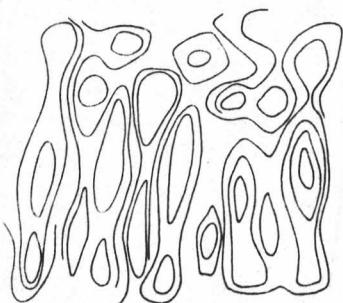


## LABRADOR TROUGH: 2.3 BILLION YEARS OF HISTORY

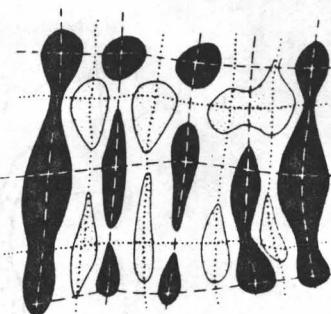


by

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### INTRODUCTION

The Labrador Trough in western Labrador and Quebec, now represents the eroded remains of an ancient mountain chain that once extended from Ungava Bay almost as far south as the Gulf of St. Lawrence (Fig. 1).

The geological history of this region can be traced back in time some 2.3 billion years. In this article, we will first describe the early development history (depositional stage) of the Labrador Trough, and then discuss the subsequent deformation and metamorphism of these rocks during two distinct mountain building periods (orogenic stage). The last section will be devoted to major deposits of iron ore which are currently being mined around Schefferville and Labrador City - Wabush.

### GEOLOGICAL SETTING

Labrador is geologically a part of the Canadian Shield (see Vol. 3, No. 1). Within the Shield are 'tectonic provinces' delimited on the basis of the prevailing age of deformation and metamorphism of the rocks. The Superior Province is composed of rocks deformed and metamorphosed during the Kenoran Orogeny about 2,500 million years ago, the Churchill Province contains rocks deformed and metamorphosed during the Hudsonian Orogeny about 1,750 million years ago and the Grenville Province contains rocks deformed and metamorphosed during the Grenvillian Orogeny about 1,000 million years ago. An orogeny, or period of mountain building, involves

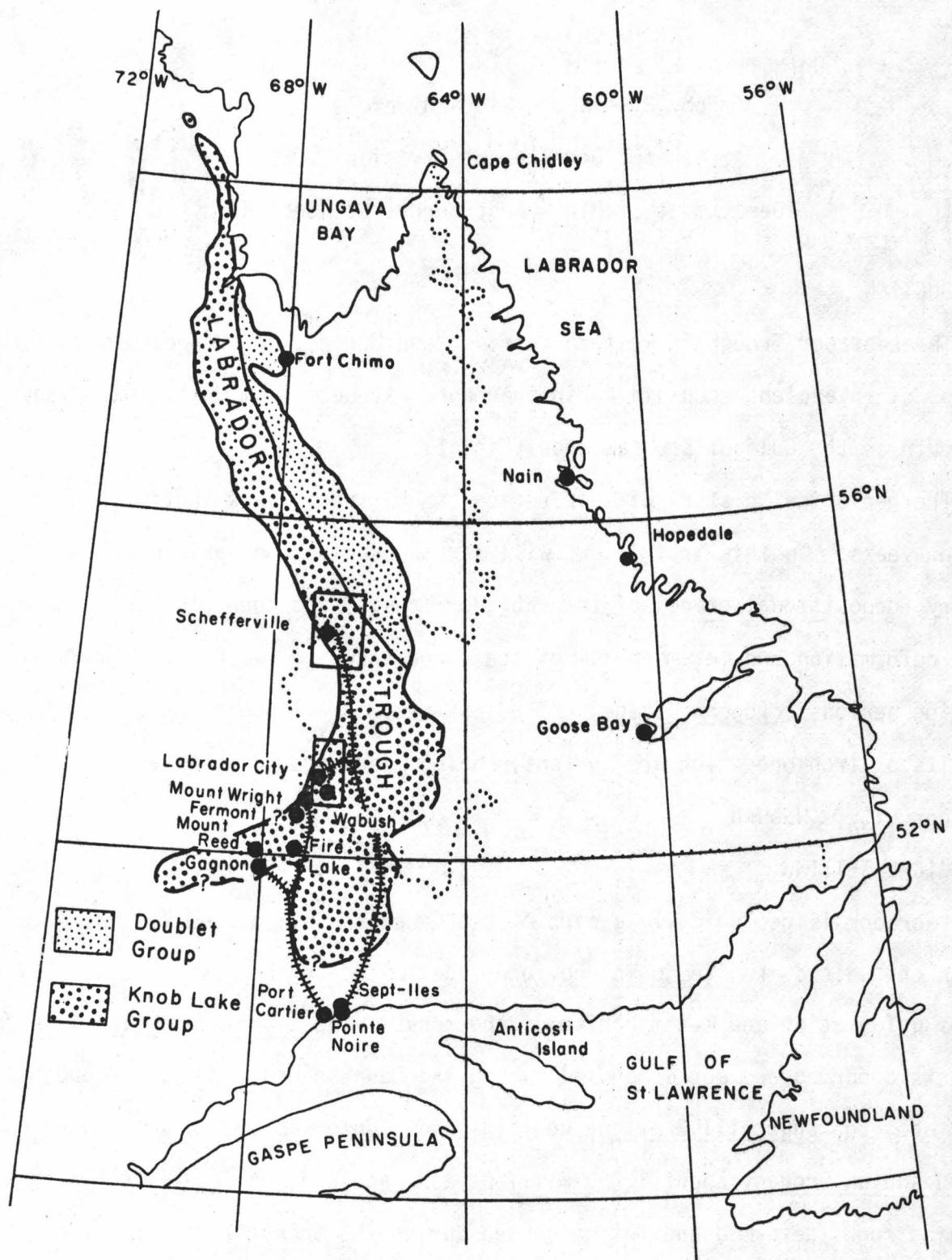


Figure 1. Sketch map of part of eastern Canada showing the location of the Labrador Trough, and the main iron ore mining centres in Labrador and eastern Quebec.

deformation and metamorphism of rocks, often at great depth beneath the surface of the Earth. During this process the rocks are typically uplifted to become mountain chains, e.g. Alpine-Himalayan system, and are eventually eroded to base level.

The sedimentary and volcanic rocks of the Labrador Trough were deposited as sediments and lavas 2,300 - 1,800 million years ago, in an interval of time called the Aphebian era (Fig. 2). They occur in a narrow belt infolded between two extensive areas of gneisses; when viewed from the air, the belt forms a depression, hence the name Labrador Trough.

On its western margin the broadly U-shaped Trough lies unconformably upon gneisses of the Superior Province (Fig. 3). On its eastern margin the Trough is in fault contact with gneisses that were structually redeformed and metamorphosed in the Hudsonian Orogeny. Rocks of the Trough were also folded and weakly metamorphosed in this orogeny, and together with the gneisses on their eastern side, are therefore referred to as the Churchill Province. In southern Labrador, the Trough and Archean rocks have been redeformed in a younger event, the Grenvillian Orogeny, and form a north east trending belt of rocks known as the Grenville Province.

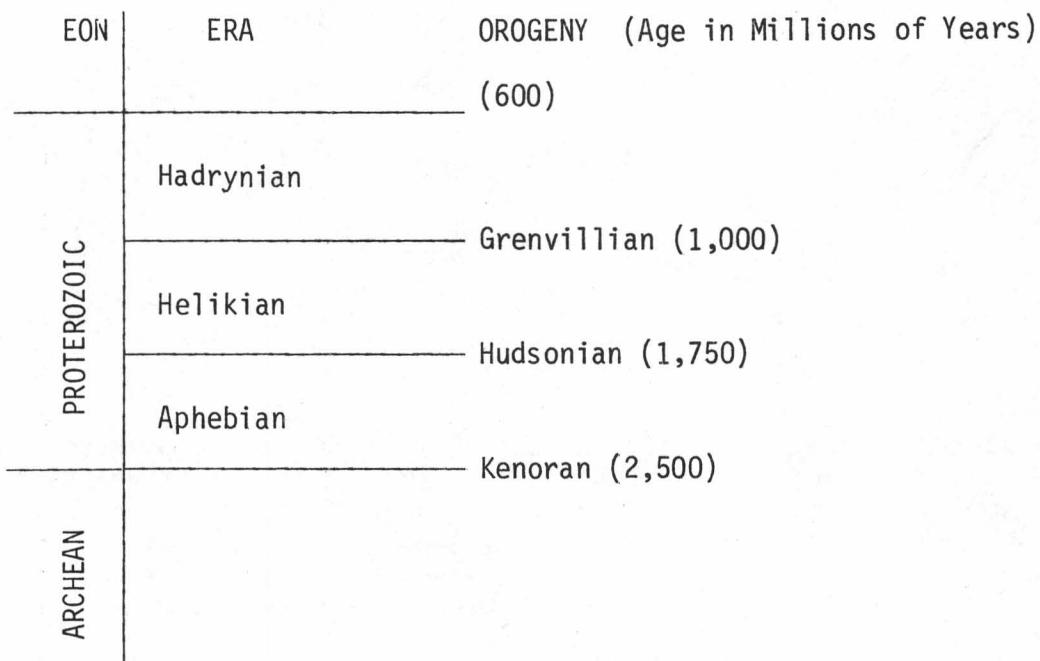
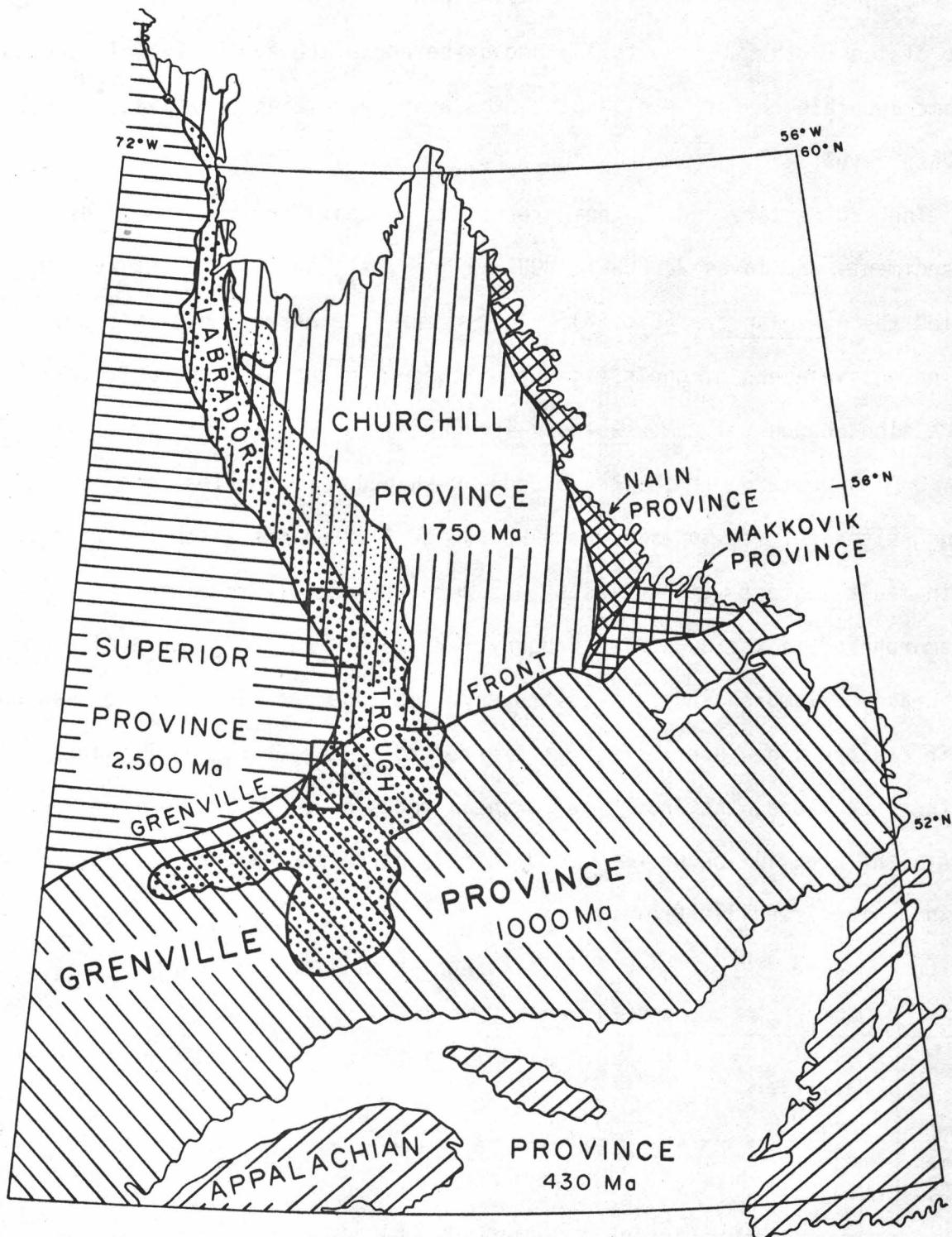


Figure 2 Precambrian time scale in relation to orogenies of the Canadian Shield.



**Figure 3.** Sketch map of part of eastern Canada showing geologic provinces with their approximate radiometric ages (Ma = millions of years). The Nain and Makkovik Provinces are small geologic provinces that have the same radiometric ages as the Superior and Churchill Provinces respectively. Note that the Aphebian rocks of the Labrador Trough occur in both the Churchill and Grenville Provinces.

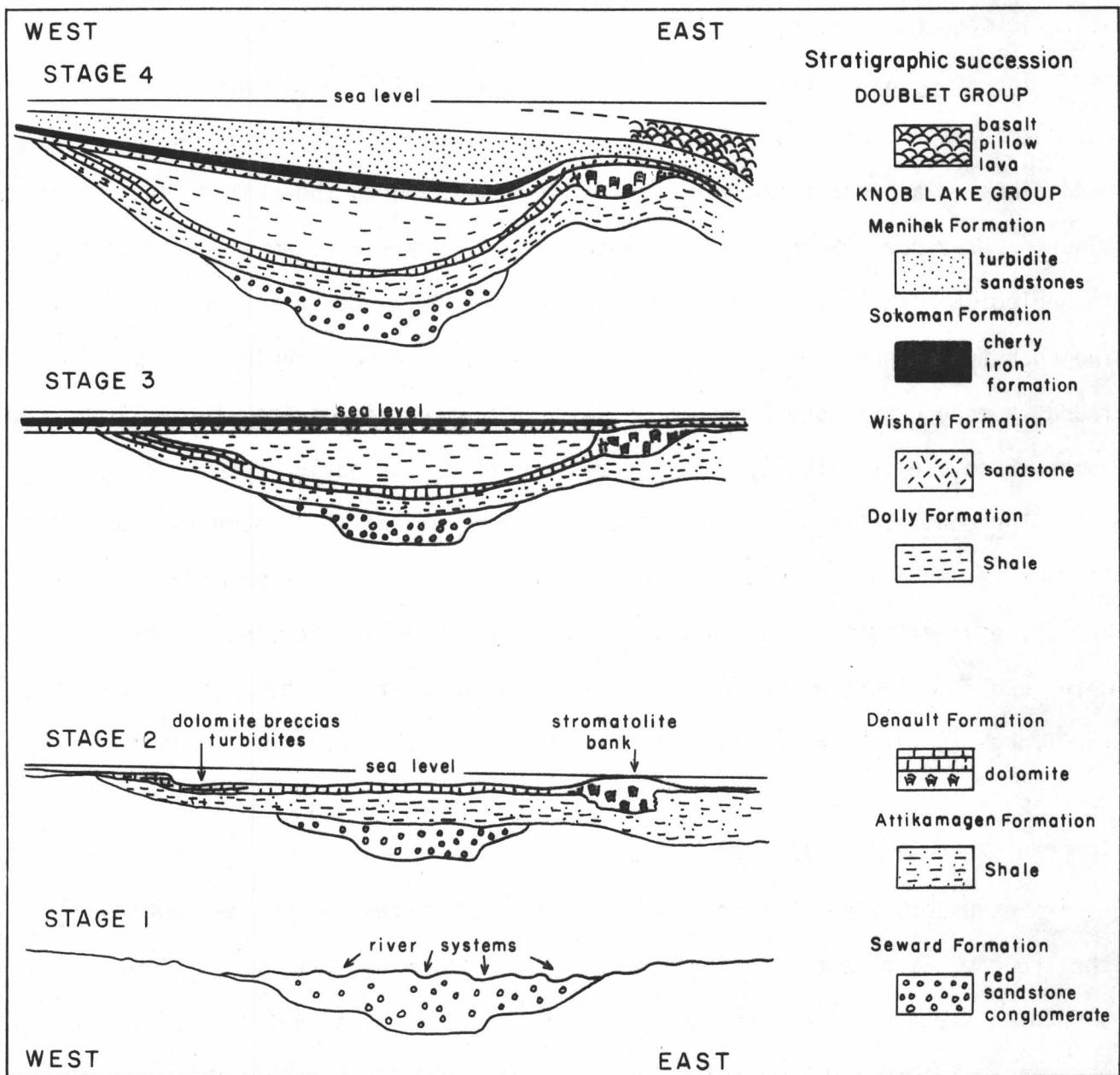


Figure 4. Early Development of the Labrador Trough

## ROCK TYPES

As shown in Fig. 4, the Trough is comprised of a lower, predominantly sedimentary sequence, termed the Knob Lake Group and an upper, dominantly volcanic sequence, known as the Doublet Group.

The Knob Lake Group is composed largely of sandstones, shales, carbonates and chemical precipitates. These sediments were deposited in shallow water conditions on a broad submarine 'shelf' which lay around the eastern edge of the Superior Province. Such shelf sequences, often referred to as miogeosynclines in geological literature, are found on the margins of nearly all orogenic belts. The rock types encountered in the Knob Lake Group are comparable to those found in more recent shelf sequences, with the exception of iron formation rocks which are practically entirely restricted to the early Precambrian.

The Doublet Group occurs on the eastern margin of the Trough and consists of massive amounts of basalt. These volcanic rocks, were formed under submarine conditions as pillow lavas, and mark an end to the stable, shallow water shelf upon which the Knob Lake Group was deposited. The eastern half of the Trough in which the Doublet Group occurs is usually referred to as a eugeosyncline.

## EARLY HISTORY OF THE LABRADOR TROUGH

Let us consider in more detail the various stages in the development of the Trough. Each depositional stage shown in Fig. 4 has been prepared by unfolding the present cross-section of the Trough (Fig. 5) and restoring the various rock formations back to their original geographic positions.

### Stage 1: Deposition by 2.3 Billion Year Old Streams

The Trough began with fluvial deposition of red sands and gravels in a narrow, elongate basin that was probably a rift valley. These deposits lithified to sandstones and conglomerates and are now known as the Seward Formation.

Measurements on cross-bedding preserved in these deposits indicates that the sediments were deposited by rivers flowing from the southeast to the northwest.

#### Stage 2: Subsidence and Flooding by the Sea, Evidence of Marine Plants

The embryonic Trough and the surrounding land masses sank and became covered by a shallow sea. This incursion of the sea, known as a marine transgression, started in the east and proceeded west until practically all of the present area of the Trough was submerged. Muds were the first sediments to be deposited in this shallow sea; they lithified to shale, now termed the Attikamagen Formation, and were succeeded by the dolomites of the Denault Formation.

The dolomites provide fairly clear evidence of the shape of the ancient sedimentary basin. In the west, they occur as coarse breccias and turbidites produced by slumping and gravity flowage of unconsolidated sediment off the edge of a platform which lay on the extreme western side of the Trough. This platform has since been eroded away but the breccias and turbidites remain and enable us to deduce the ancient geographic position of the western slope of the basin. In the east, the Denault Formation is represented by a thick, lens shaped body of stromatolitic dolomite, somewhat analogous to a modern coral reef. Stromatolites are layered bulbous mounds formed by colonies of microscopic marine algae which flourished in the Precambrian. Algae require clear and very shallow water conditions in order to obtain the light necessary for their survival. Consequently, as the sea floor sank, the colonies continually built their mounds upwards in order to stay near the sea surface. The thick stromatolite bank constructed, as a result, extends along the eastern side of the Trough for hundreds of kilometres. This bank probably faced an open sea to the west and provided a protected lagoonal environment to the east in which finely laminated, muddy dolomite was deposited.

### Stage 3: Shallow Marine Conditions Continue - Iron Minerals Form

Following deposition of the Denault Formation, the Trough west of the stromatolite bank sank and was infilled with a thick lens-shaped body of grey mud that hardened to shale, now termed the Dolly Formation. The whole area was then uplifted, locally eroded, then covered again by a shallow sea with deposition of sands of the Wishart Formation; as shown in the sketch, these sandstones rest unconformably upon a variety of older formations in the eastern and western parts of the Trough.

Overlying the Wishart Formation is the Sokoman Formation, which consists of up to 500 m of iron formation. This is the economically most important formation in the Trough since it hosts the enormous iron deposits which are currently being mined around Schefferville and Labrador City-Wabush.

Iron formation is essentially a chert, formed by the precipitation of colloidal silica, and contains high quantities of iron (usually 20 - 35%) in the form of iron oxides (hematite and magnetite), various iron silicates and iron carbonates (siderite, ankerite).

### Stage 4: Deep Marine Sedimentation and Volcanism

Following deposition of the Sokoman Formation, which occurred in shallow water conditions, the Trough subsided and, except for a small area on the eastern margin, became covered with deep water turbidite sands and muds of the Menihek Formation.

On the eastern side of the Trough, deposition of the Menihek Formation was followed by extrusion of great thicknesses of pillow basalt of the Doublet Group. This completed the early development of the Labrador Trough.

During Doublet Group times, the crust underlying the Trough was pulled apart under tensional stresses, and the resulting fractures allowed basaltic magma from the Earth's interior to have direct access to the surface where it poured out to form great thicknesses of pillow lava. Similar pull-apart

processes (termed rifting) in modern sea-floor spreading situations usually result in the complete separation of crustal plates and the formation of a new ocean floor, composed of ultrabasic rocks, gabbro and pillow lava, in the intervening gap. We do not see the formation of any ocean floor material in the Trough and it is evident that the rifting process which allowed the extrusion of the Doublet Group basalts was short-lived and never produced enough crustal separation to allow the formation of new ocean floor. The process, however, can be viewed as a fore-runner to the widespread rifting and ocean floor development seen during the early development of more recent orogenic belts such as the Appalachians and the Alps.

#### LATER DEVELOPMENTS IN THE LABRADOR TROUGH: THE OROGENIC STAGE

In this section we shall discuss the earth movements that took place after deposition of the sediments. These movements resulted in the deformation and metamorphism of the Knob Lake Group of rocks and are known as the orogenic stage in the evolution of a fold mountain belt. At this point, it should be emphasized that the Labrador Trough is not a complete orogenic belt, rather it is only the western edge of a much more extensive belt which is the Churchill Province (Fig. 3).

The effects of two distinct orogenies are recorded in the rocks; the 1750 million year old Hudsonian Orogeny affects the northern Trough; the 1000 million year old Grenvillian Orogeny is restricted to the southern part of the Trough within the Grenville Province (Fig. 3). We shall be considering the effects of each orogenic event: firstly around Schefferville, which will illustrate the Hudsonian Orogeny, and secondly around Labrador City/Wabush, where the Grenvillian Orogen may be examined.

Figure 5

LEGEND

SYMBOLS

APHEBIAN

Intrusive Rocks

8

Wakuach Gabbro - gabbro

----- geologic boundary

7

Nimish Volcanics - basalt, andesite  
and associated pyroclastic rocks

~~~~~ reverse fault

6

Menihek Formation - carbonaceous  
shale and sandstone

♂ iron mine, past or present  
producer

5

Sokoman Formation - iron formation

4

Wishart Formation - sandstone, chert

3

Denault Formation - dolomite

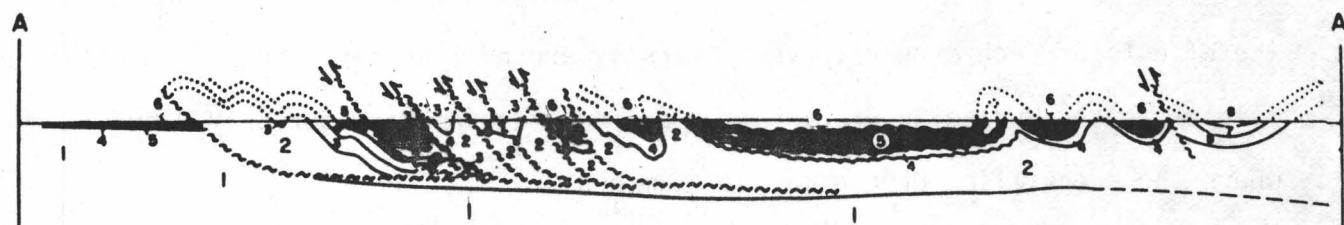
2

Attikamagen Formation - shale

ARCHEAN

1

Ashuanipi Complex - migmatitic gneiss



67°00'W

66°45'W

- 29 -

66°30'W

66°15'W

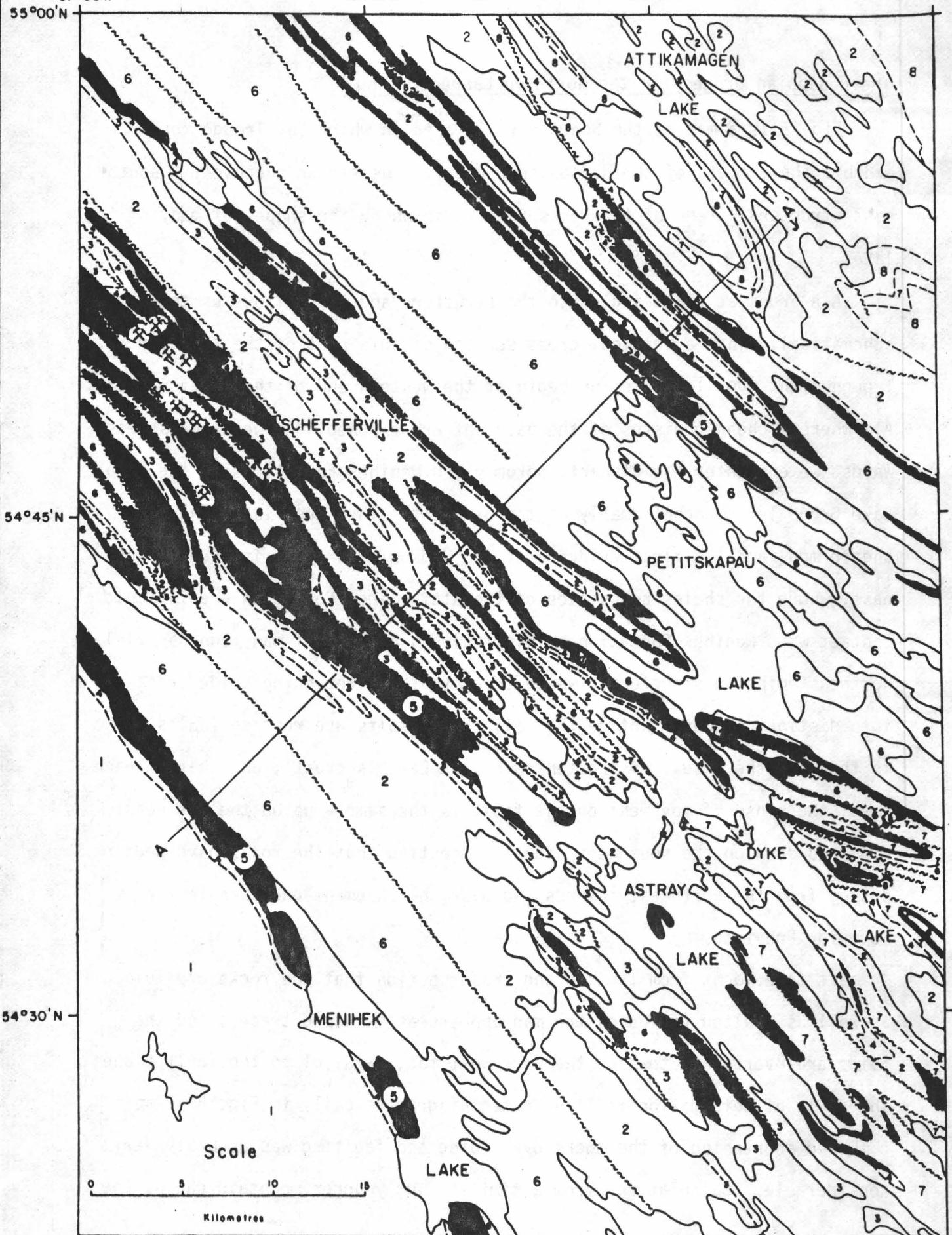


Fig. 5. Geological Map of the Schefferville Area

### The Hudsonian Orogeny in the Northern Labrador Trough

Fig. 5 is a map of the Schefferville area in which the Trough rocks exhibit the effects of the Hudsonian Orogeny. The strong northwest - southeast structural trend of the rocks is even shown by the shapes of many of the lakes.

A-A<sup>1</sup> runs at right angles to the structure and thus allows us to see schematically what a vertical cross section of this part of the Labrador Trough might look like. Let us begin at the western end of the section (point A), where Archean gneisses of the basement are exposed. As we progress eastwards, we encounter the Wishart, Sokoman and Menihek Formations of the Knob Lake Group lying unconformably on the basement. They are flat-lying and undeformed, and the first evidence of the Hudsonian Orogeny is seen further east, where the shales and slates of the Attikamagen Formation are in fault contact with Menihek Formation. This fault is but one of many sub-parallel northeast dipping structures, which separate the intervening folded rocks into distinct slices. Notice that all these faults are reverse faults (that is they are the result of shortening of the Earth's crust), and that in each case, the sense of movement on the fault is the same - up on the northeast side and down on the southwest side - suggesting that the rocks have been pushed from the northeast towards and over the basement gneisses in the Superior Province.

It is evident from the map and cross section that the rocks are folded as well as faulted (folds on the map appears as U-shaped traces) and the folds are overturned towards the southwest too, parallel to the fault planes. The style of deformation is illustrated diagrammatically in Fig. 6. The combined shortening of the rocks by folding and faulting was probably very considerable. Calculations from a similiar but younger mountain chain, the

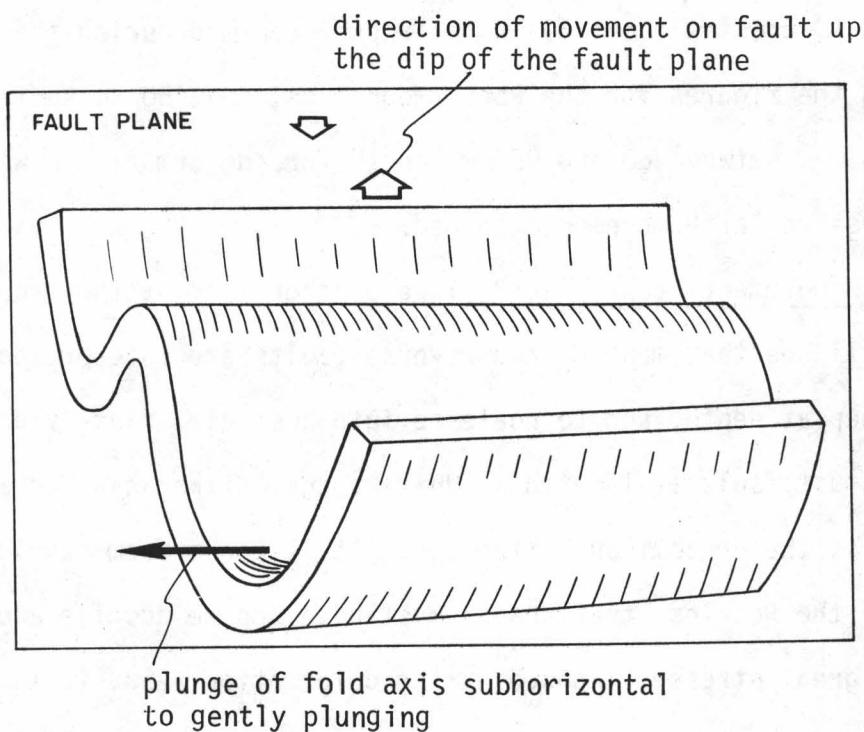


Figure 6. Sketch of the style of deformation characteristic of the Schefferville area.

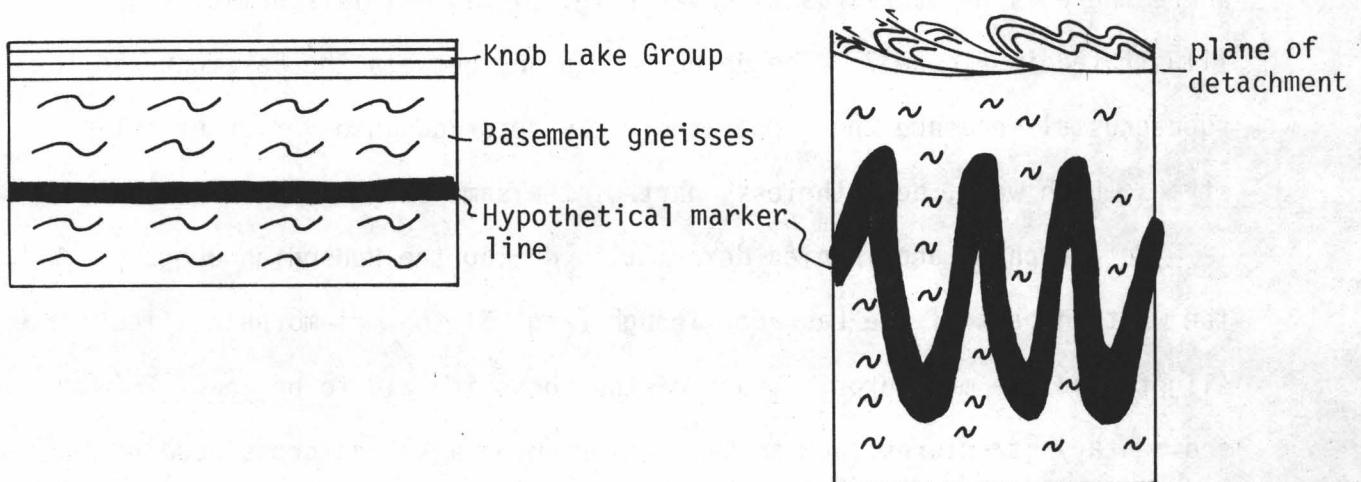


Figure 7. Schematic diagram illustrating the different styles of deformation in the basement and cover sequences, and the location of the detachment plane.

Rocky Mountains of Western Canada, suggested that crustal shortening was in the order of 30 to 50% of the original undisturbed length. In Figure 5, our cross section A-A<sup>1</sup> crosses about 50 km of rocks deformed during the Hudsonian Orogeny. Using the figures for the Rocky Mountains, that 50 km section of the Labrador Trough was between 60 and 75 km long before deformation - we are dealing with massive Earth movements indeed.

How do such movements take place? Take another look at the cross section A-A<sup>1</sup> and you will see that many of the reverse faults are interpreted to become less steep at depth, and to coalesce into a single, flat-lying thrust fault. This thrust fault is located in Unit 2, the Attikamagan Formation, in which shale is the predominant lithology. It is known from studies elsewhere, e.g. the Rockies, that shales must have become ductile and 'flowed' under the very great stresses imposed during deformation. So, it is likely that many of the faults die out in the shale unit, which essentially acted as a lubricated zone or detachment plane. Within the basement gneiss complex beneath the thrust fault, shortening was probably accommodated in a very different way, by ductile folding, as can be seen east of the Labrador Trough where there is no supracrustal cover (Fig. 1), and as is schematically illustrated in Figure 7. The detachment plane between the basement and the supracrustal sequence thus separates rocks deformed into very contrasting styles which were, nevertheless, part of the same orogenic event.

Metamorphism accompanied deformation during the Hudsonian Orogeny. Within the western part of the Labrador Trough (Fig. 5) the metamorphic effects are slight, and the metamorphic grade of the rocks is said to be low. Primary sedimentary structures such as bedding, ripple marks and cross bedding in sedimentary rocks, and primary igneous textures and structures such as pillows and chilled flow margins in volcanic rocks are still visible;

original rock types are easily distinguished. We may infer, however, that the grade of metamorphism increased at depth, and the basement gneisses were probably at very great temperatures and pressures (high metamorphic grade) during the orogeny, thus allowing these massive rocks to deform plastically (i.e. like plasticene) by folding. The detachment plane thus broadly separates rocks of low metamorphic grade which deformed predominantly by brittle deformation (faulting with associated buckling and open folding), from rocks at higher metamorphism grades which deformed in a ductile or plastic manner predominantly by tight folding.

#### The Grenvillian Orogeny in the Southern Labrador Trough

In the Southern Labrador Trough (Fig. 8), we are dealing with essentially the same stratigraphic sequence, albeit with a different name<sup>1</sup>, lying on the same basement complex. An important difference is that the rock types in the Wabush area are all metamorphic in contrast to the sedimentary rocks around Schefferville.

A cursory glance at Fig. 8 is enough to show that the map pattern is quite different to that in Fig. 5 where most contacts are straight and parallel. In Fig. 8, formation boundaries instead tend to be curvilinear and frequently close completely upon themselves in oval shapes. Patterns such as this are the result of multiple deformations superimposing their effects one upon the other - in the area around Wabush the effects of three phases of deformation

<sup>1</sup> The metamorphic equivalent of the Knob Lake Group is known as the Gagnon Group in the Grenville Province. If you compare the legends in Figs. 5 and 8, you will notice that many of the formations can be traced directly between the two areas: i.e. the Katsao Formation is the metamorphic equivalent of the Attikamagen Formation, the Duley Formation of the Denault Formation, the Wapussakatoo Formation of the Wishart Formation, the Wabush Formation of the Sokoman Formation, and the Nault Formation of the Menihek Formation. There are, however, apparently no equivalents to the Seward and Dolly Formations and the Doublet Group in the Southern Labrador Trough.

## LEGEND

Figure 8  
Geological Map of the Wabush -  
Labrador City area

### HELIKIAN INTRUSIVE ROCKS

7 Shabogamo Gabbro - gabbro

APHEBIAN GAGNON GROUP

6 Nault Formation - graphitic schist

5 Wabush Formation - iron formation

4 Wapussakatoo (Carol) Formation -  
quartzite

3 Duley Formation - marble

2 Katsao Formation - quartzo -  
feldspathic schist

ARCHEAN

1 Ashuanipi Complex -  
migmatitic gneisses

## SYMBOLS

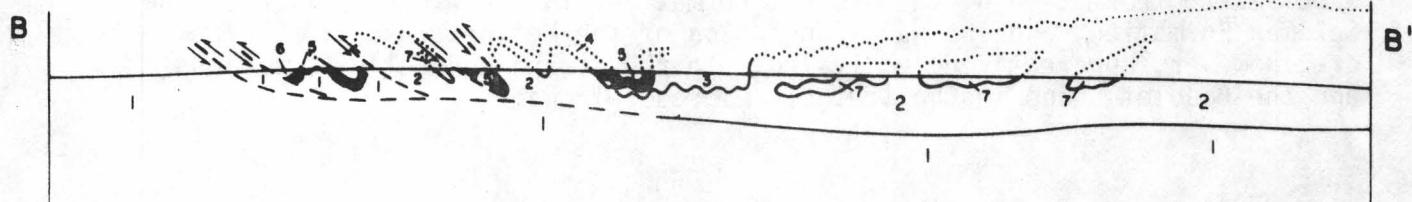
Geological boundary

Thrust fault

Reverse fault

\*

Producing mine - Fe

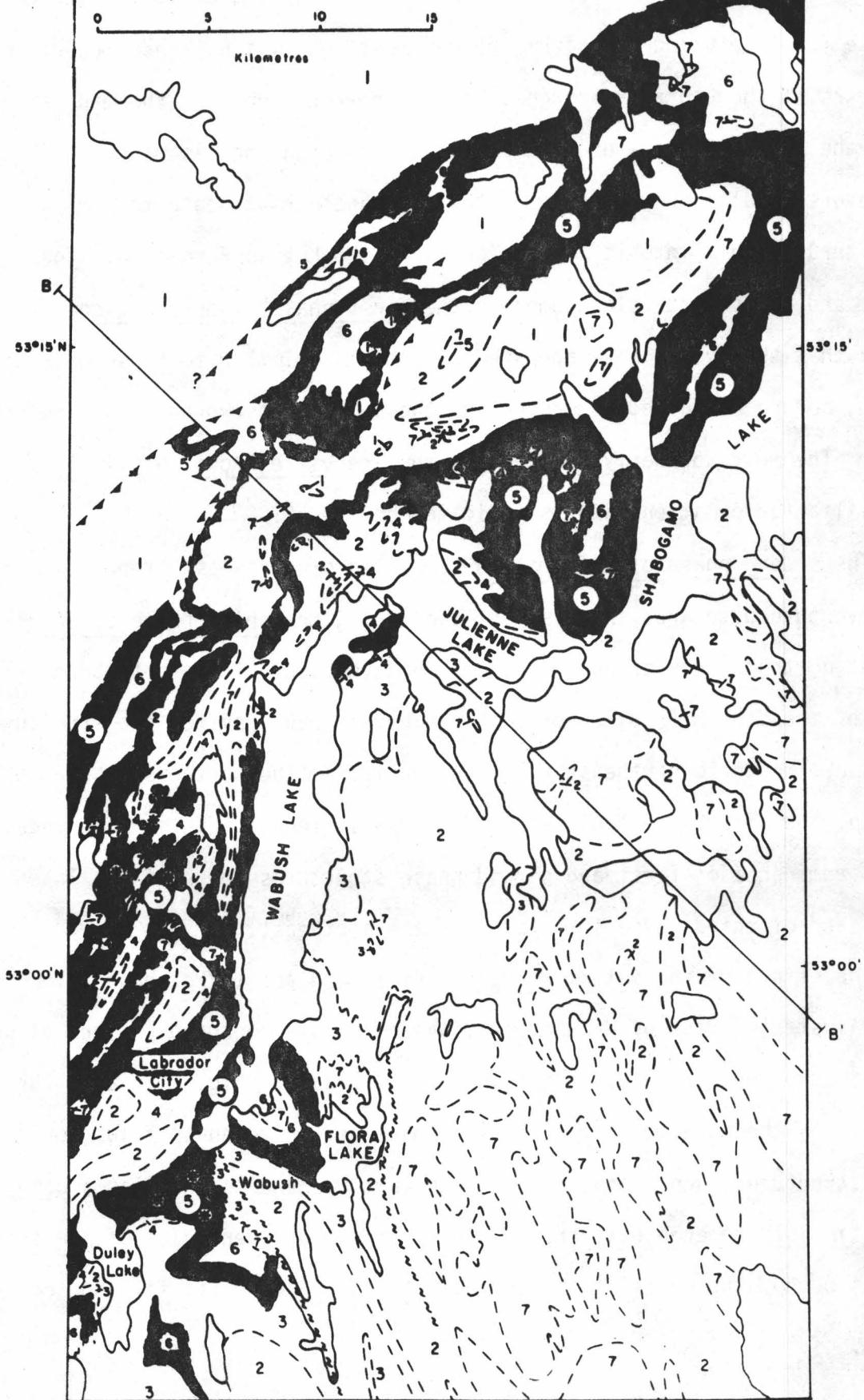


67°00'W

66° 30' w

Figure 8  
Geological Map of the Wabush  
Labrador City area

### Scale



have been described. However, you will also notice that the cross section B-B<sup>1</sup> looks surprisingly similar to A-A<sup>1</sup>. Once again, there are a series of reverse faults dipping away from the basement into which is now incorporated the rocks of the Labrador Trough in the northwest corner of the map, and once again the inferred sense of movement is up and onto the basement. As before, the reverse faults are interpreted to join together at depth to form a flat-lying thrust fault in unit 2, here known as the Katsao Formation. These faults and associated folds comprise the first phase of deformation; it is likely that they would have appeared essentially similar to those shown in Fig. 6, before being reformed during the subsequent two phases of deformation. The most northerly fault forms the Grenville Front, or limit of Grenvillian deformation, and is indicated on Fig. 3.

The second phase of deformation consisted of northeast trending folds, also overturned towards the basement and during the third phase of deformation, upright northwesterly trending folds were developed. It is noteworthy that north of the Wabush - Julienne Lake - Shabogamo Lake system the structural trends are north to northeast trending, whilst in the southeast corner of the map, the structural trend is northwest - southeast. This difference is due to dominance of first and second phase structures north of the lake system and of third phase structures in the southeast.

The effect of the interference of the second and third phase folds is well illustrated west of Wabush Lake, where the oval outcrop pattern of unit 2 within the younger units recurs in several places. Fig. 9 is an illustration of how the interference of second phase and third phase folds could cause structures such as these. The egg carton shape is known as a dome and basin interference pattern. After erosion the lower units of the succession occupy the cores of the domes, with the upper units filling the centre

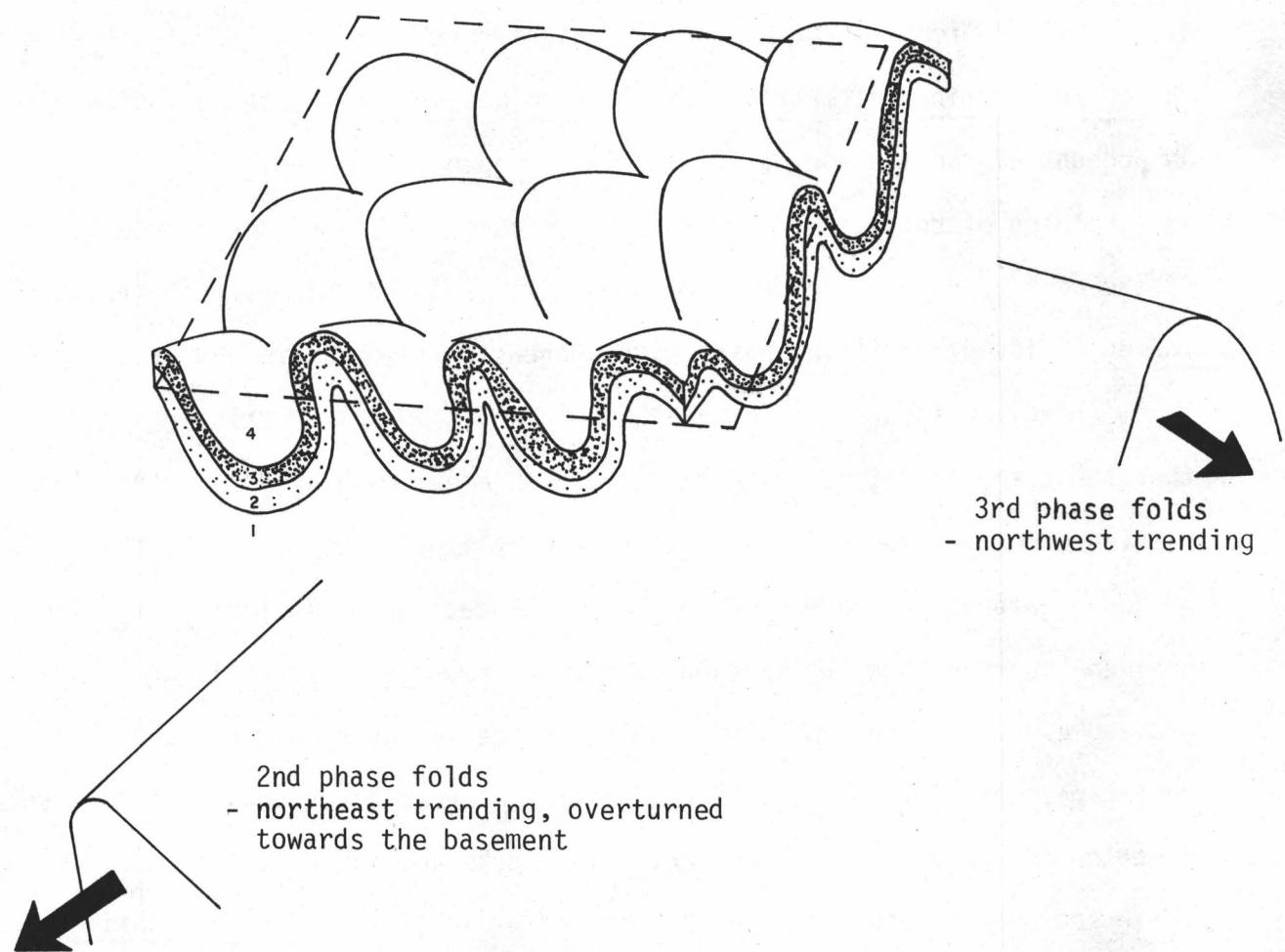


Figure 9. Block diagram illustrating the interference of second and third phase folds in the Wabush area, and the resultant dome and basin pattern. The dashed line is a hypothetical erosional surface - the outcrop pattern on that surface is shown in Figure 10.

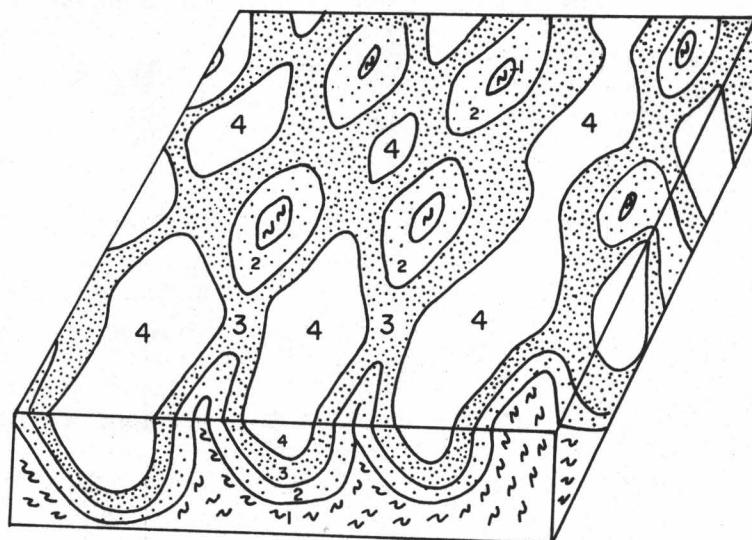


Figure 10. Typical outcrop pattern seen in areas of dome and basin structures, such as that shown in Figure 9.

of the basins (Figure 10), Iron formation, being high up in the succession of the Gagnon Group, occupies the centres of several basinal areas. Most of the operating mines at Labrador City/Wabush are located in these basins which, on account of their shape, are suitable for open pit mining.

Folding of rocks in such complex ways as this can only be accommodated if the rock is plastic or ductile (i.e. will bend and not crack or fracture). The ductility of rocks increases with increasing temperature and pressure (i.e. broadly with grade of metamorphism), so it is not surprising to find that the grade of metamorphism in the Wabush area was high during the Grenvillian Orogeny. Most of the rocks have completely recrystallized, and primary features are rarely seen. For instance, the equivalent of the fine grained shales of the Attikamagen Formation around Schefferville are coarse grained quartz-feldspar-biotite schists of the Katsao Formation, and other rock types are similarly transformed in their crystal textures. It is likely that the deformation took place while the rocks were recrystallizing from their sedimentary parents. The process of grain growth (crystallization) involves internal restructuring of rocks, which temporarily reduces their internal strength, rendering them susceptible to deformational stresses. Thus, deformation and metamorphism were broadly contemporaneous and their effects are intimately related.

#### SUMMARY OF OROGENIC EVENTS

- (a) The Archean basement of the Superior Province formed a rigid buttress towards which the supracrustal rocks were thrust during the Hudsonian and Grenvillian Orogenies.
- (b) The rocks in the Schefferville area of the Labrador Trough were deformed during the Hudsonian Orogeny, about 1,750 million years ago. The style of deformation was predominantly by faulting with subordinate large scale

folding and buckling, and the grade of metamorphism was low in the rocks of the Labrador Trough.

(c) 750 million years later during the Grenvillian Orogeny, the rocks in the south of the Labrador Trough were again involved in an orogeny, but this did not affect the rocks to the north. During the Grenvillian Orogeny, the grade of metamorphism was high in the Labrador Trough rocks; the rocks totally recrystallized and deformed plastically, predominantly by tight folding.

(d) The nature of the deformation and metamorphism in the two areas has had a profound effect on the iron ores, rendering mining operations at Schefferville and Labrador City - Wabush different in several respects. This aspect will be discussed in the final section.

#### IRON FORMATION

Cherty iron formations which closely resemble those of the Trough are practically unique to the Precambrian and most are of Aphebian age. Similar iron formations are found in the Lake Superior district of the northern USA and in all the Precambrian Shield areas of the world, e.g. Western Australia, Brazil, Central Russia, India, and South Africa. Together, they account for the greater part of the world's iron ore reserves.

#### Origin

Various models have been put forward to account for the sudden world-wide appearance of iron formation during the Aphebian. One that is commonly cited is that the Earth's atmosphere suddenly changed from a reducing to an oxidising state. This change was presumably due or related to photosynthetic organisms, such as the colonial algae in the Denault Formation, enriching the atmosphere in oxygen. Most iron compounds are soluble in the ferrous state, but insoluble in the ferric state; with a change in the oxygen content of the atmosphere, additional oxygen became available for incorporation into ferric compounds, and iron formation minerals were precipitated.

One shortcoming of this explanation is the fact that the various bodies of iron formation throughout the world, although all of Archean age, span a time period of about 400 million years; any major change in the Earth's atmosphere probably only occurred once during this period and therefore would not account for the appearance of iron formation over such a prolonged period.

Other models favor precipitation of iron during intense evaporation of shallow seas and by replacement of carbonate rocks..

Much work yet remains to be done on iron formation before its origin is completely understood. A major problem in any interpretation of iron formation is finding a source for the enormous amounts of iron locked into these rocks. Two sources are usually proposed for the iron present in the Labrador Trough:

(a) Surrounding areas of Archean gneisses were subject to intense weathering with the result that their iron content was leached out by circulating ground water. The iron was then transported by rivers to the sea where it precipitated, along with silica, as iron formation.

(b) Iron was derived from submarine basaltic volcanics, abundant in the eastern part of the Trough, then precipitated with silica as iron formation.

#### Ore Deposits of the Labrador Trough

Iron ore is currently being mined around Schefferville in the central part of the Labrador Trough and around Labrador City - Wabush, and various smaller centres in the south (Fig. 1). Ore was first shipped from Schefferville in 1954, whilst operations began in Labrador City in 1962 and in Wabush in 1965. The ore types differ greatly in the two areas and will be described separately.

Minor occurrences of copper mineralization have been found in volcanic rocks on the eastern margin of the Trough, but these are of insufficient tonnage to be economic at present.

### Schefferville Deposits

In the Schefferville area, iron formation crops out in long linear north-west trending belts, parallel to the regional trend of the Hudsonian Orogeny. Not all the exposed iron formation is mined, however, as much of it is too lean to be economic. Mines are located in areas that underwent secondary alteration during the Cretaceous period, 130 - 60 million years ago. At that time, the whole of Labrador was uplifted to form an exposed land mass and subjected to intense weathering, probably in a tropical environment. During the weathering process, ground water circulated deep into the iron formation and leached out the silicate and carbonate minerals to leave a highly porous rock composed largely of iron oxides. Later solutions moved through the porous rock and deposited more iron oxides and hydroxides in the pores, producing an ore which is not only highly enriched in iron (65% iron) in comparison to normal iron formation (35% iron), but is also soft and crumbly and therefore easy to mine.

We know that this weathering and leaching took place during the Cretaceous period, as Cretaceous tree trunks and other floral fossil remains have been recovered from one of the mines. They were found in what must have been a deep fissure in the Cretaceous land surface which was subsequently infilled with erosional debris from the iron formation together with the vegetational remains.

There are presently seven producing mines in the Schefferville area. All are open pit operations run by the Iron Ore Company of Canada. The majority of the mines are located in synclines which are faulted. The faults are believed to have acted as conduits for ground water and allowed leaching and ore formation processes to penetrate deep into the iron formation.

Some of the deposits are located in narrow, down-thrown fault blocks

(graben) which formed during Cretaceous times and became infilled with fresh water clays and rubble ore. The latter formed by slumping of leached material off the sides of the graben.

Much of the Schefferville ore used to be shipped directly to blast furnaces wherever it was required. The modern trend in steel making, however, has been to use pelletized ores, that is, finely ground iron ore which has been chemically cemented into round pellets about 1 cm in diameter.

In 1973, the Iron Ore Company of Canada opened a new pelletizing plant at Sept Iles to process the Schefferville ore and now much of the ore is shipped abroad in this form.

#### Wabush Lake Deposits

Iron ore is mined in seven open pits around Labrador City and Wabush. Four of these, located on the west side of Wabush Lake, are operated by the Iron Ore Company, whilst Wabush Mines runs the three at the south end of Wabush Lake. The ores mined in the two operations, despite their close proximity to each other, are rather different, so we will describe them separately.

Textures of ores in the Iron Ore Company of Canada deposits on the west side of Wabush Lake reflect the elevated grade of metamorphism which occurred during the Grenvillian Orogeny. They are generally coarse grained rocks in which individual crystals of magnetite and hematite are easily visible to the naked eye. Small veinlets of quartz and hematite are common, attesting to the mobility of these phases during the metamorphism. One grade varies from between 30 - 40% Fe, considerably lower than at Schefferville, but because of the coarse grain size, the amount of crushing necessary to release the iron is less, and so it is economic to beneficiate (i.e. concentrate) the ores to approximately 66% Fe.

In contrast to the coarse grained crystalline ores in the Iron Ore Company deposits, the ores at the Wabush Mines deposit are typically rather finer grained and earthy in texture. They were leached, presumably during the Cretaceous period and at the same time as the Schefferville ores, although fossil evidence has not been found there. The leached ores in the Wabush deposit have not been enriched to the same degree as the Schefferville ores, and the average grade of Fe is between 30-35%. These ores, too, are beneficiated to approximately 66% Fe before shipping to Pointe Noire (near Sept Iles).

Crushing and beneficiating the ores is performed on site at the Iron Ore Company and Wabush Mines plants. Crushing is achieved by putting the ore rock into autogenous grinders, essentially large rotating cylinders, in which the ore gradually breaks down by frictional impact. When the desired grain size is achieved, the ore passes out of the grinders and is flushed with water into Humphrey spirals. These are like large corkscrews in which the dense iron ore is concentrated by gravity near the centre of the spiral whilst the lighter quartz and carbonate gangue is flushed out to the periphery.

Iron Ore Company recently built a pelletizing facility at Labrador City, and presently about one half of the concentrate is pelletized there before being shipped to Sept Iles. Most of Wabush Mines product is pelletized at Point Noire on the Gulf of St. Lawrence.

#### Economic Value

Iron ore accounted for about 83% of the annual mineral wealth of the Province of Newfoundland and Labrador in 1978, and sufficient reserves exist for many years to come at the present rate of mining. The number of people directly employed in mining and treating the ore is difficult to ascertain, but the existence of the towns of Labrador City and Wabush in Labrador, and Schefferville, Gagnon, Fermont, and Fire Lake in Quebec, is directly due to

iron mining; Sept Iles was only a small fishing village before it became the busy rail and shipping terminus it is today.

Much of the raw material for the Canadian iron and steel industry is supplied by Wabush Mines, whilst Iron Ore Company exports iron ore to the United States of America, several European countries, and Japan. In the light of the scale of development, it can easily be seen that the iron mining and associated industries have had a significant impact on the economy of eastern Canada, and of Newfoundland-Labrador, and Quebec in particular. With enormous reserves of ore still existing, it is likely that it will continue to do so for a long time in the future.

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**WORK FORCE (complete project)**

| 1977 Average  |             |
|---------------|-------------|
| Schefferville | 1123        |
| Labrador City | 2970        |
| Sept-Iles     | 3333        |
| <b>TOTAL:</b> | <b>7426</b> |

| <b>PRODUCTION AND SHIPMENTS</b><br>(in thousands of long tons) | <b>1976</b>   | <b>1977</b>   |
|----------------------------------------------------------------|---------------|---------------|
| <b>PRODUCTION</b>                                              |               |               |
| A) Schefferville (total)                                       | 8,870         | 9,256         |
| B) Labrador City (Pellets)                                     | 10,194        | 10,253        |
| C) Labrador City (Concentrates)                                | 18,063        | 17,358        |
| D) Sept-Iles (Pellets)                                         | 3,687         | 4,680         |
| <b>TOTAL:</b>                                                  | <b>40,814</b> | <b>41,547</b> |
| <b>SHIPMENTS EX: SEPT-ILES</b>                                 | <b>1976</b>   | <b>1977</b>   |
| A) Schefferville (direct)                                      | 4,060         | 3,021         |
| B) Labrador City (Concentrates)                                | 7,186         | 6,334         |
| C) Labrador City (Pellets)                                     | 9,925         | 10,982        |
| D) Sept-Iles (Pellets)                                         | 3,528         | 4,480         |
| <b>TOTAL:</b>                                                  | <b>24,699</b> | <b>24,817</b> |

**RECORD MONTHS**  
(in thousands of long tons)

| <b>PRODUCTION</b>               | <b>1976</b> | <b>1977</b> |
|---------------------------------|-------------|-------------|
| A) Schefferville                | Aug. 1,427  | June 1,464  |
| B) Labrador City (Concentrates) | June 1,769  | Dec. 1,798  |
| C) Labrador City (Pellets)      | Dec. 1,047  | Dec. 1,146  |
| D) Sept-Iles (Pellets)          | Oct. 412    | Dec. 553    |