cm in diameter. Site LD980420.*

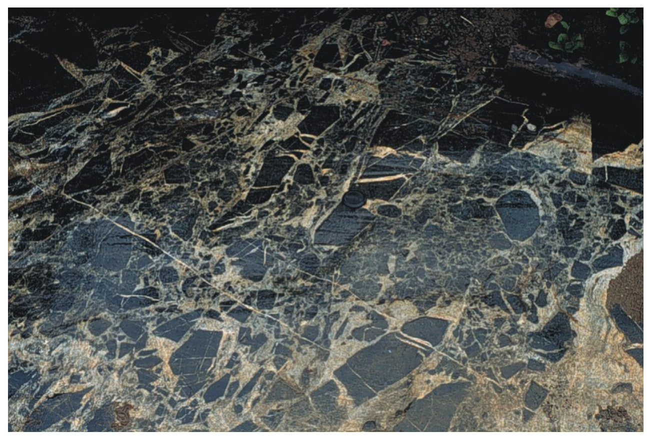


Plate 12. *Intensely granite-veined fine-grained gabbro, Unit SHgp of the Hodges Hill intrusive suite, 1 km southwest of Rocky Pond; lens cap (near centre of plate) is 5 cm in diameter. Site LD980319.*

Massive, Medium-Grained, Two-Feldspar Granite and Granodiorite (Unit SHgk)

Two-feldspar granite and granodiorite occurs throughout the area with the largest continuous area found east of

Frozen Ocean Lake. Small granitic intrusions are common in the gabbro in the Twin Lakes area. Along the southeastern shore of South Twin Lake, grey to buff granodiorite and rarely tonalite appear to form a transitional rock type between the gabbro to the west and granite to the east. The typical rock of Unit SHgk is massive, medium-grained, buff to pink, biotite ± hornblende granite or granodiorite locally containing 1- to 2-cm-long K-feldspar phenocrysts. An unusual medium-grained, blue-grey, biotite–hornblende granite outcrops 2 km southeast of South Twin Lake. South and southeast of New Bay Pond, small intrusions (<1 km^2) of leucocratic, pink, biotite granite occur within the gabbro terrain.

Massive, One-Feldspar Granite and Associated Fine-Grained Granite (Unit SHgc)

An extensive area of the Hodges Hill intrusive suite in the area east of Middleton Lake is underlain by a variety of one-feldspar (hypersolvus), locally two-feldspar, leucocratic granites. East of Cornfield Pond, the suite is bordered by an approximately 1-km-wide band of fine-grained, two-feldspar, biotite granite that is in assumed gradational contact with the main granite. The high ground in the vicinity of Hodges Hill is underlain by massive, medium-coarse-grained to coarse-grained, mainly equigranular, one-feldspar, locally miarolitic granite (Plate 13). The colour of this granite varies throughout the area, but pink and red are the main colours; buff, grey, orange, purple and green varieties have also been noted. Detailed thin-section analysis of the granites has been done by Kerr (1995) and the following observations are based on this work. The feldspar is microcline perthite and the mafic mineral content of the granite is low at less than 5 percent. The dominant mafic mineral is hornblende and this is locally found with a core of green clinopyroxene and, in some samples, the hornblende is mantled by sodic amphibole. In the red and orange granites, the hornblende is partially replaced by iron oxides and fine-grained biotite. Kerr (*op. cit.*) also noted that many samples from this area contained graphic intergrowths of quartz and K-feldspar. The presence of sodic amphiboles indicates that the one-feldspar granite has a peralkaline affinity and Kerr (1995) has noted similarities with the Silurian Topsails intrusive suite.

The coarse-grained granite is poorly exposed to the northeast of Hodges Hill and the dominant rock-type is pink, equigranular, biotite granite; some of the mafic minerals may be amphibole. The low ground east of Hodges Hill is underlain by mainly red to pink, medium-grained, miarolitic, ?biotite–hornblende granite and minor coarse-grained granite. The rock is extremely friable and is locally cut by thin quartz veins.

The fine-grained granite along the margin of the Hodges Hill intrusive suite forms a nearly continuous band about 500 m to 1.5 km wide. It is in gradational contact (i.e., there is evidence for assimilation), to the west, with gabbro at Cornfield Pond. It has also intruded the Badger group sedimentary rocks, 1.5 km southeast of Cornfield Pond, where thick granite dykes cut the thin-bedded sandstone and screens of Badger group occur within the granite.

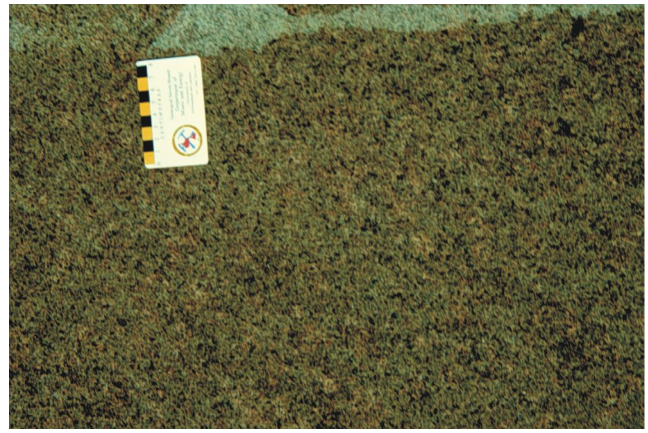


Plate 13. *Massive one-feldspar granite, Unit SHgc of the Hodges Hill intrusive suite, 2 km south of Hodges Hill; Scale-card in centimetres. Site AK941037.*

The contact between the fine-grained and coarse-grained granite is not exposed, but coarse-grained granite outcrops 300 m to the east, along the main road to Hodges Hill. Thin veins and patches of fine-grained aplitic granite cut the coarse-grained granite near the contact. Kerr (1995) suggested that the fine-grained granite veins may be offshoots from the marginal phase of fine-grained granite and indicate that the fine-grained granite is the younger phase. This is also supported by the presence of a narrow aeromagnetic anomaly along the trace of the assumed contact between the granites (Geological Survey of Canada, 1988b). Three kilometres southeast of Cornfield Pond, the contact zone displays evidence of a transitional contact as there is 1), a gradual increase from fine- to medium-coarse-grained rock within the two-feldspar granite toward the contact with the one-feldspar granite 2), the miarolitic cavities occur in both units 3), the mafic mineralogy appears similar, i.e., amphibole occurs in both types of granite and, 4) the granites have very similar deep red coloration. The thin, fine-grained granite veins could be late-stage residual liquids from the coarse-grained granite.

A prominent feature of the coarse-grained granite, in the Hodges Hill area, is the well-developed subhorizontal jointing and widely spaced vertical joints. The horizontal joints commonly produce ledges 60 cm to 1.5 m thick (Plate 6 of Kerr, 1995). The wide spacing of the vertical joints produce large slabs commonly having surface areas of more than 4 m^2. These features along with the interesting colours and uniform texture has led to extensive staking and exploration of the dimension-stone potential of the Hodges Hill area (Kerr, 1995).

Diabase Dykes (Unit SDd)

A feature of nearly every unit within the survey area is the presence of diabase dykes. Only the Wigwam Formation of the Botwood Group, which is very poorly exposed, is not known to contain any dykes, but isolated dykes are known to occur within the formation in the Botwood area (e.g., Dickson, 1994). The dykes have intruded mainly Silurian-aged units but some within the Ordovician units could be of Ordovician age.

The greatest concentration of diabase dykes is in the "Gull Pond"–New Bay Pond area where nearly continuous exposures over 200 m long are composed of >90 percent diabase dykes with a few screens of country rock. In these areas, the dykes are parallel and commonly the early dykes are split by later dykes (Plate 14). The dykes are commonly 20 cm to 3 m thick but locally thicker dykes, some up to 15 m thick, were found. Thin, fine-grained (chilled) margins are usually well developed and the cores of the dykes are medium grained. In the very large dykes (>5 m thick), the cores of the dykes are medium-grained gabbro. In this area, a distinctive variety of diabase is conspicuously plagioclase–porphyritic and contains abundant rectangular, zoned phenocrysts up to 1 cm in length. This type cuts earlier fine-grained, equigranular diabase and is cut by similar fine-grained diabase dykes. Screens of granodiorite occur rarely in the dykes.

The Badger group is also cut by dykes and these are mainly 1 to 2 m thick. A very thick coarse-grained gabbro dyke cuts the thin-bedded sandstone and conglomerate west of Middleton Lake.

The foliated granite (Unit SHgf) and the gabbro (Unit SHgp) at Mary Ann Lake are also cut by numerous but solitary dykes. These dykes commonly range in thickness from 10 cm to 3 m and rarely thicker dykes are found. The dykes are commonly equigranular and some contain small plagioclase phenocrysts. The coarse-grained dykes locally display ophitic textures. A common feature of many dykes that cut the granites in the Twin Lakes area is veining of the diabase by remobilized granite. Commonly, the diabase dyke forms zones of ovoid xenoliths displaying chilled margins (Plate 15). The diabase dykes that cut the granite at Hodges Hill are fine grained and equigranular.

The dykes in the "Gull Pond"–New Bay Pond area generally trend northeastward (030 to 060°) and are steeply dipping. In the Wild Bight Group, the dykes generally parallel the regional northwest strike of the units. On Mary Ann Lake, two general orientations are apparent, *viz.*, 060 and 100°. The dykes are similar in texture and mineralogy. Crosscutting dykes are rare and, where in contact, the northeast dykes cut the east-trending dykes. However, the overall similarity of the dykes suggests little difference in age.

Plate 14. *Medium-grained diabase dyke cut by fine-grained diabase dyke (Unit SDd) displaying a chilled margin, north shore of Gull Pond; lens cap is 5 cm in diameter. Site LD980082.*

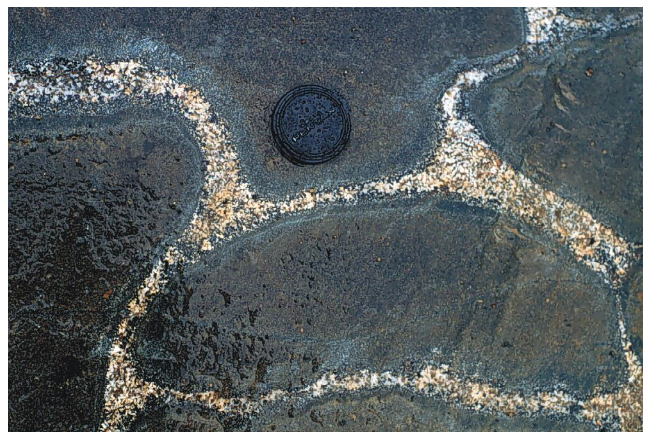


Plate 15. *Diabase dyke "pillows" (Unit SDd) in a hornblende granodiorite (Unit SHgk) matrix. The hot intrusive dyke has remobilized the older granodiorite and chilled against the relatively cool granodiorite, 3 km south of South Twin Lake; lens cap is 5 cm in diameter. Site LD980628.*

The age of the dykes is uncertain. The youngest units that are commonly cut by diabase are the Lawrenceton Formation and the massive granites of the Hodges Hill intrusive suite. The general lack of diabase in the Middle Silurian? Wigwam Formation may indicate that the dykes predate this formation. Extensive basalt volcanism is exhibited by both the Charles Lake sequence and the Lawrenceton Formation. The conspicuously plagioclase-porphyritic diabase dykes in the "Gull Pond"–New Bay Pond area resemble the plagioclase-porphyritic basalts in the Lawrenceton Formation indicating that they may be related. Similarly, the equigranular dykes may be related to the aphyric basalts in Lawrenceton Formation and the Charles Lake sequence. The dykes within the Hodges Hill intrusive suite appear to have no potential volcanic equivalents. Diabase dykes in the country rocks (e.g., Badger group) close to the suite may be offshoots from the gabbro. Geochemical analysis of the various igneous components, currently in progress, may provide insight into the possible and impossible sources for the dykes.

GEOCHEMISTRY

The granites and gabbros of the Hodges Hill intrusive suite have been randomly sampled using a 2- by 2-km grid system. Miscellaneous samples have also been collected from the volcanic rocks and diabase dykes and mineralized veins and rocks for a total of 128 samples. These will be analyzed for major and trace elements. Assays from three pyritic samples have been noted in the description of the Wild Bight Group and the Shoal Arm Formation. No significant Au values were obtained. Three other samples have been submitted for assay.

ECONOMIC POTENTIAL

The base-metal potential of the Wild Bight Group around New Bay Pond has been investigated by many exploration companies. The areas that have received the greatest interest lie along the top of Unit OWp, located south and west of New Bay Pond, where most exploration took place during the 1970s and 1980s. Numerous geophysical and geochemical anomalies were explored in detail but no economic mineralization was found. Swinden and Jenner (1992) showed that this unit has clear similarities with the horizon containing the Point Leamington massive sulphide deposit. The known association of the deposit with felsic volcanic rocks suggests that other areas of felsic volcanic rock that have not been studied in detail are potential targets. In particular, the area east of New Bay Pond contains large areas of rhyolitic flows, possibly high-level felsic intrusions and felsic tuffs, and these are all associated with mafic volcanic rocks of the Wild Bight Group.

The Shoal Arm Formation is highly pyritic in places and may have some potential for gold mineralization. One assay was done but did not produce a significant gold value. A pyritic vein was discovered in the Point Leamington Formation north of New Bay Pond but no significant base-metal values were obtained.

The foliated granite in the Mary Ann Lake area locally appears highly altered displaying widespread rust staining. The staining appears to be related to numerous biotite psammite xenoliths in the granite and no significant sulphide mineralization was observed.

The dimension-stone potential of the granite at Hodges Hill is well known (Kerr, 1995) and much of the ground has been staked. Two test pits were developed by International Granite Corporation and blocks have been extracted. These pits have been developed on the side of a small hill. The granite contains well-developed horizontal joints spaced 60 cm to 1.0 m apart. The widely spaced vertical joints allow the extraction of large sheets of granite. Other areas of the Hodges Hill intrusive suite show some potential for dimension stone, including a small area of very dark grey, medium-grained, massive pyroxene gabbro located along the variably overgrown and washed out, woods-road east of Rocky Pond (UTM 768 468, NTS 2E/4). The gabbro has widely spaced vertical and horizontal joints and is virtually vein free.

Another site showing potential is the northwest side of Bob's Hill (UTM 737 437), which is located 1.5 km south of Rocky Pond and accessible by an overgrown woods-road. A vertical face of dark grey, medium-grained, massive gabbro contains 1- to 4-m-spaced horizontal joints and widely spaced vertical joints.

An area of dark grey gabbro is located around a high ridge 4 km south of Frozen Ocean Lake (UTM 923 424). The rock type is a massive, medium- to coarse-grained pyroxene gabbro, which locally contains mafic pegmatite patches. Jointing has a spacing of up to 2 m and moderate-sized blocks could be obtained. The area is accessible by roads that run to the east and north of the ridge.

A poorly exposed area of blue-grey, medium-grained granite is located 2 km southeast of South Twin Lake along the south side of the woods-road (UTM 865 474). The granite, which appears to be fresh, forms 50- to 70-cm-thick sheets in a low-lying area covered by extensive deposits of gravel. A similar granite occurs 1.5 km to the west about 100 m south of the road but it is in contact with screens of sandstone and is cut by diabase.

Other areas of massive rock with few joints include the agglomerates south of Frozen Ocean Lake (e.g., UTM 985 494), where virtually unjointed agglomerate forms a long ridge. Very large blocks could be extracted if a grey-green mottled rock similar to serpentine or green marble was required.

International Granite Corporation has two small granite test quarries, 3.5 km south of Hodges Hill, from which granite blocks are being used for monument bases.

SUMMARY

The oldest unit in the Hodges Hill area (NTS 2E/4) is the Early to Middle Ordovician Wild Bight Group comprising a lower sequence of island-arc mafic and minor felsic volcanic rocks, overlain by turbiditic sedimentary rocks derived from the arc, and an upper sequence of non-arc mafic volcanic rocks. The upper sequence is conformably overlain by fine-grained turbiditic thin-bedded chert and slate of the Caradocian Shoal Arm Formation. This formation is conformably overlain by the coarse-grained turbidites of the Point Leamington Formation of the Badger group. Other sandstones and conglomerates assigned to the Badger group, located in the southwestern part of the survey area are also interpreted to be turbidites. Probable Silurian volcanic rocks of the Charles Lake sequence form a subaerial bimodal volcanic sequence of massive basalt flows and rhyolitic flows and tuffs and minor interbedded sandstone. The Botwood Group is composed of the Lawrenceton Formation containing bimodal subaerial volcanic rocks, including basalt and felsic tuff and minor sandstone, and the Wigwam Formation composed of mainly fluvial sandstone.

The Hodges Hill intrusive suite contains a variety of gabbroic and granitic rocks. The oldest component is an extensive, variably foliated granite. Various gabbros dominate the northwestern portion of the area and these include pyroxene-rich varieties, and layered gabbro. Granodiorite and granite have intruded the older components of the suite and contact zones are interpreted to be zones of assimilation. The youngest major component of the suite is a high-level, one-feldspar hornblende granite with a peralkaline affinity that covers a large area around Hodges Hill.

Diabase dykes are common throughout the survey area and two major concentrations occur in the New Bay Pond area and Mary Ann Lake. These dykes generally trend northeastward.

The basaltic rocks of the lower Wild Bight Group have the greatest potential for base-metal mineralization as they show geochemical features similar to the host rocks of the Point Leamington massive sulphide deposit. The dimension-stone potential of the granites in the Hodges Hill area is known and test quarries have been established. Other areas of gabbro and granite also have potential for dimension stone.

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