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GEOLOGICAL REPORT ON THE SOUTHWESTERN PART OF THE QUEBEC APPALACHIANS AND OF THE ST LAWRENCE LOWLANDS

S O Q U I P

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1) INTRODUCTION

The present report outlines very briefly the major tectonic, stratigraphic and sedimentologic feautres of the cambrian and ordovician rocks exposed in the St. Lawrence Lowlands and in the southwestern part of the Quebec Appalachians. The report is based on field work carried out by the writer for SOQUIP in the summers of 1971, 1972 and 1973. The area covers over 2,500 square miles and it corresponds to that part of the province which is located on the south shore of the St. Lawrence River, delineated by the St. Lawrence River to the west, the Canada-U.S. border to the south, the Sutton-Notre Dame Mountains to the southeast and a line joining St. Antoine de Tilly and Lyster to the east.

Our data are compiled on a scale of 1:250,000 and they are presented on the Montreal Sheet (31H), Trois Rivières Sheet (31I) and Quebec Sheet (21L) of the National Cartographic Reference System.

2) OUTLINE OF THE GEOLOGY

The cambrian and ordovician rocks of this part of the Province of Quebec can be regrouped into five litho-tectonic domains which are, from west to east, as follows:

the autochtonous domain:

1. - the St. Lawrence Lowlands Platform the allochtonous domains:

2. - the external belt of imbricated blocks

3. - the internal belt of imbricated blocks

4. - the allochtonous masses,

the Monteregian Hills

5. - a series of discordant basic intrusions cutting the rocks of the autochtonous and allochtonous domains.

3) BRIEF DESCRIPTION OF THE LITHO-TECTONIC UNITS

3.1) The autochtonous domain

The autochtonous domain is characterized by the almost flat-lying strata of the Chambly-Fortierville synclinorium, which include at its base a transgressive sequence composed successively by the Potsdam arenites, the dolomites and arenites of the Beekmantown Group, the limestones and arenites of the Chazy, then the carbonates of the

Black River and Trenton, overlain by a terriginous flysch sequence regrouping the pelites and sandstones of the Utica-Lorraine, which, in turn, is overlain by a regressive sequence of pelites and sandstones, the Richmond Group. The Potsdam rocks are Cambrian in age, the Beekmantown strata are Lower Ordovician, the Chazy, Black River, Trenton, and part of the Utica ones are Middle Ordovician and the remaining part of the Utica, Lorraine and Richmond are Upper Ordovician (see figure 2). All these units are described in two reports submitted to SOQUIP in 1971 and 1972. This structure and strata correspond to the St. Lawrence Lowlands Platform.

3.2) The allochtonous domains

In the area east of the synclinorium, the rocks are all allochtonous and formed well defined belts which are divided into three parts, from west to east:

i - an external belt of thrust-imbricated rocks with Foothill-type structure,

ii - an internal belt of thrust-imbricated rocks with Main range-type structure,

iii - the allochtonous masses, the nappes brought in place by gravitational sliding.

3.2.1) The external belt

The external belt is caracterized by west-facing strata cut by east-dipping thrust faults resulting in a series of imbricated blocks with a style similar to that of the Foothill Belt of Alberta. Omission of strata between successive overlapping blocks of the belt is the rule here. Except for a short distance immediately north of Lake Champlain where the Trenton carbonates are involved in the thrust belt, the bulk of the rocks implicated in this zone belongs to the Lorraine flysch. The younger strata of the Lorraine outcrop in the western part of the belt and as we proceed eastward, older and older rocks of the same unit are exposed. It must be realized that the Utica lithology is not recognized in this belt because it is indistinguishable from the pelites and sandstones of the Lorraine flysch, throughout most of this domain. Furthermore, Utica is also used as a stage name by J. Riva and many other paleontologists, which represents the age of certain rocks belonging to the Lorraine flysch. Finally, there are rocks in the Lorraine flysch which are older than the Utica stage, these rocks are indistinguishable from the Lorraine and they are properly grouped as such. For these reasons and to avoid confusion, the term Utica is restricted as a time term in this belt, and it occurs between Eden and Canajoharie stages (see Hubert, 1971; Riva, 1969, 1972; Bergstron, 1971). It must also be realized that the Lorraine flysch is a time transgressive unit throughout southern Quebec: this unit representing

the Canajoharie, Utica and Eden stages in the external imbricated belt and Utica-Eden in the autochtonous domain corresponding to the St. Lawrence Platform (see figure 2). The rocks of this belt were described in detail by Hubert in 1971.

3.2.2.) The internal belt

The internal belt is caracterized by east-facing strata cut by east-dipping thrust faults also resulting in a series of imbricated blocks. This belt is similar in style to the Main Range of Alberta. Repetition of strata between successive overlapping blocks is the common rule here. The Trenton carbonates are chiefly repeated throughout this belt but along the frontal thrust, the Lac Champlain - St. Dominique - St. Antoine fault, the Black River, Chazy and Beekmantown rocks are locally brought up to the surface along with the Trenton carbonates. Throughout the internal belt, the Trenton carbonates occur with and incorporate three bands of syn-sedimentary breccia called wildflysch on the map. These breccia are caracterized by two distinct periods of deformation, the earlier one consists of faulted-and sheared-recumbent folds, oriented NW-SE, the latter are open folds and faulted folds, oriented NE-SW. The early folds being present only in the breccia zone and not in the intervening normal carbonate sequences are inter-

preted as syn-sedimentary slump-fold whereas the latter are parts of the regional fold system related to the Taconic orogeny. The breccia are composed chiefly of carbonates similar to those of the normal Trenton carbonates but also includes exotic blocks of allochtonous nature (olistolithes). These blocks will be described in the next section with the allochtonous nappes as they are of the same nature and are probably derived from those masses. The Trenton carbonates are Normanskill and Canajoharie in age throughout the internal belt. This unit is also time transgressive when we compared it with the Trenton of the St. Lawrence Lowlands Platform (see figure 2). The rocks of the uppermost sheet of this belt reappears to the east of some of the allochtonous masses where they form windows. The St-Cyrille and Cowansville windows are two such examples. The Melbourne limestones exposed in these windows are interpreted as equivalent to the Trenton limestones and are therefore also considered Normanskill and Canajoharie in age. The rocks of this belt were described by Hubert in 1972.

3.2.3) The allochtonous masses: nappes brought in place by gravitational sliding

The allochtonous masses include the following nappes: wildflysch with olistoliths, Stanbridge, Highgate, Saxe Brook, Rosenberg, Granby-Chaudière and Oak Hill.

3.2.3.1) The wildflysch with olistoliths

The wildflysch is generally the first nappe encountered and it occurs directly above the Treonton-Melbourne carbonates of the uppermost sheet of the internal zone. Although it is relatively thin, its distribution is very widespread throughout southern Québec. Generally the unit underlies the Stanbridge nappe but locally where the Stanbridge nappe is absent, the wildflysch may underly the Granby-Chaudière nappes. At other places, the wildflysch is absent and in this case the Stanbridge and the Oak Hill nappes may rest directly on the Melbourne limestones. At other places, a thin belt of wildflysch may appear between the Stanbridge and Granby-Chaudière nappes.

The wildflysch corresponds to a polydeformed breccia composed of small and large fragments of exotic nature set in a black calcareous highly deformed pelites. Early, recumbent slump-folds with axis transverse to the regional tectonic grain of the Quebec Appalachians are very common and often these folds are limited to one fragment or an olistolith within the breccia. Most commonly, these folds are sheared off and no corresponding structure appears in the matrix. The olistoliths are made up of chert, calcareous sandstones, various limestones, dolomites, red and green mudstones,

green and black mudstones, lavas and agglomerates, diorite, gabbro, pyroxenite, amphibolite and serpentinite. The sedimentary fragments are far more frequent than their igneous-metamorphic counterparts. Most of the olistoliths are exotic in character and do not have lithological similarities to the normal underlying rocks making up the thrust sheets of the internal zone. Such lithologies however, with similar textures and compositions, are common in the overlying nappes, particularly the Stanbridge, Granby-Chaudière and Oak Hill. The olistoliths are believed to be derived from these units and they represent detached fragments from these units. In the internal belt, the wildflysch is Normanskill in age. The olistoliths themselves are of various ages, Middle and Lower Ordovician, Cambrian and possibly Precambrian. It is worth noting here that similar breccia encountered in the Lorraine flysch in the external belt are younger, Canajoharie age, than those in the internal belt (see Hubert, 1971, see also figure 2).

3.2.3.2) The Stanbridge nappe

The Stanbridge nappe is also a polydeformed unit presumably containing rocks of Early Middle Ordovician and Lower Ordovician. It is a nappe that is fairly continous in the southern half of the map-area, made-up of complexely sheared, recumbent-folded sequences of pelite-calcareous

sandstones, thin-bedded dolomites with limestone conglomerates, pelites alternating with dolomitic sandstones, lithic sandstones and arenaceous dolomites. Breccia are also common in this nappe, particularly near the top, immediately below the Granby or Chaudière nappes. The olistoliths observed here are mostly calcareous dolomites, agglomerates and lavas, diorite, pyroxenite and gabbro masses set in a grey pelite matrix. All of these olistoliths are believed to be derived from the Oak Hill and more particularly from the serpentine belt, located immediately to the east of the Oak Hill nappe (Hubert 1972). As it is understood at present, this nappe includes rocks of different characters and ages. More detailed work is needed to sort out the different lithologies. The assemblage of pelites with the calcareous sandstones have much similarity with rocks seen on the south shore of Orleans Islands that has been dated as Tremadoc (Lower-most Ordovician, Hubert, 1968). The thin-bedded dolomites with limestone conglomerates are definitely Arenig (Lower Ordovician) (based on several collections of graptolithes made by the writer and M. Beaupré in 1973) and are identical to some parts of the Levis Group near Quebec City. The remaining pelites alternating with dolomitic sandstones, lithic sandstones and arenaceous dolomites have many affinities with the lower part of Lorraine flysch and they are consequently thought to be Middle Ordovician (Lower Canajoharie).

3.2.3.3) The Highgate-Saxe Brook-Rosenburg nappes

The Highgate, Saxe Brook and Rosenberg nappes are restricted to a small area near the Canada-U.S. border. These nappes are visualized as large slivers brought up from an area intermediate in characters between the rocks of the Philipsburg and Oak Hill units. These nappes are composed of dolomites and/or pelites dates as Cambrian and Lower Ordovician. They are discussed by Hubert in 1972.

3.2.3.4) The Granby-Chaudières nappes

The Granby-Chaudière nappes are made up of similar rock sequences and, being detached from one another, have been given two distinct names. Each of these nappes is composed of a basal, contorted, sheared, complexely folded and refolded mudstone breccia overlain by a more normal stratigraphic sequence of red and green mudstones interbedded with grey arkosic sandstones. The lower part is made up, almost exclusively of red and green mudstone breccia that incoporate small massifs of diorite, pyroxenite and gabbro. Some of these igneous masses are olistoliths in the breccia but others show discordant contacts and metamorphics aureoles. The latter masses are interpreted as hot intrusions through the basal part of the Sillery but they are thought to be presently unrooted from

their former site of emplacement and to have slid as a cohesive mass enclosed within the Granby and Chaudière nappes. Like many other nappes of Southern Quebec, the basal mudstones of the Granby and Chaudière units do show early recumbent folds oreinted NW-SE, that are refolded by another system oreinted NE-SE. The earlier system is thought to be syn-sedimentary and is related to the emplacement of the Granby-Chaudière nappes throught gravitational sliding. The latter set of folds are parts of the regional system associated with the Taconic orogeny. The upper mudstones and sandstones of the Granby-Chaudière units do show a relatively simple structure, open folds and faulted folds that are similar in style, dimension and orientation to those that are generally attributed to the Taconic orogeny. Locally, several imbrications can be observed in this part of the nappe. In the southern half of the Chaudière nappe, there are very few scattered out-crops throughout the area, and because of this, the writer has not attempted to interpret the internal structure of this nappe. The rocks of the Granby-Chaudière nappes are most probably Cambrian in age and they represent a sedimentary facies typical of a more internal geosynclinal zone that was shoved westward onto and over the carbonate platform (Hubert, 1972).

3.2.3.5) The Oak Hill nappe

The Oak Hill nappe consist in a series of early recumbent folds, oriented NW-SE, which have been refolded into a large anticlinal flexure with many parasitic folds on each flank (Osberg, 1965). The sequence includes at the base, basic volcancis overlain by a thick assemblage of phyllites and wackes, and include two bands of dolomites. This sequence is interptreted as Cambrian by most workers, Clark, 1934; Osberg, 1965. Near Danville and in the area just north of that locality, there is no doubt that the Oak Hill sequence overlies the Middle Ordovician Melbourne limestones and it is mainly for this reason that the Oak Hill is interpreted as a nappe. In the area east of Victoriaville and Princeville, the Oak Hill sequence as used by Cooke on his maps of the area, is a package term including rocks that are Oak Hill in character but also others that have strong affinities with the Sillery, Levis, wildflysch and some that could be termed olistoliths. More detailed work is neeeded to sort out all the different formations and to study their stratigraphic and structural relationships. At present, the rocks of these areas are classed as nappes of Sillery-Levis-Oak Hill-wildflysch on our map.

3.3) The Monteregian Hill domain

Six of the Monteregian Hills cut the sedimentary rocks of the area. The writer has not done any work on these intrusions and therefore he refers the reader to a recent publication prepared by Pouliot (1969) which deals specifically with these massifs. It is worth to note however, that in the vicinity of each intrusion, we observed a metamorphic aureole than can be up to two miles in width and that in the surrounding sedimentary rocks, dykes and sills related to these intrusions are encountered for a distance of up to twenty miles from each hill. These massifs are Upper Cretaceous in age (Pouliot, 1969).

4) A SEDIMENTARY-TECTONIC MODEL

Collectively the Potsdam arenites, the arenites and dolomites of the Beekmantown, the arenites and limestones of the Chazy, the limestones of the Black River and Trenton units of the autochtonous and of the external and internal belts of the allochtonous domains constitute a well-defined platform in southern Quebec. Epiorogenic mouvements along two sets of normal faults, oriented E-W and N20^{o}E respectively, are particularly important in Beekmantown, Chazy and Trenton times as evinced by large variations in the thickness of these formations over short distances (Hubert, 1972). Such

mouvements are also active in the autochtonous and in the external belt of the allochtonous domains during the Utica and Lorraine because these units thin and thicken abruptly in those areas. The Lorraine shows many affinities to a syn-orogenic flysch facies (Hubert, 1971). In the internal zone, the carbonate platform must have foundered considerably in Middle Ordovician time in order to form a basin that will receive and collect nappes brought along by slides from a more internal part of the appalachian orogen. These nappes and olistoliths are made up of rocks very different in texture and in composition from those of the platform and they must have been shed westward on and over the Trenton carbonates. These nappes appear with a certain order, the youngest Middle Ordovician one below, covered by other nappes bearing older and older rocks. The Lorraine flysch of the external belt is interpreted to be contemporaneaous with the emplacement of the nappes in the internal belt. Finally, a regressive sequence represented by rocks of the Richmond Group occupies the central part of the autochtonous domain.

Put into a chronological order, the development of the basin is as follows:

1. - End of Premcambrian -

Establishment of a carbonate platform that will last until Middle Ordovician time.

Several epiorogenic mouvements along two sets of normal fualts affect the stability

of this platform.

2. - Middle Ordovician -

The internal part of the platform foundered forming a basin which receive nappes brought westward by slides. Development of a syn-orogenic flysch trough on the external side of the platform. With the final emplacement of all the nappes near the close of the Middle Ordovician, the rocks of the flysch trough and of the internal zone are shoved westward to form the imbricated structures of the internal and external belts of the allochtonous domains.

3. - Upper Ordovician -

End of the flysch development. Close of the Taconic orogeny, Development of a regressive sequence in the St. Lawrence Lowlands.

4. - Upper Cretaceous -

Intrusions of basic massifs along a E-W line through the region.

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6) LIST OF PLATES.

Pl. 1: Geological MAP of the southwestern part of the Quebec Appalachians and of the St-Lawrence Lowlands.

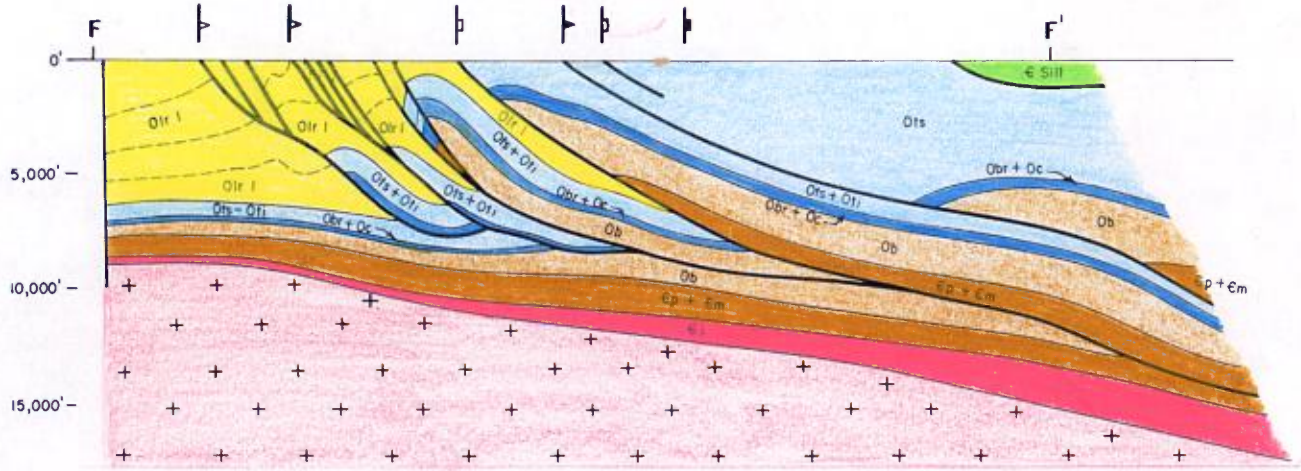
Pl. 2: Table of stratigraphic Units.

Pl. 3: Southwestern Part of the Quebec Appalachians and of the St-Lawrence Lowlands.
Structural map.

Pl. 4: Profile D - D' - D''

Pl. 5: Profile E - E' - E''

Pl. 6: Profile F - F'



LEGEND — LÉGENDE

ORDOVICIAN – LORRAINE "UTICA"	Olr I	ORDOVICIEN – LORRAINE "UTICA"
ORDOVICIAN – UPPER AND LOWER TRENTON	Ots+Olr	ORDOVICIEN – TRENTON SUPÉRIEUR ET INFÉRIEUR
ORDOVICIAN – BLACK RIVER AND CHAZY	Obr+Oc	ORDOVICIEN – BLACK RIVER ET CHAZY
ORDOVICIAN – BEEKMANTOWN	Ob	ORDOVICIEN – BEEKMANTOWN
CAMBRIAN – POTSDAM	Ep	CAMBRIEN – POTSDAM
MIDDLE CAMBRIAN	€m	CAMBRIEN MOYEN
LOWER CAMBRIAN		CAMBRIEN INFÉRIEUR
PRECAMBRIAN		PRÉCAMBRIEN
CAMBRIAN – GRANBY – CHAUDIERE NAPPE	€ Sill	CAMBRIEN – NAPPE DE GRANBY – CHAUDIÈRE

SOQUIP

PROFILE F-F'

(See Pl. 3)

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