THIRD PROGRESS REPORT ON THE STRATIGRAPHY, VOLCANOLOGY, SEDIMENTOLOGY AND STRUCTURE OF ROUYN-NORANDA AREA, COUNTIES OF ROUYN-NORANDA, ABITIBI-WEST AND TEMISKAMINGUE.

by

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INTRODUCTION

This report resumes the preliminary results, obtained during the summer 1974, of a continuing study of the stratigraphy, volcanology, sedimentology and tectonics of Rouyn-Noranda Area, Quebec. Results obtained in previous years, summarized by Dimroth et al. (1973, 1974) are not repeated here, and this report supplements and does not replace previous reports.

Most of the material obtained during the study will serve as basis of number of M. Sc. and Ph. D theses at the Ecole Polytechnique and the Université de Montréal, where they are supervised by Drs L. Gélinas, J. Lajoie and H.J. Hofmann and the senior author. Work on the following these problems was done in the field season 1974:

M. Rocheleau (Ph.D., U. de Montréal): Sedimentology of coarse-grained sediments.
P. Trudel (Ph.D., E. Polytechnique): Stratigraphy, volcanology and tectonics of the Reneault-Cléricy area.
R. Côté (M.Sc., E. Polytechnique): Stratigraphy, volcanology and tectonics of the area south of Rouyn.
N. Tassé (M.Sc., U. de Montréal): Sedimentology of ash-flow tuffs.
G. Provost (M.Sc., E. Polytechnique): Volcanology of rhyolite flows.

The parts of this report concerned with these thesis problems were translated or modified from written contributions by the thesis-students. The other parts of this report were written by the senior author.

LITHOLOGY

Most of the more obvious features of the lithologies in Rouyn-Noranda area were described in previous reports (Dimroth et al., 1973-1974). This report will comment on the following subjects:

1) Petrography, fracture mechanisms and emplacement mechanisms of fragmental volcanic rocks (E. Dimroth)
2) Determination of flow directions of mafic and intermediate flows by means of imbricated pillow breccias (R. Côté and E. Dimroth)

3) Geology of rhyolite flows (G. Provost)
4) Sedimentology of pyroclastic flows (N. Tassé)
5) Sedimentology of coarse-grained terrigenous sediments (M. Rocheleau)

Chapters (3), (4) and (5) supersede the discussions in previous reports.

PETROGRAPHY, FRAGMENTATION AND EMPLACEMENT OF MAFIC AND INTERMEDIATE FRAGMENTAL ROCKS

In the past, flow breccias and pyroclastic rocks commonly have been confounded in this area. Furthermore, virtually no information is available on the explosion mechanism, and the mechanism of emplacement of the volcanic rocks of the area. Such information obviously is required for the elaboration of a genetic model of the deposition of the ore deposits in the area; in turn, elaboration of a scientifically sound genetic model of ore deposition will greatly aid the difficult sub-surface prospecting.

In the study of fragmental volcanic rocks, the mechanisms of fragmentation and of the emplacement must be considered separately.

Fragmentation: Fragmentation of volcanic rocks may take place by the following four processes. In the first three cases, the energy of fragmentation is supplied by volcanic heat, and the fragmental rocks are called autoclastic. In the last case, fragmentation energy is supplied by weathering and resulting fragmental rocks are called epiclastic.

A. Autoclastic fragmentation.

1) Thermal shattering takes place where hot volcanic glass comes in direct contact with cold water. Thermal shattering accompanies abrupt chilling of very hot lava.
2) Facturation due to mechanical deformation takes place where different parts of an advancing flow differ greatly in viscosity, either because they have different temperatures of for other

reasons. In this case, the less viscous part of the flow will deform by plastico-viscous flowage, whereas the more viscous parts of the flow will suffer brittle deformation.

3) Facturation may take place by expansion of gas, mainly water vapor. Where the expansion of gases is comparatively slow, little kinetic energy is transferred to fragments; in this case, the magma disintegrates without explosion. Where gas expansion is rapid, much kinetic energy is transferred to the fragments which are thrown out. In this case, we speak of a volcanic explosion. Disintegration and explosion may be caused by exsolution and expansion of gases dissolved in the magma. In this case we speak of magmatic explosion or magmatic disintegration. Alternatively the source of expanding gas may be the evaporation of sea ~~on~~ or ground water that comes in contact with the magma; this case is described by the term hydroexplosion or disintegration.

B. Alloclastic fragmentation.

Fragmentation of solidified volcanic rocks by meteoric agents falls in this category. Alloclastic rocks are considered by M. Rocheleau, in this report. They are not further considered here.

Emplacement: There are three major modes of emplacement.

1. In flow breccias the fragmental material travels passively on the surface, or within the advancing lava flow.

2. In pyroclastic falls each volcanic fragment moves on an independent trajectory determined by the initial impulse and kinetic energy of the particle and its interaction with the ambient medium. Pyroclastic falls my be distinguished by the amount of energy exchanged between the fragments and the ambient medium:

   a) In ballistic fall-back fragments travel on a ballistic trajectory. They are, of course, slowed down by friction, but still contain part of their initial kinetic energy at impact.

   b) In fall-out, all of the initial kinetic energy is lost by friction. Deposition of the fragments is determined by their settling velocity. Small fragments may be entrained by oceanic currents.

3 a) Base-surge deposits (Waters and Fisher, 1972) are a special type of pyroclastic ~~falls~~ flows not occurring in a sub-marine environment.

3. In pyroclastic flows, strong interaction exists between the volcanic fragments and/or the fragments and the interfragment medium. This type of transport is described as mass flow. Various types of mass flow exist, depending on the density, viscosity, temperature of the flow and the nature of the interaction between the transported particles. Examples are rock slides, cohesionless grain flow, mud flow (lahars), and turbidity currents. It is immaterial whether pyroclastic flows are directly triggered by a volcanic explosion, or whether they formed due to the gravitational instability of an accumulating volcanic pile.

Many authors concerned with Archean volcaniclastic rocks, consider reworking of pyroclastic material. Reworking of pyroclastic falls and flows by rivers, waves, and ocean currents, does in fact occur on a large scale in continental and shallow marine environments, but it should be virtually non-existent in the deeply marine environments discussed here. Presence of sedimentary structures like cross-bedding or ripple-cross lamination, erosion channels etc. are not evidence for reworking; these erosion and traction structures are a natural consequence of erosion and bottom traction during the emplacement of fall-out and pyroclastic flows. Evidence of the reworking mechanism must be presented in order to make reworking a credible hypothesis.

TERMINOLOGY

As in other fields of geology, there is considerable variation in the usage of terms, even between authors as widely read as Rittman (1960) and Macdonald (1972). It appears therefore necessary to define the usage of terms in this paper.

Tephra: A collective term for any material thrown out in fragmentary form, that is for pyroclastic materials and for pyroclastic rocks. Fragments of hyaloclastites and of flow breccias have not been thrown out and are not tephra. Tuffs are consolidated rocks composed of tephra. Grain size is indicated by modifiers: ash-tuff (<2mm), lapilli tuff (2-64mm), bomb and block tuffs have fragment sizes larger than 64mm. Following Carlisle (1960) we use the term aquagene tuff for the matrix of pillow breccias and hyaloclastites, as well as for the bedded tuffs, composed of hyaloclastic fragments, directly associated with pillow breccias. Of course, the matrix of a pillow breccia is not tephra, and is not a tuff in the proper sense, but all transitions between hyaloclastites that are entirelly in place and hyaloclastites that have been thrown out and deposited from suspension exist.

Explosion: Explosions during volcanic eruptions to be place by the sudden expansion of gases (mainly water vapor). We use the term magmatic explosion where the energy of explosion is provided by the exsolution and expansion of gases dissolved in the magma. Hydro-explosion is the term employed where the explosion is caursed by contact of a magma with water of an extraneous source (sea water or ground water) and in hydromagmatic explosions both mechanisms are active. We coin the term steam explosion for gas-blast eruptions (Rittman, 1960) where the water was heated not by a magma but by a hot mass of solid rock. No juvenile material is present in the products of steam explosion.

BLOCK-SHARD HYALOCLASTITES AND ASSOCIATED ASH-FALL TUFFS

This type of hyaloclastites and associated tuffs has been described in typical form by many previous authors: Peacock (1926), Peacock and Fuller (1928), Noe-Nygard, (1940), Rittman (1958), Carlisle (1960), Honnorez (1962), Silvestri (1963), Re (1963). It forms from poorly vesiculated basalt and andesite flows. Three rock types will be separately described here: (1) Sideromelane hyaloclastites, (2) basalt hyaloclastites and (3) laminated aquagene ash-fall tuffs. All transitions exist between types (1) and (2).

Sideromelane hyaloclastites: Fragmental material of sideromelane hyaloclastites consists of chloritized ultramafic, basaltic or andesitic glass (sideromelane) containing few small vesicles. Fragments are of three types ~~(Fig. 1A)~~.

(1) Elongated, laminated fragments of pillow rims, occasionally deformed to warped sheet-like bodies, in other cases thick, platy bodies. They may be several cm long.
(2) Globules and granules or several mm across, occasionally spherical, but more commonly with irregular outlines. In some cases the globules have long drawn-out, edge-rounded corners.
(3) Blocky shards derived from (1) and (2), with convexconcave boundaries, and extremely sharp, jagged corners.

Phenocrysts may be present, where the lava was porphyritic.

Evidence of chilling is most obvious in large fragments, which contain numerous cracks. The small fragments have been produced by perlitic cracking of the larger fragments of type (1) and (2). In many cases, fragments were little displaced, and can still be re-assembled in the fashion of a jig-saw puzzle. Fragments are strongly oxidized*; recrystalization is responsible for a zonar texture following fragment boundaries and cracks. Occasionally, minor welding of fragments may be observed and gives the rock a pseudo-fluidal texture.

Most fragments are composed of sideromelane free of microlites. Very large fragments, particularly the pillow-rims may contain millimetric varioles and extremely fine, radiating fern-like crystallites of quench pyroxene. Spherulitic crystallization during devitrification in common.

The intergranular pore space between fragments has been filled by chalcedony, quartz, albite, epidote and chlorite during diagenesis. Rim-cements were observed in the least metamorphosed rocks.

Petrography and geology of these hyaloclastites leave little doubt that disintegration of pillows, and quenching of basaltic lava, essentially without explosion, was responsible for their disintegration.

* oxidized = stained brown by Fe-Ti oxides; chemical analyses are not available at the time of writing.

Basaltic hyaloclastites: Fragmental material of basaltic hyaloclastites consists of microcrystalline basalt. All transitions between sideromelane hyaloclastites and hyaloclastites composed alone of basalt fragments are present. The basalt fragments are centimetric-decimetric sized, and have sharpedged, edge-rounded or rounded outlines ~~(Fig. 1B)~~. Perlitic cracks generally are absent.

Chilling of fragments is indicated by marginal oxidation and by variation of crystallinity. Plagioclase quench crystals, where present, are fairly densely set and large in the less rapidly chilled part of the fragments. Sizes of pyroxene quench crystals also decrease with increasing amount of chilling. Quench plagioclase and pyroxene also become more slender needles toward more rapidly chilled parts of the fragments. Chilled margins may be englobed in less rapidly cooled material. By no means all boundaries of the basaltic fragments show chilling, as breakage occurred, in part, after crystallization of the microlites.

Fragments may be loosely spaced and then are cemented by quartz, chlorite, epidote, pumpellyite and albite. In other cases fragments are very closely spaced and have been displaced very little.

Broken-pillow breccias typically contain some basaltic fragments in a predominant sideromelane hyaloclastite. Hyaloclastites forming at the contact of massive flows devoid of a pillowed zone are typically basaltic with or without a subordinate sideromelane component.

Laminated aquagene ash-fall tuff: Laminated aquagene ash-fall tuffs, derived from block-shard hyaloclastites, were observed at number of localities. Their petrographic properties are poorly known, due to their strong deformation and metamorphism.

PUMICEOUS HYALOCLASTITES AND ASSOCIATED AQUAGENE ASH-FALL AND ASH-FLOW TUFFS.

Pumiceous hyaloclastites have not previously been described. Pumiceous hyaloclastites formed at the expense of extremely vesicular pillow lavas. Within the present area, pumiceous hyaloclastites are most typically developped in the area south of Lac Hébecourt, around Lac Bayard and between Lac Hébécourt and Duparquet Lake. Pumiceous hyaloclastites also appear to be present west of Clericy. Aquagene ash-flow and ash-fall tuffs typically are associated with pumiceous hyaloclastites.

Pumiceous hyaloclastites: Fragmental material of pumiceaous hyaloclastites is highly vesiculated devitrified glass, in many cases feldspar porphyritic. Very commonly, several generations of vesicles are present. Fragmental material is of five types ~~(Fig. 2A)~~:

(1) Sharp-edged fragments of microlitic lava from the interior of pillows. These larger fragments may show the effects of chilling through the increase of the size of microlites inward. Parts of the laminated pillow-crusts may still be present. Vesiculation may increase toward the border of the pillow fragments.
(2) Fragments of pillow-crusts; large fragments are platy and show laminations. Pillow crusts generally are highly oxidized.
(3) Pumice lumps and angular block-shards of highly vesiculated lava. Several generations of vesicles of different size may be present and vesicles may be drawn out to tubes.
(4) Blocky shards of non-vesiculated lava.
(5) Bubble-wall shards and phenocrysts of feldspar.

However, phenocrysts are present only where the lava is porphyritic.

Effects of chilling are absent or are poorly visible . They are indicated mainly by the oxidation of chilled crusts on pillow fragments, the increase of microlite size and content inward in pillow fragments and the presence of a sequence of fragments with essentially identical phenocryst content, but differing in the size and density of the quench microlites. Small fragments devoid of quench microlites, derived from the pillow zones with strongest chilling, commonly are strongly oxidized. Perlitic cracks are rare or absent, and fragments generally do not show the jagged knife-shapes of hyaloclastic shards.

This aquagene tuff forms the matrix between pillows and broken pillows. Pillows manifestly fragmented in place are common, and it is evident that pumiceous pillow breccias essentially formed by disintegration of pillow crusts and pillows as did the block-shard hyaloclastites. Outlines of fragments suggest that disintegration occured partly by expansion of magmatic gases, but mainly by thermal strain and by expansion of extraneous steam.

Pumiceous aquagene ash-fall and ash-flow tuff: These tuffs are nearly invariably associated with flows containing pumiceous hyaloclastites. They contain the same type of fragments, except for the larger sizes. Recognizable pillow fragments are rare even in coarse-grained tuff breccias. Rounded pumice lumps, produced by disintegration due to expansion of magmatic gases appear to be more common than in the hyaloclastite. Fine-grained ash-tuffs generally contain a high proportion of bubble-wall shards.

Thin beds (5-100cm) of pumiceous aquagene tuff generally overlie flows with pumiceous hyaloclastites. They are thin-bedded and, in general, are fairly fine-grained. Their sedimentary structures have not yet been studied systematically, but graded bedding and parallel lamination are present. These thin tuff beds probably formed by very weak magmatic explosions and hydroexplosions taking place at the flow surface. They belong to the underlying flow, from which they are derived.

The origin of number of thick (up to 100m) pyroclastic units of local extent, petrographically similar to aquagene ash-flow tuffs, is yet undetermined. They may form by moderate magmatic and hydro-explosion affecting the front of advancing lava flows. Contrary, to the pyroclastic ash-flows described below, these tuff units cannot be traced for considerable distances.

PYROCLASTIC FLOWS

The composition and texture of typical pyroclastic flows is best studied in the area between Duparquet Lake and Reneault, where major pyroclastic flows produced bystrong magmatic and hydro-explosions are present. The sediment structures of these rocks are discussed by Tassé, later in this report.

Flows produced by magmatic explosion are strongly heterolithic. Accidental fragments are either angular, or are rounded by abrasion and are extremely heterogeneous, comprising basalts and andesites of various lithologies and crystallized subvolcanic intrusive rocks. Most accidental fragments are at least vaguely related to the extruding magma; in the case in question, this is indicated by their strongly feldspar-porphyritic character. Pumice and feldspar fragments are the assential components. Pumice occurs in two forms, as the case may be, namely as pumice lumps, and as a partly welded matrix, of non-particulate appearance, between accidental fragments and feldspar phenocrysts. Pumice lumps have been emplaced in the cold state, whereas the partly welded pumiceous matrix has been emplaced in form of hot fragments that later were welded and thereby lost their individuality.

Flows produced by hydroexplosion appear to contain less accidental fragments. Fragments commonly have blocky, angular outlines, less commonly are abraded. Reentrant angles are very common in the very large fragments. Fragmentation of these breccias occurred by very strong hydroexplosion of volcanic spines and domes.

BALLISTIC FALL-BACK OF HYDROMAGMATIC AND STEAM EXPLOSIONS

Study of these rock types is in its early phases and the following descriptions are very preliminary. Both form rubble piles of very limited lateral extent, with very poor size sorting, generally massive but containing some, vaguely defined layering. Long axes of fragments are oriented in bedding, and may parallel the current direction. Emplacement was apparently by impacting, followed by tumbling of fragments downslope and by rock avalanches.Generally the size of fragments decreases upward in one or several cycles.

Fragments generally are extremely angular, but they may be abraded. Steam explosion breccia grade downward into the slightly brecciated source rock, and containly only fragments than can be directly related to the country rock. No essential fragments are present.

The hydromagmatic breccia pile studied contains very few essential fragments at the base. Toward the top the proportion of essential fragments increases until,in the higher part of the pile, most of the fines-grained fragments as well as the matrix are of essential material.

DETERMINATION OF THE EMPLACEMENT MECHANISM

The interpretation of the emplacement mechanism of pyroclastic rocks is basically a question of sedimentology. Probably the most powerful tool for recognition of the emplacement mechanism is the relation that exists between stream power of the transporting current, grain size, and bed form of the sediment (Allen, 1970; Rocheleau and Lajoie 1974), and the vertical sequence of bed forms that develop during the disposition individual sedimentation units (Bouma, 1962; Allen, 1970; Walker, 1970). The main problem in the determination of the flow mechanism is the distinction between pyroclastic fall-out and distal pyroclastic flows.

Investigation of the sedimentary structures of pyroclastic rocks in this area is in its very beginning stages. Consequently, the following discussion must remain extremely tentative.

Pyroclastic flows: Fiske (1963) and Fiske and Ma~~b~~tsuda (1964) used bed thickness to distinguish between pyroclastic flows and falls; arbitrarily, graded beds 1 meter or more thick were considered flows and thinner graded beds were considered falls. This is not a sound criterium. Basically, a pyroclastic flow should show evidence of transport by mass flow, whereas a pyroclastic fall should contain evidence against transport by mass flow.

The proximal high-density mass flows (rock slides, grain flows and proximal high-density turbidites) pose no real problem, despite their complex sedimentology (Walker, 1970). These form relatively thick (larger than 1m) beds of poorly sorted " chaotic" tuff. There may be traces of graded or more commonly, reversed graded bedding, and erosional features (erosion channels, flute casts) may or may not be present. Structures indicating bottom traction (cross-beds, parallel laminae) may be present, and where evident indicate high stream power (pebbly dunes, rip-up, parallel laminae of the upper flow regime). Zones of ash tuff overlie the massive zone and generally show traction features.

Normal turbidites should contain sedimentary structures that indicate decreasing stream power during deposition of each sedimentation unit (Walker, 1970). Erosional structures (channels, flutes) are common at the base. Because of the relatively high stream power generated by volcanic mass flows, upper flows regime bed forms (parallel laminae of the upper flow regime, dunes, rip-ups) are present in most cases, whereas beds devoid of erosional bases and containing only bed forms of the lower flow regime (current ripples and lower flow regime parallel laminal) should be present only in very distal forms.

Pyroclastic falls: *Ballistic fall back breccias* are easily recognized, because they form piles of very small lateral extent of moderately well sorted, centimetric-decimetric debris. There may be a vague layering. Lateral grain-size variations are rapid. Evidence for emplacement in part by rock slides is present. Such deposits, exemplified by the breccias immediately north and north east of the Joliette mine, are totally different from pyroclastic flows and from pyroclastic fall-out.

Pyroclastic fall-out has not yet been investigated seriously in this area, and its properties are very poorly known. However all deposits interpreted as fall-out show the following properties: graded bedding, where present, is present in centimeter of decimeter-sized units, not in thick units; the base of graded sedimentation units do not show erosional features (flute casts, flame structures), as have been observed in distal ashflows. Parallel laminae and ripple cross-laminae are present, but there does not appear commonly to a exist a defined sequence of sedimentary structures, as in the Bonma cycle. Bed forms of the upper flow regime appear to be absent.

CONCLUSIONS

With certain restrictions, the petrographic criteria defined by Carlisle (1960), Heiken (1972) and others, can be applied to the Archean rocks of Rouyn-Noranda area. However, in addition to the block-shard hyaloclastites of Carlisle, there exists a class of pumiceous hyaloclastites that does not appear to have been described previously. Minor explosion during the formation of these pumiceous hyaloclastites gives rise to aquagene ash-fall tuffs and ash-flow tuffs that by their petrographic character, appear to be produced by hydro-magmatic explosion. Data obtained by Moore (1965), Jones (1969), Moore and Fiske (1969) and McBirney (1963), among others, appear to support the idea that highly vesiculated lavas (and, therefore, pumiceous hyaloclastites) form only in shallow water, and that magmatic and hydroexplosions also indicate fairly shallow marine conditions.

DETERMINATION OF FLOW DIRECTION OF BASALT AND ANDESITE FLOWS FROM IMBRICATED PILLOW BRECCIAS

(E. Dimroth and R. Côté).

A simple routine method, by which the flow direction of many basalt and andesite flows may be determined, has been worked out in 1973. Details on the method will be published (Côté and Dimroth, in preparation) and need not be discussed here.

In many flows of andesite and basalt, pillow breccias at the flow top are imbricated (Fig. 3). From various observations (See Côté and Dimroth, in preparation for details) we conclude that the imbrication forms by plastic shear at the top of the advancing flow. Measurement of flow direction from imbricated pillows is a simple routine procedure: Strike and dip of the bedding plane (=lower surface of a flow) and the imbrication plane of the pillows and pillow fragments are measured, and the top is noted. The flow vector is perpendicular to their intersection, and is directed toward the direction of imbrication (Fig. 4). Vectors so determined have to be corrected for tectonic tilt.

RHYOLITES AND RHYOLITE FLOW BRECCIAS (Gilles Provost)

This report resumes the observations on facies and facies distribution within rhyolite flows made during the Summer 1974. Material obtained will serve as basis of an M. Sc. thesis at Ecole Polytechnique, Montreal.

The study area is situated south of the Pumphouse Bay of Lake Dufault. 7 flows, belonging to the Don Rhyolites have been mapped at 400 feet equal 1 inch, and the lateral and vertical changes of their volcanogenic facies has been studied.

Mapping of flow contacts is based on the size, density and mineralogy of telluric phenocrysts. Size, density and mineralogy of phenocrysts remain constant within any single flow, whereas they differ from flow to flow. This report describes in sequence the character of the flow contacts, and the properties of the volcanogenic facies and their mutual relationships. Relations are schematically represented in Fig. 1 and 2.

CHARACTER OF FLOW CONTACTS

Contacts between two flows may have the following aspects (1) Sharp, unbrecciated contact; (2) Sharp brecciated contacts; (3) Complex contacts; (4) gradational contacts; (5) contacts demarkated by a tuff layer.

Sharp, unbrecciated contact

This type of contact is defined by an absolutely sharp break of the size, density and/or nature of phenocrysts in what, upon superficial inspection, appears to be a homogeneous material. In many cases, both flows show the same volcanogenic facies at the contact. Thus, the contact is visible only upon the most detailed inspection, but then can be shown to be sharply defined. Contacts may be straight, sinuous, or may show numerous irregularities on a decimetric scale. Facing directions cannot be deduced from this type of contact. Contacts of this type can be followed for distances exceeding 300m, and grade laterally into other types of contacts.

Sharp, brecciated contact

In this case a zone, about 30cm thick, at the base of the flow contains angular fragments of white rhyolite 2-5cm across. Fragments are widely spaced (15-20% by volume) and are set in a grey rhyolite. On occasion a vague layering is visible in the breccia. Heterogeneous rhyolite with linguid structures overlie the breccia. Linguid structures are drawn out along the contact. Any facies of the underlying flow may be in contact with the breccia. Contacts of this type may be followed for distances of 300 meters or more.

Facing directions may be determined because the basal breccia contains fragments of the underlying flow and the matrix of the basal breccia may penetrated fissures in the surface of the underlying flow.

Gradational contacts

Gradational contacts laterally grade into brecciated, sharp, contacts. However, the phenocryst content at these contacts does not change abruptly but within a gradational zone about 30cm thick. Commonly lentils, showing the characteristic phenocrysts of both flows, alternate.

Only a tentative interpretation of the origin of this type of contact may be presented at this time: It appears that in this contact fragments of the underlying flow have been mechanically deformed, rolled out, or ground up and, perhaps, have also been partly digested by heating and softening.

Contacts demarkated by tuff interbeds

In few cases, tuff appears at the top of rhyolite flows. The tuff beds, only a few meters thick, may be followed laterally for more than 100 meters. The tuff grades into a flow breccia beneath, whereas its upper contact, with the overlying flow, is sharp.

Lapilli tuff beds, up to 30cm thick, alternate with beds of ash-tuff of 2-3cm average thickness. Graded bedding, parallel stratification and

Small-scale (5-10cm) cross-stratification and various synsedimentary deformation structures (microfaults, folds) have been observed. Larger phenocrysts are, of course, absent from the ash-tuff, even where they occur in the underlying flow.

ROCK TYPES

Each flow consists of three rock types (1) white, homogeneous rhyolite; (2) grey, heterogeneous rhyolite and (3) rhyolite with a pseudobreccious, "cellular" surface texture.

Homogeneous white rhyolite:

This type of rhyolite generally is homogeneous, less commonly is laminated on a millimetric scale. It alters white to yellowish white and is white, grey, dark grey or pink on the fresh surface. It is very fine grained, the surface is smooth, and the fracture conchoidal.

This rock type forms the inclusions and fragments in flow breccias, and forms linguid masses of any dimension, set in the grey, heterogeneous rhyolite. Linguid masses with diameters exceeding 20 meters not uncommonly show columnar joints 5-30cm across.

Grey rhyolite:

This rock type alters light to dark grey, and occasionally is nearly black. Its weathered surface generally is rough. It is darker on the fresh surface than the corresponding white rhyolite. The grey rhyolite commonly is somewhat heterogeneous and may show considerable variability of colour and texture of the weathered surface. It forms the matrix of flow breccias and between linguoid structures.

Cellular rhyolite:

The cellular rhyolite shows an apparent breccia structure. Fragment-like objects, rounded or angular, weather black or dark grey, and have a rough surface similar to the surface of the heterogeneous rhyolite. They are set in a "matrix" of white rhyolite identical to the homogeneous rhyolite described above. The "fragments" weather more readily than the "matrix" which stands out in relief.

Laminations are common in cellular rhyolite. Laminations may be followed from "fragment" to "fragment", which seems to indicate that little, if any, movement occurred between the fragment-like objects. On the other hand, "fragment" boundaries appear to be fractures, and numerous white silicified cracks also intersect the "fragments". Thus, it is possible that the white matrix of this type of rhyolite formed by silicification at numerous small cracks, essentially without movement.

The cellular rhyolite grades into the white, homogeneous rhyolite on the one hand, and into the grey, heterogeneous rhyolite on the other.

FACIES AND FACIES RELATIONS

Large masses of white rhyolite

Internal structures: Columnar joints are fairly common, occurring either within the whole or in parts of the masses of white rhyolite. They have 6-4- sides and, on the average are pentagonal or hexagonal. Very commonly columns are deformed and they may fracture quite irregularly, particularly in the center of the masses. In many cases, column show a fan-shaped disposition, fanning outwards from the center of the masses. Their gross disposition is at an angle of $30\text{-}50^{o}$ with bedding; they are not perpendicular to the flow surface. The orientation of columns appears to reflect more directly the geometry of the white masses than the geometry of the flows.

Crevasse structures are very common in the white masses. Crevasses are zones 1-30 mm thick, separating columns or sheets of white rhyolite, filled with a light yellowish-grey rhyolite that in character is intermediate between the white and the grey rhyolite. Crevasses show a rough orientation parallel to the bedding plane.

The dimensions of the white masses very considerably, from 60m to about 100m. Their outlines are quite irregular.

Relations to the surrounding material: The white masses are surrounded by the facies of grey rhyolite with linguoid structures. The outlines of the contact are extremely irregular; the contact is not only folded, but protrusions, lobes and linguid masses of white rhyolite extend into the grey facies and detached tongues, balls and folded masses of white rhyolite are included in the grey facies. Folds, lobes and linguoid structures at the contact are asymetric: they form wide arcs with a large radius of curvature where the white rhyolite is on the convex side of the contact; on the other hand, they are sharply pinched where the grey rhyolite is at the convex side of the fold.

Flow layering, on a millimetric on centimetric scale generally is well developed in a zone 10-50cm away from the contact. On occasion, larger parts of the white masses are flow layered. Crevasses, 1-30 mm, wide, filled with grey rhyolite, not uncommonly cut the white masses and also intersect the flow banding.

Geometry: White masses, although grossly equidimensional, are inclined obliquely to the flow surface, plunging at angles of 10-30^{o} toward the front of the flow. The white masses are found mainly in the lower half of the flow, and commonly overlie the basal contact. They more commonly occur in the proximal than in the distal facies.

GREY FACIES WITH LINGUOID STRUCTURES

Internal structures: This facies is the most extensive facies of the flows investigated. It consists of a predominating matrix of grey rhyolite into which are set lobes and tongue-shaped masses of white rhyolite which commonly show extreme contortion. Fragments of white rhyolite are common, so that there are complete gradations into the flow breccias.

The linguoid white masses generally are from 30cm to 5 meters wide and several meters to several decameters long. Contacts between the linguoid masses and the matrix may be sharp, in which case a well developed flow layering is present in the contact zone. In other cases gradational contacts are present and flow layering is vague. Where contacts are gradational, many unsharply bounded and partly assimilated fragments of white rhyolite are present in the matrix.

Linguoid structures commonly show some crevasses 1-50 mm thick, filled with the grey rhyolite. Complete transitions exist from poorly crevassed linguoid structures to strongly crevassed linguoid structures, to layers of closely set sharply bounded fragments in flow breccias.

Flow folding: The grey facies with linguoid structures is the site par excellence of flow folds. Linguoid structures and the flow layering at their surfaces are folded and refolded in the most complex manner. However, the asymetry of flow folds, already described from the surface of the white masses, persists: The folds have a relatively wide radius, where the white material is at the concave side, whereas they commonly are tightly pinched where the grey material is at the concave side. This geometry of the flow folds suggests that the white rhyolite was much more viscous than the grey rhyolite.

Geometry: This is the most extensive facies in the flows investigated. Generally, the linguoid structures show a general alignment, despite their complex folding. In the upper half of the flows, they are aligned parallel to the flow surface; in the lower part of the flow, they are inclined toward the flow front at angles of 10^{o}-30^{o}.

Considerable variation exists within the grey facies in a proximal-distal direction. In general, proximal zones show greater degree of assimilation of the white rhyolite by the grey rhyolite. Linguoid masses show little crevassing, and their contacts are comparatively unsharp. Inclusions of white rhyolite in the grey rhyolite are rounded and irregular and their contacts are gradational. Toward the flow front the degree of crevassing and of brecciation of the white masses increases and more breccia fragments are present. Contacts between white and grey rhyolite tend to be sharper, and fragments of breccia tend to become angular and sharply bounded.

RHYOLITE BRECCIAS

Composition and morphology of fragments: Fragments are composed of white rhyolite, either homogeneous or flow banded. Flow banding may be extremely contorted and folded. Shape and character of contacts vary together: Angular fragments have sharp contacts against the matrix, whereas rounded or irregular fragments have gradational contacts.

Structure: Layering, defined by variations of the spacing and size of fragments is the most common structure observed. Layers are 30-500 cm thick and are unsharply bounded. Massive breccias, devoid of layering, also exist. We have observed neither sorting, nor graded bedding within the layered flow breccias, but both are present in pyroclastic breccias.

Geometry: The flow front generally consists of massive, un-layered coarse-grained breccia. Blocks are fairly closely set; the matrix generally makes up less than 40 per cent of the rock.

The lower half of the median part of the flow contains breccias with rounded and angular fragments alternating with layers of grey rhyolite with linguoid structures. These zones of linguoid structures on the average are 150 meters long. They are inclined toward the flow front at an angle of 10-25°.

This material grades upward into layered flow breccia, where layering is sub-parallel to the flow contacts. Occasionally a fine-grained pyroclastic breccia with graded bedding may be at the very top of the flow. The basal contact of the pyroclastic breccia appear to be gradational.

CELLULAR RHYOLITE AND VEIN SYSTEMS

Cellular rhyolite: Cellular rhyolite resembles a flow breccia in which dark weathering fragments appear to be set in a white, homogeneous matrix.

It appears to form at the expense of the masses of white rhyolite. Complex transitions exist from the white rhyolite into the cellular rhyolite and finally into the grey rhyolite, by an increase of the surface area that shows dark alteration.

Although the cellular rhyolite resembles flow breccias, the fragments defined in it apparently were not displaced. In many cases fragments in cellular rhyolite are flow layered. Flow layering can be traced without displacement from fragment to fragment, and has a common alignment. On the other hand, in the true flow breccias, fragments have been displaced and commonly have also been rotated.

Within the dark weathering patches of the cellular rhyolite a dense network of white silicified veins may be seen, and it appears that the white matrix has been produced by partial silicification of a material intersected by closely spaced cracks. Little displacement took place at the cracks.

Vein systems in ribboned rhyolite: The ribboned zone at the contact between white and grey rhyolite shows a closely spaced network of silicified veins. Possibly these veins formed at the same time as the cellular rhyolite.

RHYOLITE TUFF

Rhyolitic lapilli tuff covers the surface of number of the flows. Its basal contact is unsharp, whereas the contact to the overlying flow is sharp. The tuff layers are several meters thick. They are bedded. Graded bedding, parallel lamination, cross-lamination, flame structures and syn-sedimentary deformation structures have been observed.

INTERPRETATION

The new observations largely confirm earlier interpretations of the flow structures in rhyolite flows by Spence (in Goodwin and Ridler, 1972) and Dimroth et al (1973), to which the reader is referred. Facies relations within the flows are schematically represented in Fig.

It is quite clear that the differentiation of the grey and white rhyolite took place during the flowage, probably during relatively late stages of flowage. Hydrothermal transport of silica and alkalies are the only feasible mechanism. It is obvious that the differentiation occurred nearly in situ, not in the very early stages of flowage.

The geometry of flow folds attests to a large difference in viscosity between the grey and white rhyolite, the white rhyolite being the more viscous material. Observations suggest three mechanious of brecciation: (1) brecciation may take place by crevassing of linguoid masses of white rhyolite, followed by injection of grey rhyolite into crevasses and disintegration of the white masses. (2) Brecciation may occur by plucking of fragments from the surface of the white masses. (3) At the surface of the flow and at the flow front, fragmentation occurs in part by hydro-explosion and tuffs form.

Relations between the facies of rhyolite and differential viscosity of white and grey rhyolite have been discussed by Dimroth et al, 1974.

SEDIMENTOLOGY OF THE RENEAULT TUFF (Normand Tassé)

INTRODUCTION

A large tuff unit, named Reneault Tuff (Dimroth et al., 1973) extends from Dufresnoy lake to the center of Duparquet Lake. It overlies a sequence of calc-alkaline andesite flows showing pillow structures and including hyaloclastic breccias (Boivin, 1974). Six stratigraphic sections were measured in detail; Sections 1, 2 and 3 are situated on the hills 600m north of d'Alembert River, 6km east of Duparquet Lake, and Sections 4, 5 and 6 are situated on the first high hill, 900m west of the Macamic road.

SECTIONS AT D'ALEMBERT RIVER

The outcrop at D'Alembert River consists of interbedded coarse-grained (blocks and coarse lapilli) and fine-grained (fine lapilli and ashes) and has an exposed thickness of 300m. The beds of coarse-grained tuff are 2-30m thick, with an average of 10m. The proportion of coarse fragments varies greatly (from 5 to 70%) between beds and, in places, from the base to the top of a single bed. Fragments of poorly vesiculated, feldspar-porphyric lavas and of pumice are present. Tuff fragments are rare. The fragments are set in a matrix of fine-grained tuff of the same composition, containing many feldspar phenocrysts. The largest fragments have about 25cm diameter.

Beds of fine-grained tuff are several mm to 3.7m thick, with an average of 75cm. Parallel and oblique stratification is common. The fine-grained tuff has the same composition as the matrix of the coarse-grained tuff. Some beds contain blocks of non-vesiculated porphyritic lava. Nests of 4-5 large blocks are common. Blocks have an average diameter of 0.5m and largest diameter of 1.12m. In most cases, the long axis of the blocks is perpendicular to the stratification.

The lower contact of the coarse-grained beds is not erosive. However, one bed has been observed to channelize up to 7 meters deep into the underlying beds. On the other hand, amalgamation of tuff beds is common, but does not persist laterally; thus, the top of a bed may re-appear a few meters beyond the amalgamated zone.

Sedimentation units are subdivided in graded division (with normal and reversed graded bedding), and laminated divisions (parallel and oblique laminations). Very few sedimentation units only show parallel laminae. Flames and rip-ups are minor sedimentary structures.

Grain-size variation within the graded division of beds are complex: A zone of reversed graded bedding is present at the base of beds and occupies about the lower fifth of the graded division. Normal size-grading may be nearly imperceptible above the reversed graded zone, but generally is more accentuated toward the top of the graded division. The quality of size-grading, whether normal or reversed, depends on the matrix content; size-grading, in particular reversed grading, is accentuated where matrix content is large. In this case, matrix content also decreases toward the coarsest part of the bed. These relations, best shown by the non-vesiculated material, are complicated by density grading, leading to an enrichment of pumice at the top and, occasionally, to reversed graded bedding of pumice lumps.

The division of parallel lamination appears above the massive graded division. A relatively rapid break in grain sizes separates both. Rarely, laminations are present at the base of a graded bed. Blocks of a meter size, commonly occurring in nests of 4-5, occur at the top of the graded division and within the laminated division. The long axes of the blocks are oriented perpendicular to bedding. Laminations below the blocks are sharply cut at the contact and are depressed below the block, whereas laminae are draped over the block. Pumice lumps also occur in the laminated divisions but exercise little influence on the laminations. Rip-ups exist at the top and within the laminated division; in rip-ups the laminations have been detached and have been folded upon themselves. Flames are present at the contact between the laminated division and the base of the overlying sedimentation unit.

Oblique laminae more commonly occur at the top of the massive division than overlying a zone of parallel laminae. Oblique laminae generally are present in zones only a few cm thick; however we have observed troughs 40 meters wide which, in their center, are 2 meters thick. On occasion, oblique laminae are tangential at base and top. Very low angle divergence (angle of 5°) occurs within the zone of parallel laminae.

It has been possible to measure trough directions in a few cases and these suggest that flow was from the S-SE toward the N-NW. Fragments in the breccia show planar orientation parallel to stratification, but it was not possible to determine the direction of their alignment. The thickness of one bed of coarse-grained tuff decreases from 14.8 m to 6.6 m over a lateral distance of 100m, in a northerly direction. This observation also indicates a provenance from the south. Lack of outcrop, and common amalgamation of fine-grained beds do not permit to verify this observation at other beds.

THE RENEAULT SECTION

220 meters of alternating coarse-grained and fine-grained tuff are exposed in the Reneault section. The essential fragments of both are poorly vesiculated feldspar-porphyritic lavas. A few occidental rhyolite fragments are present. The matrix of the coarse-grained tuff contains the same types of fragments and an appreciable proportion of feldspar phenocrysts. The beds of coarse-grained tuff breccia are massive and occasionally show normal or reversed graded bedding. Beds of fine-grained tuff show the graded and laminated divisions (parallel and oblique laminations) of Bouma (1962). A single bed of fine-grained tuff only shows the laminated division. Channels, rip-ups and flame structures are rare.

Two distinct facies are exposed. The basal part of the section (northern part of outcrop) is characterred by a ratio of coarse-grained to fine-grained tuff lower than 2, whereas the ratio is about 4 in the upper part of the section (southern part of outcrop area). Coarse-grained tuffs in the northern area show relatively small lateral variability, whereas those of the upper part of the section show great lateral variation of grain size.

Lower part of Section: Three types of coarse-grained tuff are exposed: the first consists of beds 2-3 m thick containing fragments up to 30cm across dispersed in 6-70% of a matrix of ash tuff. The coarse fraction of the tuff shows reversed graded bedding in the lower 2/3 of the bed; a zone of normal graded bedding follows.

Two beds, up to 14 and 27 meters thick, represent the second type; both beds appear to be massive. The largest fragments attain 1.11 m, their average diameter is around 20-25 cm. The matrix makes up less than 40% of the coarse-grained tuff, except at the top of the 14 m - bed, where meter-sized blocks float in a matrix of fine-grained tuff without intermediate grain sizes. These beds pass laterally into the type described above about 150m farther west, beyond a small andesite intrusion. We believe that these massive beds are amalgamated, because channels filled with coarse-grained tuff up to 15m wide and 3m deep are present, and because they pass laterally into several, lenticular, channelized beds of alternating coarse-grained and fine-grained tuff.

The third type of tuff is composed of massive beds with a maximum fragment size of 15cm and a mean of 8cm. The coarse-grained tuff grades upwards into fine-grained tuffs.

The thickness of the fine-grained ruff beds varies from a few millimeters to 5 meters, with an average of 1.5m. They have the same composition as the matrix of the breccia tuff. Blocks, up to 1.2 m large, rarely are set in the tuff. General several blocks are grouped in nests, as is the case at d'Alembert River, but their long axis is parallel rather than perpendicular to the stratification. The fine-grained tuffs show graded bedding, parallel and oblique laminations, and rarely flame structures and rip-ups.

A diffuse normal graded bedding is present in most beds of fine-grained tuff. Reversed graded bedding has been observed at the very base of a few units. A division of parallel laminations appears above the graded division. In one case, the whole bed shows parallel lamination. At a single location rip-ups have been observed and, at a different locality, flame structures.

Oblique laminations occur at the top of the division with parallel laminae, rarely directly above the graded division. In one case, they are at the base of a bed, below a massive zone, and have very low angles (5-10°) with bedding. Sets of cross-laminae are never thicker than 15cm; only isolated troughs are present.

Upper part of section: The beds of coarse-grained tuffs are 1-5-8.3m thick, with an average of 4.5m. The bed thickness may vary along strike by a factor 2 over a strike distance of less than 50m, in both directions from a point of maximum bed thickness. The largest fragments attain 52cm, but generally are below 25cm. They are set in about 40% matrix. The proportion of matrix may vary from 35% to 85% laterally. Only two beds show graded bedding. One bed shows reversed graded bedding in the lower half of the bed and normal graded bedding in the upper half, whereas the other bed, 5.5 meters thick, only shows reversed graded bedding. All others beds are structureless.

The beds of ash tuff are 0.7-2.3 m thick with an average of 1.2m. Normal and reversed graded bedding here and there overlain by a division of parallel laminae, are the only sediment structures. Reversed graded bedding may be restricted to the base of the beds and be followed by a zone with normal graded bedding or with massive structure. In other cases, the whole bed may show reversed graded bedding, and grain size attains up to 12cm at the top of the bed.

Paleocurrents: There is no three-dimensional outcrop of cross-beds; therefore it was not possible to measure current directions from oblique lamination. Fragments are aligned in a north-south direction.

CONCLUSIONS

The presence of abundant pumice in the matrix of the tuffs of the d'Alembert River section, and its absence from the tuffs of the Reneault section suggest an origin respectively by magmatic explosion and hydro-explosion (Heiken, 1972). Paleocurrents determined from cross bedding and from thickening of beds in the d'Alembert River section, and from fragment orientation in the Reneault Section are concordant: Flow was from the south to the north or, at any rate, had a strong northerly component.

It is difficult to establish a model of the sedimentation, at the present time. More data on other outcrop areas, and granulometric data are required in order to develop a model of the sedimentation of both units. However, it appears to be clear that all pyroclastic flows studied were deposited from mass flows where both transport in suspension and by traction took place. However the character (density, viscosity, temperature) of the mass flows responsible for deposition of the tuffs at D'Alembert River and at Reneault must have been sensibly different. The pyroclastic flows at d'Alembert River were apparently emplaced at high temperature, as shown by slight welding of pumice (Boivin, 1974). It is very doubtful, whether this was also the case at Reneault.

Comparison of the facies represented by both sections with descriptions of other subaqueous pumice flows (Yamada, 1973), and with conglomeratic turbidites (Hendry, 1973; Hubert et al., 1970; Rocheleau and Lajoie, 1974; Walker and Pettijohn, 1971) suggests that the Reneault section represents a more "proximal" facies than the d'Alembert section. However, this may in part be due to the different explosion mechanism responsible for the eruption of both tuff sequences. As noted above the tuffs of the d'Alembert section were produced by a magmatic explosion, those of the Reneault section by hydro-explosion. The resulting mass flows may have had quite distinct viscosity and density even at the place of eruption.

SEDIMENTARY FACIES AND MODELS OF SEDIMENTATION (Michel Rocheleau)

The sedimentology of several stratigraphic units in Rouyn-Noranda area is presently under investigation. The data and results of this study will form part of a Ph. D. thesis at the University of Montreal.

As the stratigraphic relations between the various sedimentary units of the area are not yet well understood, the three units studied are described separately. They are:

I- The Duparquet Group

II- Conglomeratic sandstones of the Cadillac Group in Joannès township.

III- Conglomerates and sandstones of the Temiskaming Group at McWatters and at Lac Bouzan.

In the following pages the various facies present in each of these units will be described; it will be attempted to clarify their mutual relations, and models of sedimentation will be proposed. The term facies is used in the sense defined by Moore (1949) and designs any part of a stratigraphic unit distinguished from other parts of the same unit by its sedimentary properties (assemblage of sedimentary and biogenic structures, texture, composition, etc..). This method is commonly used by sedimentologists and stratigraphers (Turner and Walker, 1973; Walker and Pettijohn, 1971; Hubert et al., 1970).

I-DUPARQUET GROUP

Four facies have been defined by their texture, and by the assemblage of their sedimentary structures.

Facies A: Pebble, cobble and boulder conglomerate with sandstone interbeds:

Sedimentation units of conglomerate appear to be laterally continuous at the scale of the outcrop. Their thickness varies from the width of a pebble to about 20 meters, but generally remains below 10 meters. Sandstone interbeds are thinner and are very lenticular. They rarely exceed 1m thickness; generally they are several mm to 40cm thick.

Contacts between sedimentation units are of three types (1) Abrupt changes of granulometry in a conglomerate unite may indicate that two amalgamated beds are present. (2) Contacts between sandstone and underlying conglomerate are sharp, but irregular. (3) The top of sandstone beds is sharp and straight, except where it is erosional. Sandstone generally makes up less than 5% of the rock volume, a proportion that increases at 25% at the top of the section.

The conglomerates contain 25-40% sand matrix, of a composition identical to the interstratified sandstone lenses. Very well rounded pebbles, cobbles and boulders are the large fraction of the conglomerate. They are more or less spherical or ellipsoidal. The largest diameter of fragments is below 75cm, except in two outcrops where it exceeds 1 meter. The average diameter of the ten largest fragments decreases from the east to the west, except near the central N-S line of Duparquet township, where it increases abruptly, to decrease again farther west. The proportion of sandstone beds also increases considerably in a westerly direction.

The conglomerate is petromict, consisting mainly of various types of volcanic fragments (about 90%), some sandstone, tuff, jasper, magnetite, black chert and vein quartz. Although a great number of lithologies are present, none of those characteristic of the Blake River Group has been found. On the other hand, several lithologies are characteristic of very local provenance, others are characteristic of the Kinojévis Group. Examples are the coarse-grained quartz-feldspar porphyrys, the Syenite porphyries with big feldspar phenocrysts ("plum porphyries") described by Graham (1954), spinifex-bearing ultramafic lavas, gabbro, jasper, and magnetite. Petrographic comparison of some pink or grey granite fragments with the Palmarolle granite could perhaps furnish information on their provenance.

The conglomerates never show graded bedding. Apart from imbrication, they lack all internal stratification. In contrast, the sandstone beds commonly show internal parallel or oblique stratification; thickness of parallel or cross-laminae varies from a few mm to 2cm. Sets of cross-strata generally exceed 10cm thickness and may attain 80cm. Sandstone beds commonly contain internal stratification marked by aligned pebbles, they contain some isolated pebbles. Occasionally they fill channels cut into the underlying conglomerate bed.

At the base of the section, facies A shows some particularities. Fragments are larger and are more angular. Close to the base of the Duparquet Group, fragments derived from local lithologies and fragments of an apple-green material (fuchsite?) are more common. The basal contact of the group, observed at a single locality, is very sharp. It is an erosive contact cut into an underlying porphyry; some relatively well rounded porphyry fragments are present in the conglomerate above.

The best section of facies A is close to the Duparquet - Destor township line.

Facies B: Medium - to coarse-grained sandstone with isolated pebbles and some pebble stratification:

Sandstones of this facies appear at first sight to be more massive than the sandstone of facies A. This massive aspect may in part be attributed to the appearance of a fairly well developed cleavage and relatively strong carbonatization. Apart from pebble layers and disseminated pebbles, occasionally one finds crossbeds in sets thicker than 10cm, and coarse-parallel stratification. Some rare interbeds of conglomerate are similar to facies A. The best outcrops of this facies are situated S-W of the gravel-pit. East of Duparquet.

Facies C: Medium - to fine-grained sandstone and pelites: The fine-grained sandstone beds are 2-30cm thick; they are thinly laminated and quite continuous at the scale of an outcrop. They alternate with pelite beds several mm to 5cm thick. Some of the pelite beds are very lenticular and brecciated, and very angular fragments of pelite are present in the sandstone beds. The sandstone beds here and there show graded bedding, but this is unusual. Thin crossbeds, and ripple-marks have been observed.

This facies generally in thin (less than 5 meters) and alternates with strata of facies A or B. The best outcrops are found along the Reneault-

Duparquet Road, about 100 meters W of the power transmission line.

Facies D: Sandstone and pelites with graded bedding: Sandstone beds of this facies always show graded bedding. They are fine-grained; beds generally are between 0.5 and 30cm thick with an average thickness of 10cm. The a and b division of Bouma (1962) generally are present, whereas the c division has never been observed. Some beds show convolute bedding, flame structures and load casts. These sandstones are interpreted as proximal turbidites deposited in a relatively quiet environment. A certain transition between facies D and facies A and B has been observed close to the bridge over Duparquet River, in Hébécourt township, where the conglomerate of facies A is overlain by a sequence of conglomerate, sandstone and pelite grading upwards into alternating sandstone and pelite. The best outcrops of the facies or found on the north share of Duparquet Lake.

Sedimentary model: We interprete the facies A and B of the Duparquet Group as result of deposition by flood surges on a piedmont fan, in analogy to the Ament Bay Formation described by Turner and Walker (1973). Petrographic and granulometric data suggest that at least two fans were present, and that the source was situated to the north or north-east. The coarse-grained sandstone lenses represent the filling of shallow channels on the alluvial cone.

Toward the west a transition into a more distal facies (facies B) and finally into marine sediments (facies D) appears to be indicated. The rocks of facies C are intercalated with the alluvial facies and are laterally discontinuous. They formed in a much more quiet environment, and may be lacustrine deposits of abandoned alluvial channels. Richard Hyde (personal communication, 1974) observed a similar facies in the Temiskaming Group at Kirkland Lake and arrived at similar conclusions.

II-Conglomeratic sandstones and conglomerates of the Cadillac Group in Joannès township:

The conglomeratic sandstones and conglomerates of Joannès township (unit 1 of Dimroth et al., 1974) are about 100 meters thick. They overlie and alternate with pillowed andesite flows, flow breccias and some tuff beds. The grade into an overlying flysch-type sequence of alternately medium-grained sandstone and pelite that is strongly folded. The conglomeratic facies is different from any other sequence in the region, due to its peculiar textures, sedimentary structures and stratigraphic relations.

Certain textures and certain mineralogical characteristics of this unit may still be observed, although the biotite-grade metamorphism has destroyed a good part of the original minerals and grain-size characteristics. The conglomeratic fraction of the sandstone generally varies from 5 to 40 per cent. Very angular boulders rarely exceed 50cm, except for a few beds that may be of volcanic origin. Two types of terrigenous fragments are present, namely feldspathic andesites and black pelites. Very rarely one may find rhyolite fragments, whereas acidic plutonic rocks have never been observed. It appears that the quartz content of the sand fraction is pow, an observation that will be verified in thin section.

It is commonly difficult to establish the contacts between the sedimentation units. Nevertheless, several beds show graded bedding and have the conglomeratic fraction at the base. Internal unsharp parallel or oblique stratification occurs in conglomeratic beds, and the fine grained parts of the beds also commonly show laminations. Some inverse graded bedding, convolute bedding, flame structures and small erosion channels are present. The beds of conglomeratic sandstone alternate with thin bedded siltstone and very fine-grained sandstone, showing lamination and graded bedding.

The best outcrops of this facies are situated in the N-E quarter of Joannès township, range VII, lot 28.

Sedimentary model: The sandstones of unit 1 probably have been deposited in a marine environment by powerfull sub-marine mass-flows. Fragments were transported in suspension and internal lamination prove that bottom traction also occured. Rocheleau and Lajoie (1974) described a similar mechanism of emplacement of the conglomerate of l'Islet, Quebec. Pillow basalts below, and interstratified with, unit 1, and the appearance of flysch-type alternation of very fine-grained sandstone and pelite at the top confirm the inferred deposition in a marine environment. The angularity of fragments reveals that fragments did not suffer abrasion in a fluviatile or beach environment in the source area or during transport. The source area was underlain by mafic-intermediate volcanic rocks similar to the volcanic rocks stratigraphically below.

The reader is referred to Dimroth et al. (1974) for a tentative interpretation of the evolution of the lower part of the Cadillac group. It is pointed out that the increase of quartz content from unit 1 to unit 2 indicates simultaneous changes in source and depositional environment.

III-Temiskaming Group

The stratigraphy and structure of the Temiskaming Group are presently under investigation by Normand Goulet (Queen's University). We attempt to complement this study by more detailed sedimentological investigations, in order to be able to compare them with other facies of the area. However, sedimentological studies in this area face very serious problems. These rocks have been metamorphosed to biotite grade, the degree of deformation is so strong that some fragments have been stretched to cigar-shape, and the presence of several phases of superposed folds makes it difficult to correct paleocurrent directions. Strong deformation and metamorphism make it difficult to recognize the contacts between the sedimentation units and the internal sedimentary structures commonly are masked by recrystallization and strong schistonities.

The conglomerates and sandstones have mainly been studied in two areas: (1) North of the railway station of McWatters and (2) South of Lake Bouzan. Their characteristics are described below.

The conglomerates consist of well rounded fragments forming an intact framework. The dimensions of the largest fragments rarely exceeds 60cm, and is about 10-30cm in most cases. Commonly the matrix is indistinguishable from the strongly deformed incompetent fragments. Fragments are mainly mafic and acid volcanic and intrusive rocks, and some black chert, magnetite, jasper and probable fuchsite(?)

The sedimentation units of the conglomerate vary in thickness from several meters to stratifications of a few pebble-thicknesses in the coarse-grained sandstone. Isolated fragments identical to the pebbles of the conglomerate are loosely set in the sandstone. Internal sedimentary structures like graded bedding or internal stratification are absent from the conglomerate beds.

Thickness of the sedimentation units of coarse-grained sandstone intercalated between conglomerate varies from a few mm to 2.5 meters. Thickness of sandstone beds in more sandy facies are difficult to evaluate because it is impossible to trace beds.

Sandstones also appear to be massive at first sight. However, on close inspection, parallel stratification is commonly found, and erosion channels, pebble stratification, and isolated pebbles are observed. Some trough cross-beds 10-50 cm thick and 1 bed of planar cross-beds 2 meters thick have been observed, although conditions commonly do not permit to establish the relations between internal stratification and bed surface. Isolated trough cross-beds in massive-appearing recrystallized sandstone units and divergent stratifications within sandstone layers suggest that large-scale cross-bedding has been obscured by strong deformation and metamorphism in many cases.

The assemblage of coarse- grained sandstone and conglomerate forms lentils that disappear laterally to give way to sandstones with graded bedding whose sedimentary structures permit an interpretation as proximal turbidites. The transition is shown in the section at lake Bouzan by intercalation of graded sandstone and by augmentation of thinbedded sandstone, siltstone and argillite toward the top of the sequence. Toward the south the conglomerate gives way to graded sandstone beds showing the a- and b-divisions of Bouma (1962).

Sedimentary model: .

The coarse-grained sandstone and conglomerate of McWatters and Lake Bouzan are remarkably similar to facies A and B of the Duparquet Group. On the other hand, the absence of graded bedding and the absence of defined sequences of sedimentary structures within a sedimentation unit distinguishes them sharply from marine conglomerates described by Hubert et al. (1970), Walker and Pettijohn (1971), Hendry (1973), and Rocheleau and Lajoie (1974). For this reason we believe that the McWatters section represents an alluvial piedmont fan deposit, whereas the Lac Bouzan section shows a transition between such an alluvial and a marine environment. The conglomerates and coarse-grained sandstones grade southward into fine-grained sandstone and siltstone with graded bedding, and both appear to form a delta.

DIAGENESIS

Work on diagenetic alteration is in its beginning stage. However, certain observations on the alteration of pebbles are important enough to merit brief description. Most pebbles show haloes, generally pale-coloured but here and there darker than the core of the pebble. The haloes are somewhat more resistant than the pebble core. Alteration affects all of the circumference of the pebbles, even where rounded pebbles broke into angular fragments; this proves that alteration occured in place, during diagenesis. Three pairs of preliminary chemical analysis indicate an augmentation of the contents of SiO_2, K_2O, Ba, Rb and a diminution of total Fe, MgO, CaO, Ni, Sr. In a few pebbles of the Temiskaming conglomerate complex alteration haloes have been observed. A older haloe stained red by hematite dust is overprinted by a second alteration that lead to bleaching. Considerable petrographic and chemical work will be done on these alteration haloes.

E. Dimroth (pers. commun., 1974) and M. Larouche (1974) observed carbonate rim cements in a few thin sections of sandstone of the Duparquet Group.

REGIONAL GEOLOGY

Descriptions of the stratigraphy and structure of two areas are included in the present report: (1) Richard Côté studied the parts of Rouyn and Beauchastel townships situated between the Cadillac and the Horne Creek faults, and (2) Pierre Trudel studied a NW-SE trending zone between Reneault and Clêricy. The sequences studied in 1973 all belong to the Blake River Group. In order to relate the following descriptions to those of previous reports, a general stratigraphic table of Rouyn-Noranda area (Table I), a table of the stratigraphy of the Blake River Group south of Rouyn (Table II) and a table of the stratigraphy of the Blake River Group in the region between Hébêcourt Lake and Clêricy (Table III) are presented.

AREA BETWEEN THE CADILLAC AND HORNE CREEK FAULTS (Richard Côté)

The study area comprises the parts of Rouyn townships and of the east half of Beauchastel township between the Cadillac and Horne Creek faults, underlain by rocks of the Blake River Group.

Stratigraphy

The volcanic sequence of the area may be subdivided into four main units:

(1) The lower basalt sequence (ca. 1800m.);
(2) The Stadacona Breccia (up to 900m.);
(3) The upper basalt sequence (up to 1,300m.);
(4) The Beauchastel and Glenwood Rhyolites and associated andesites.

Units 1 to 3 follow in normal sequence; relations between units 3 and 4 are complex. Both may be correlative at least in part and interfingering is likely.

1. Lower basalt sequence: Three well-defined variolitic basalt units averaging 200m. in thickness are the best markers in the lower basalt sequence. A rhyolite unit 40m. thick and a very amygdaloidal pillowed rhyodacite may be traced at least 11 kilometers. On the other hand, porphyritic and glomeroporphyritic flows appear to have limited lateral extent; it was not possible to follow them for any considerable distance. Sections measured across the unit just northwest of the intersection of the Bellecombe road with the limit of ranges IV and V, Rouyn township, are presented in Fig.

Individual basalt flows are 10-100m. thick with an average of about 30m. Basically, two types of flows are present: (a) pillowed flows with a thin top zone of isolated and broken-pillow breccia, and (b) massive flows capped by isolated or broken pillow breccia. A zone of closely set pillows may or may not be present in former (b). Imbrication of pillows or pillow breccias is rare.

All flows, except for the rhyodacitic marker, are poorly vesiculated (vesiculation generally below 2%) and vesicles are small (generally below 2mm.). According to Moore (1965) and Jones (1969) this suggests emplacement in deep-sea environments. It is worth mentioning that Bryan, Moore et al, in 1974, observed submarine pillow basalts in the Mid-Atlantic ridge valley in certain instances showing apparently appreciable vesiculation. However, numerous factors are involved in the degasification mechanism of submarine basalts, and it appears that the earlier work by Moore (1965) and Jones (1969) is nevertheless valid (Bryan, personal communication).

A discontinuous band of sediments, about 5m. thick and traceable for 350m. is located on Lot 27, range V, Rouyn township, just west of the Bellecombe road. The sediments are graded volcano-sedimentary greywackes in beds 10-50cm. thick, alternating with thin interbeds (2-30cm.) of laminated pelites.

The contact relationships between the lower basalt sequence and the Temiscamingue sediments to the south are fairly complex. Contacts have been observed at four localities:

(1) Lot 40, range V, Rouyn township: A thin (2-30cm.) polymict conglomerate composed of mafic volcanic and greywacke fragments set in a chloritic matrix, overlies the volcanic rocks with a 60° angular unconformity. Tuffaceous sediments with graded bedding overlie the conglomerate. The rocks suffered virtually no internal deformation at this locality and the unconformable nature of the contact cannot be doubted;

(2) Lot 21, range IV, Rouyn township: Coarse polymict conglomerate, composed of pebbles of granite, porphyry, gabbro-diorite, rhyolite and variolitic mafic lava is in sharply discordant contact with mafic flows;

(3) Lot 19, range IV, Rouyn township: Oligomict conglomerate interbedded with sandstone beds 30-100 cm. thick is in discordant contact with mafic flows;

(4) Lot 14, range IV, Rouyn township: Oligomict conglomerate containing angular-looking pebbles and cobbles of mafic and intermediate volcanic rocks is in discordant contact with mafic flows. Sandstone and pyritic shale follow southward of the conglomerate.

Rocks are strongly deformed at localities 2 to 4; therefore, a straightforward interpretation is not possible (see tectonics).

Two important lithology changes have been made in the lower basalt sequence with respect to Wilson's map (1962):

(A) The volcanic unit directly north of Adeline Lake, previously mapped as rhyolite, consists of two dacitic to rhyodacitic very amygdaloidal pillowed flows. Further petrographic work may link these with the similar amygdaloidal rhyodacite unit further east.

(B) Investigation by N. Goulet in the McWatters area has shown that certain outcrops previously mapped as agglomerates are essentially highly deformed Temiscamingue conglomerate with minor intercalated greywacke beds.

2. Stadacona breccia: An east-trending roughly lenticular-shaped zone averaging about 600m. in thickness is predominantly underlain by pyroclastic rocks interfingering with minor mafic flows. The pyroclastics consist mainly of ash flow tuffs (graded pumice tuffs) and tuff breccias of predominantly intermediate composition save for the uppermost eruption units which are dacitic to rhyolitic.

A strongly feldspar porphyritic (1-6mm.) texture characterizes the intermediate phase. Sedimentary structures when visible resemble those associated with turbidites. However, one or several of the divisions of the Bouma Cycle may be absent. With the exception of a well-exposed section just south of the old Val d'Or road, exposure is restricted mainly to small, poorly visible, and sporatically distributed outcrops. A single flow unit may show reversed graded beddings of pumaceous fragments (often 64mm.) at its base inverting to normal graded bedding in somewhat finer material followed by the finely laminated tuff at the top of the unit. Detailed work in this and related material is presently under way in the Dalembert River area (see contribution by N. Tassé in this report).

3. Upper basalt sequence: The upper basalt sequence, up to 1,200m. in thickness, underlies a wedge-shaped area widening eastward. Marker units have

not been recognized, although varioles have been observed in mafic flows at a few localities, notably on the north-west shore of Rouyn Lake. Flow thickness, facies of flows and vesicularity differ little from those of the lower basalt sequence, and a similar deep-sea environment of emplacement is inferred. Flow-top breccias very commonly are imbricated and indicate provenance from the west-northwest. The graded rhyolite tuffs and shales of the Rouyn Lake basin overlie the upper basalt sequence, apparently with conformable contact.

4. Beauchastel and Glenwood rhyolites and associated andesites: This sequence is separated by faults from the upper basalt sequence in the western part of the area. It may underlie part of the upper basalt sequence southeast of Rouyn, where the contact is perhaps unfaulted. Rapid changes of facies and thickness in this stratigraphic unit and lack of top criteria complicate stratigraphic work.

Beauchastel rhyolite: Previously 12 different flows had been distinguished in the Beauchastel rhyolite, based on the nature, dimension and quantity of telluric phenocrysts and on amygdule content. However, our investigation has revealed some important similarities between several of these flows. For this reason, a detailed petrographic study is in process, and the results are hoped to reveal whether these flows are not in fact repeated by folding and faulting. Flows may reach a total thickness of up to 450m. but generally average about 120m. Homogenous rhyolite as well as all the various facies of heterogeneous rhyolite (Dimroth et al, report 1973), with the exception of broken column breccia, have been recognized in this area. A study of the distribution of these various facies should contribute to a better understanding of the stratigraphy of these acidic volcanics (see Provost, this report).

Glenwood rhyolite: Contrary to the Beauchastel rhyolites, the rhyolites in and around the city of Rouyn (Glenwood Rhyolite, Wilson 1962) consist of at lease three distinct east-northeast-trending flows with associated pyroclastics. One particular rhyolite flow breccia is cross-cut by a large intrusive rhyolite body showing intricate folding.

Pillowed andesites and andesitic flow breccias are present in Rouyn-Noranda but lack of outcrop and a profusion of gabbro and diorite intrusives make it difficult to analyse their stratigraphic relationships.

Intrusive rocks: At lease three generations of gabbro and diorite intrusions are known to exist in this area. Petrographically the intrusives are identical to the associated mafic lavas and can often only be distinguished from the latter by their cross-cutting contacts. Fig. indicates that most are sub-concordant, sill-like bodies.

STRUCTURAL GEOLOGY

Folding: Four fold phases have been recognized in this area. The corresponding schistosities have been designated S_1, S_2, S_3 and S_4, S_1 being the oldest and S_4 the youngest. These same schistosities are present and are well developed in the Temiscamingue sediments to the south (N. Goulet, personal communication). The oldest phase F_1 is a large scale isoclinal folding with steeply dipping axial planes ~~(Fig.)~~. In the study area the stratification invariably dips to the north. Folds thus are slightly overturned to the south. From south to north the following folds are present:

(1) An east-trending anticline southeast of Adeline Lake;
(2) The anticline north of McWatters;
(3) The Rouyn Lake Syncline and an anticline a little farther to the north.

In most cases, hinge zones are extremely narrow. Rocks are schistose in hinge zones and bedding generally cannot be recognized. Therefore, fold hinges are determined mainly by opposite "younging" directions. These folds likely are of the flexure-shear type. The associated axial plane schistosity (S_1) rarely deviates more than 15° from the bedding direction. Information regarding fold axis orientation is extremely limited. The maximum stretching of varioles within the S_1 plane reflects to some extent the degree of flattening associated with the folding.

Three later phases of deformation overprint the F_1 structures. All are characterized by a schistosity which presumably also are axial planar to flexure-shear folds. Contrary to S_1, S_2 is very poorly developed in the volcanic rocks. Its strike is essentially coincident with that of S_1 and is distinguished from the latter only by its shallow dip (20-30° north). The resulting sub-horizontal lineation (S_2/S_1) is weak and not widespread. In contrast, this same schistosity is well developed in the Temiscamingue sediments (N. Goulet, personal communication).

A third schistosity, S_3, trending southeast and dipping steeply to the northeast is only barely detectable. Field measurements are few and dispersed. Its chronological relationship is uncertain but it would appear to be younger than S_2. Its effect on a mesoscopic scale appears to be minor.

The youngest known fold phase is F_4 whose axial plane schistosity S_4 trends east-northeast and dips subvertically to the northwest ~~(Fig.)~~. Generally the intensity of this schistosity is subordinate to S_1 but in a few areas it is more pronounced. Thin section study shows S_4 to be relatively wide-spaced shear planes of asymmetrical crenulation folding on S_1. S_2 is also affected but to a lesser degree. Microfolds of this generation have steeply plunging axes and are invariably asymmetrical being characterized by a very long and a very short fold limb on either side of the axial plane (S_4). One outcrop just west of the Bellecombe road, Range V, shows S_4 axial planar to intrafolial folds arranged more or less en echelon. In areas where deformation is more intense, minor folding of the oldest schistosity may show kinking changing progressively into tight folding. Field observations indicate non-cylindrical folding during this deformation. Compilation of kink band shear planes ~~(Fig.)~~ and fold axes ~~(Fig.)~~ shows a close resemblance with S_4 and L_4 (S_4/S_1) respectively. On a larger scale, a similar mode of deformation is suggested by the trend line analyses of S_0 and S_1 (see annexed map).

Thin section observations reveal syn-kinematic metamorphism for at least fold phases F_1 and F_4 .

Faulting: Faulting clearly plays an important role in the structural geology of this region. Part of the mineralization, as shown by previous exploration, is without doubt directly or indirectly related to the various major fault zones. Several generations of faults exist. The Cadillac-Larder Lake fault which extends east-west across the entire map area is the most important. A preliminary study on the state of strain within the volcanic rocks based on variole deformation shows a direct relationship between the intensity of deformation and distance from the fault zone. In effect, varioles in proximity to the fault zone essentially are prolate deformation ellipsoids but become progressively less deformed away from the fault. The varioles most distant fromthe fault (approximately 1.5km.) registered relatively small strain. The Cadillac fault is regarded as a thrust fault where the older volcanic flows have been trhust over the younger sediments. However, subsequent and/or contemporaneous strike-slip faulting have complicated the history of the fault zone.

Furthermore, the fault may already have been active during the sedimentation of the Temiscamingue Group (Dimroth et al, 1974).

Direct volcanic-sediment contact along the fault is infrequent and therefore limits the tectonic/stratigraphic work along its strike. The few contacts exposed are nevertheless interesting and merit further investigation.

(1) Contact southeast of Moore Lake, Lot 40, Range V: Southeast-trending variolitic pillow lava (tops north) are clearly truncated for a distance of approximately 10m. by east-northeast-trending Temiscamingue sediments to the south. All rock types are weakly schistose but the contact is clearly not faulted. "Younging" direction in the sediments is south. This contact clearly exposes an angular unconformity and suggests the volcanic rocks were tilted before deposition of the Temiscamingue sediments.

(2) Contact south of the C.N.R., Lot 21, Range IV: Outcrops permit to trace a narrow tongue of polymict conglomerate apparently some 10 to 15m. wide trending approximately 200m. across the volcanic rocks. Two alternative interpretations of the contact relations may be proposed: (a) The sediments may represent an erosional remnant of the fill of a channel or valley; (b) The sequence may be repeated by

thrust faulting. In the latter case, bedding-schistosity relationships within the conglomerate suggest that faulting occurred prior to the first fold phase.

(3) <u>Contact east of Granada, Lot 18, Range IV</u>: This contact is characterized by an extremely schistose zone extending anywhere from 15 to 40m. in thickness and cut by numerous quartz veins. Extensive rock alterations include carbonatization and chloritization of both volcanic and sedimentary units and in certain instances, lithological identification is extremely difficult if not impossible. Where contact is discernible, overlying volcanics usually are truncated at a low angle by the sediments below. At certain localities the sediments also appear to be truncated in a similar manner. This could conceivably be the result of strike-slip faulting along contact but more detailed work is required in order to better understand the complex nature of this zone. The amount of displacement along strike of this fault zone, if existent, is not known. Earlier estimates given by some authors appear to be largely unsubstantiated. Certainly the important gold mineralization associated with this shear zone warrants further investigation of its structural features.

Other important faults found mostly by diamond drilling and sited by Wilson (1962) include: (a) the west-southwest trending and steeply dipping Horne Creek fault and east-trending Wasa Lake and Abberville faults in the western part of the map area; and, (b) the highly complex system of faults associated with and generally sub-parallel to the regional Cadillac fault in the McWatters area.

Stereographic projection ~~(Fig.)~~ of the mesoscopic fault compilation (relative displacements vary from 2 to 100cm.) shows two prominent directions of subvertical faults striking south-southeast and northeast respectively. There is a predominance of left-hand strike-slip faulting.

Not shown in the preceding diagram are two other systems of minor subvertical faults with displacements of 1 to 5m. and generally striking northwest and east-west respectively.

RENEAULT - CLERICY AREA (Pierre Trudel)

The study area covers parts of the townships of Destor and Dufresnoy, east of Route 46, and is not yet large enough to permit discussion of the complete stratigraphic section. Its stratigraphy will be described in function of previous descriptions of the sequence west of Route 46 by Dimroth et al. (1973) and Boivin (1974) (See table III).

STRATIGRAPHY

Sequence west of Route 46: The section west of Route 46 consists of 3000 meters of basalt and andesite flows, overlain by 600 meters of very proximal pyroclastic flows of andesite or dacitic composition.

Basalt flows with a well defined variolitic marker unit about 300m above the base of the Blake River Group form the lower part of the sequence. The upper, predominantly andesitic, part of the pile begins with a marker characterized by densely set large (3-5mm) feldspar phenocrysts, about 600m above the base of the Blake River. This marker units comprises pillowed flows, pillow breccias, and pyroclastic rocks. The higher part of the andesite sequence, aphanitic, is quite monotonous. Several rhyolite domes about 300m across are present in it. 600m of andesitic and dacitic pyroclastic flows containing blocks up to 2m across are at the top of the sequence.

Sequence West of Route 46: West of the road, this sequence does not change much, except that we find a sequence of andesite and basalt flow breccias and a dome of quartz-porphyritic rhyolite overlying the pyroclastic unit. This upper part of the sequence is moderately well exposed on the hills that extent from the sharp corner of Route 46 south of Reneault to the westernmost tip of Dufresnoy Lake.

The basal variolitic marker of the Blake River Group is continuous through the area, but is difficult to trace, due to lack of outcrop. The porphyritic marker has been traced about 800m east of Route 46 where it disappears below cover, in a large zone without outcrop. The unit of pyroclastic flows has been observed just east of Route 46 in a much more distal facies (largest fragments 15cm diameter). Lack of outcrop did not permit to trace it north of Dufresnoy Lake. The unit reapears at Destor beach and at shoreline outcrops of Dufresnoy Lake in a very distal facies, from where it can be followed toward the east for another three kilometers. The pyroclastic unit grades from a very proximal facies west of Route 46 into a very distal facies of thin-bedded tuff alternating with graphitic shale, over a distance of 8 kilometers.

Domes and small flows of rhyolite appear here and there in the andesite sequence above and below the main pyroclastic units. These are local flows and domes erupted from local fissures and their lateral continuity is insignificant, contrary to the rhyolite flows west of Clericy.

The total thickness of the sequence from the base of the Blake River Group to the base of the main pyroclastic unit decreases from 3000 meters west of Route 46 to about 1200 meters east of Dufresnoy Lake. Our study indicates that these thickness variations determine the style of the tectonic structures: Areas where the sequence is very thick have a fairly simple structure with very large folds, whereas folding is quite complicated in areas where the sequence is thin.

Results of a study of the vesicularity of basalt and andesites are not yet available.

TECTONICS

Regional structures

Major folds: Two large-scale folds have been traced across the whole study area (see map 2). It appears that these folds do not continue west of Dufresnoy Lake, where a homoclinal sequence is present. This change from a folded to a homoclinal sequence co-incides with a change of the stratigraphic thickness, as is the case also between Duparquet and Hébécourt Lakes (Boivin, 1974). The large-scale folds are isoclinal and have a subvertical axial plane trending E-W close to Route 46 and SE-NW east of Dufresnoy Lake. Previous maps correlated the large syncline south of the pyroclastic unit in the area west of Route 46 with the Clericy syncline of this area. This correlation is excluded by our top determinations.

Minor folds: Reversals of polarities indicate the presence of folds on the scale of a few hundred meters at two localities:
1) Lot 27, range II and III, Destor township, north of the road.
2) Lot 46, rang IX and X, Dufresnoy township, north of the road.
Lack of outcrop did not permit exact tracing of both folds.

Strike faults: Some evidence indicates the presence of several strike faults. In particular, the pyroclastic unit is not repeated in the cone of the Clericy syncline north of Destor Beach, and a fault must be present at this locality.

Cross-faults: Small transverse faults, apparently with strike-slip movement have been observed at number of localities, particularly at lot 46, range IX and X, Dufresnoy township, south of the road. They trend NNE. The displacement observed is on the order of several ten meters. The sense of movement varies.

Small-scale structures

Two, locally three schistosities, and two systems of kink-bands are present in the area.

The first schistosity is a flow cleavage. Generally, it is subparallel to the stratification and, like the letter, trends E-W close to Route 46 and SE-NW east of Lake Dufresnoy. The second schistosity is a crenulation cleavage; it forms cm angle of about 30^o with S_1, in counter clockwise direction. This relation remains constant, regardless of the trend of S_1. Both schistosities have nearly vertical dips.

The two kink systems trend NNE and NVW and dip nearly vertically. Both appear to form a system of conjugate planes. Movement on the NNE system generally is right hand, whereas the NNW system shows left hand displacement.

The intensity of the schistosities and of the kink bands varies greatly within the area. This variation is in part controlled by lithology. For example the rhyolites and shales generally show much stronger cleavage than basalts. However the location of the two zones of exceptionally strong schistosity unquestionably is tectonically controlled

These zone are situated (1) in the core of the faulted clericy syncline, following the north shore of Destor Beach and (2) in a zone 600 meters wide from the corner of Route 46 South of Reneault to the extreme west tip of Dufresnoy Lake.

All lineations form by the intersection of steeply dipping schistosities and, thus, have sub-vertical plunges. Micro-faults are extremely common; several systems appear to be present, but the analysis of their directions has not been completed at the time of writing.

ECONOMIC GEOLOGY

Rouyn-Noranda area is one of the most important mineral producers in the Province of Quebec, with important Cu-Zu and Aumineralization. Copper-zinc deposits are of two types: (1) Lenses of massive stratiform polymetallic sulfide ore underlain by alteration pipes that contain stringer ore and (2) disseminated sulfides and sulfide stringers in the Flavrian and Powell granites. Gold ores occur (1) in stringers, veins and cracks of strongly deformed volcanic rocks and (2) in carbonatized conglomerates, grauwaches, and volcanic rocks. Very good descriptions are available of the massive stratiform polymetallic sulfide deposits and these are the only type that will be discussed here. General properties of this type of deposit have been described by Sangster (1972), and deposits of the present area are described by Boldy, 1968, Simmons et al, 1973, Spence and Spence, in print, and in the C.I.M.M. Centennial field excursion guide book.

STRATIFORM POLYMETALLIC SULFIDE DEPOSITS

Geometry: The sulphide deposits ore lens-shaped bodies emplaced at a contact between flows. They are generally underlain by an alteration pipe, with stringers and veins of ore minerals. Ore lenses generally grade into silicified tuff. Tuff also may overlie and underlie the ore bodies, along strike. Many ore deposits are well banded with bands parallel to the upper contact of the ore lenses. Breccia ores, containing blocks of sphalerite and/or chalcopyrite-rich material set in other materials also are common. The upper contact of the ore bodies may be sharp; breccia composed of ore blocks in a tuff matrix may be present at the top of the ore body. The lower contacts are unsharp, ore grading either into barren rock or into stringer ore.

Stratigraphic situation: Generally the ore bodies are said to occur at the boundary between rhyolite (below) and andesite (above). Numerous exceptions to this rule exist; some ore bodies are located at the contact between rhyolite flows, or at flow contacts entirely within andesites. From published descriptions of the Millenbach and Norbec Mines

(Purdie, 1967; Simmons et al., 1973) it appears that many ore deposits are not located at the contact of the extensive regional rhyolite sheets, but are related to rhyolitic domes.

It is particular significant that several ore lenses may occur at the same locality, in different stratigraphic positions. In this case, each of the ore lenses appears to have its own stringer zone. For example, in the Millenbach deposit, essentially three independent ore lenses exist: (1) the Dadson zone, at the contact between the lower and upper quartz porphyry; (2) the Hillman zone at the contact between a dacite underlying the lower quartz porphyry and the upper quartz porphyry and (3) a small ore lens at the contact between the upper quartz porphyry and the overlying andesite.

Possible origin: It is likely that the ore deposits were precipitated from solfataric brines. Precipitation may have occurred at the sediment-water interface, or during the diagenesis, within an already deposited tuff or shale. Successive emplacement of several ore bodies at the same locality suggests that the solfataric activity may have been continuous for a considerable time-span and that ore deposition was interrupted by volcanic eruptions. In this case, one would suspect that the root of the dome acted as a heat-source initiating the brine circulation.

Brine water may be derived from marine water, as seems to be the case for present Red-Sea brines (Degens and Ross, 1969). Such marine brines, circulating in the joint systems of the volcanic sequence would extract solubles from the volcanic rocks, and thus would be enriched with respect to sulfur, chlorine, and with heavy metals. The brines would rise at a heat source. Thus, the writer considers it likely that the rhyolite domes so commonly underlying ore deposits are not themselves the source of the ore metals, but acted as a heat source. Ore metals may have been extracted from a much larger volume of volcanic rock, by means of a brine circulation that was initiated by a heat source.

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TABLE III Stratigraphy of the Blake River Group between Cléricy and Hébécourt Lake

Hébécourt Lake	Reneault	W of Cléricy
Porphyritic and aphanitic andesite flows, flow breccias and aquagene tuffs.	Rhyolite (spheralitic) aphanitic andesite with few rhyolite domes and flows.	Aphanitic andesite with few rhyolite domes and flows.
	Porphyritic pyroclastic flows.	Porphyritic pyroclastic flows.
Rhyolite of Hébécourt Lake.	Aphanitic andesite with few rhyolite domes	Aphanitic andesite with few rhyolite domes
	Feldspar - porphyritic andesite flows and pyroclastics.	
Variolitic marker and associated aphanitic basalt.	Variolitic marker and associated aphanitic basalt.	Variolitic marker and associated aphanitic basalt.

TABLE II Stratigraphic relations south of Rouyn-Noranda

Blake River Group	Upper basalt unit		Beauchastel and Glenwood rhyolites, andesite, tuffs and pyroclastic fallback.
	Stadacona breccia	Pyroclastic flows with intercalated andesite.	
	Lower basalt unit	dacite variolitic basalt non-variolitic basalt rhyolite and rhyolite flow breccia non variolitic basalt tuff (local) non-variolitic basalt variolitic basalt non-variolitic basalt variolitic basalt	

TABLE I Stratigraphy of Rouyn-Noranda area

	Sparts of Rouyn and Beauchastel Townships	N parts of Rouyn and Beauchastel Townships		Joannès Townships	Northern area	
Temiskaming Group	Conglomeratic sandstone	Conglomeratic sandstone	Cadillac Group	Greywacke and conglomerate		
	Porphyry conglomerate	Porphyry conglomerate				
	Greywacke and conglomerate	Greywacke and conglomerate		Greywacke	Duparquet Group:	
	Magnetite conglomerate	McWatters conglomerate		Conglomerate sandstone	Conglomerate and Greywacke	
	Conformable contact	Unconformable contact		Conformable contact	Unconformable contact	
Pontiac Group	Channel-fill conglomerate					
	Greywacke	Blake River Group		Blake River Group	Blake River Group	1)
					Kewagama Group	1)
					Malartic Group	1)
					Lac Caste Group	1)
					Kinojévis Group	1)

1) Stratigraphic relations poorly known; Kinojévis Group is below Blake River Group.

FIGURES 1 AND 2

LEGENDE

1 Larges masses of white rhyolite
2 Linguoid structures
3 Flow front breccia
4 Rounded and angular fragments breccia
5 Layered flow breccia
6 Rhyolitic lapilli tuff
7 Disintegration of white masse
8 Sharp brecciated contact
9 Sharp unbrecciated contact
10 Flow layering of white masse

▒ Grey rhyolite

☐ White rhyolite

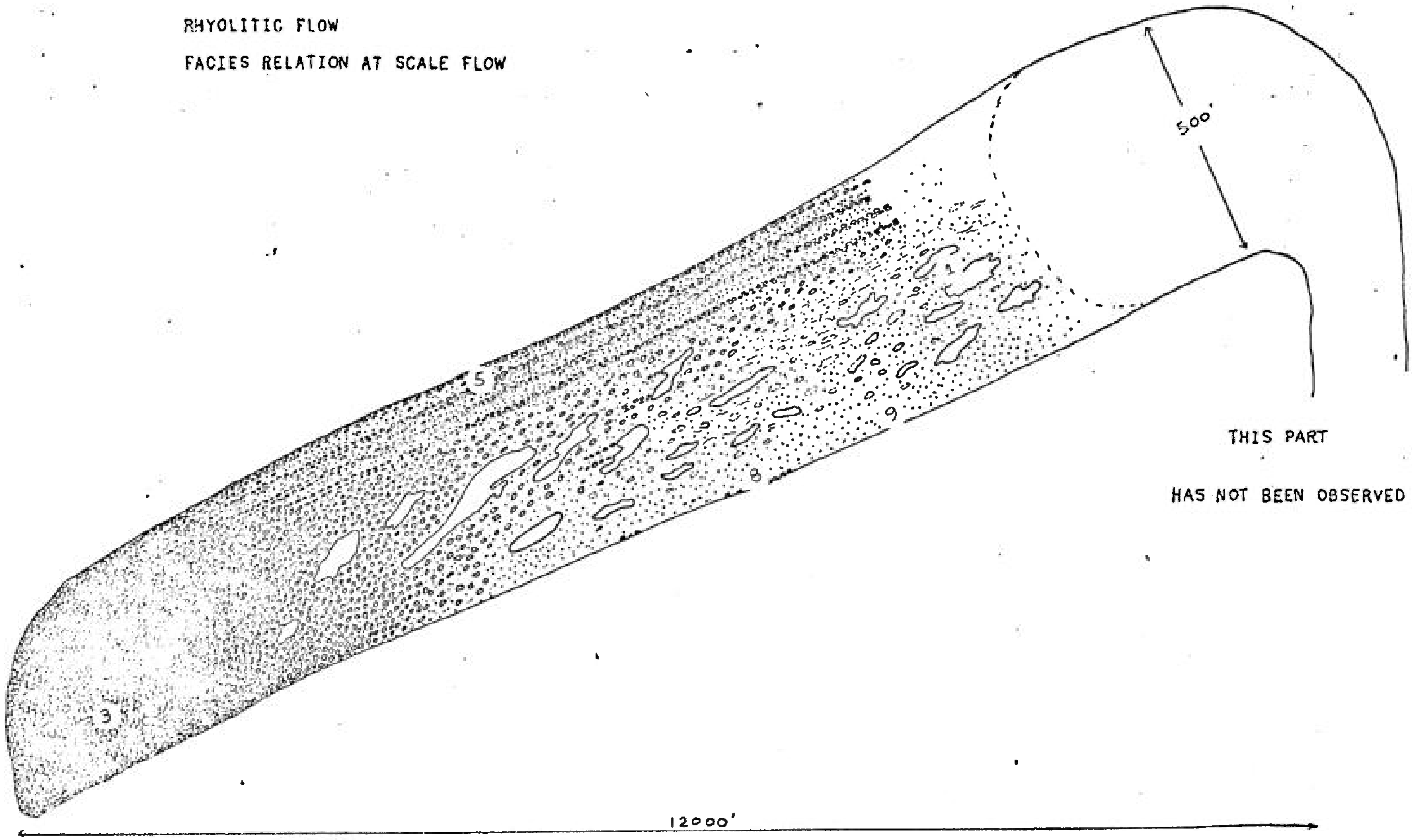
⁘ Breccia

▦ Densely brecciated
▨ Moderately brecciated

FIGURE 1

RHYOLITIC FLOW

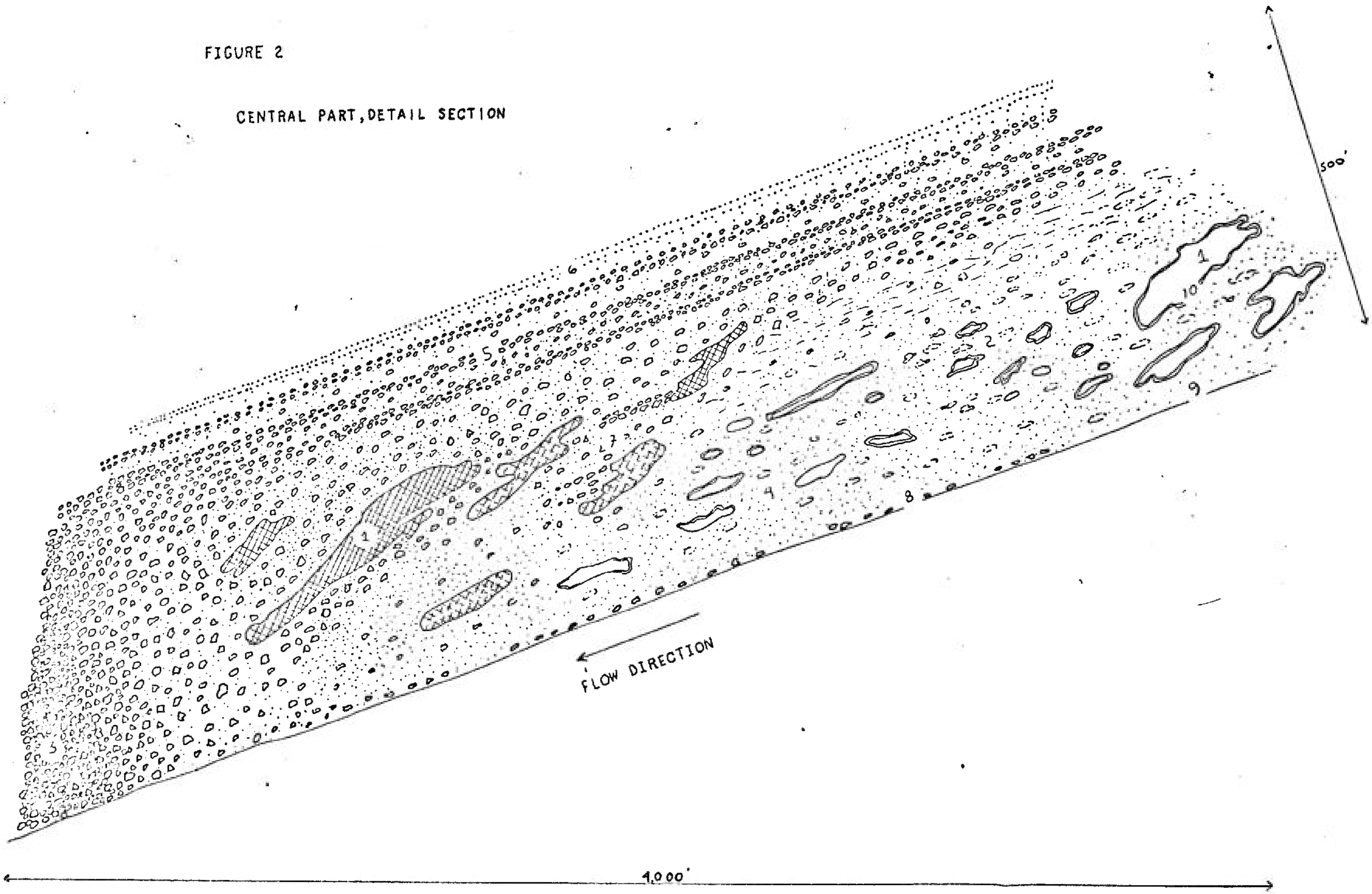
FACIES RELATION AT SCALE FLOW



N.B. VERTICAL SCALE EXAGGERATED

FIGURE 2

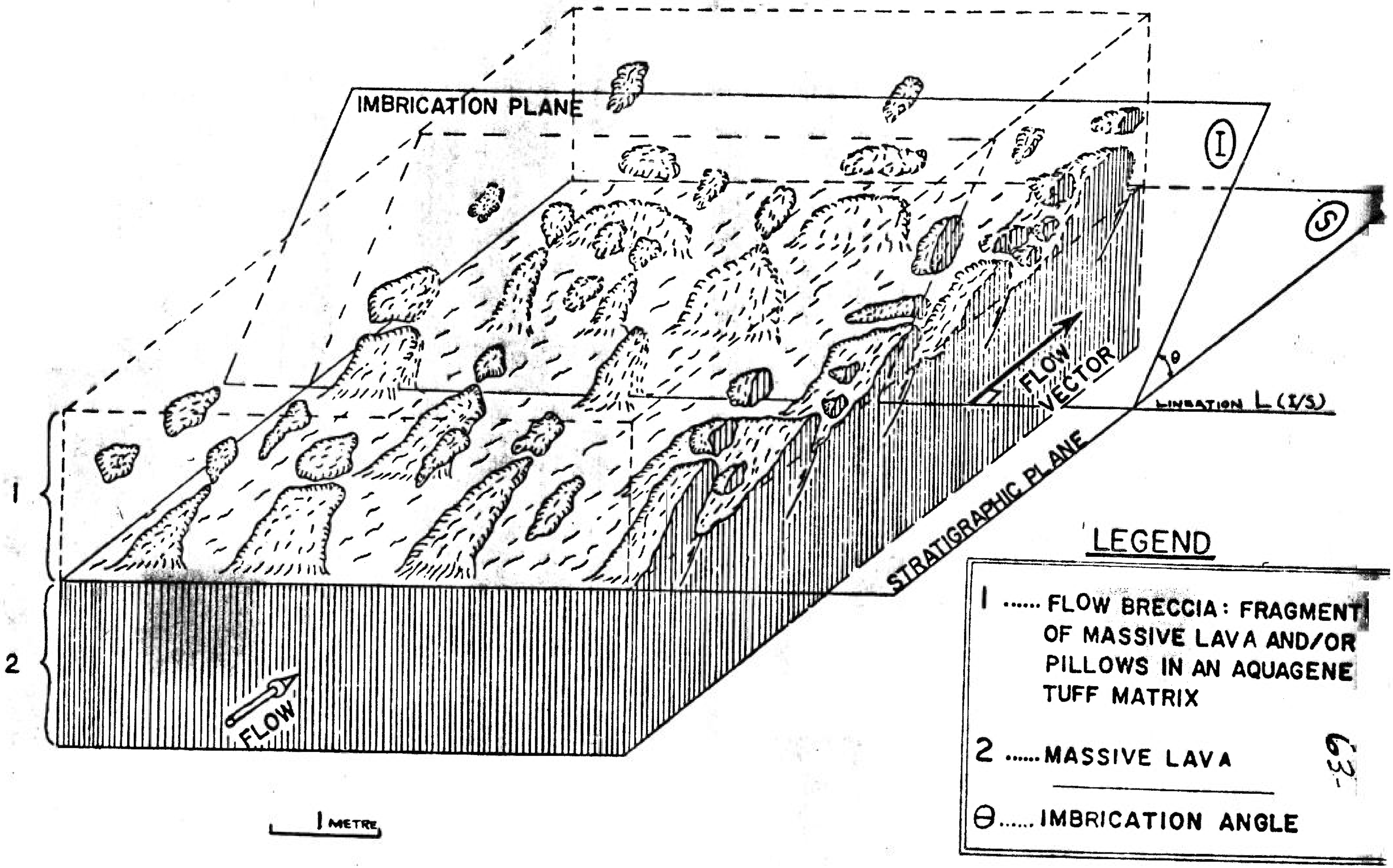
CENTRAL PART, DETAIL SECTION



N.B. VERTICAL SCALE EXAGGERATE

FIG 3

FLOW DETERMINATION FROM IMBRICATION FEATURES IN MAFIC FLOWS



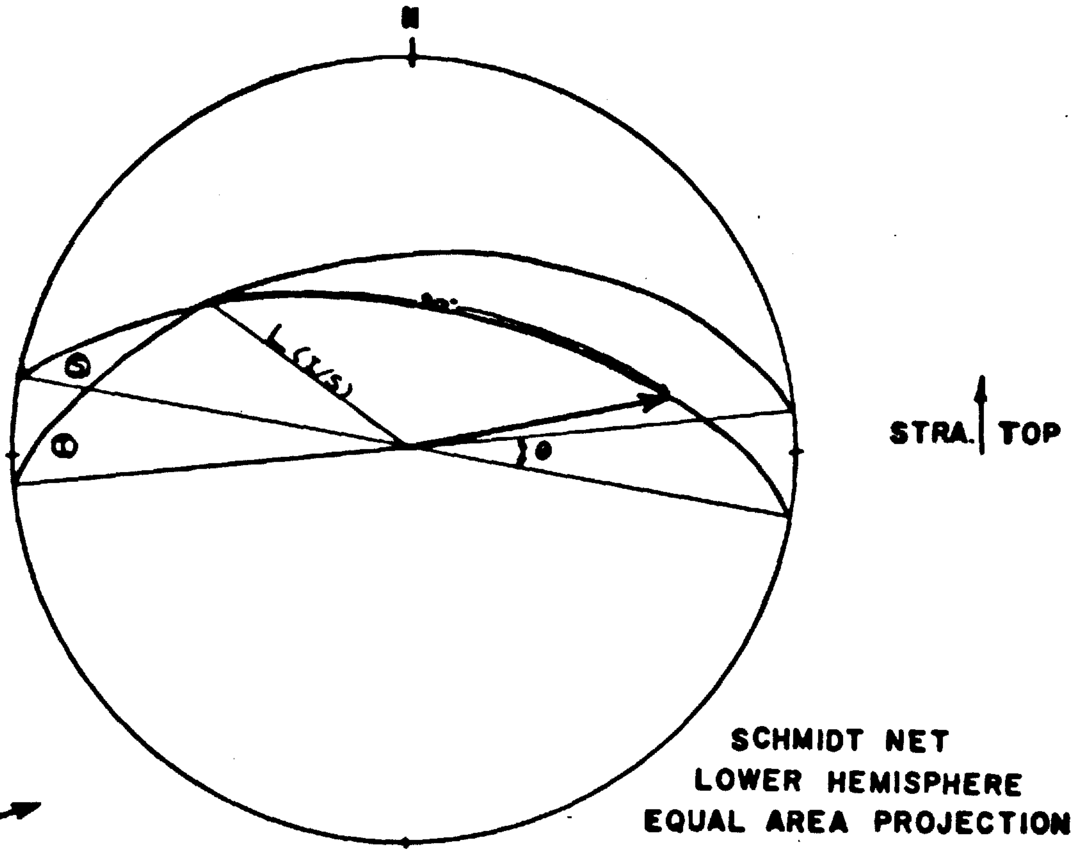
LEGEND

1 ...... FLOW BRECCIA: FRAGMENT OF MASSIVE LAVA AND/OR PILLOWS IN AN AQUAGENE TUFF MATRIX

2 ...... MASSIVE LAVA

θ ...... IMBRICATION ANGLE

FIGSTEREOGRAPHIC METHOD FOR DETERMING THE FLOW VECTOR



FLOW VECTOR: ↗

SCHMIDT NET
LOWER HEMISPHERE
EQUAL AREA PROJECTION

1 - STRATIGRAPHIC AND IMBRICATION PLANES ARE PLOTTED TO DETERMINE THE LINEATION L(I/S).

2 - THE FLOW VECTOR LIES ON THE STRATIGRAPHIC PLANE PERPENDICULAR TO L(I/S).

3 - THE DIRECTION OF THE STRATIGRAPHIC TOP ENABLES THE DETERMINATION OF THE DIRECTION OF FLOW ONCE THE ORIENTATION OF THE VECTOR IS ESTABLISHED.

FIG. 4