GEOLOGICAL MAPPING OF THE WABUSH-LABRADOR CITY AREA, SOUTHWESTERN LABRADOR

by T. Rivers

INTRODUCTION

As part of the program of 1:50,000 scale mapping and reassessment of the mineral potential of the Labrador Trough, mapping was initiated this year in the southerly continuation of the Trough rocks within the Grenville Province in the Wabush-Labrador City area. Extensive iron deposits occur in the area, four of which are presently being exploited.

Previous work

Geological reconnaissance, principally by Labrador Mining and Exploration Company and Newfoundland and Labrador Corporation, began in the 1930's and 1940's, with detailed mapping and economic evaluation of the iron deposits continuing into the 1950's. Full scale mining operations were started by the Iron Ore Company of Canada in 1962 and by Wabush Mines in 1965 Both companies have since continued detailed exploration mapping, supplemented by diamond drilling and geophysical work in the immediate vicinity of the mining areas, but little attention has been paid to the extensive areas of non iron-bearing rocks outside the limits of the present mines. Existing coverage by detailed company maps is therefore patchy.

Geological Survey of Canada regional maps at 1 inch: 4 mile scale by Fahrig (1960) and 1:125,000 scale by Jackson (1976) include all the area covered by this season's mapping. The area was also included in regional investigations by Knowles (1967), Dimroth *et al.* (1970), Wynne-Edwards (1972), and Séguin (1973). Detailed studies of the mineralogy and metamorphism of the iron formation have been made by a number of authors, including Mueller (1960), Kranck (1961), Klein (1966, 1973), and Butler (1969). A comprehensive report by Gross published in 1968 dealt with occurrences of iron formation in both Quebec and Labrador.

OBJECTIVES

It is the aim of this project to:

(1) map, at a scale of 1:50,000, the geology of the area, utilizing detailed company maps where available;

(2) interpret the structural and metamorphic geology

(3) assess the mineral potential of the area.

GENERAL GEOLOGY

The Wabush-Labrador City area lies close to the junction of the Superior, Churchill and Grenville tectonic provinces. The rocks of the Superior Province, known locally as the Ashuanipi Complex, are composite gneisses and migmatites of high metamorphic grade. In the region of the Labrador Trough, this basement terrain is overlain by Aphebian strata (including iron formation) in unconformable or simple fault contact.

North of the Grenville Front, within the Churchill Province, Aphebian rocks exhibit the effects of low grade metamorphism. South of the Grenville Front the grade of metamorphism increases gradually to the sillimanite zone over a distance of 15-40 km, and superposed deformations produce complex interference patterns on a variety of scales. The unconformity surface between the Archean and Aphebian rocks (the latter being known as the Gagnon Group within the Grenville Province) is folded and disrupted, as rocks on both sides of the surface are involved in the later reworking. The age of this reworking is generally assumed to be Grenvillian as K/Ar dates in the area yield an age of about 1000 Ma.

Thus the Grenville Front separates areas of simple (Churchill Province) and complex (Grenville Province) tectonic history, and in the field it is marked by the northern limit of Grenville structures.

ARCHEAN BASEMENT ROCKS

No Archean basement rocks are exposed in the map area, though glacially transported boulders are common locally. However, reconnaissance immediately north and west of the map area has revealed the presence of basement rocks. They are typically of granodiorite to diorite in composition, and are composite in texture, being composed of alternating mafic and felsic layers. Mafic layers contain orthopyroxene, indicating metamorphism in the granulite grade. Coarse grained phases are cut by an irregular fracture cleavage, giving rise to a marked cataclastic texture. Though not occurring in the map area, this unit has been described because several authors, *e.g.* Gross (1968), have noted difficulty in distinguishing reworked basement from the schists and gneisses of the Gagnon Group.

GAGNON GROUP

Katsao Formation (unit 1)

A quartz-feldspar-biotite (rarely amphibole) schist/gneiss, frequently garnetiferous and locally kyanite bearing, forms the base of the sequence. The biotite content of these rocks is quite variable, resulting in both schistose and gneissic textures. In one locality a thin band of marble with calc-silicate minerals is intercalated within the gneiss; this, together with the presence of kyanite and rarely staurolite, indicates a sedimentary origin for the formation.

Rocks included in this unit are commonly migmatitic, with a quartz-feldspar leucosome component interbanded with the gneiss/schist melanosome. These migmatities were subdivided during mapping into three units based on the proportion of the leucosome component:

(1a) <30 percent leucosome component,

(1b) 30-60 percent leucosome component, and

(1c) >60 percent leucosome component

The migmatite is the lit-par-lit variety, with leucosome contacts parallel to the pervasive schistosity in the rock. Potash feldspar is rare in the leucosome as it is in the metanosome, indicating that the leucosome was endogenously derived.

Units lb and lc occur predominantly in the east of the map area, indicating that the degree of migmatism increases in that direction.

Duley Formation (unit 2)

Overlying the Katsao Formation is a dolomitic marble which comprises the Duley Formation. In most exposures, this is a buff colored, well banded rock which commonly contains minor calcite and segregations of quartz and tremolite; the tremolite becomes more common and of larger crystal size towards the south.

The formation occupies a broad band along the east side of Wabush Lake; this band widens in the southwest of the area where dips are shallow. In the northwest this formation is absent and quartzite (unit 3) lies directly on the gneisses of the Katsao Formation.

Wapussakatoo (or Carol) Formation (unit 3)

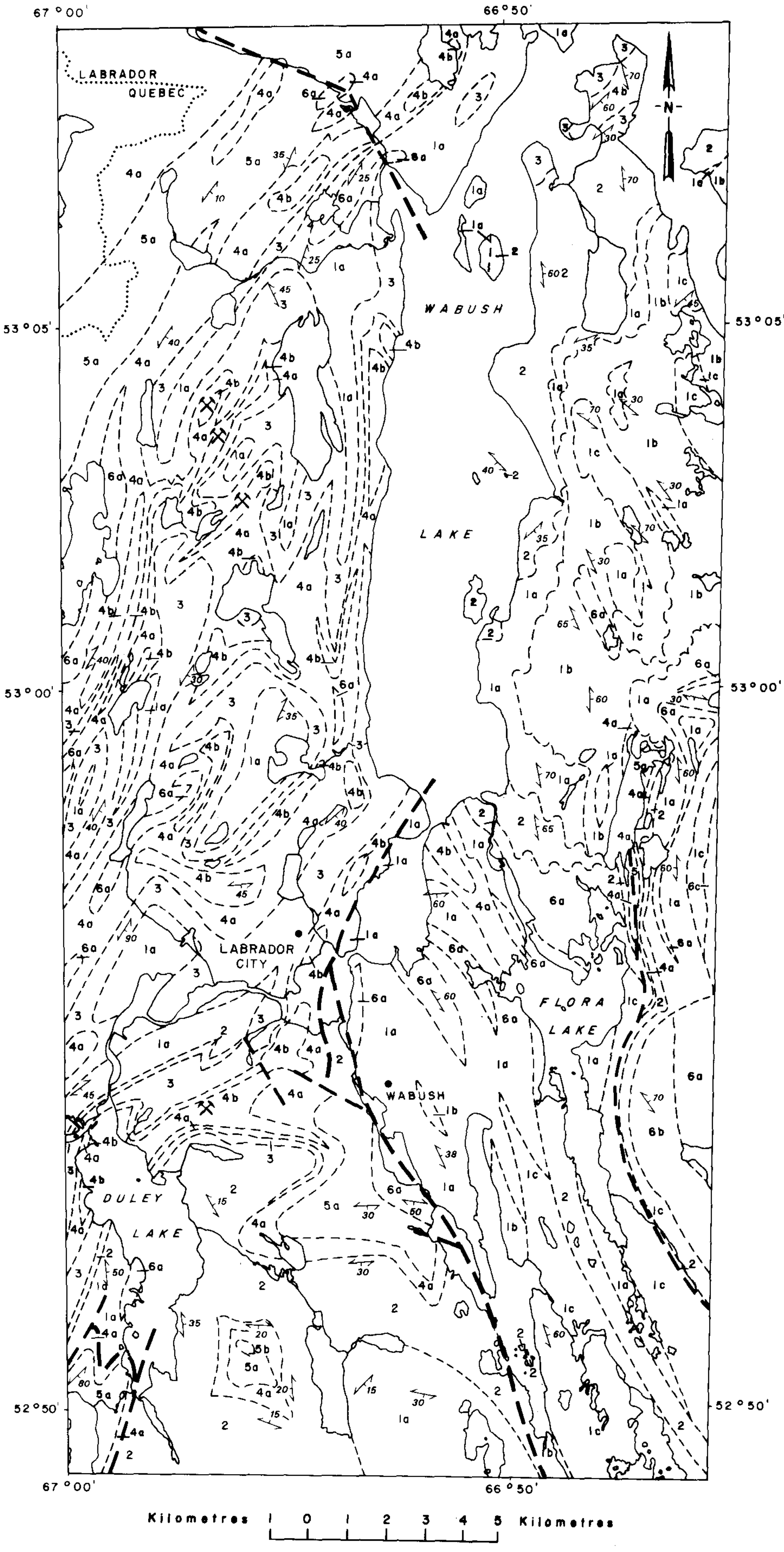
The Wapussakatoo quartzite is a massive, coarsely crystalline, featureless rock in most exposures; immediately west of Wabush Lake it forms the core of the Wapussakatoo Mountains. In places the quartzite contains a relict, discontinuous banding of iron oxides which may represent original bedding. Towards the top of the unit muscovite and minor garnet become common, and the rock assumes a schistose texture.

Wabush Formation (unit 4)

The Wabush Formation, which directly overlies the quartzite of unit 3, consists of two distinct varieties of iron formation; namely, silicate-carbonate iron formations (unit 4a) and oxide iron formation (Unit 4b). Stratigraphically, the Wabush Formation is divided into three units, a lower silicate-carbonate, a middle oxide, and an upper silicate-carbonate unit. The oxide unit is the basis of the mining industry in the region.

The silicate-carbonate iron formation is typically well banded with alternating silicate and carbonate layers, though locally one type may predominate. A variety of minerals are present. Quartz, grunerite-cummingtonite, actinolite, tremolite, hornblende, diopside and hypersthene are the common minerals in the silicate bands; the carbonate bands are characterized by dolomite, ferrodolomite, siderite and ankerite. Thin bands of oxide iron formation (<5 m), often containing a high proportion of magnetite, are also common in the silicate-carbonate iron formation.

The oxide iron formation of Unit 4b consists mainly of hematite and magnetite with either quartz or chert in varying proportions. In most cases the magnetite/hematite (specularite) ratio does not exceed O.5. Texturally, the rock is quite variable with schistose, specular hematite and fine grained granular hematite being two of the more common types. The variation in texture appears to be due to the degree of recrystallization that the rock has undergone; the grain size of specular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LEGEND

LOWER PROTERZOIC

SHABOGAMO GROUP

6 *Gabbro, diorite, anorthositic gabbro, pyroxenite and associated metamorphic and migmatitic rocks;* **6a,** *gabbro and metagabbro, diorite and metadiorite, pyroxenite, amphibolite and biotite schist;* **6b,** *anorthositic gabbro;* **6c,** *migmatitic gabbro.*

GAGNON GROUP

5 **NAULT FORMATION:** *Quartz-feldspar-biotite bearing schists and gneisses and associated migmatitic rocks;* **5a,** *schists and gneisses, including those migmatites with a granitic component of 30 percent;* **5b,** *migmatite, with granitic components 30 percent.*

4 **WABUSH IRON FORMATION: 4a,** *Silicate-carbonate iron formation;* **4b,** *oxide iron formation.*

3 **WAPUSSAKATOO (CAROL) FORMATION:** *Quartzite.*

2 **DULEY FORMATION:** *Marble.*

1 **KAKAO FORMATION:** *Quartz-feldspar-biotite bearing schists and gneisses and associated migmatitic rocks;* **1a,** *schists and gneisses including those migmatites with a granitic component of30 percent;* **1b,** *migmatite with a granitic component 30-60 percent;* **1c,** *migmatite with granitic component 60 percent.*

SYMBOLS

Geological contact

Fault

Schistosity, gneissosity

Producing open-pit iron mine.

hematite is considerably larger than that of granular hematite, and crystalline quartz tends to be present in the former in contrast to chert in the latter. There is a general increase in grain size and quartz to chert proportion southwards from the Grenville Front, though the trend is quite uneven, and patches of fine grained granular iron formation with relict sedimentary structures are present throughout the area.

In the Wabush Mines area between Wabush Lake and Duley Lake, the middle oxide iron formation is divided into two units by a quartzite horizon up to 30 m thick. This is a local subdivision, however, as the quartzite is not present in the Iron Ore Company of Canada mines to the north.

Nault Formation (unit 5)

Overlying the iron formation is another quartz feldspar-biotite schist/gneiss (Unit 5a) which may appear similar to the Katsao Formation in some outcrops. It is graphitic in places, but this feature is not diagnostic. Since it is also migmatitic (Unit 5b) it is distinguished from the Katsao Formation primarily on the basis of its stratigraphic position.

MONTAIGNAIS AND SHABOGAMO GROUPS (undifferentiated) (unit 6)

A suite of gabbroic and related rocks intrudes the rocks of the Gagnon Group. Unit 6a consists of gabbro, diabase, diorite and pyroxenite and their metamorphosed equivalents, principally garnetiferous metagabbro, hornblende gneisses, amphibolite and biotite schist. Unit 6b is anorthositic gabbro. These rocks occur as lenses, sills and pods from less than a metre to several kilometres across within the metasedimentary rocks of the Gagnon Group. The larger intrusions appear to be relatively little affected by metamorphism and deformation in their central portions as igneous textures are preserved. The smaller bodies and the margins of the large bodies contain a penetrative foliation which has frequently obliterated all traces of previous textures. As with the quartz-feldspar-biotite gneisses, some gabbroic rocks are intruded by granitoid phases in places; in such places they are mapped as migmatitic gabbro (Unit 6c).

Correlation of these rocks with either the Montaignais or Shabogamo Group elsewhere in the Churchill and Grenville Provinces is not certain; however, it is likely that some intrusions are part of the younger Shabogamo Group.

STRUCTURAL GEOLOGY

Folding. The rocks of the area have undergone three phases of deformation, two of which have been recognized previously by most company geologists. Folds of the first generation are isoclinal and for the most part of small scale, so that there was no major disruption of the stratigraphy over much of the area. A foliation parallel to the primary layering, penetrative in schistose rocks and marble but absent from quartzite and granular iron formation, was the result of this deformation.

During the second deformation this S_0/S_1 surface was folded into northeast-southwest trending folds which are in places overturned to the northwest, with axial surfaces dipping as low as 45° to the southeast. Plunges of F_2 folds are generally less than 20° towards either the northeast or southwest.

Third phase folds are quite variable in direction and plunge because they are imposed on an already folded surface. In general they trend northwest-southeast but east of Wabush Lake a north-south trend is dominant, and small folds in the Iron Ore Company of Canada pits trend almost east-west.

No penetrative fabric was formed parallel to the axial surfaces of F_2 or F_3 folds.

Lineations are present in many outcrops. Over the map area as a whole their orientation is quite variable but subareas of consistent orientation can be delimited. Crenulation, intersection and mineral lineations are three common types; it is probable that they were developed during each of the three deformational events, though it was not possible to separate them accurately on this basis.

The superposition of F_3 folds on F_2 folds has given rise to structural interference patterns. These are well illustrated by the outcrop patterns of Wapussakatoo quartzite west of Wabush Lake and of iron formation south of Wabush Lake. A pattern of elongate domes and basins is apparent, with the oxide iron formation occupying many of the basinal areas.

East of Wabush Lake few good marker horizons are available to map out the structures in detail, but a dome and basin pattern is apparent in one location about 3 km northeast of Flora Lake.

Faulting. Faults are present in several of the open pits in both Iron Ore Company of Canada and Wabush Mines properties. They are generally steeply dipping (60°) and of small displacement, but evidence concerning the nature of displacement is not available in most cases. Since the faults are not folded, they are assumed to be late structures that postdate the ductile deformations, (D_1 - D_3) described above.

Several such faults in the Wabush Mines pits are the sites of planar deposits of a glutinous, pink clay which appears to be a secondary alternation product of a fault breccia. The alteration was probably associated with leaching (see below) as the faults are also the sites of banded limonite, goethite and manganese oxide deposition.

Clarke *et al.* (1975) also note the existence of tectonic slides associated with both F_1 and F_2 folds. Since it is likely that folds of the first deformation were subhorizontal, the existence of slides parallel to flat-lying axial surfaces allows for the possibility of considerable repetition of strata. Whether this widely occurred is not certain, but in one case it appears likely. At the south end of Flora Lake there is a repetition of marble and migmatites, and the more easterly of the repeated units are considered to be in fault contact with the underlying rocks to the west.

METAMORPHISM

Metamorphic grade in the area increases from northeast to southwest. Tremolite is common in dolomitic marble, except in the extreme north of the area mapped, but no diopside was observed in the marble. Kyanite is common locally throughout the area in rocks of suitable composition, and one occurrence of the pair staurolite-kyanite was found. Sillimanite was not seen in the map area, though it has been reported to the south (Fahrig, 1960, 1967). Garnet is ubiquitous in both amphibolite and quartz-feldspar-biotite gneisses. These minerals suggest that the grade of metamorphism varies from lower to middle amphibolite facies, with much of the area probably being in the staurolite-kyanite zone.

This indicates a temperature in the range of 600° C (Winkler, 1976), an estimate that is consistent with the suggestion made previously of *in situ* partial melting of hydrous quartzofeldspathic rocks to form migmatite.

AGE OF DEFORMATION, METAMORPHISM AND INTRUSION

Migmatitic portions of the Katsao Formation are pervasively deformed by F_2 and F_3 folds, indicating that migmatism occurred before the D_2 deformation. Since the migmatite banding is parallel to the S_1 schistosity, it is reasonable to assume that migmatism predated or was synchronous with the D_1 event. The metamorphic peak also occured at this time.

The age of intrusion of the gabbroic rocks is not certain. Since some of the rocks are migmatitic, it is considered that intrusion took place before or during the first deformation. However, the relatively little deformed nature of other bodies suggests that they were intruded after this penetrative deformational event. Furthermore, a few small diabase dikes crosscut the migmatitic layering and are not themselves deformed. Thus, it is likely that intrusion of this group of rocks spanned a long period of time, but radiometric dating is needed to confirm this hypothesis.

A number of radiometric ages have been determined for other rocks from the region. Fahrig (1967) reports K/Ar ages of 1,125 Ma and 980 Ma from coexisting biotite and muscovite in rocks of unit 1, 10 km east of Wabush Lake; these ages must reflect the Grenvillian event in the area. However, 20 km northeast of the map area and also south of the Grenville Front, biotite from rocks in the same map unit yields an age of 1,615 Ma, suggestive that the metamorphism was Hudsonian in age. It is recognized that further dating is necessary to clarify the geological history of the region, but tentatively it is considered that the first deformation and associated metamorphism and migmatism are Hudsonian in age, and that younger K/Ar ages are due to a Grenvillian thermal overprint. Whether the second and third deformational events are Hudsonian or Grenvillian has not yet been determined.

LEACHING

In the Wabush Mines pits southwest of Wabush Lake, the ore has a sandy, friable texture which is a result of leaching of silica and carbonate from the rock. This "softore" texture is in marked contrast to the hard ores of the Iron Ore Company of Canada pits a few kilometres to the north. It is an advantageous feature to the mining company because, in addition to rendering the ore easier to crush, it also increases the iron content of the oxide ores by removal of gangue minerals. Furthermore, parts of the silicate-carbonate iron formation are also enriched sufficiently to be of economic value.

Leaching is not restricted to the Wabush Formation. Crumbly quartzite of the underlying Wapussakatoo Formation occurs a few kilometres west of Labrador City and in the Iron Ore Company of Canada mining area north of the town, indicating that it, too, has been extensively leached.

Evidence pertaining to the origin of the leaching was not found in the map area. However, Gross (1968) considers that it was a result of surface weathering in a tropical climate. The age of leaching is not known, but by analogy with the Schefferville area to the north, where Cretaceous tree trunks are found in deeply weathered cracks in the ore bodies, a Mesozoic age is likely.

ECONOMIC POTENTIAL

The extensive iron deposits constitute the greatest economic potential for the area. No new deposits were discovered during the season's mapping program, but the deposit at Julienne Peninsula (on the northeast side of Wabush Lake and presently in Crown control) was examined in some detail. It is predominantly oxide iron formation, and being in the northern (low metamorphic grade) part of the area, it is less recrystallized than most of the deposits to the south. Fine grained, cherty, granular hematite is the dominant ore type at the surface, though many varieties exist. The ore occupies an overturned, synformal structure, similar in style to the structures mined by Iron Ore Company of Canada a few kilometres to the southwest. However, the ore is considerably leached, making the rock texture more like that of the ores of the Wabush Mines project.

Kyanite is locally present in low concentrations in schists of the Katsao Formation throughout the area. At one locality at the south end of Flora Lake up to 20 percent kyanite is present in a band 30-50 m wide which extends along strike for about 1 km; further extension to the south is possible. Garnet is also present in this rock in an amount generally equal to or greater than the kyanite.

A scintillometer was carried on most of the traverses during the summer. Background radiation levels are low; one small anomaly ten times background was found in migmatites of unit 1c.

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