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P.R.-577

GOUVERNEMENT DU QUÉBEC
DEPARTMENT OF NATURAL RESOURCES
Honorable PAUL-E. ALLARD, Minister

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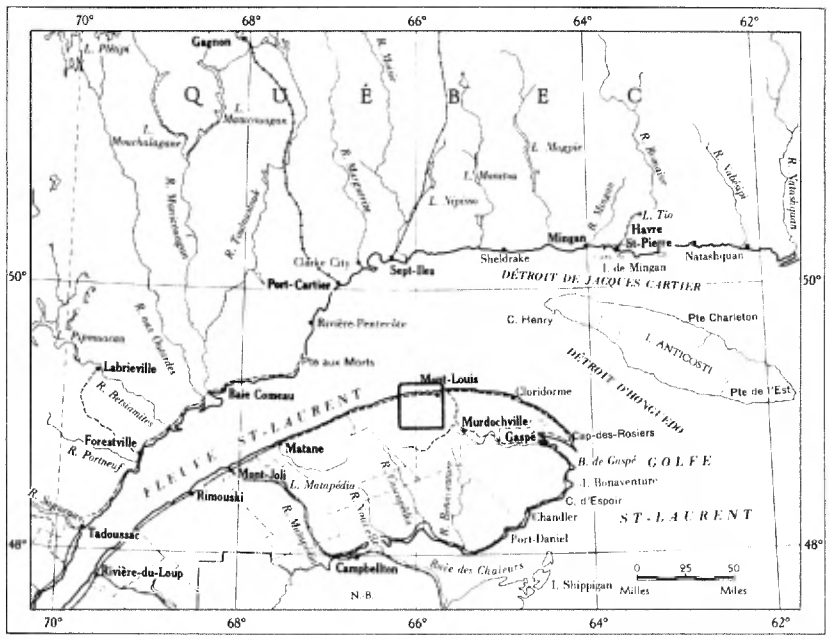
MADELEINE LAKE AREA

GASPÉ-NORTH COUNTY

PRELIMINARY REPORT

by

H.S. de Romer



QUÉBEC 1969

P.R.-577

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GEOLOGY

of

MADELEINE LAKE AREA

Gaspé-North County

Preliminary Report

by

H.S. de Römer

INTRODUCTION

The Madeleine Lake area, mapped during 1966 and 1967 at a scale of 1 inch equals 1,000 feet, is located in the Gaspé National Park, at approximately 35 miles SE. of Sainte-Anne-des-Monts. Thirty square miles in area, it includes parts of Deville, Lesseps and Deslandes townships and is bounded by latitude 48°47' and 48°54', and longitudes 65°50' and 65°55'.

Access to the southern half of the map-area is provided by the Park road and a network of rough lumber roads. Except for the partly passable Bélanger road and a short extension of the Lepage road, the northern half is accessible only on foot.

Physiographically, most of the area is a maturely dissected, densely wooded upland with hills rising to an altitude of 2,500 feet and broad intervening valleys. Maximum relief is about 1,000 feet. In the extreme northwest corner of the area the soil- and débris-covered terrain rises steeply to 2,850 feet, forming the southeastern slopes of the McGerrigle mountains.

The main watershed follows an arcuate line from the height of land west of Crochet lake through Martin lake to the hills northeast of Madeleine lake. North of this line, drainage is to the Saint-Lawrence through the sinuous Madeleine river and its main tributaries, Petite Madeleine river and Barter brook. The area to the south, which is part of the Chaleurs Bay drainage basin, is drained through Lesseps creek, Petite Cascapédia Est river and Lac Long brook to Petite Cascapédia river. Lac Long brook flows in a through-going, NNW.-trending, ½-mile-wide trench, which is probably the site of a major fault zone.

Except for the camp of the Department of Tourism, Fish and Game at Madeleine lake, the area is virtually uninhabited. Timber cutting operations are carried out by Consolidated Bathurst Paper Company Ltd. in the southern half of the area.

Except for scattered outcrop areas along Lesseps creek and the Park road, the southern part of the area is virtually devoid of outcrops. The best exposures are found near Madeleine lake and along the western segment of Madeleine river. In the north-central part of the area, rectilinear northeast-trending ridges, readily observable on aerial photographs, are directly related to the underlying lithology.

The Madeleine Lake area is part of the Lesseps and Tabletop areas geologically mapped at a reconnaissance scale by Jones (1931, 1933)*. It is also immediately east of the Lesseps Creek area mapped by J.L. Robert (1967), and approximately 8 miles southwest of the western boundary of the Madeleine River area mapped by McGerrigle (1959).

GENERAL GEOLOGY

The Madeleine Lake area lies within the Gaspesian segment of the Appalachians. It straddles the boundary between a Cambro-Ordovician complex to the north and Siluro-Devonian formations to the south.

The northwest corner of the area is occupied by rocks of the Québec Complex which consist of interlayered limestones and siltstones, limestone conglomerates, and impure quartzites adjacent to an assemblage of complexly folded schists and hornfels forming part of the contact aureole that adjoins the southern part of the McGerrigle mountains. The remainder of the area comprises

* References at the end of the report.

Silurian and Devonian rocks, which form a belt, almost 8 miles wide, consisting of moderately dipping siltstones, limestones and sandstones interbedded in places with felsite sheets and pyroclastic deposits. These rocks are separated from those of the Québec Complex by a much-faulted conglomeratic zone. The stratigraphic units, mapped primarily on the basis of lithologic and structural correlation, represent an apparently conformable sequence. In ascending order, they are: the Val Brillant, Sayabec, Saint-Léon, Cap Bon Ami, Grande Grêve and York River Formations.

Igneous rocks include northward-trending quartz-feldspar porphyry dikes, pyroclastic deposits and conformable felsite sheets. In addition, occasional bodies of gabbro and diabase follow N.-S. joints or form thick concordant sheets.

Two areally separate and probably genetically unrelated alteration zones have been recognized. One is definitely associated with the McGerrigle mountains (Tabletop) igneous mass and the other may belong to a younger intrusion, possibly underlying the Siluro-Devonian sequence southwest of Barter lake.

Owing to almost complete lack of exposures, practically nothing is known about the structure of the Québec Complex. The Siluro-Devonian rocks are broadly folded into a northeast-trending and gently plunging syncline (Lesseps syncline) and a complementary anticline to the south.

East- and northeast-trending fractures, clearly recognizable on aerial photographs, characterize the area. North- and northwest-striking joints and faults, apparently radiating from the McGerrigle mountains igneous massif, are superimposed on these fractures.

SEDIMENTARY AND VOLCANIC ROCKS

Cambro-Ordovician

The writer has adopted the appellation "Québec Complex", used first by Ollerenshaw in the Cuoq-Langis area (1967, p. 10), for the assemblage of sedimentary and metamorphic rocks in contact with the Silurian and Devonian Formations in the area. Future work farther north will certainly lead to a further subdivision of this assemblage into lesser rock stratigraphic units, such as supergroup and group.

TABLE OF FORMATIONS

PLEISTOCENE AND RECENT		Alluvial deposits, morainic material, and humus
	UNCONFORMITY	
DEVONIAN	IGNEOUS ROCKS	Gabbro and diabase dikes and sills Quartz-feldspar porphyry dikes Felsite
LOWER DEVONIAN	York River Formation (1500'-)	Quartzofeldspathic wacke and arkose Argillaceous sandstone
	Grande Grève Formation (1500'-2000')	Cherty and silty or argillaceous limestone Silty or argillaceous limestone; minor quartz arenite, conglomerate and coquina; pyroclastic rocks, minor felsite
	Cap Bon Ami Formation (400'-500')	Dark gray or black argillaceous and carbonaceous limestone; minor argillaceous or silty limestone Garnetiferous skarn and some hornfels; pyroclastic rocks and minor felsite
UPPER SILURIAN TO LOWER DEVONIAN	Saint-Léon Formation (1500'-2500')	Calcareous siltstone, silty limestone, minor red shales Hornfels (altered siltstone); pyroclastic rocks and felsite; hornfels (altered pyroclastic rocks and felsite); laminated silty limestone; limestone-siltstone; limestone conglomerate
LOWER TO UPPER SILURIAN	Sayabec Formation (600'-900')	Fossiliferous, reefy limestone Limestone pseudoconglomerate Dolomitized limestone
	Val Brillant Formation (250'-300')	Quartz sandstone; minor conglomeratic sandstone
	UNCONFORMITY	
CAMBRO-ORDOVICIAN	QUÉBEC COMPLEX	Interlayered limestone and siltstone, limestone conglomerate, calcareous shale and slate, phyllite Garnetiferous skarn; minor calcareous schist Calcareous schist, impure crystalline limestone, skarn; minor calc-silicate hornfels Irregularly banded garnetiferous pelitic hornfels

The Québec Complex is subdivided into four ill-defined, ENE.-trending belts. This division is only provisional since the few scattered exposures encountered in the area of the complex can hardly be considered representative of the lithology involved. From south to north, the writer has recognized: a) a belt, 1,000 to 1,500 feet wide, of interlayered limestone and siltstone, limestone conglomerate, calcareous shale and slate, and phyllite; b) a belt, about 1,000 feet wide, comprising garnetiferous skarn and minor calcareous schist; c) a belt, 3,000 feet wide, of calcareous schist, impure crystalline limestone, skarn, and minor calc-silicate hornfels; 4) a belt, about 500 feet wide, of irregularly banded garnetiferous pelitic hornfels. Some 3,000 feet north of the map-area, the belt of pelitic hornfels is in intrusive contact with reddish, medium-grained, locally contaminated granite of the McGerrigle mountains. The low ground covered by a thick blanket of humus material in the north-central part of the area provided no geological information.

Interlayered Limestone and Siltstone, Limestone Conglomerate, Calcareous Shale and Slate, Phyllite

An outcrop of what the writer believes is part of the Québec Complex is exposed on the north bank of Madeleine river, near the western boundary of the area. It consists of dove-weathering limestone layers, $\frac{1}{4}$ to $\frac{1}{2}$ inch thick, alternating with light brown, laminated and calcareous siltstone layers one inch or so thick. In general, the outcrop has a ribbed appearance due to faster weathering of the limestone layers. The bedding, very regular, strikes northeast and dips steeply to the southeast. Some of the silty layers display a faint but discernible crossbedding, indicating top to the south. At one place, there is a small, tight fold of tectonic origin. An east-trending fault was observed on this outcrop. It belongs to the fault that, farther south, separates the rocks of the Québec Complex from the Sayabec Formation.

Similarly interlayered rocks occur outside the area, in a small, northerly striking valley, at approximately 1,000 feet west of the above-mentioned outcrop. Large and slightly displaced angular blocks are seen to be made up of regular, light- and dark-gray bands showing the effects of incipient induration and may be mistaken for banded hornfels.

Farther up the river and slightly north of an east-west lumber road, outcrops of limestone conglomerate may be seen. The rock consists of sub-rounded to angular fragments of light

gray limestone embedded in a darker calcareous and phyllitic matrix made up of finely comminuted material. It shows brecciation, flowage phenomena and numerous calcite veins.

North of Barter lake, outcrops of similarly brecciated limestone conglomerate are found here and there for about 1,000 feet along the south bank of Madeleine river. Some of these outcrops show zones of dark gray calcareous shale and slate containing pebble- to cobble-sized limestone and calcareous siltstone fragments. Phyllitic slates containing boulders made up of pebbles of oolitic limestone are also seen. Except for a slight parallelism of the phenoclast-bearing zones, there is little evidence of bedding. Recrystallized calcite veins cut irregularly across the fragments or follow thin partings between the contorted beds. Loose, angular fragments of a high fossiliferous limestone (mainly brachiopods), appearing to be in place, were noted beside the outcrops.

It seems to be fairly well established in the literature that the northern contact of the Cambro-Ordovician with Siluro-Devonian rocks represents an angular unconformity. It is concluded from the fragmentary description given above that the southernmost outcrops of the Québec Complex are deformed and brecciated limestone-siltstone and limestone conglomerate beds, and that its southern boundary, at least in the Madeleine Lake area, is the site of a regionally important fault or shear zone. This does not invalidate the evidence from other areas to the east and west that the above contact is an unconformable one.

Garnetiferous Skarn and Calcareous Schist

It would appear from a few exposures, the majority of them immediately west of the area, and some angular débris, that a zone of garnetiferous skarn and minor calcareous schist constitutes the periphery of the actual alteration aureole bordering the McGerrigle mountains massif to the south. The rocks vary considerably in color and fabric. Some of the reddish green variety show even laminations or bands of ferromagnesian minerals and coarse, garnet-rich material. Closer observation reveals that the fine laminations are warped by tiny porphyroblasts or aggregates of minerals, an indication that some metamorphic segregation and reconstitution of the original material have taken place. In places, the segregation takes the form of rounded, $\frac{1}{4}$-inch knots made up of fine-grained calc-silicates surrounded by wavy seams of darker chloritic material. In other parts of the same outcrop, a more advanced stage of reconstitution has resulted in light gray, discontinuous lenses, a fraction of an inch long, alternating irregularly with garnet- or chlorite-

rich pockets or layers. This type of metamorphism having almost completely obliterated the original layering or schistosity, the rock may, at places, conveniently be described as irregularly banded hornfels.

What the writer believes to represent an early schistosity or layering strikes east and dips steeply to the south.

The fabric and mineral assemblage of the rocks making up this zone suggest that they are largely derivatives of limestones and dolomites in which any calcareous matter has been entirely eliminated or reconstituted.

Calcareous Schist, Impure Crystalline Limestone, Skarn, Calc-silicate Hornfels

The belt of rocks north of the garnetiferous skarns is occupied essentially by finely banded impure calcareous metasedimentaries. Generally, they consist of 1/16- to 1/4-inch-wide recrystallized calcareous beds alternating with seams of brownish weathering siltstone and dark gray or greenish shale partings. Angular débris collected in this belt shows the calcareous beds to contain tiny, unoriented amphibolite needles embedded in a matrix of recrystallized carbonate. In places, the recrystallized calcareous material has penetrated minute fractures which cut across the argillaceous and silty layers. Where the effects of metamorphism were more pronounced, discontinuous 1/32- to 1/16-inch-thick greenish seams of a hornfelsic material alternate with bands consisting entirely of up to 3/16-inch-long greenish amphibolite prisms. At one place, the rock is a gray-brownish impure limestone in which bedding is manifested by disrupted, but readily discernible shreds of dark indurated material. Where observed, such remnants of original stratification strike east and dip vertically or steeply to the south.

The rock and mineral assemblage briefly described above indicate that the parent rocks were probably a series of interbedded limestone and shale, comprising here and there quartz-rich horizons.

Irregularly Banded, Garnetiferous Pelitic Hornfels

This belt is established on the basis of what the writer believes to be locally derived, angular débris. The tough and very fine grained rock consists of a series of elongated and intertongued lenses of green and light gray flinty

material. Some of the lenses contain ovoid knots or layers of brown-weathering garnet aggregates ¼ inch across. At places, the light gray material displays a hazy purplish coloration, which gives the rock the streaked appearance of a mylonite.

If one judges from exposures some ¾ of a mile to the west of the present area, anomalous dips seem to characterize this belt. Although the degree of alteration in the belt is too advanced for bedding to be identified with certainty, it is probable that this bedding trends E.-W.

Regarding the origin of the banded hornfels, of considerable interest is a series of well-exposed outcrops along the north branch of Madeleine river, some 4 miles north of Madeleine lake, outside the area. It is probable that the calcareous slates, phyllites and quartzites forming these outcrops are continuous in strike with argillites and, farther southwest, the hornfels described above. In other words, the non-schistose hornfels bordering the McGerrigle granitic massif to the south constitutes the contact facies of regionally metamorphosed, calcareous and siliceous, but essentially alumina-rich, parent rocks.

A few reconnaissance traverses on the southeastern flank of the McGerrigle massif north of the area revealed that the surface trace of the contact between the granitic and Cambro-Ordovician rocks is a very sinuous one, with tongue-like apophyses and broad swells of granitic material invading the adjoining metasedimentary rocks.

The alteration belt bordering the massif is 1 mile to 2 miles wide and consists of two N.- to NE.-trending zones cutting across the regional strike of the lithologic units. The inner zone, in contact with the granitic mass, comprises pelitic hornfels, calcareous schist, and skarn. These may be traced, outside the map-area, into argillite and calcareous argillite of the outer zone. Still farther northeast and outside the contact aureole proper, the rocks of the inner zone grade into an assemblage of calcareous shales and slates, green, red and black slates and phyllites, such as can be observed west of the north branch of Madeleine river.

LOWER TO UPPER SILURIAN

Val Brillant Formation

In northern Gaspé, the Val Brillant Formation maintains a remarkable uniformity in structural attitude and composition, extending eastward almost continuously from west of

Matapédia lake to the Dartmouth valley in the Madeleine River area, a total distance of over 180 miles (Lajoie, 1962, p. 4; McGerrigle, 1959, p. 26-28).

In the present area, the formation is 250 to 800 feet wide and is traceable by outcrops, débris, and topography from north of Barter lake to the northern boundary of the area and beyond. On account of its greater hardness, it forms two elongated and narrow ridges, the continuity of which is offset here and there by northwest-trending cross faults.

Typically, the Val Brillant is a medium-grained, white to purplish weathering quartz sandstone of fairly uniform composition. At the base of the formation silica-cemented quartz-sandstone beds 10 inches thick alternate with conglomeratic sandstone layers 3 to 5 inches thick. Towards the top, the rock has a locally sugary appearance and is composed of well sorted and sub-rounded quartz grains embedded in a largely calcareous matrix. Near the contact with the overlying Sayabec Formation, it contains an increasingly larger proportion of calcareous matter. The rock has a purplish hue due to traces of hematite; at places, dispersed, small pyrite cubes and limonite stains are common.

Bedding is well defined, striking NNE. to ENE. and dipping 10° to 30° to the SE.

Although the contact with the underlying rocks is nowhere exposed, the author is reasonably sure that the base of the northern ridge constitutes the base of the formation. There is no evidence that Awantjish rocks are present in the map-area. Scattered angular débris and structural considerations suggest that the Val Brillant overlies unconformably interbedded limestone-shale and quartzites of the Québec Complex. The upper contact with the overlying Sayabec Formation is gradational for the most part and is surely conformable.

The thickness of the Val Brillant in the area is estimated to be 250 to 300 feet, a figure comparable with the values reported farther west (Béland, 1960, p. 4; Lajoie, 1962, p. 3; Ollerenshaw, 1967, p. 8). A few traverses outside the area revealed that the section thins to the east (150'-180'). McGerrigle reports an approximate thickness of 10 to 75 feet in the Madeleine River area (1959, p. 27).

Paleontological age determinations from other areas place the Val Brillant Formation into the Late Llandoverian — Early Wenlockian stage (Burk, 1964, p. 440; Boucot, 1965, p. 2297).

Sayabec Formation

As in other parts of northern Gaspé, the Sayabec here rests conformably on the Val Brillant and is overlain conformably by the Saint-Léon Formation. In the western part of the area the formation occupies 800 feet of low ground along the Madeleine River valley, then swings ENE. to form two parallel-trending ridges, easily traceable on aerial photographs.

Generally, the rock is a buff to gray, fossiliferous (reefy), and commonly conglomeratic limestone. Although a complete section of the formation was not seen in one place, it appears to consist of quartz-rich and dolomitized limestones at the base, overlain by limestone pseudoconglomerates and reefy limestones, and succeeded by silty limestones and fossiliferous limestone conglomerates.

The basal zone consists of cream- to buff-colored quartz-bearing limestone, which, in the western part of the area, is extensively silicified and dolomitized. In some outcrops exposed on the south bank of Madeleine river, 800 feet west of the area, the thick-bedded, well-sorted rocks consist of rounded quartz grains cemented by a calcareous matrix. Similar rocks occur in an E.-W.-trending fault zone at the western boundary of the area. Here, the basal Sayabec rocks have been altered by intense silicification and dolomitization to buff, limy quartzites, in which partly replaced remnants of corals and algae can still be recognized.

There are good exposures of the middle part of the Sayabec Formation succession on both banks of Madeleine river, at and east of Barter's camp. The rocks are in the eastward extension of the above-mentioned fault zone and consist of medium- to coarse-grained buff-weathering dolomite intruded by acidic sills and dikes. At the Lepage Road - Madeleine River intersection, an E.-trending, 40-foot-wide acidic sill is flanked by 20 to 40 feet of gray, silicified and disturbed limy rocks containing here and there faint remains of corals and algae. Abundant flow structures in the contact zone and the chaotic aspect of the material suggest that this is a remobilized and injected rock. A 90-foot-wide area of almost flat-lying, 6-inch-thick dolomitic beds adjoins it immediately to the south. The rock contains sporadic lenses and pockets of white, recrystallized limestone. At one place, an upward swelling, irregularly shaped inclusion of marble, approximately 25 feet long and 5 to 10 feet wide, displays faint but definite concentric layers attributed to algae growth. Commonly, such reef pockets are partly or entirely surrounded by seams of evidently injected, basaltic material that appears to have been very mobile.

There seems to be enough evidence to suggest that iron- and magnesium-rich solutions have been introduced and that selective replacement of the Sayabec limestone has taken place. The reefy parts were not affected by the solutions, probably on account of their massiveness or superior degree of compaction, but simply recrystallized to medium-grained marble.

Immediately overlying the dolomite is a series of limestone pseudoconglomerate beds forming structures typical of biohermal limestone.

A few hundred feet east of Barter's camp, the beds are made up of finely comminuted, possibly autochtonous organic débris, characteristic of reef talus. Excellent specimens of well-preserved halysitids, a foot or so in diameter, and stromatolites have been observed here and there. The contacts between the 1- to 2-inch-thick beds are largely gradational and wavy. On Madeleine river, south of the main fault zone, the beds strike east and dip consistently 15° to 25° degrees south. A striking feature of the Sayabec fragmental limestones in this particular area are the abundant, rectilinear, N.- to NW.-trending features. They are 1/16 to 1/8 inch wide and are generally filled with limonite-colored dolomitic or ankeritic material.

In the north-central part of the area, the Sayabec Formation comprises mainly limestone pseudoconglomerates and fragmental limestone made up almost entirely of recrystallized crinoid stems and stromatolites.

Although the actual boundary between the Sayabec and the overlying Saint-Léon is concealed, the contact is almost certainly a conformable one. In fact, it appears that there is a 100- to 15-foot-wide contact zone of slightly silty and more evenly bedded limestones between the two formations.

The Sayabec Formation occupies the northern limb of the Lesseps syncline. Except where slightly disturbed by cross faults, the beds dip consistently 10° to 30° southeast.

The thickness of the formation in the area is estimated to be between 600 and 900 feet. Thicknesses reported in the literature vary considerably, but, generally speaking, they decrease going east. Thus, the formation is 1,000 to 2,000 feet thick in the Matapédia-Témiscouata region (Stearn and Hubert, 1966, p. 33) and only 200 feet thick in the Madeleine River area (McGerrigle, 1959, p. 27).

The age of the Sayabec Formation appears to extend from Wenlock to Lower Ludlow (Naylor and Boucot, 1965, p. 159; Ollerenshaw, 1967, p. 111).

UPPER SILURIAN TO LOWER DEVONIAN

Saint-Léon Formation

Two northeasterly trending belts of Saint-Léon rocks are exposed in the area. The northern one, approximately 3,000 to 4,500 feet wide, is located on the northern limb of the Lesseps syncline; the other, 2 to 3 miles wide, forms the core of a complementary, northeasterly plunging anticline, some 3 miles to the southeast. Apart from a few exposures along Lesseps creek and the Park road, the southern belt is virtually devoid of outcrops.

The formation comprises chiefly limestones and siltstones intertonguing with rocks of intermediate composition and interstratified with zones of pyroclastic deposits. A characteristic of all sedimentary Saint-Léon rocks is the continuous and even stratification marked either by delicate laminations or by alternating siltstone-limestone beds.

Sedimentary Rocks

Lower part of the formation

Generally speaking, the lower part of the formation consists of dark-gray finely laminated limestone beds, of a sequence of limestone-siltstone, and of limestone pseudoconglomerates. Several zones of pyroclastic rocks of acid to intermediate composition are also present. Estimated to be 500 to 800 feet thick, this part of the formation represents a facies gradational with the underlying Sayabec Formation.

Some of the best exposures of the laminated limestones occur along Madeleine river, west of Barter lake, where they rest conformably on Sayabec rocks. The beds strike east and dip slightly south; some of the more massive beds contain abundant crinoid stems. A few outcrops of the same type of limestone occur about 2,000 feet SW. of the Bélanger Road - Deslandes-Lesseps Township intersection, east of the area. The lithology of these outcrops and the fact that they are located near the axial part of an anticline suggest that they also belong to the basal part of the Saint-Léon Formation.

Stratigraphically above the limestone beds is a conspicuously banded limestone-siltstone sequence, outcrops and débris of which are particularly well shown in a cut on the

Lepage road, west of the area. The sequence is made up of 1- to 2-inch-thick, slightly wavy, gray to blue limestone beds alternating with 1/8- to 1/2-inch-thick laminated silty beds. At places, the outcrops have a ribbed appearance owing to faster weathering of the limestone layers. The sequence contains a lens, about 100 feet long, of highly fossiliferous beds, containing mainly crinoid and favositid fragments. Débris, almost in place, of a similar sequence occurs 2,000 to 3,000 feet NE. and also NNE. of Barter lake.

Limestone pseudoconglomerate overlies the limestone-siltstone sequence. At certain places, as near a trail 2,500 feet NNW. of Petit Madeleine lake, the rock is made up of disconnected limestone lenses, 1 inch thick and 2 to 3 inches long, surrounded by silty calcareous material. In a series of outcrops making up a section several tens of feet thick immediately north of the NE. corner of the area, these lenses may be traced laterally and vertically into a succession of ribbed limestone-siltstone beds.

Upper part of the formation

The upper part of the Saint-Léon succession, estimated to be 1,000 to 1,700 feet thick in the northern belt, but presumably much thicker in the southern one, comprises, in decreasing order of importance, the following rocks: gray to greenish calcareous siltstone; dark gray silty limestone; pyroclastic rocks and minor felsites; red, silty shales. As the overlying Cap Bon Ami Formation is approached, the silty limestones become gradually darker and more argillaceous.

The calcareous siltstones are particularly well exposed near the intersection of Lesseps creek and the Park road. They are evenly laminated and brown weathering. Muscovite flakes are common on the separation planes and the rock breaks into large flat flagstones. Sedimentary structures include small-scale crossbedding and convolute bedding suggesting penecontemporaneous slumping. Several measurements of current laminations indicate that the probable source of sediments was to the SE. The rock is fossiliferous at places, containing monograptids and well-preserved crinoids. Excellent exposures of the upper Saint-Léon occur also along the segment of road parallel to Lesseps creek. The gray, silty limestone is twisted and contorted by primary slumping and sliding, and the strike and dips of the beds are extremely irregular.

An outcrop of silty and argillaceous limestone, which the writer believes to belong to the Saint-Léon Formation, was found 3,000 feet NW. of the northern tip of Madeleine lake.

The attitude of the beds, which strike NE. and dip 30° SE., and the relation of cleavage to bedding indicate that the outcrop is part of the northern limb of the Lesseps syncline.

Pyroclastic Rocks

Apart from a few felsite sheets of possibly rhyodacitic composition, most of the volcanic material noted in the area consists of pyroclastic deposits. Some of these are interbedded with siltstone-limestone sequences and limestone pseudoconglomerates of the basal Saint-Léon; however, the middle and upper part of the formation contains the most significant bodies of pyroclastic rocks.

The best outcrops, which belong to the basal part of the Saint-Léon, are observed along Madeleine river, west of Barter lake, and north and south of Lepage road, immediately west of the area. On fresh surface, the rock is greenish to gray and hard; on weathered surface, it is highly porous and characteristically white or creamy, this being presumably due to kaolinization.

Although they have not been distinguished on the map, two main types of pyroclastic material, based essentially on composition and texture, were noted in the field. The first type, which is of common occurrence, is a tuff made up of small, dark, rectangular crystals or angular crystal fragments embedded in a glassy, aphanitic matrix. Unoriented and 1/16 to 3/16 inch in diameter, these particles are invariably surrounded by a thin, white alteration film, a feature commonly found in rocks affected by deuteric alteration. Small, brilliant and apparently unaltered quartz crystals or glass shreds are usually present. The rock generally exhibits a notable streaky lamination or fluidal banding and, in pleces, resembles welded tuffs.

The other type of pyroclastic material is a green, white-weathering pisolitic tuff made up entirely of concentrically laminated pellets which may reach 3/16 inch across. Some of the pellets are altered to clay or surrounded by films of this material.

Tuffs of the types just described make up the volcanic material west of Petit Madeleine lake and southeast of Barter lake. Well layered in places, they are interstratified with silty limestones and calcareous siltstones.

An east-striking band of pyroclastic rocks is exposed south of the Bélanger road, NW. of Crochet lake. As the band is part of an alteration zone, it will be considered in the section dealing with alteration.

The above-described pyroclastic deposits, which range from 20 to 250 feet in thickness, are an integral part of the Saint-Léon Formation. Owing to the insufficient continuity of outcrops, determination of possible lateral or vertical facies variations within the deposits is prevented. This lack of outcrops may also explain their apparent absence on the southern flank of the Lesseps syncline.

Thickness and Age

The total thickness of the Saint-Léon ranges from 1,500 to 2,500 feet in the northern limb of the Lesseps syncline, but it may be greater in the broad anticlinal fold to the south. Robert (1967, p. 6) estimates a maximum thickness of 4,050 feet in the Lesseps Creek area, immediately to the west, and McGerrigle (1959, pp. 26-27) gives an approximate thickness of 1,000 feet for Saint-Léon-like rocks, some 10 miles NE. of the area.

The age of the Saint-Léon Formation is controversial. A recent restudy of graptolite fauna of the "Lesseps Brook" locality disclosed that it may range from Late Llandoverian to post-Ludlovian (Boucot, 1965, p. 2297; Berry, 1965, p. 2304). In other words, part of the Saint-Léon may reach up to Lower Devonian.

LOWER DEVONIAN

Cap Bon Ami Formation

Gently folded about northeasterly trending synclinal and anticlinal axes, the Cap Bon Ami Formation forms three bands bounded by the underlying Saint-Léon and conformably overlain by the Grande Grève Formation. Owing to fault displacements and low dips, the surface expression of the bands may reach 2,000 to 2,500 feet, as can be observed north of Crochet lake and at Lesseps brook.

The formation consists essentially of sedimentary rocks, interbedded at places with volcanic material. Being less resistant than the adjacent Grande Grève or Saint-Léon, it occupies valleys and swampy areas and is consequently very poorly exposed.

Except for narrow, argillaceous or silty facies bordering Grande Grève or Saint-Léon, the typical Cap Bon Ami

is a fairly massive, soft, argillaceous and carbonaceous limestone. The rock is typically dark gray to black on fresh surface, but weathers to a faint grayish or brownish cast. Bedding is not conspicuous, except where the rock is altered, presumably as a result of metamorphic segregation and recrystallization. Where disturbed, the rock is commonly graphitic or brecciated and veined by calcite.

Northwest of Madeleine lake, the middle of the Cap Bon Ami section contains a 300-foot-thick sheet of heterogeneous acidic volcanic rocks. At some places, the fine-grained, gray, pink or greenish rock is massive and feldspar- and quartz-rich, suggesting a dacitic or rhyo-dacitic composition. Commonly, however, the porous rock contains tiny spheroidal concentric structures and exhibits a discontinuous lamination. Small, vitreous aggregates are embedded in a fluidal aphanitic groundmass and are commonly surrounded by a thin,dull white alteration rim. At one place, faint but distinct columnar joints were noted.

Although contacts with the sedimentaries were nowhere observed, the attitude of the banding indicates that the sheet is conformable. The textural and structural variations observed in it may be the result of gravity sorting of the fragmental material or may represent different parts of a thick ash deposit. Whether the sheet is of extrusive or pyroclastic origin cannot be satisfactorily solved without a detailed petrographic examination.

Apart from the volcanic fragmental rocks just described, the Cap Bon Ami comprises several thin horizons of unquestionable lithic or crystal tuff, mostly in the upper part of the section.

The exact upper and lower contacts of the Cap Bon Ami were not recognized in the area. It can be assumed that these contacts are conformable and transitional, owing to the presence of Grande Grève and Saint-Léon lithologies in the contact zones.

Surface widths and regional dip suggest a thickness of 400 to 500 feet for the formation. This is in agreement with the values recorded to the west (Robert, 1967, p. 6). The formation appears to thicken in the Madeleine River area, to the east, where McGerrigle reports an estimated thickness of about 2,000 feet (1959, p. 31).

Recent paleontological studies seem to confirm the view that the Cap Bon Ami is of Lower Devonian age, more precisely, equivalent to the Gedinnian (Boucot et al., 1967, p. 11).

Grande Grève Formation

The Grande Grève Formation occupies for most of its length a 1.5- to 2.0-mile-wide, northeasterly trending axial belt of the Lesseps syncline. Traverses outside the area revealed that another band of Grande Grève, located on the southern limb of an anticline, crosses the SE. corner of the area. It consistently overlies the Cap Bon Ami rocks and is itself conformably succeeded by the York River Formation.

The Grande Grève Formation is characterized by an interfingering lithology which, although not separable on the map, includes silty or argillaceous limestones with minor quartz arenite and conglomerate or coquina at the base and, in succession, cherty and silty limestones in the upper part. It also includes several discontinuous sheets of pyroclastic rocks and felsite, exposed solely on the northern flank of the Lesseps syncline and concentrated in the basal part of the formation.

The basal limestone is commonly a thinly to coarsely laminated rock, dark gray to bluish when fresh. Owing to leaching of the carbonate, the exposed surface is usually brown, porous, and gritty to the touch. Weathering penetrates deeply into the rock, leaving irregular gray-bluish patches or lenses of unaltered material. An outstanding feature distinguishing Grande Grève limestone from Cap Bon Ami or Saint-Léon lithology is their irregularly undulating bedding planes. Commonly, the rock consists of slightly pinching and swelling limestone beds, 1/2 to 6 inches in thickness, alternating with thinner silty or argillaceous layers.

The basal Grande Grève rocks on the northern limb of the Lesseps syncline are lithologically somewhat different from those on the southern limb. On the northern flank, the lower part of the Grande Grève is a gray quartz arenite, 50 to 100 feet thick and 100 to 200 feet stratigraphically above the base of the formation. This arenite is exposed 6,000 feet due west of Crochet lake and its débris can be traced eastward almost to Madeleine lake. The fine- to medium-grained rock is well sorted and pure, consisting of tightly packed, subangular quartz grains and very little matrix. At places, it is peppered with small limonite stains.

Overlying the quartz arenite is a zone, perhaps 100 feet thick, of lithic tuff. This is evidenced by the abundant float encountered 2,000 feet WNW. of Crochet lake and 2,500 feet NW. of Madeleine lake. The gray, fresh-looking rock is finely laminated and, locally crossbedded. It forms tapering

lenses, 1/2 to 1 inch thick, intertonguing with irregular pockets of breccia. At places, slightly oriented spindle-shaped fragments and subangular quartz aggregates produce a faint primary layering.

Other thin, conformable tuff horizons are exposed west of Madeleine lake, approximately 500 feet above the base of the formation. At one locality, about 1,000 feet west of the lake, the lithic tuff is associated with roughly layered pisolitic tuff, consisting of ash pellets in a siliceous flow matrix.

The large surface expression on the map of the pyroclastic zone NW. of Madeleine lake is mainly due to topography; in fact, this conformable zone is less than 100 feet thick and dips 20°-30° SE.

The basal beds of Grande Grève on the southern limb of the Lesseps syncline occupy an approximately 500-foot-wide band extending from Lesseps brook northeastward to the southern tip of Madeleine lake. Outcrops occur on the road leading to Parent camp, 3,000 feet SW. of Long lake, at Gagnon camp, and at the road fork SE. of Madeleine Lake camp.

The rock is dark gray on the fresh surface and consists mainly of angular fossil fragments embedded in a fine-grained argillaceous or silty matrix. The weathered surface is a characteristic limonite-brown and generally coarsely porous owing to leaching of the carbonate. The rock commonly contains angular fragments of black shale varying in size from microscopic to 1 inch across. On the road to Parent camp, 2-inch-long lenses made up of comminuted rock débris are embedded in a matrix of siliceous composition. A few small coal particles have been noted. The outcrop near Gagnon camp shows undulating and contorted bedding planes. At places the rock has the appearance of a typical coquina.

The continuity of this horizon marker and its fixed stratigraphic position indicate that the above-described fragmental rock is not a fault breccia. Furthermore, the angularity and variety of its components, as well as its association with slumped beds, suggest that it is a sedimentary breccia, formed as a result of possibly repeated submarine slumping and gliding. Lithologically similar and stratigraphically equivalent "key beds" have been reported by Robert in the Mount Hog's Back region (1966a, pp. 7-8), some 10 miles west of the present area.

A large part of the middle and upper Grande Grève Formation is made up of hard, dark gray to bluish, siliceous limestones. Some of the best exposures are along the N.-S. lumber road and in the hills east of Madeleine lake. The rock is finely bedded and shows laminae curving around gently swelling and pinching silty interbeds.

In the axial zone of the Lesseps syncline, the rock is massive, thick-bedded and strongly cleaved. At places, bedding in the siliceous limestone is marked by lenticular depressions formerly occupied by carbonate material.

In the upper part of the section, the siliceous limestone passes to a softer, argillaceous or silty limestone. Gradually, perhaps through a stratigraphic distance of 300 to 500 feet, the silty partings become more evident; the rock is irregularly layered with alternating silty and dark gray calcareous beds. Still higher in the section, small, interconnected pockets of brown-weathering clastic material, comprising chiefly fine-grained feldspar and quartz, are embedded in a Grande Grève-type lithology. This succession represents the transitional facies between the Grande Grève and York River Formations, referred to by some geologists as the York Lake series or facies.

Typical outcrops of the transitional facies are well exposed south of Parent camp and on the slopes of the hill west of Madeleine lake. At the latter locality, load casts and other sole marks are common. Usually, such structures consist of bulbous protrusions of silty and arenaceous material extending into the underlying, argillaceous limestone of the Grande Grève type.

It has been generally accepted that the Grande Grève - York River contact is characterized by alternating zones of both lithologies. Following other geologists, the writer has drawn the upper boundary of the Grande Grève rather arbitrarily at the first appearance of typical York River lithology.

The thickness of the Grande Grève Formation is estimated to be 1,500-2,000 feet, a figure in agreement with the values recorded east and west of the area. The age is universally accepted as being Lower Devonian.

York River Formation

The York River Formation is incompletely exposed in that only the basal 1,500 feet of the section is preserved in the area. It forms the core of the Lesseps syncline west of Long lake and also appears as an outlier west of Madeleine lake. As mentioned above, the contact of the York River with the underlying Grande Grève is both conformable and gradational.

Some of the best outcrops occur SSW. of Parent camp and 4,500 feet west of Madeleine Lake camp. At the latter locality, the gray greenish rock is a thick-bedded, medium-grained quartzofeldspathic wacke or argillaceous sandstone. On weathered surface, it is characteristically peppered with tiny whitish feldspar grains and limonite stains.

The rock contains abundant black, disc-shaped, argillaceous inclusions of Cap Bon Ami lithology suggesting sedimentary boudinage structures. At places, these flat inclusions, ¼ inch to 2 inches long, are completely isolated and embedded in an unsorted matrix made up of a largely unstable mineral assemblage. Where the inclusions are laterally continuous, the beds exhibit excellent sole marks; the load and current structures consist of siltstone and sandstone filling depressions in the underlying mudstone.

In outcrops and débris near Parent camp and along the road paralleling Lesseps creek west of the area, the rather fresh-looking sandstone is made up of weakly cemented, subangular quartz and rectangular feldspar grains, and carries occasional acidic tuff(?) fragments.

Reconnaissance traverses beyond the area disclosed a 1.5-mile-wide band of York River rocks at the core of a northeasterly trending syncline, some 3 miles south of the Park road. The base of the section comprises volcanic flows and tuffs, of intermediate composition, and 1,000 to 2,000 feet thick, overlain by gray, medium-grained feldspathic sandstones or arkoses with conglomeratic interbeds at the base. At places, the hematite-stained rock contains abundant tube-like structures attributed to boring organisms.

The York River Formation in the area is correlated on general lithologic grounds with similar rocks recorded in areas to the west (Robert, 1966b, 1967) and to the east (McGerrigle, 1959). Its age is generally accepted to be Lower Devonian.

INTRUSIVE ROCKS

A few types of intrusive rocks are exposed in the area. Differentiated in terms of texture, composition and age of intrusion, they may be conveniently described as quartz-feldspar porphyry, felsite, gabbro and diabase. The first and last types occur as dikes and the other two as dikes and sills.

Quartz-feldspar Porphyry

The quartz-feldspar porphyry or porphyritic granite is a gray to pink rock, 10%-25% of which consists of euhedral quartz and feldspar phenocrysts embedded in a pink, fine- to medium-grained matrix of quartz, feldspar, biotite and amphiboles.

The quartz, characteristically vitreous and colorless, occurs in the form of stubby, hexagonal bipyramids up to ¼ inch in diameter. The feldspar is white to gray, conspicuously zoned, and forms euhedral crystals 1/8 to 3/4 inch long. The biotite and amphiboles occur separately or together and form distinct crystals within the quartzofeldspathic groundmass. The rock is commonly little altered and is probably alkalic to calc-alkalic in composition.

Almost all the porphyry dikes are located in a relatively small region SW. of Barter lake. The few exposures available suggest that the dikes are emplaced along N.-S.-trending, steeply dipping fractures. Although a good number of them are 10 to 50 feet thick, the distribution of the débris indicates that some may reach 300 to 400 feet. Their association with mineralized and altered rocks suggests that the fresh-looking porphyritic bodies represent late offshoots of an unexposed granitic mass that invaded the Siluro-Devonian sequence.

Brecciated contacts with already altered country rocks indicate that the emplacement of the dikes into ancient fractures occurred after the main alteration of the country rocks had taken place. Traverses on the SE. flank of the McGerrigle massif revealed that numerous dikes of identical lithology and texture occupy fractures cutting across and radiating from it. Occasional crosscutting relationships and slight alteration at contacts with country rocks indicate that some of the rocks incorporated within the pyroclastic deposits are certainly intrusive.

Felsite

Sheets of gray to beige, evidently layered rocks are interstratified with basal Saint-Léon between joints located 2,000 and 3,000 feet west of Barter lake. The upper and lower contacts are marked by a slight alteration zone in the adjacent silty limestone. In hand specimen, the rock consists of tightly packed subrounded vitreous phenocrysts up to 1 mm. in size, surrounded by thin concentric layers of dull white material.

Embedded in a cryptocrystalline groundmass, they give the rock a perlitic structure reminiscent, in places, of pisolitic sedimentary rocks. Another lithologically similar rock cuts the Grande Grève in the immediate vicinity of Parent camp.

With few exceptions, the felsite bodies are generally concordant and have evidently undergone the same type of metamorphic alteration as the enclosing sediments. This consideration leads one to believe that they antedate the quartz-feldspar porphyry intrusions and are an integral part of the Silurian and Devonian Formations.

Whether the above-described rocks are of volcanic origin or whether they represent intrusive sheets requires further investigation. In any case, felsite is a convenient field term for them.

Gabbro

Scattered outcrops of gabbro were noted in the area. The rock is dark gray to green, fine to medium grained and generally porphyritic, the phenocrysts consisting of equant, dull, white feldspars. The gabbro near and south of the Park road is considerably altered to a grayish to bluish, waxy rock, in which the feldspars are almost completely changed into aggregates of epidote, calcite and, at places, zeolite.

Diabase

Part of a possibly 100- to 200-foot-thick diabase sill is well exposed 2,000 feet NNW. of Madeleine lake. The rock strikes N.45°E. and dips slightly to the SE., being probably conformable with the enclosing felsites and pyroclastic rocks of the Cap Bon Ami Formation. The rock is relatively fresh, consisting of abundant, slender laths of zoned feldspars embedded in a medium-grained matrix of subhedral pyroxenes. It exhibits a typical ophitic or intergranular texture.

ALTERATION

Contact alteration effects observed in Cambro-Ordovician rocks SE. of the McGerrigle massif have already been mentioned.

The areally and economically significant zone of alteration is located NW. of Crochet lake. The 3,000-foot-wide belt of altered Saint-Léon and Cap Bon Ami forming this zone represents the eastern extension of a much wider zone in the Mount Vallières-de-Saint-Réal and Lesseps Creek areas (Robert, 1966b, 1967). Owing to their superior hardness, these altered rocks underlie an E.-trending ridge, which rises sharply from the lower unaltered sedimentaries to the north. The abrupt eastern boundary of the ridge, 500 to 800 feet west of the Bélanger road, is marked by an east-facing scarp, indicative of an important N.-S. fault.

The wider, northern part of the zone is made up of massive and tough hornfels or porcellanite derived from volcanic and sedimentary rocks of the Saint-Léon Formation. The southern part comprises mainly garnetiferous skarn and some hornfels, which are the metamorphic equivalents of the Cap Bon Ami argillaceous and carbonaceous limestone. The alteration effects in rocks of these formations are described below.

Altered Saint-Léon

In the vicinity of the Bélanger road on the north side of the alteration zone, the Saint-Léon consists of a somewhat hardened, dark gray silty limestone or limy siltstone, in which the characteristic fine and regular laminations are still perfectly preserved. Farther south, the laminations give place to alternating, light green and whitish, irregular streaks and bands of non-calcareous material. With advanced metamorphic segregation, the bands desintegrate into an agglomeration of interconnected, white beads, varying from microscopic to 1/8 inch in diameter. At places, the hard, spotty rock is entirely made up of such small ovoid knots embedded in a light gray or greenish, aphanitic matrix. The greater part of the altered Saint-Léon rocks are white to beige, compact and cryptocrystalline hornfels with a conchoidal fracture. At places, the uniform texture and dull white luster of these flint-like rocks is suggestive of porcellanite.

There is insufficient exposure to determine whether the alteration within the Saint-Léon follows a definite pattern. While it is generally true that the grade of metamorphism is less pronounced at the periphery of the alteration zone than in the center, it is equally significant that pockets of relatively unchanged material occur side by side with completely reconstituted rocks. Since the alteration is of the contact-metamorphic type, the degree of reconstitution of these rocks will

be determined not only by their proximity to the intrusive body believed to be hidden in depth, but will also depend on their original composition.

It is difficult to ascertain whether the altered Saint-Léon rocks are derived from the siltstones or the pyroclastic rocks which, outside the alteration zone, form a considerable part of the formation. Since both rock types have been silicified to light gray to beige hornfels, hand specimens are of little help. The occasional relicts of partly recrystallized quartz and feldspar grains in some hornfels suggest a faint felsophyric texture indicative of volcanic parentage. The widespread kaolinization observed on the weathered surface of these hornfels is also supporting evidence.

It is concluded from the above description that the most striking alteration effects in the Saint-Léon as a whole consist of loss of carbonaceous matter and lime and addition of silica.

Altered Cap Bon Ami

The southern boundary of the alteration zone cuts diagonally across the Cap Bon Ami, NW. of Crochet lake. Some excellent outcrops of black, soft, argillaceous limestone can be seen on an exploration roadcut, immediately south of the alteration zone, near the western limit of the area. The rock, in contact with a quartz-feldspar porphyry dike, is somewhat hardened and slightly bleached, but still preserves the essential characteristics of the typical Cap Bon Ami lithology. As the rock débris is traced eastward into the alteration zone, bedding in the normally massive limestone is increasingly more evident. The rock weathers to a creamy color and becomes a tough, dark, non-calcareous hornfels. It is irregularly banded or, more commonly, streaked with purplish, flint-like material and grades imperceptibly into a dark-gray, cryptocrystalline hornfels. Considering that the rock débris is found close to the southern limit of the alteration zone, it is possible that it represents altered equivalents of the lower Grande Grève.

What we believe to be a typical equivalent of the Cap Bon Ami impure limestone was seen farther inside the alteration zone. The gray-green rock has a porous, yellowish brown weathering surface and reacts readily to diluted hydrochloric acid. It contains irregularly shaped knots of coarse, recrystallized calcite and small greenish to reddish garnets with perfectly developed crystal outlines. The color of the garnets

suggests that they belong to the grossularite-andradite series. Study of thin-sections may reveal the presence of idocrase. The calcite has been leached out in places, producing a vuggy rock deeply altered to a beige, earthy material. The mineral assemblage and general aspect of the rock are those of a typical garnetiferous skarn. Where the parent rock was more argillaceous, a lighter colored, at places garnetiferous, but much harder and more massive rock developed which does not react to acid and is evidently silicified and bleached. In presence of sufficient silica, the impure Cap Bon Ami limetsones were readily altered to a calc-silicate hornfels, owing to their high alumina content.

Origin of Alteration

The writer is of the opinion that neither the volcanic rocks nor the quartz-feldspar porphyry dikes can be held responsible for the alteration effects observed. The volcanic deposits are themselves bleached and silicified, and the country rocks in contact with the dikes outside the alteration zone are only slightly transformed. Moreover, these fresh-looking dikes invade and brecciate already altered country rocks and it is believed that they were emplaced after the alteration as offshoots of an intrusion at depth. As mentioned before, they occupy fractures that not only radiate from, but also cut across and penetrate the southeastern portion of the McGerrigle mountains massif.

It is plausible that the alteration of the Siluro-Devonian rocks reflects the proximity of a cupola of the McGerrigle mountains massif. In that case, the unaltered rocks in the Madeleine River valley would represent some sort of a roof pendant. This hypothesis requires a Devonian age for the McGerrigle mountains granitic intrusion, but a K/A age determination on a sample from the west-central part of the intrusive mass ("Jacques Cartier granite") indicates a Silurian age (Lowdon, Stockwell et al., 1963, p. 81). It should be kept in mind, however, that a single determination for a 40-square-mile stock can hardly be regarded as representative.

Pending further work, the writer tentatively suggests that the McGerrigle massif represents a composite stock made up of several intrusions of different age. A late addition of magmatic material, comparable in age to that of the porphyry at Gaspé Copper, may have been instrumental in bringing about the alteration. This renewal of igneous activity in Devonian time would have caused a reactivation or reopening of the radiating fractures into which the quartz-feldspar porphyries were injected.

PLEISTOCENE AND RECENT

The U-shaped profile of the Barter Lake - Long Lake valley in the center of the area and the presence of excellent glacial striae on the rocks found in the valley indicate broadening by glacial action. It is possible that southward-moving ice has gouged out the elongate depressions now occupied by small lakes. This is suggested by the presence in the valley of particularly thick and varied morainal deposits which may have blocked the normally southward directed drainage.

Most of the area east and west of Vert lake and Long lake is covered by rounded boulders and blocks. These are evidently derived from the McGerrigle mountains massif and its surrounding aureole, some 5 miles to the north.

The thickness of the overburden ranges between 10 and 20 feet in some higher areas and reaches 40 to 60 feet on valley sides.

With the exception of some locally thick morainal and recent alluvial deposits, fragments in the overburden reflect closely the subjacent bedrock, such as can be observed at the base of uprooted trees. Most soil is residual and podsolic, except along valleys and in swampy areas.

STRUCTURE

In spite of the scarcity of outcrops, the structural pattern of the area is not very complex. The Cambro-Ordovician rocks have been intricately deformed, whereas the Siluro-Devonian rocks have been folded into two major northeast-trending, broad and shallow plunging folds. Both structural units are crossed by a set of important fractures which radiate from the McGerrigle igneous massif and which cut across and probably offset ancient or reactivated fractures or fault zones trending E.-W. and NE.-SW.

There is very little lithological and consequently structural information available from the area underlain by the Cambro-Ordovician belt. Most of the following description will therefore apply to the area of the Siluro-Devonian rocks since field information therein is more plentiful.

SEDIMENTARY STRUCTURE

The Siluro-Devonian rocks exhibit at certain places a variety of features that can be described as sedimentary structures. In addition to the common ones, these features include sole markings, such as protrusions of silty material filling depressions in the underlying argillaceous limestone. At some places, current marks, such as crossbedding and washouts, were also observed.

Other sedimentary structures are attributed to deformation of the sediments while still in a semi-consolidated state. Good examples of convolute bedding were found in the Saint-Léon calcareous siltstones and limestones. This bedding shows disharmonic folds bounded above and below by undeformed laminated layers. Along Lesseps creek, contorted beds are interpreted as primary slump structures due to subaqueous gliding. Sedimentary boudinage is common in rocks of the lower Saint-Léon.

At some places outside the area the Cambro-Ordovician rocks exhibit excellently preserved primary sedimentary structures. They show current marks, in particular flute casts, as well as other structures associated with tops of beds. Such structures, typical of a flysch-type lithology, will be very valuable in the future for the study of the paleogeography of the area occupied by these rocks.

FOLDS

From rock debris and a few very poorly exposed outcrops it is thought that the Cambro-Ordovician rocks outside the alteration aureole are slightly folded and have a conspicuous slaty cleavage. Several outcrops on the Murdochville - Anse Pleureuse road, 20 miles NE. of the area, show a parallel type of folding. Only one cleavage, of the early type, was noted in these outcrops and there is no evidence to suggest that refolding has taken place. This is surprising, considering the age of the rocks and the deformations to which they have been subjected. The writer believes that this might be an isolated case and expects that future work will uncover isoclinal or similar folds overturned and thrusted towards the north, such as has been suggested by McGerrigle (1959, p. 23, 39-40).

Structurally, the area underlain by the Siluro-Devonian rocks is characterized by a NE.-trending, broad and open syncline and a complementary anticline some 3 miles to the south. The syncline is the eastern continuation of the Lesseps syncline mapped by Robert (1966b, 1967) west of the area. It merges into the Bonnécamp syncline east of the area (McGerrigle, 1959).

The dips of the beds range from almost horizontal in the axial part of the folds to 50° on the limbs; they average 30°. The steep ones are related in large measure to slight movement along cross faults. The axial plane of the folds is vertical or nearly so.

Regarding the surface expression of the Lesseps syncline, the area occupied by the string of small lakes in the central part of the area is of particular interest. North of Parent camp, as is evident from the attitude of the bedding W. and SW. of Barter lake, the fold relinquished its SW. plunge and swings north. On the east side of the Barter Lake - Long Lake valley, it trends almost E.-W. before turning gradually to the NE. and plunges gently in the same direction. The convergence of the strike of the beds in the central part of the fold, along with a reversal of plunge directions, represents a structure in the shape of an hour-glass, with the Barter Lake - Long Lake valley cutting the neck of the structure. It is fairly certain that this hour-glass structure has been brought about by movement along an important NNW.-trending fault or fault zone.

Owing to almost complete lack of exposure, much of what is known about the complementary anticlinal fold has been collected from outside the area. This broad, NE.-trending structure brings Saint-Léon rocks to the surface, along with those of the adjacent Cap Bon Ami and Grande Grève Formations. It is probable that the fold represents the SE. continuation of the Béland anticline, recorded by McGerrigle in the extreme SW. corner of the Madeleine River area (1959).

Reconnaissance traverses have located a NE.-striking syncline with York River sedimentaries and volcanics occupying its core, approximately 3 miles SE. of the above anticline.

FRACTURES

The term as used in this report comprises structural features ranging from fracture cleavage to joints and faults or fault zones.

Fracture cleavage is particularly evident in the Grande Grêve siliceous limestones NE. and SW. of Madeleine lake. It is parallel to the axial plane of the Lesseps syncline and is evidently contemporaneous to the folding. Its intersection with the well-developed bedding clearly defines the direction and amount of plunge of this important fold.

What the writer believes to be columnar jointing, with the hexagonal form of the columns still recognizable, was observed in a sheet of felsite or pyroclastic rocks, 1,500 feet NW. of Madeleine lake. Assuming that the joints developed at right angles to the layering and taking into account the tilting of the columns, the writer concludes that the sheet dips 40 to 50° SE.

A systematic study of aerial photographs revealed that the area is criss-crossed by regionally important fractures comprising both joints and faults. They have been grouped together on the map owing to insufficient field evidence to separate them; in addition, structures normally associated with faults indicate that movement has taken place along some joint surfaces.

Based on their orientation and relative age, the following four main sets of fractures have been distinguished in the area: regional E.-W. fractures, major NW.-SE. faults, some NE.-SW. fractures, and a swarm of joints and faults radiating from the McGerrigle igneous massif.

E.-W. fractures

The most important E.-W. fracture is the fault zone separating the Québec Complex from the Siluro-Devonian rocks, west of Barter lake. This zone, consisting of several, approximately parallel lineaments readily observable on aerial photographs, was traced westward to south of Mt. Albert.

A series of breccia horizons was observed in outcrops along a small south-flowing tributary of Madeleine river, 1,000 feet west of the area, and also at several places over a distance of 1,000 feet along Madeleine river, starting at a point 2,000 feet west of Barter lake. The outcrops consist of angular, beige fragments of limestone-conglomerate and siltstone embedded in highly contorted and veined calco-phyllitic matrix. At places, unoriented phenoclasts of ŏolitic limestone, 2 to 3 inches across, are enclosed in a heterogeneous matrix of fragmental, dove-weathering limestone and siltstone. In general,

the outcrops bear a striking lithological similarity to the Ordovician exposure along Isabelle brook and along the Murdochville - Grande Vallée road.

In an area about 1,000 feet NW. of Barter lake, the E.-W. lineaments are deflected northeastward. This deflection is due to displacement along an important cross fault whose strike coincides with the Barter Lake - Long Lake depression. The extension of this fault in the Madeleine River valley, NNE. of Barter lake, is uncertain owing to heavy vegetation and absence of outcrop float. Aerial photographs indicate, however, that it parallels the regional strike of the formations, south of Madeleine river.

It is probable that the fault zone, as observed in the area, is the eastern continuation of the South Shickshock fault recorded by Ollerenshaw in the Cuoq-Langis area. Both Jones (1933, p. 19-20) and Ollerenshaw (1967, p. 149) imply a downthrow of the Silurian block along a normal fault. Other workers familiar with Gaspé geology assert that the contact between the Cambro-Ordovician and Siluro-Devonian rocks is an angular unconformity (Cumming, 1959, p. 15-18; McGerrigle, 1959, p. 22; Béland, 1960, p. 2; Burk, 1964, p. 455). The spectacular difference in tectonic style between the two units, as well as the presence of conglomerate, suggests that the contact is unconformable. However, conspicuous lineaments in association with observed breccia horizons indicate that it is the site of a major fault or shear zone.

A series of other E.-W. striking lineaments was detected on aerial photographs; one of them, 5,200 feet south of Long lake, is particularly evident. East of Madeleine lake, huge blocks of frost-heaved Grande Grève siliceous limestone are bounded by NE. cleavage and E.-W. joints.

The fact that the E.-W. fractures, some of which appear to be regional in size, cut diagonally across the formations without apparently offsetting or disturbing this general trend suggests that they may be joints. There is, however, also the possibility that they reflect movement along ancient fractures in the pre-Siluro-Devonian rocks.

NW.-SE. fractures

The NW.-SE.-trending fracture recorded as a fault by Robert (1967) along Lesseps creek extends into the present area. Anomalous strike and dip attitudes infer that some displacement has taken place along this valley. Although the exact

nature of the fault is unknown, the pattern of the truncated formations suggests a downthrow of the east block relative to the west. Lineaments on aerial photographs indicate that it probably extends as far northwest as Porc-Epic brook in the northern corner of La Potardière township.

Another probably local fracture of unknown attitude is assumed to follow a NW.-SE. valley near Parent camp.

NE.-SW. fractures

Some NE.-SW.-trending fractures are presumed to parallel the regional strike of the formations. This assumption is based mainly on the presence of a well-defined set of lineaments on aerial photographs and the observation in the field of a graphitic zone in the argillaceous and carbonaceous limestone of the Cap Bon Ami Formation south of Madeleine lake. This zone, which shows conspicuous development of gouge, extends for some 2,000 feet.

Radial fractures

The most obvious fractures on aerial photographs, as well as in the field, are joints and faults radiating from the McGerrigle mountains massif. In the western part of the area, the N.-S.-striking fractures are occupied by quartz-feldspar porphyry dikes cutting across altered Saint-Léon and Cap Bon Ami rocks. Numerous vertical joints and faults, some of them showing displacements several tens of feet long, are very well exhibited in the gorge cut by Madeleine river, east of Barter camp. They transect gently southward-dipping Sayabec and Saint-Léon strata.

Some of the radial fractures occupy the Barter Lake - Long Lake valley. The writer believes that this ½-mile-wide depression represents structurally, as well as economically, one of the most significant fracture zones in the area. That this is a zone of dislocation is attested by the following lines of evidence.

a) The E.-W.-trending alteration zone ends abruptly at the east-facing scarp west of Bélanger road.

b) North and south of the alteration zone, the beds of the axial part of the Lesseps syncline dip 20°-30° degrees south.

c) The scattering of débris of Cap Bon Ami rocks over a wide area in the valley indicates a much larger surface expression than is usual for the formation. This suggests a decrease in dip of Cap Bon Ami beds, possibly as a result of downward tilting of the northern part of the block.

d) It has been mentioned above that the changes in trend of the axis of the Lesseps syncline east and west of the valley are a strong indication of faulting.

e) Anomalous strike and dip attitudes in the Grande Grève rocks SW. of Vert lake, as well as on the eastern flank of the valley, indicate that the eastern limb of the fold may be broken by N.-S.-trending faults.

f) There are indications that the Barter Lake - Long Lake fracture zone dies out farther south.

In view of the above-mentioned evidence, the writer assumes that the fault-bound valley is the site of a tilted block, the northern part of which was depressed as the result of rotation about an E.-W. hinge somewhere to the south.

In the northern part of the area, the radial fractures veer to the NW. Clear-cut lineaments on aerial photographs and field observations indicate that the fractures are typical cross faults. The amount of displacement along them changes from place to place, but does not involve overturning of beds.

It is fairly certain that the radial fractures represent the youngest structural features in the area, since they truncate and displace contacts, as well as all other fractures.

ECONOMIC GEOLOGY

MINERALIZATION IN THE CAMBRO-ORDOVICIAN BELT

A thick blanket of overburden and vegetation covers the area underlain by Cambro-Ordovician rocks. At one locality, small concentrations of pyrite and pyrrhotite are erratically distributed in vertically dipping calcareous schists. Another small occurrence of pyrite and pyrrhotite mineralization was noted in the band adjacent to the north. The sulfides form irregular veins or seams paralleling here and there the banding of the rock.

Reconnaissance traverses in the alteration zone farther north disclosed a somewhat larger concentration of such sulfides. The mineralization occurs in a 2,000-foot-wide band, approximately 4,000 feet NE. of the NW. corner of the area. Here, pyrite and pyrrhotite form stringers or irregularly shaped clusters, normally associated with replacement-type deposits. In addition, a test with dimethylglyoxime gave a faint positive reaction. Situated 2,000 feet east of the contact with the McGerrigle igneous mass, the rusty-weathering, apple-green host rock is a banded and streaked, garnetiferous hornfels. The occasionally high amounts of amphiboles and chlorite suggest that parts of the host rock are of volcanic origin.

MINERALIZATION IN THE SILURO-DEVONIAN BELT

Sulfide mineralization occurs at several places within the belt underlain by Sayabec, Saint-Léon and Cap Bon Ami Formations. A series of pinching and swelling, but continuous quartz veinlets containing galena, sphalerite, chalcopyrite, pyrrhotite and pyrite was seen in a 25- by 80-foot outcrop situated on the north bank of Madeleine river at the extreme western boundary of the area. The veinlets occupy vertical NW.-striking fractures, which form part of the above-mentioned set of radial joints and faults. Similar fractures in the gorge east of Barter camp and in the alteration zone to the south are occupied by quartz-feldspar porphyry dikes and a fracture-filling type of sulfide mineralization. The host rock, which extends beneath Madeleine river, is an almost flat-lying, brown-weathering, pitted and fractured limy quartzite, in which gray, oval remains of favositid and algae are still preserved. Field relations indicate that it probably represents the basal, silicified part of the Sayabec Formation. A sample taken by the author from the vein material and assayed by the laboratories of the Department of Natural Resources gave the following results: Cu, 0.08%; Pb, 2.27%; Zn, 4.34%; Ag, 7.185 oz./ton.

Another very similar type of sulfide mineralization, believed to be associated with an important dislocation zone, occurs near the Lepage Road - Madeleine River intersection, at a locality described by Jones as "Barter's camp" (1931, p. 225-226; 1933, p. 30-31). On the south bank of the river, several quartz stringers and veinlets carrying galena, sphalerite, chalcopyrite, pyrite and minor pyrrhotite are localized by vertical, NW.-striking fractures in the dolomitized, basal part of the Sayabec. At one place, a stringer was found to expand and form a lens 2 feet long and 8 inches wide consisting of sulfides in a gangue of quartz. On the north side of the river, a similar mineral assemblage seems to be confined to two parallel,

20- to 60-foot-wide belts of intensely silicified and disturbed Sayabec rocks. Squeezed between them is a 40-foot-wide, E.-striking and probably vertical felsite dike. Fine lamination and banding in the wall rock immediately in contact with the vein material suggest that mineralization is of the replacement type and that the NW. fractures served as channelways for the mineralizing solutions. A preliminary study indicates that, following partial dolomitization of the Sayabec limestone, an additional supply of Mg, Fe and Si resulted in the formation of talc and calcite, both of which replace marginal parts of the dolomite. The sulfides and quartz seem to have been introduced last. A specimen collected from lean vein material assayed as follows: Cu,0.08%; Pb,0.35%; Zn,0.96%; Ag,1.039 oz./ton.

Of considerable more economic interest is the sulfide mineralization found in the alteration zone west of Barter brook. Geochemical quick tests of stream sediment samples in the field gave a very strong copper anomaly, localized in a small area centered near a small tributary of Barter brook, about 1,500 feet west of the Bélanger trail. Subsequently, several samples rich in chalcopyrite and pyrite were collected in that area. The mineralization, which is of the fracture-filling type, occurs in a gray, rusty-weathering skarn, containing pockets of coarse, recrystallized calcite and small, greenish red garnet octahedra. The fine-grained bleached rock reacts to diluted hydrochloric acid and is almost certainly the metamorphic equivalent of the Cap Bon Ami argillaceous and carbonaceous limestone. There are indications that the mineralization is directly related to an important NNW.-striking fracture belt forming the eastern boundary of the alteration zone.

In 1966 and 1967, Terra Nova Explorations carried out an extensive exploration programme in this area (Sullico-Lepage and Sullipek claims); thirteen holes were drilled, one of which reached down to more than 1,500 feet.

Generally speaking, the type of alteration,including mineralization, described above is remarkably similar to that at Gaspé Copper mines. In both areas, hydrothermally or contact-metasomatically altered calcareous sediments are involved and the mineralization is strictly confined to zones of altered rock.

The writer believes that the mineralization in the area is of both the replacement and fracture-filling types and that it is the product of at least two phases of activity. An early introduction of mineralizing solutions may have taken place at the time of the alteration of the rocks. Subsequent igneous activity in the area having brought about extensive fracturing of the silicified and brittle rock, remobilization of sulfides

and probable addition of new material resulted in the fracture-filling type of mineralization.

Scattered specks of pyrite and pyrrhotite were found here and there in felsites of the Saint-Léon Formation, east of Barter camp. Small, insignificant concentrations of pyrite and pyrrhotite are also normally associated with basic dikes and sills. Spots of these sulfides have also been observed in places in unaltered Grande Grève and Saint-Léon rocks.

GEOCHEMISTRY

The survey party collected a total of over 500 stream sediment samples in the area. These were analyzed for Cu, Zn, Pb, Mo and U by the laboratories of the Department of Natural Resources, and the results are shown on the accompanying geochemical map. It should be noted that the geology and geochemical results for the western part of the area are also shown on map B-894, which was distributed in the fall of 1967. This map, which also includes the geological and geochemical data for the Lesseps Creek area (Robert, 1967), gives histograms and cumulative curves for the Cu, Zn, Pb, and U distributions.

Some of the samples collected in the western part of the area in 1966 were analyzed in the field for their "Total Heavy Metal" content (Smith, 1964) and for Cu (Canney and Hawkins, 1958) by means of cold extraction procedures. The results are very reliable, as, on a relative scale, they correspond closely to the results obtained in the laboratory. This is particularly so in the case of Cu, as shown by the following groups of results:

Field	Laboratory
0-10 ppm.	2-40 ppm.
10-30 ppm.	40-200 ppm.
100-175 ppm.	560-10,000 ppm.

The high anomalous values, clustered in a 4,500-foot-long and 1,500-foot-wide area NW. of Crochet lake reflect the observed Cu mineralization in the eastern part of the alteration zone described above.

High values in U, ranging up to 80 ppm., were obtained from different parts of the area. Although their distribution is, in places, erratic, they appear to be concentrated within, or close to, the alteration zone. The uranium background, at least in the western half of the area, is probably in the order of 8 to 10 ppm. The origin, as well as the economic significance of these anomalous values, is as yet unknown.

Results of analyses in p.p.m

Sample No. on the map	Code No. of sample in files of Dept.	Cu	Zn	Pb	Mo	Ni	U	Mn	
1	2053	-	-	-	-	18	16	1320	
2	1065	24	90	50	7	33	6	300	
3	2054	30	50	20	5	15	28	644	
4	1020	6	75	10	0	20	8	517	
5	6043	30	90	36	-	38	20	1150	
6	6042	36	75	40	-	25	32	1850	
7	6041	36	75	16	0	18	32	685	
8	6040	20	90	20	0	13	8	480	
9	1061	24	100	20	1	10	6	535	
10	1062	16	75	30	1	13	14	590	
11	6039	36	90	20	-	13	10	190	
12	6038	20	140	30	-	18	20	1550	
13	6037	-	-	-	-	13	12	465	
14	6036	40	140	36	0	18	16	736	
15	6035	36	150	40	0	28	8	818	
15A	6034	140	150	30	0	28	6	517	
16	1063	24	110	30	0	38	10	1120	
17	4051	70	125	40	-	45	1	2280	
18	2070	10	140	20	0	28	2	668	
19	2069	24	125	20	0	28	2	716	
20	2068	24	100	16	0	28	4	390	
21	2064	16	110	40	0	23	8	1850	
22	2065	20	125	16	0	28	8	2020	
23	4053	-	-	-	-	35	8	495	
24	1050	4	60	10	0	10	3	-	
25	4050	30	200	10	0	48	2	2350	
26	1051	6	90	6	0	28	2	596	
27	1067	40	220	20	0	45	2	1400	
28	1066	60	180	50	0	48	2	1380	
29	2035	30	140	40	0	25	4	2350	
30	1052	6	75	6	0	25	2	200	
31	1049	6	110	6	0	30	3	1475	
32	2029	50	60	4	-	23	4	614	
33	1053	40	90	10	-	21	2	-	
34	4063	160	300	30	0	13	8	1800	
35	4064	140	600	110	-	28	16	2850	
36	4065	150	500	80	-	30	16	596	
37	1060	6	50	10	0	3	3	345	
38	1054	6	75	6	-	8	4	300	
39	1055	10	125	20	-	11	4	418	
40	1056	100	500	160	-	54	10	734	

Results of analyses in p.p.m.

Sample No. on the map	Code No. of sample in files of Dept.	Cu	Zn	Pb	Mo	Ni	U	Mn	
41	6026	300	1000	225	0	43	12	2850	
42	3004	26	280	44	0.4	-	36	751	
43	2051	180	500	60	0	33	10	900	
44	3002	100	750	40	0.4	-	32	-	
45	2050	210	560	70	0	38	12	1320	
46	2049	-	-	-	-	-	8	1850	
47	3022	4	180	10	0.4	-	28	1120	
48	3023	6	180	16	0.4	-	24	782	
49	3024	8	90	14	0.4	-	32	677	
50	2032	10	55	10	0.4	-	1	205	
51	2028	6	60	6	0	15	4	602	
52	2035	140	800	44	0.4	-	8	-	
53	2030	6	60	20	0.4	-	16	280	
54	2027	2	80	24	0.4	-	6	595	
55	2031	36	80	36	0.4	-	-	-	
56	2039	92	65	14	0.4	-	48	-	
57	1030	6	60	10	0	16	6	450	
58	2031	20	60	4	0	15	24	632	
59	1029	4	100	6	-	7	-	-	
60	1027	6	1100	10	-	21	2	-	
61	1028	4	125	36	-	-	-	-	
62	1064	20	125	24	0.8	38	-	1920	
63	2034	10	60	4	0	17	8	596	
64	2033	20	60	6	0	22	16	2850	
65	2032	10	140	6	0	20	18	2420	
66	1122	70	85	14	0.4	-	3	345	
67	1121	1120	240	14	0.4	-	36	-	
68	1124	560	60	20	0.4	-	72	695	
69	3020	8	70	4	0.4	-	28	320	
70	3021	14	180	24	0.4	-	32	677	
71	2040	140	110	14	6	-	64	1440	
72	2038	72	100	26	0.8	-	32	-	
73	2039	92	65	14	0.4	-	48	-	
74	2037	60	100	12	2	-	48	-	
75	1065	60	1000	70	0.4	-	4	1340	
76	1064	100	1250	56	0.4	-	6	-	
77	1066	44	400	36	0.4	-	3	500	
78	1067	50	280	30	0.4	-	1	485	
79	2024	20	75	20	0.4	-	16	97	
80	2023	4	85	28	8	-	24	2440	
81	1025	4	80	16	0.4	-	6	490	

Results of analyses in p.p.m

Sample No. on the map	Code No. of sample in files of Dept.	Cu	Zn	Pb	Mo	Ni	U	Mn
82	1048	14	90	24	0.4	-	6	-
83	2022	4	40	12	0.4	-	32	577
84	2026	6	100	26	0.4	-	2	613
85	2006	3000	650	36	0.8	-	20	1100
86	1114	2200	900	40	0.4	-	20	-
87	1115	2300	460	50	0.4	-	28	-
88	1116	2800	500	56	0.4	-	24	-
89	1118	1200	340	46	5	-	16	-
90	1117	10000	1000	36	0.4	-	48	-
91	1119	1000	300	36	0.4	-	16	-
92	1120	1600	300	90	0.4	-	16	-
93	3006	40	360	44	0.4	-	6	462
94	1068	50	320	100	0.4	-	16	806
95	3003	50	800	40	0.8	-	10	-
96	1069	20	600	75	2	-	6	328
97	1044	20	60	6	0	50	4	1140
98	1045	6	60	10	0	22	2	542
99	1047	10	60	10	0	-	2	-
100	1031	6	60	6	0	28	2	440
101	2024	6	60	4	-	17	0.5	-
102	2025	6	60	6	0	0	0.5	596
103	2023	6	60	4	0	25	0.5	-
104	2022	4	50	4	-	15	-	-
105	2021	4	60	6	-	-	0.5	-
106	4026	2	60	6	0	20	0	400
107	1032	6	75	6	0	18	2	400
108	1046	6	50	10	0	15	2	318
109	1042	6	90	6	0	28	2	1690
110	1041	6	60	6	0	25	0.5	490
111	1040	2	50	6	0	27	1	1314
112	1043	6	60	6	0	30	2	560
113	4041	-	-	-	-	-	2	-
114	1093	8	20	16	0.4	-	2	75
115	1094	8	35	14	0.4	-	1	85
116	4042	6	70	6	2	10	1	163
117	1095	10	80	44	0.4	-	0	260
118	1092	6	60	18	0.4	-	1	142
119	2007	6	20	2	2	-	56	218
120	2008	4	100	75	3	-	8	594
121	3035	16	180	110	0.4	-	6	95
122	3034	2	85	14	0.4	-	-	315

Results of analyses in p.p.m.

Sample No. on the map	Code No. of sample in files of Dept.	Cu	Zn	Pb	Mo	Ni	U	Mn
123	3033	4	200	36	0.4	-	-	300
124	1061	20	220	30	1	-	28	-
125	1060	16	65	40	0.4	-	-	-
126	1059	24	280	40	0.4	-	16	2600
127	1096	4	50	12	0.4	-	16	134
128	1097	6	60	14	0.4	-	80	25
129	1098	6	140	50	0.4	-	-	2345
130	4044	6	65	10	0	20	2	455
131	4043	36	60	16	-	-	8	-
132	2011	4	45	16	0.4	-	18	138
133	1090	6	85	10	0.4	-	8	1240
134	4049	10	70	6	0	20	4	566
135	1086	4	40	16	0.4	-	-	329
136	4048	6	50	10	0	18	1	298
137	4039	4	150	6	0	20	2	438
138	4047	6	50	10	0	20	2	485
139	4046	6	60	6	0	20	3	475
140	4045	4	50	10	0	20	2	465
141	2026	4	60	6	0	21	0.5	450
142	1034	10	90	4	0	20	4	1260
143	1033	30	110	6	0	35	6	1750
144	1015	36	90	10	0	30	4	-
145	1035	6	75	4	0	22	3	295
146	4031	6	65	4	0	10	9	385
147	4030	20	65	4	-	18	2	630
148	4029	4	60	6	-	20	0.5	455
149	4028	4	75	6	-	25	1	455
150	4027	6	60	6	0	30	-	523
151	4032	24	70	4	-	16	12	470
152	4033	30	70	4	-	10	12	-
153	4034	6	65	6	-	10	11	608
154	4035	20	65	10	-	-	10	-
155	1017	6	60	10	0	22	1	370
156	1016	4	75	6	0	13	2	620
157	1036	6	110	6	0	25	3	1236
158	1037	24	75	6	0	50	2	485
159	4037	50	60	6	0	-	8	330
160	1038	6	60	10	0	44	1	650
161	1086	4	40	16	0.4	-	-	329
162	1088	6	75	20	0.4	-	4	-
163	1085	6	35	16	0.4	-	8	140

Results of analyses in p.p.m

Sample No. on the map	Code No. of sample in files of Dept.	Cu	Zn	Pb	Mo	Ni	U	Mn
164	1084A	4	65	6	0.4	-	12	-
165	1084B							
166	1087	6	50	16	0.4	-	12	85
167	1003	6	115	24	0.4	-	12	824
168	1002	8	140	16	0.4	-	6	445
169	1001	24	140	26	0.4	-	6	435
170	1070	4	90	16	0.4	-	8	-
171	1071	6	85	12	0.4	-	3	342
172	1072	6	80	20	0.4	-	2	800
173	1073	8	60	14	0.4	-	1	614
174	1076	10	100	12	0.4	-	8	290
175	1077	6	90	20	0.4	-	10	-
177	1083A	6	25	8	0.4	-	-	34
178	1018	4	75	6	0	18	2	590
179	1019	4	50	10	-	-	14	-
180	1020	6	75	10	0	20	8	517
181	1021	6	60	6	0	15	2	728
182	1022	6	90	10	0	17	2	626
183	1010	10	60	10	0	26	-	644
184	1011	6	75	6	0	20	1	517
185	1012	4	60	6	0	21	1	570
186	1013	-	-	-	-	-	4	-
187	1014	10	60	10	-	-	-	-
188	4036	-	-	-	-	-	4	-
189	1023	10	125	6	-	-	6	1166
190	1024	-	-	-	-	-	-	-
191	1024B	50	50	8	0	25	40	65
192	1025	16	1400	10	-	5	-	-
193	1024A	16	60	6	0	15	6	950
194	2020	16	140	6	0	13	8	1610
195	2019	24	140	6	0	20	16	-
196	3008	6	85	10	0.4	-	2	165
197	3014	6	60	26	0.4	-	4	-
198	3009	6	115	14	0.4	-	10	-
199	3010	2	90	6	0.4	-	1	130
200	3011	4	115	16	0.4	-	4	480
201	3012	4	125	16	0.4	-	2	-
202	1081	6	90	10	0.4	-	4	288
203	1082	8	100	14	0.4	-	6	243
204	1080	6	85	8	0.4	-	4	215
205	3013	10	140	20	0.4	-	-	-

Results of analyses in p.p.m.

Sample No. on the map	Code No. of sample in files of Dept.	Cu	Zn	Pb	Mo	Ni	U	Mn
206	1078	6	85	12	0.4	-	6	-
207	1075	2	55	16	0.4	-	0	400
208	1074	6	50	12	0.4	-	0.5	395
209	2001	12	60	16	0.4	-	1	591
210	3015	6	70	10	0.4	-	-	295
211	3016	6	65	4	0.4	-	8	262
212	3017	4	85	12	0.4	-	2	65
213	2017	24	140	10	0	17	12	812
214	2018	16	140	10	0	18	11	1490
215	1026	-	-	-	-	-	16	-
216	1026A	180	60	10	0	43	12	305
217	1026B	40	60	10	0	33	12	520
218	2010	-	-	-	-	-	4	-
219	4021	4	75	6	0	-	2	-
220	4022	6	60	6	-	5	1	-
221	2016	-	-	-	-	-	6	620
222	4023	6	60	10	-	-	-	-
223	3018	2	100	24	0.4	-	4	-
224	3019	2	90	10	0.4	-	1	220
225	2019	4	65	16	0.4	-	1	95
226	3001	20	85	16	0.4	-	2	-
227	1034	8	75	22	0.4	-	12	1100
228	1033	10	60	16	0.4	-	10	746
229	1035	10	80	10	0.4	-	4	1280
230	1036	6	70	16	0.4	-	8	510
231	1030	6	80	16	0.4	-	8	-
232	1022	30	65	12	0.4	-	3	410
233	1021	44	250	6	0.4	-	12	370
234	1020	8	110	14	0.4	-	4	445
235	1026	6	65	12	0.4	-	14	450
236	1019	16	100	12	0.4	-	1	345
237	1027	6	70	14	0.4	-	6	352
238	1018	16	70	10	0.4	-	1	380
239	1017	14	90	12	0.4	-	2	340
241	1016	16	100	10	0.4	-	1	280
242	1029	4	60	20	0.4	-	8	854
243	1031	4	70	20	0.4	-	6	662
244	1028	24	60	20	0.4	-	1	460
245	1015	10	90	16	0.4	-	2	440
246	1014	20	85	12	0.4	-	2	465
247	1013	12	100	12	0.4	-	2	460

Results of analyses in p.p.m

Sample No. on the map	Code No. of sample in files of Dept.	Cu	Zn	Pb	Mo	Ni	U	Mn
248	2021	6	90	14	0.4	-	-	-
249	2020	16	85	16	0.4	-	1	618
250	2018	22	90	16	0.4	-	2	835
251	2017	8	65	24	0.4	-	8	2000
252	2015	6	40	14	0.4	-	12	847
253	2016	4	125	20	0.4	-	-	853
254	2014	6	90	14	0.4	-	12	-
255	2013	6	70	10	0.4	-	8	1040
256	4024	4	60	10	0	8	2	213
257	4020	4	110	6	-	88	2	372
258	4025	6	60	6	-	-	-	250
259	4017	-	-	-	0	-	0	-
260	4018	4	60	4	-	10	-	310
261	4019	4	60	4	-	-	1	-
262	4015	6	60	6	-	15	1	-
263	4016	6	60	6	0	20	2	380
264	4013	4	60	24	-	-	-	-
265	4014	4	75	4	-	13	2	-
266	2013	30	110	10	0	25	12	4280
267	2003	30	80	6	0	-	8	-
268	2004	-	-	-	-	-	-	-
269	2005	20	100	20	-	15	-	-
270	2006	10	90	20	-	4	-	412
271	2007	50	90	10	-	-	12	-
272	2012	40	90	10	0	25	12	4950
273	2011	30	60	20	-	-	-	-
274	2008	40	90	10	-	6	16	-
275	2009	-	-	-	-	-	6	300
276	4012	4	60	6	-	12	3	-
277	4008	6	60	4	0	15	3	-
278	4009	10	75	6	0	17	2	-
279	4007	16	40	4	0	8	5	-
280	2015	6	110	36	-	-	-	-
281	2014	20	90	20	-	8	-	-
282	4004	6	60	6	0	20	8	432
283	4005	6	110	6	0	11	6	950
284	1011	10	110	14	0.4	-	1	360
285	1012	16	125	16	0.4	-	4	626
286	2005	6	110	32	0.8	-	8	-
287	2012	4	60	8	0.4	-	4	-
287A	4006	6	75	6	0	13	14	746

Results of analyses in p.p.m.

Sample No. on the map	Code No. of sample in files of Dept.	Cu	Zn	Pb	Mo	Ni	U	Mn
288	4010	6	75	6	0	12	2	348
289	4002	10	90	4	0	20	14	460
290	3029	2	80	2	0.4	-	12	619
291	3030	2	60	30	0.4	-	-	492
292	4003	10	75	4	0	20	9	523
293	4001	6	60	4	0	20	8	490
294	4011	6	60	6	0	20	2	450
295	1002	6	90	4	0	23	2	348
296	2002	-	-	-	-	-	6	-
297	1006	10	90	10	0	35	1	950
298	3027	14	100	16	0.4	-	2	629
299	3031	16	90	16	0.4	-	2	627
300	3028	4	90	14	0.4	-	10	1100
301	1113	4	40	14	0.4	-	14	847
302	1099	26	80	10	0.4	-	4	2600
303	1041	28	60	14	0.4	-	0.5	460
304	1040	6	100	8	0.4	-	6	-
305	1039	6	100	8	0.4	-	6	794
306	1038	4	90	4	0.4	-	8	-
307	2003	6	110	10	2	-	4	-
308	1037	14	115	14	0.4	-	6	1200
309	1036	6	70	16	0.4	-	8	510
310	1106	4	75	36	0.4	-	6	2350
311	1105	6	90	14	0.4	-	4	847
312	2004	10	90	16	1	-	6	612
313	1104	10	90	8	0.4	-	6	782
314	1103A	14	60	10	0.4	-	10	-
316	1102	8	85	8	0.4	-	16	502
317	1101	10	85	10	0.4	-	2	-
318	1100	16	85	12	0.4	-	3	500
319	1107	28	90	14	0.4	-	1	594
320	1108	6	125	12	0.4	-	2	507
321	1109	14	90	10	0.4	-	4	659
322	1112	16	100	16	0.4	-	4	1240
323	1113	6	85	12	0.4	-	10	425
324	1110	10	115	14	0.4	-	5	600
325	3026	2	170	30	0.4	-	6	5840
326	3025	6	90	14	0.4	-	4	735
327	1001	6	125	2	0	21	3	692
328	1003	6	140	4	0	20	4	542
329	1004	6	100	2	0	24	2	345

Results of analyses in p.p.m

Sample No. on the map	Code No. of sample in files of Dept.	Cu	Zn	Pb	Mo	Ni	U	Mn	
330	1005	10	100	6	0	23	2	214	
331	1007	6	60	10	0	21	2	375	

Results of analyses in p.p.m.

Sample No. on the map	Code No. of sample in files of Dept.	Cu	Zn	Pb	Mo	Ni	U	Mn	
332	1008	6	90	10	0	20	2	480	
333	1009	10	90	10	-	24	2	-	

N.B. Dashes indicate the absence of results for the element concerned.

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