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STRATIGRAPHY & STRUCTURAL RELATIONSHIPS ACROSS THE CADILLAC-LARDER LAKE FAULT, ROUYN-BEAUCHASTEL AREA, QUEBEC

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STRATIGRAPHY AND STRUCTURAL RELATIONSHIPS ACROSS THE CADILLAC-LARDER LAKE FAULT, ROUYN-BEAUCHASTEL AREA, QUEBEC

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STRATIGRAPHY AND STRUCTURAL RELATIONSHIPS ACROSS THE CADILLAC-LARDER LAKE FAULT, ROUYN-BEAUCHASTEL AREA, QUEBEC

by

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ABSTRACT

The southern part of the Superior Province is characterized by large tracts of Archean granitic rocks and high-grade metamorphic rocks within which are interspersed east-trending belts of relatively little metamorphosed Archean volcanic and sedimentary rocks. The Abitibi belt of eastern Ontario and western Quebec is one of the largest of these east-trending volcanic-sedimentary belts. In the Rouyn-Beauchastel area the deformed Archean rocks are overlain with angular unconformity by relatively flat-lying clastic sediments of the Aphebian Cobalt Group and comprise five main rock stratigraphic units:

1. the volcanic rocks of the Blake River Group in the north
2. the metasedimentary and associated volcanic rocks of the Pontiac Group in the south and between these the metasedimentary rocks of the
3. Cadillac Group
4. the Timiskaming Group and
5. the "Granada Group" (informal unit)

The basic stratigraphic relationships in the Rouyn-Beauchastel area and in the larger region of which it is a part are obscured by rapid lateral variations in volcanic and sedimentary facies. The stratigraphic and structural continuity across the area is disrupted by the Cadillac-Larder Lake Fault, a major regional east-west structure that is marked by a steeply dipping zone of ankerite-talc-chlorite schist. Similarities in composition, textures and structural fabric between the Timiskaming Group and the "Granada Group" indicate that they are correlatives across the fault and this conclusion supports a correlation, based on composition, texture and structural fabric between the combined Blake River and Cadillac Groups, north of the fault and the Pontiac Group and associated mafic volcanic rocks which are tentatively assigned to the Blake River Group, south of the fault.

Sedimentation is fault controlled and four environments are present: (1) alluvial fan, (2) alluvial marine transition, (3) turbidite fan and channel-fill, (4) basinal turbidite blanket. The main source of the sediment was granite batholiths and uplifted volcanic chains that lay to the north.

The dominant feature of the geologic structure are two main sets of superposed folds. The younger set is characterised by east-west striking axial surfaces, that are not conspicuously deformed. This east-west trending set is responsible for the main structural grain discernible on the maps of the area. The older set which was generally north-south striking and upright is deformed about these east-west axial surfaces. These large scale folds are essentially isoclinal steeply plunging with almost vertical axial planes.

RÉSUMÉ

La partie sud de la province du Superieur se caracterise par de grandes zones de roches granitiques et de roches hautement métamorphisées à l'intérieur desquelles se situent des ceintures de roches volcaniques et sédimentaires, peu métamorphisées et d'âge archéen. La ceinture de l'Abitibi, près de la bordure est de l'Ontario et dans la partie ouest du Québec constitue une des plus grandes ceintures volcano-sedimentaires, orientées est-ouest.

Dans la région de Rouyn-Beauchastel les roches déformées d'âge archéen sont recouvertes en discordance angulaire par les sédiments clastiques, sub-horizontaux du groupe de Cobalt et sont d'âge aphébien et comprennent cinq unités stratigraphiques majeures:

1 - au nord, les roches volcaniques du groupe de Blake River
2 - au sud, les métasediments du groupe de Pontiac et les roches volcaniques associées
3 - entre celles-ci les roches métasedimentaires du groupe de Cadillac,
4 - du groupe de Timiskaming, et
5 - du groupe de Granada.

Les relations stratigraphiques fondamentales de la région de Rouyn-Beauchastel et d'une plus grande région dont elle fait partie, sont difficiles a interpréter à cause des variations latérales de facies des roches volcaniques et sédimentaires. La continuité stratigraphique et structurale à travers la région est interrompue par la faille Cadillac-Larder Lake, une structure majeure d'étendue régionale, orientée est-ouest, marquée par une zone fortement pentée, composée de schiste à chlorite-talc et ankérite. Les ressemblances dans la composition, la texture et l'arrangement structural entre les groupes de Timiskaming et de Granada, nous indiquent qu'ils sont équivalents de part et d'autre de la faille. Cette conclusion entraine également une corrélation, basée sur la composition, texture et fabrique structurale, entre la combinaison des groupes de Blake River et de Cadillac situés au nord de la faille et des groupes de Pontiac et des roches volcaniques basiques associées à ce dernier et situés au sud de la faille et que nous associons avec le groupe de Blake River.

La sédimentation est controlée par des failles et quatre milieux de sédimentation ont été reconnus:

1 - une plaine alluvionnaire, 2) une transition marine-alluvionnaire, 3) turbidite de delta et remplissage de chenaux, 4) couche de turbidite basale. Des batholithes granitiques ainsi que le soulèvement de chaînes volcaniques situées au nord constituent la principale source de sédiments.

La géologie structurale se caractérise par la superposition de

deux périodes de plis. La phase la plus jeune est caractérisée par des surfaces axiales orientées est-ouest et ayant subies, par la suite peu de déformation. Cette phase est-ouest est responsable du grain tectonique que l'on peut apercevoir sur les cartes de la région. Une période de plis antérieurs, orientés nord-sud et droits est replissée par les surfaces axiales est-ouest. Ces plis de grande dimension sont essentiellement isoclinaux, fortement pentés avec des plans axiaux sub-verticaux.

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TABLE OF CONTENTS

Page

ABSTRACT ---------- ii

RESUMÉ ---------- iii

ACKNOWLEDGEMENTS ---------- iv

CHAPTER I - INTRODUCTION ---------- 1

CHAPTER II - TECTONO-STRATIGRAPHIC FRAMEWORK ---------- 6

CHAPTER III - STRATIGRAPHY AND SEDIMENTOLOGY ---------- 13

- Introduction ---------- 13
- Blake River Group ---------- 16
- Cadillac Group ---------- 27
- Pontiac Group ---------- 38
- Timiskaming Group ---------- 50
- "Granada Group" ---------- 73
- The Sub-"Granada Group" unconformity ---------- 83
- The Pontiac-Timiskaming "unconformity" reconsidered ---------- 84

CHAPTER IV - METAMORPHISM ---------- 92

- General statement ---------- 92
- Biotite-epidote isograd ---------- 94
- Staurolite-biotite isograd ---------- 99
- Retrograd effects and post-crystalline deformation ---------- 100

CHAPTER V - STRUCTURAL GEOLOGY ---------- 106

- Introduction ---------- 106
- Method of analysis ---------- 108
- First fold set ---------- 110
- Second fold set ---------- 117
- Third fold set ---------- 123
- Fourth fold set ---------- 124
- Kink bands ---------- 126
- Faults ---------- 127

CHAPTER VI - ECONOMIC GEOLOGY ---------- 130

Page

CHAPTER VII - CONCLUSIONS ---------------------------------- 133

A tentative history of the tectonic evolution of the Rouyn-Noranda area --------------------- 133

REFERENCES CITED -- 138

LIST OF MAPS

(1:20 000)

		Page
Map 1.	Geological map of Southeast Beauchastel Tp. ------	In pocket
Map 2.	Geological map of Southwest Rouyn Tp. ------------	In pocket
Map 3.	Geological map of parts of eastern Rouyn and Joannes Tp. ------------------------------------	In pocket
Map 4.	Geology and structural data of southeast Beauchastel Tp. ----------------------------------	In pocket
Map 5.	Geology and structural data of southwest Rouyn Tp. ---	In pocket
Map 6.	Geology and structural data of parts of eastern Rouyn and Joannes Tps. ---------------------------	In pocket

LIST OF FIGURES

Page

Figure 1. Index map -- 3

Figure 2. Distribution of volcanic complexes in the Abitibi belt ------------------------------------ 7

Figure 3. Tectonic sketch of the Rouyn-Noranda area ------- 10

Figure 4. Distribution of three volcanic suites ----------- 25

Figure 5. Relationship between Na_2O/Al_2O_3 and K_2O/Al_2O_3 in greywackes from the Pontiac, Timiskaming, Cadillac and Granada Groups --------------------- 35

Figure 6. Relationships between $\log[SiO_2/Al_2O_3]$ and $\log[(CaO+Na_2O)/K_2O]$ in greywackes from the Pontiac, Timiskaming, Cadillac and Granada Groups --- 36

Figure 7. Stratigraphic sections along the Granada and McWatters roads showing thickness variations among units in the Timiskaming Group ------------ 52

Figure 8. Schematic cross section of a channel showing the onlapping of greywacke beds on the conglomerates ----------------------------------- 87

Figure 9. Distribution of critical metamorphic mineral assemblages and metamorphic isograds based on reactions: 93

- chlorite + muscovite + carbonate + quartz $\rightleftharpoons$ biotite + epidote + H_2O + CO_2 (1)
- chlorite + garnet + muscovite $\rightleftharpoons$ staurolite + biotite + quartz + H_2O (2)
- staurolite + muscovite + quartz $\rightleftharpoons$ sillimanite + garnet + biotite + H_2O (3)

Figure 10. Schematic T-X_{CO_2} "grid" at 4-5 Kb. showing mineral equilibria in metagreywacke containing both quartz and muscovite in the transition from greenschist to amphibolite facies --------------------------- 95

Figure 11. Compilation of the orientations of the various structural elements in the Pontiac Group, Domain 1 --- In pocket

		Page
Figure 12.	Compilation of the orientations of the various structural elements in the Timiskaming Group Domain 2 ---------------------------------------	In pocket
Figure 13.	Compilation of the orientation of the various structural elements in the area north of the Cadillac-Larder Lake fault, Domain 3 -----------	In pocket
Figure 14.	Schematic cross section parallel with the axial surface of F_2 folds and perpendicular to F_1 folds ------------------------------------	114
Figure 15.	Synoptic fabric diagrams of S_1 and S_o for Domain 1 ---------------------------------------	116
Figure 16.	Schematic section and relationships in Pontiac Group during Stage I ---------------------------	135
Figure 17.	Schematic cross section of stratigraphic relationships in Timiskaming Group south of Rouyn-Noranda ---------------------------------------	136
Figure 18.	Schematic relationships in Timiskaming Group showing a cross section north of Fig. 17 -------	136

LIST OF PLATES

		Page
Plate I	A) Map unit C_{3A}. Fine grained rhyolite tuff turbidite, showing graded-bedding, with load cast	29
	B) Map unit C_2. Greywacke and pelite showing graded bedding, load casts and small faults which are parallel to the schistosity	29
	C) Map unit C_2. Graded greywacke and pelite are highly deformed. The beds and the fold axis are sub-vertical	29
Plate II	A) Map unit P_1: Pontiac Group. Graded beds of the greywacke dip northwest and face southeast. A distinct schistosity truncates the bedding at high angle	43
	B) Detail of "A" showing refraction of schistosity in a graded bed	43
	C) Refolded folds of impure quartzite and mica schist from the Pontiac Group	43
Plate III	A) Map unit P_2: Pontiac Group. Monomict greywacke pebble conglomerate showing intertonguing with greywacke and flattening of pebbles in a foliation at a high angle to the bedding	46
	B) Detail of part of "A". Monomict greywacke pebble conglomerate overlies tongue of greywacke and shows reverse graded-bedding	46
Plate IV	A) Contact between map unit P_1 and P_2. Local channelling in the greywacke (P_1) filled by the monomict greywacke conglomerate (P_2)	48
	B) Detail of part of "A" showing truncation of graded bedding in unit P_1 (faces north) against greywacke of unit P_2; and continuity of schistosity across contact	48

			Page
Plate V	A)	Map unit T_{1A}, Timiskaming Group. Deformed conglomerate. The felsic clasts are least deformed, and the flattened mafic clasts are bent around them -----------------	57
	B)	Map unit T_{2A}, Timiskaming Group. Deformed cross bedding ----------------------	57
Plate VI	A)	Map unit T_{2A}, Timiskaming Group. Flame structures and load casts in a graded-greywacke ----------------------------	59
	B)	Map unit T_{2A}, Timiskaming Group. Cross lamination and rounded pebble ---------	59
Plate VII	A)	Map unit T_{3A}, Timiskaming Group. Deformed porphyry conglomerate --------------	68
	B)	Map unit T_{3A}, Timiskaming Group. Deformed conglomerate, clasts of volcanic and sedimentary rock are flattened deformed oblate spheroids ----------------------------	68
Plate VIII	A)	Map unit T_{4A}, Timiskaming Group. Pebbly sandstone with dominant feldspar porphyry pebbles ----------------------------	70
	B)	Isoclinal folding in the pebbly sandstone near the main synclinal hinge ---------------	70
Plate IX.	A)	Map unit M_1, Granada Group. Polymict conglomerate with pebbles of basic volcanic rock, jaspillite, magnetite, black chert, fuchsite, feldspar porphyry, sedimentary rock, and granodiorite ----------------------	75
	B)	Same unit as in "A" but close to the contact between Blake River Group and Granada Group -	75
	C)	Large trough cross-bedding in the Granada Group --	75
Plate X	A)	Greywacke from the Granada Group (unit M_2) --	80
	B)	Detail of "A". The faulting is parallel to the north-east fault system in the area -----	80

		Page
Plate XI	A) Contact between monomict conglomerate and greywacke, Pontiac Group --------------------	86
	B) Concordant contact between the Timiskaming Group (unit T_{1A}) and the Pontiac Group (P_1) --	86
Plate XII	A) Photomicrograph of a quartzofeldspathic bed in contact with a more pelitic one ------	103
	B) Photomicrograph showing schistosity (S_1) defined by alignment of chlorite refolded by schistosity (S_2) ------------------------	103
Plate XIII	A) Photomicrograph showing post-kinematic cross cutting biotite porphyroblasts in the greywacke ------------------------------------	105
	B) Photomicrograph of fibrous sillimanite crystals from the Pontiac Group (P_1) south of Lac Montbeillard ----------------------------	105
Plate XIV	A) Well developed S_1 schistosity refolded by F_2, with S_2 as the axial plane foliation ----	120
	B) Subvertical F_2 fold axis in a greywacke sequence --------------------------------------	120
	C) Plasticine model showing the major F_1 anticline in the Blake River (?) Group and the major syncline in the Pontiac Group -----	120
Plate XV	A) F_2 folds in a greywacke sequence with faulting and a quartz vein aligned parallel with the axial plane foliation S_2 -----------	122
	B) Spaced fractured cleavage (S_2) in the hinge zone of an antiformal syncline --------------	122
	C) Refolding by F_3 of flattened pebbles (pancake shape) in the Timiskaming Group T_{1A} --	122

LIST OF TABLES

Page

Table 1. Tentative stratigraphic table of Rouyn-Val d'Or area -- 11

Table 2. Stratigraphic correlation table from southern part to the northern part of Rouyn-Noranda area -- 12

Table 3. Stratigraphy of the Rouyn-Noranda area --------- 14

Table 4. Chemical analyses of mafic volcanic rocks of the Blake River (?) Group (unit B_1) ---------------- 26

Table 5. Chemical analysis of seven specimens of greywacke from the Cadillac Group ----------------------- 37

Table 6. Chemical analysis of five specimens of greywacke from the Pontiac Group ------------------------ 41

Table 7. Chemical analyses of six specimens of greywackes from the Timiskaming Group and two specimens of granodiorite boulders in the Timiskaming conglomerate ---------------------------------- 55

Table 8. Chemical analyses of three specimens of greywacke from the "Granada Group" ------------- 81

Table 9. Four electron microprobe analysis of fuchsite in the "Granada Group" ------------------------- 82

Table 10. Resumé of the main sedimentological properties of the different units in the Rouyn-Beauchastel area --- 91

Table 11. Mineral assemblages in lower grade metamorphic rocks north of the biotite-epidote isograd ----- 97

Table 12. Mineral assemblages found in metamorphic rocks in the higher grade rocks, south of the biotite-epidote isograd ----------------------- 98

Table 13. Mineral assemblages found in metamorphic rocks south of the staurolite-biotite isograd -------- 99

Table 14. Interpretation of sedimentary history: Cadillac, Pontiac, Timiskaming and Granada Group ---------- 137

CHAPTER I

INTRODUCTION

Systematic regional geological investigations of the Abitibi area of Northwestern Quebec, began more than half a century ago (Wilson, 1911), and although a large number of geologists have been involved, most investigations have been directed mainly towards the discovery and understanding of the economic mineral deposits in the region (Cooke, 1931; Hawley, 1932, 1934). A few of the more recent investigations have been concerned with the tectonic evolution of the volcanic and sedimentary rocks (Gunning and Ambrose, 1939; Podolsky, 1950; Bass, 1961; Goodwin and Ridler, 1970). However, many fundamental problems still remain. This study is an attempt to clarify the tectonic evolution of this part of the Abitibi Belt and particularly the relationships between the orogenic deformation of the rocks as expressed by the structures which are discernible in the rocks now, and the overall tectonic evolution of the belt as expressed by regional variation in sedimentation, volcanism, plutonism and metamorphism.

The initial approach to the problem was a regional field investigation of the Rouyn-Beauchastel area, the object of which was:

1. to obtain accurate and detailed information on the volcanic and sedimentary stratigraphy of the area,
2. to locate centres of volcanism within the area and to develop an understanding of their internal constitution,
3. to decipher the course of the orogenic deformation of the

area and to relate the orogenic structures fo the pre-existing tectonic and volcanic framework,

4. to trace the evolution of the sedimentary "basins" that are associated with the volcanic rocks.

LOCATION OF THE AREA

The Rouyn-Beauchastel area (Fig. 1) lies in the southern part of the Superior Province of the Canadian Shield. It is in the Province of Quebec about 400 miles (640 km) northwest of Montreal, near the provincial boundary between Ontario and Quebec. The towns of Rouyn and Noranda, with a total population of about 30,000, comprise the nearest urban centres and lie about 5 miles (8 km) to the north of the area.

The area is bounded approximately by latitudes 48°08' and 48°15' north and by longitudes 78°45' and 79°12' west and encompasses about 100 square miles (260 km^2).

The boundaries are better defined by relating them to the townships of the region. The area includes the southern and northeastern parts of Rouyn Township, the northwestern part of Joannes Township and the southeastern part of Beauchastel Township.

ACCESS

Almost all parts of the area are easily accessible by road. About half of the area has been cleared for farming and a good network of secondary roads crosses the area at intervals of approximately 3 miles

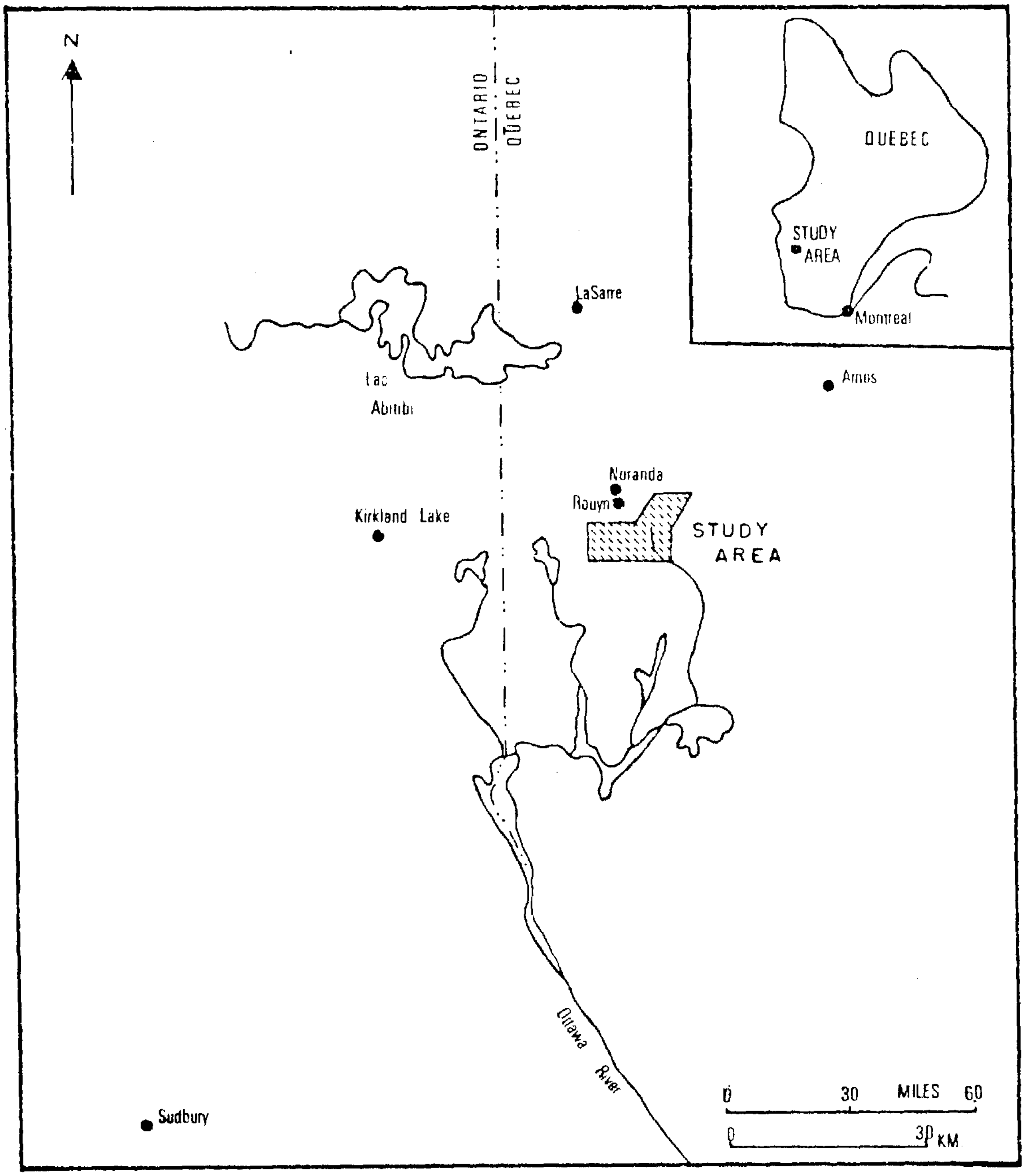


Figure 1. Index Map.

(5 km). In addition water routes provide access to the more remote parts of the area, particularly in the northeastern and southeastern corners.

FIELD AND LABORATORY WORK

This report is based upon 12 months of field work in the area over a period of 4 years between 1971 and 1974. This involved a critical review of the 1/18,000 geological map of the Rouyn-Beauchastel area published by Wilson (1962) and the preparation of a new revised map at a scale of 1/12,000, (1" = 1000'). (see maps I-2-3 enclosed).

Field relationships were recorded directly on (1/15840, scale) vertical air photographs (approximately 1 inch = 1/4 mile), taken for the Quebec Department of Natural Resources. Petrographic and structural analyses were carried out at the Department of Geological Sciences, Queen's University, Kingston, Ontario. Whole-rock chemical analyses for 21 samples were obtained by X-ray fluorescence; 200 thin sections were examined and electron microprobe analyses were carried out on 2 samples at Queen's University. The structural fabric data were analysed using facilities of the IBM 360-50 computer at the Queen's University Computing Centre.

PREVIOUS WORK

The earliest systematic geological work in the Rouyn-Beauchastel area was carried out by M. E. Wilson in 1913 (Wilson, 1914). H. C. Cooke traversed parts of the area (Cooke, 1923), and W. F. James traversed the southeastern Rouyn map area in 1923 (James, 1925). J. E. Hawley made a detailed study of the vicinity of McWatters Gold Mine and the Granada Gold Mine in 1931 and 1933 (Hawley, 1932, 1934). In the early forties J. W. Ambrose and H. C. Gunning mapped the adjacent areas to the east and northeast (Ambrose, 1941; Gunning, 1937, 1939, 1940), and in 1950 T. M. Podolsky studied the age relationship between the Pontiac and Timiskaming groups in the southern part of the area. The Kinojevis area in Joannes Township was mapped by A. S. MacLaren (1952) and M. N. Bass (1961) has reported on the tectonic evolution of the Timiskaming subprovince. A detailed regional geological map and report on the Rouyn-Beauchastel area was published by the Geological Survey of Canada in 1962 (Wilson, 1962). J. Holubec (1972) has presented an interpretation of tectonic relationship in the southern part of the area.

The present study was initiated in 1971 as part of a regional project of the Quebec Department of Natural Resources, involving a group of scientists, supervised by Dr. E. Dimroth.

CHAPTER II

TECTONO-STRATIGRAPHIC FRAMEWORK

The southern part of the Superior Province is characterized by large tracts of Archean granitic rocks and high grade metamorphic rocks within which are interspersed east-trending belts of relatively little metamorphosed Archean volcanic and sedimentary rocks. The Abitibi belt of eastern Ontario and western Quebec (Fig. 2) is one of the largest of these east-trending volcanic-sedimentary belts. In the Rouyn-Beauchastel area it consists of three subsidiary east-trending belts:

1. the volcanic rocks of the Blake River Group in the north,
2. the metamorphosed sedimentary and associated volcanic rocks of the Pontiac Group in the south, and between these
3. the metasedimentary rocks of the Timiskaming Group and the "Granada Group".

Stratigraphic Framework

The basic stratigraphic relationships in the Rouyn-Beauchastel area, and in the larger region of which it is a part, are obscured by rapid lateral variations in volcanic and sedimentary facies (see Table 1, and Fig. 3). In the Rouyn-Beauchastel area the Timiskaming Group conformably overlies the Pontiac Group to the south but is

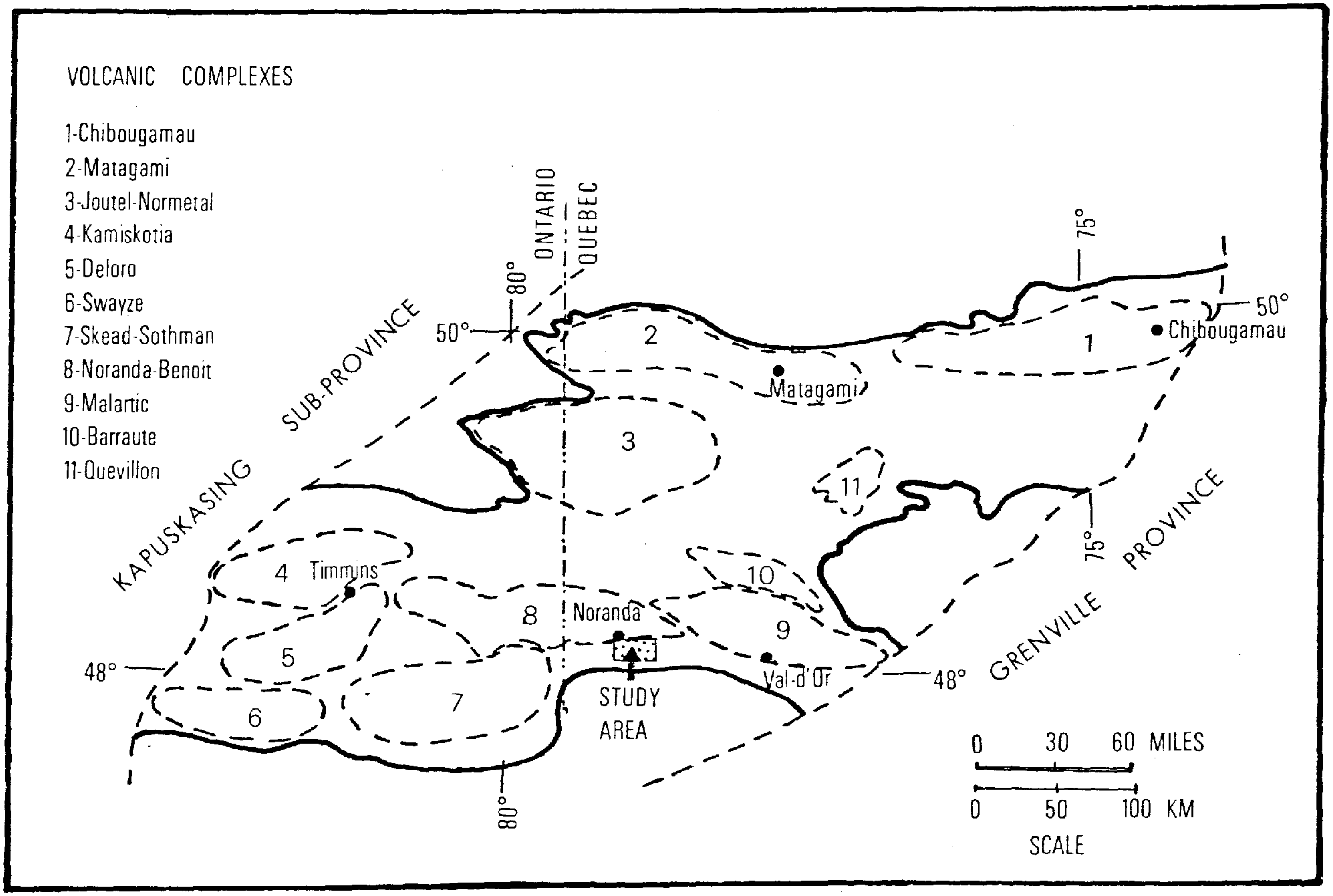


Fig. 2. Distribution of volcanic "complexes" in the Abitibi Belt (after A. M. Goodwin and R. H. Ridler, 1970).

unconformable on the Blake River Group to the north, and the determination of stratigraphic relationships between the Pontiac and Blake River Groups presents a fundamental problem of broad regional tectonic significance. Similar problems exist in nearby parts of the Abitibi belt. For example on the scale of the surrounding region eight main rock stratigraphic assemblages have been identified (see Fig. 3). Three of these, the Kinojevis, Malartic and Blake River Groups consist mainly of basic volcanic rocks, whereas the others, the Caste, Kewagama, Pontiac, Cadillac, Timiskaming, and Duparquet Groups consist predominantly of metasedimentary rocks. The stratigraphic relationships among these various stratigraphic assemblages, as they are known now, are summarized in Tables 1 and 2. Problems in correlation are localized along two linear belts each of which is at least in part the locus of large-scale faulting. The Cadillac-Larder Lake fault runs through the belt of Timiskaming rocks along the zone separating the Pontiac from the Blake River Group. The Porcupine-Destor fault separates the Blake River, Kewagama and Malartic Groups on the southwest from the Kinojevis and Duparquet on the northeast. Thus, although the Blake River Group is known to overlie the Kewagama Group and to be overlain in turn by the Timiskaming Group on the southwest side of the Porcupine Destor fault, and the Kinojevis Group is known to be overlain by the Caste Group which in turn is overlain by the Malartic Group on the northwest side of the Cadillac-Larder fault, the relationships between the Caste Group and the Kewagama Group on one hand, and the Caste Group and Duparquet Group on the other hand, is still questionable.

Fig. 3. Legend.

[10] Cobalt Group (Proterozoic)

[9] Intrusive Rocks

[8] Duparquet and "Granada" Groups →
[7] Timiskaming and Cadillac Groups →
[6] Pontiac Group →
} Mainly Archean Metasedimentary Rocks

[5] Blake River Group →
[4] Kewagama Group (Sedimentary Rocks)
[3] Kinojevis Group →
[2] Caste Group (Sedimentary Rocks)
[1] Malartic Group →
} Archean Volcanic Rocks

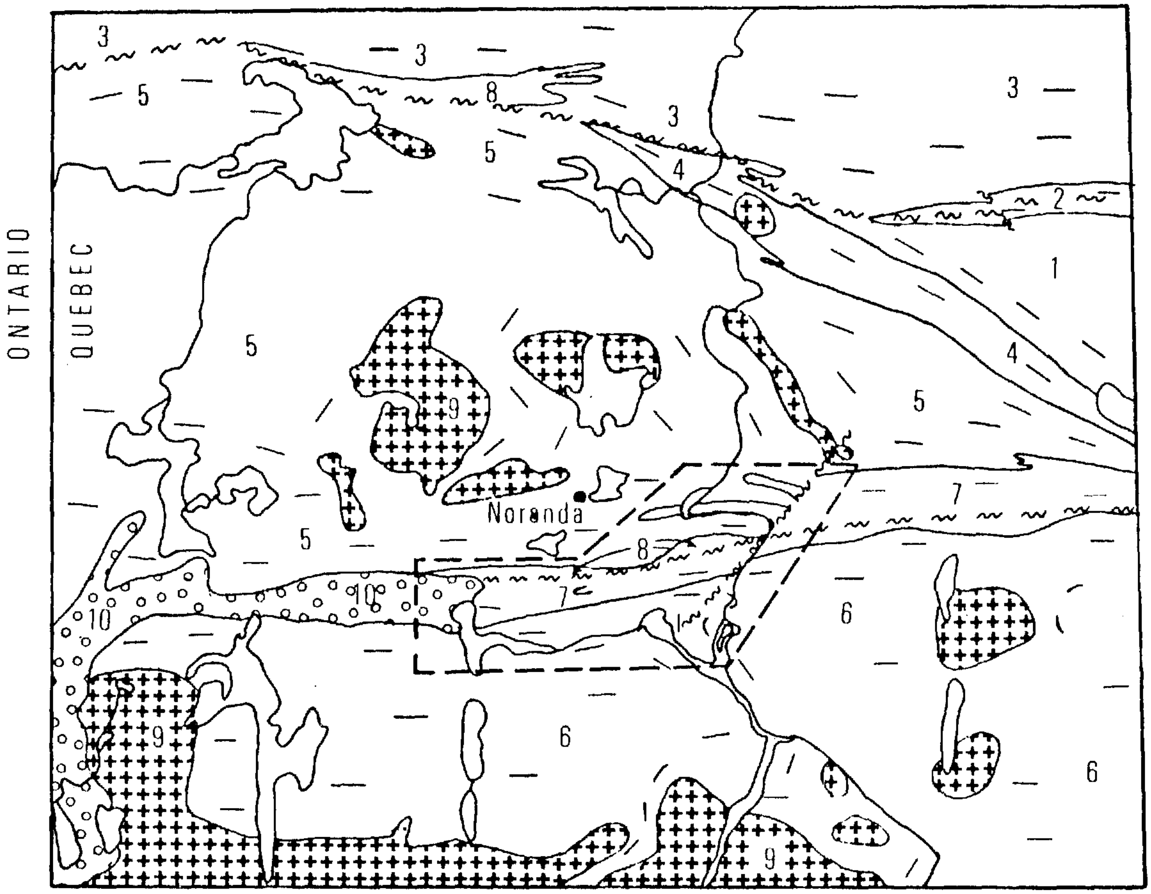
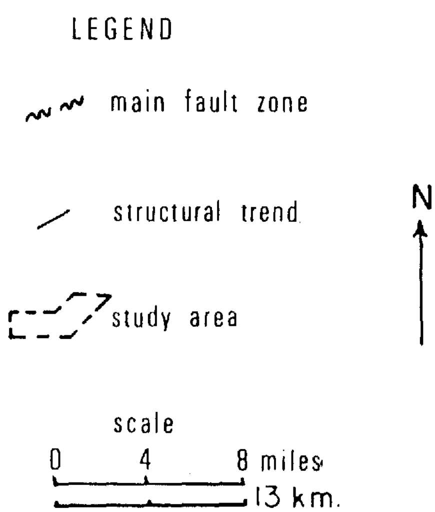


Fig. 3. Tectonic sketch of the Rouyn-Noranda area (after E. Dimroth et al., 1973).



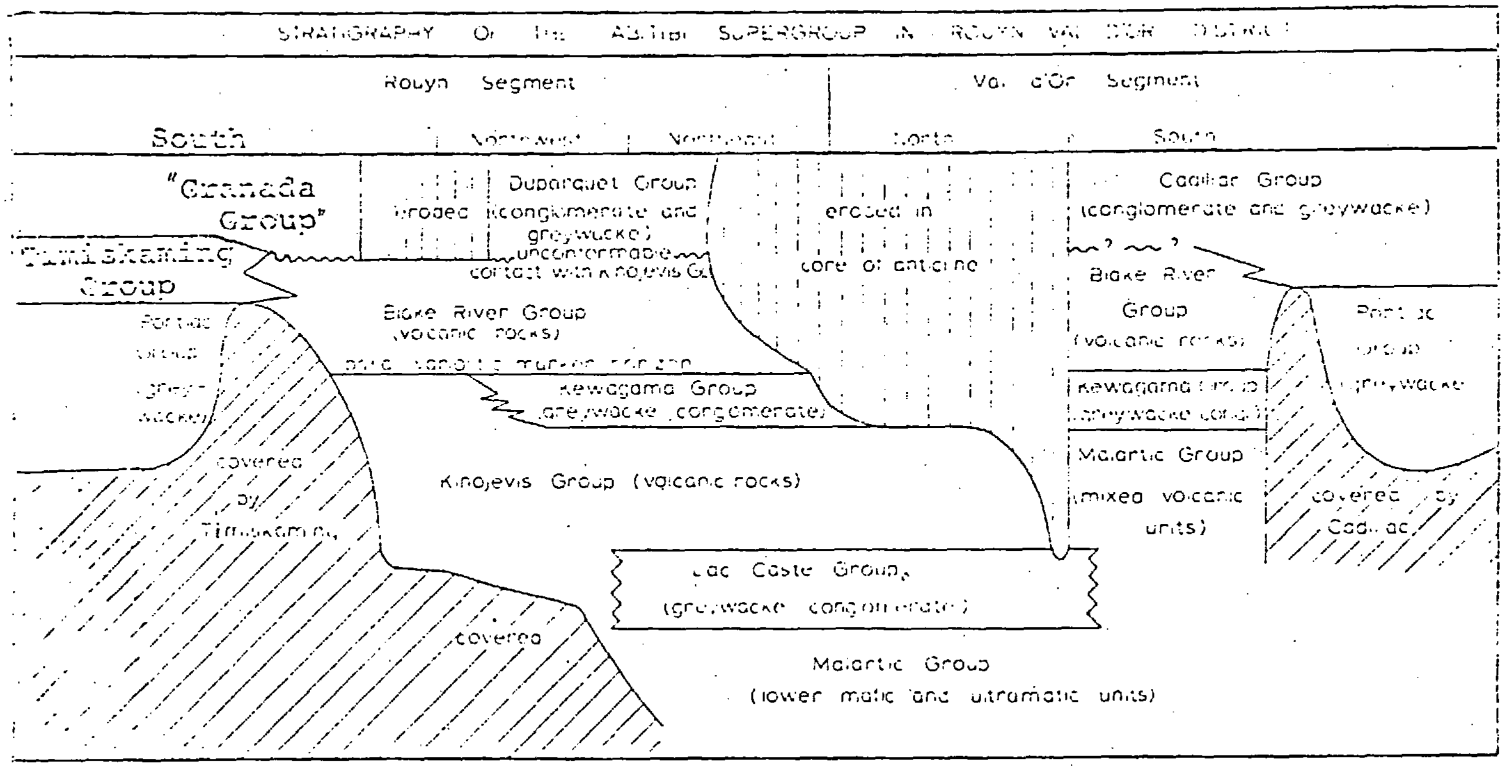


Table 1. Tentative stratigraphic table of Rouyn-Val d'Or area (modified after E. Dimroth, 1975).

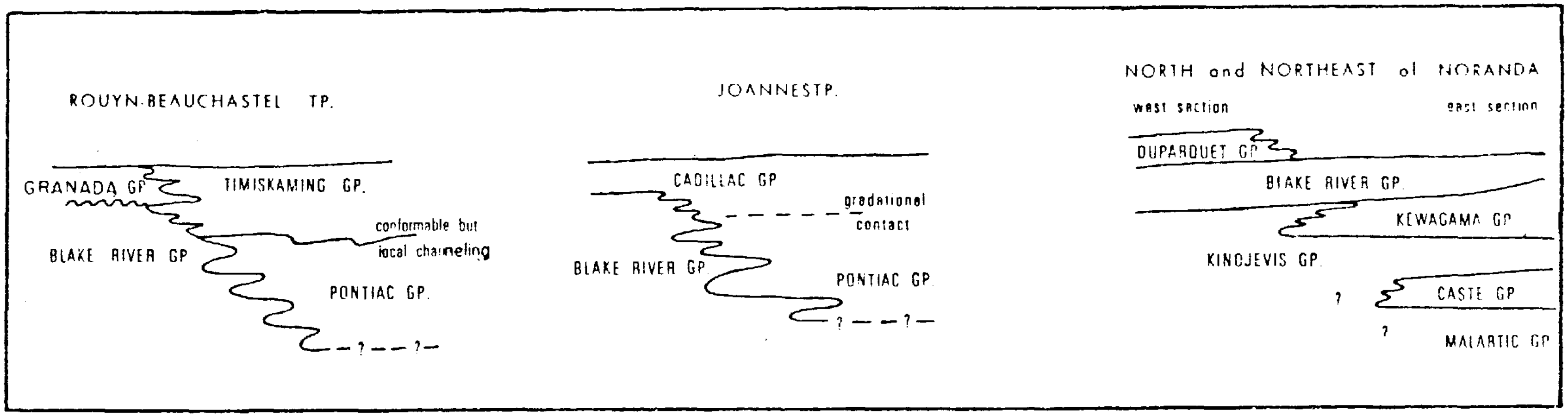


Table 2. Stratigraphic correlation table from the southern part to the northern part of Rouyn-Noranda area.

CHAPTER III

STRATIGRAPHY AND SEDIMENTOLOGY

INTRODUCTION

The deformed Archean rocks which form the bedrock throughout most of the Rouyn-Beauchastel area are overlain with angular unconformity by relatively flat-lying clastic sediments of the Aphebian Cobalt Group in the southeastern part of Beauchastel Township. They comprise five main rock stratigraphic units: (see Table 3).

(1) the Blake River Group

(2) the Pontiac Group

(3) the Cadillac Group

(4) the Timiskaming Group

(5) a unit which is referred to here informally as the "Granada Group".

A clear understanding of the stratigraphic and structural relationships among these five units is essential for unravelling the Archean tectonic evolution of the area, and this has been the main objective of the stratigraphic and sedimentologic studies reported here.

The stratigraphic and structural continuity across the area is disrupted by the Cadillac-Larder Lake fault, a major regional east-west structure. It is marked by a steeply dipping zone of ankerite-talc-chlorite schist up to several hundred feet wide, and

NOTE: LA PAGE 14 N'EXISTE PAS

extends across the area from beneath the cover of younger sediments of the Cobalt Group north of Lake Beauchastel to the hair-pin bend in the Kinojevis River east of McWatters. North of the fault, the greywacke and polymict conglomerate of the "Granada Group" lies with angular unconformity on the mafic volcanic rocks of the Blake River Group, and probably also the overlying sedimentary rocks of the Cadillac Group. South of the fault, the greywacke and polymict conglomerate of the Timiskaming Group lies conformably upon the greywacke and greywacke clast conglomerate of the Pontiac Group within which there are anticlinal infolds of mafic volcanic rocks that can be correlated with the Blake River Group.

Similarities in composition, textures and structural fabric between the Timiskaming Group and the "Granada Group" indicate that they are correlatives, and this conclusion supports a correlation, based on composition, texture and structural fabric, between the combined Blake River and Cadillac Groups north of the fault and the Pontiac Group and associated mafic volcanic rocks which are tentatively assigned to the Blake River Group, south of the fault. Because of the importance of these correlations, it is essential that the evidence upon which they are based be considered in some detail. This can be done most conveniently by considering the various units in order of relative age starting with the oldest.

Blake River Group (Map unit B_2)

The Blake River Group (Gunning, 1937), which has also been referred to as the Abitibi Group (Wilson, 1911), consists mainly of basic volcanic rocks and forms the base of the exposed section north of the Cadillac-Larder Lake fault. It consists of thick flows of variolitic and pillowed metabasalt that form both flanks of the Lake Rouyn Syncline (see maps I-2-3).

Within the Lake Rouyn syncline, it is overlain by the meta-sedimentary rocks of the Cadillac Group. Although the actual contact between the Blake River and Cadillac Groups is not well exposed, facing directions, defined by pillow structures in the Blake River Group, show that the flow layering in the volcanic rocks is conformable with the syncline outlined by the bedding in the Cadillac Group.

Southeast of the Lake Rouyn syncline, in an area of poor exposure at the major hairpin bend in the Kinojevis River, east of McWatters, the volcanic rocks of the Blake River Group, which form the southeast limb of the Lake Rouyn syncline, are replaced toward the east by northeast- to northwest-dipping sedimentary rocks of the Cadillac Group. Facing directions in the Cadillac Group are uncertain, and it is not clear, on the basis of the available exposures in this area, whether the Cadillac Group wraps around the Blake River Group in a steep northwesterly plunging synformal anticline, or whether the Blake River Group is intertongued with the Cadillac Group. However, in the extreme northeastern corner of the map-area, where exposures are better, it can be shown that the volcanic rocks of the Blake River Group do interfinger with the sediments of the Cadillac Group. There, conglomeratic sandstones of the Cadillac Group face toward the north and are overlain by pillow basalt and then by more sedimentary rocks. Accordingly the contact between the two groups around the syncline is probable a transition marked by intertonguing, and the abrupt change, east of McWatters, can be attributed to a facies change, rather than to folding.

South of the Cadillac fault, basic metavolcanic rocks which are inferred to comprise part of the Blake River Group, on the basis of their composition and stratigraphic position, occur as discrete masses within the Pontiac Group at a number of places (see maps 2-3) in the area stretching from southern Lac Vallet to Lac Kinojevis, in two small areas northeast of Lac Bruyere, and west of Lac Vallet at several places along Lac Beauchastel, and in two small areas immediately south of the Cadillac-Larder Lake fault, at the McWatters mine and east of the mine near the Kinojevis River.

Lithological character of the Blake River Group: (Map unit B2)

Although the internal stratigraphy and structure of the Blake River Group were not studied in detail as part of this investigation, it has been the subject of detailed studies by R. Côté (in Dimroth *et al.*, 1975) and of regional interpretations by E. Dimroth *et al.* (1974, 1975).

Dimroth *et al*. recognized three phases in the development of the Blake River Group:

1. An initial phase marked by sheets of tholeiitic basalt,
2. An intermediate phase marked by the development of basaltic shield volcanoes with very complex internal structures, and
3. A final phase marked by another period of extrusion of sheets of tholeiitic basalt.

Côté's studies have shown that the part of the Blake River Group which occurs in the Rouyn-Beauchastel area represents the tholeiitic basalts of the initial phase and part of the shield volcano complex. Tholeiitic flood basalt sheets occur along the north side of the Cadillac-Larder Lake fault over most of the interval between McWatters and the western boundary of the map area. They form a steep north-facing homoclinal succession about 1800 m (6000 ft) thick, which is made up of three well defined units of variolitic basalt, averaging 200 m in thickness, that are overlain by a rhyolitic unit 40 m thick and a highly amygdaloidal pillowed rhyodacite. They consist of intercalations of variolitic and non-variolitic pillowed and massive basalt, some of which are partly vesicular. According to L. Gelinas *et al*. (1976), the varioles typically consist of low-potash rhyolite and make up from 5 to 80% in the volume of the rock. In the outcrops, they are very distinctive, white-weathering, spherical or lenticular bodies from 5 mm to 5 cm in diameter, with sharp contacts and a blue-grey core; and are set in a dark green aphanitic matrix. In the vicinity of the Cadillac Fault the varioles are deformed and consist of prolate spheroids with axial ratios of 7:3:1. They are commonly etched into relief by weathering of the enclosing basalt. The variolitic basalts are overlain unconformably by the "Granada Group" in the eastern part of the area, near McWatters. Further north, the overlying shield volcano complex consists of several units of intercalated basalt and andesite, ash-flow tuffs and pyroclastic avalanche deposits, and intercalated basalt and rhyolite.

The sedimentary rocks of the Cadillac Group, which occupy the core of the Lac Rouyn syncline, are intertongued with this part of the Blake River Group.

Blake River (?) Group: (Map unit B_1)

The basic metavolcanic rocks south of the Cadillac-Larder Lake fault, which are tentatively assigned to the Blake River Group, are exposed beneath the Pontiac Group in the cores of refolded anticlinal folds. The largest area of exposure is in the Lac Kinojevis anticline, a north-south fold, between Lac Vallet and Lac Kinojevis, that has been overprinted by large east-west trending folds (see map 3). Other exposures occur near McWatters (Map 3) and along Rivière Beauchastel (Map 2).

Four rock-types have been distinguished within this assemblage of metavolcanic rocks south of the Cadillac-Larder Lake Fault:

1. metabasalt (map-unit B_{1A})
2. amphibolite (map-unit B_{1B})
3. ultramafic rocks (map-unit B_{1C})
4. andesitic-tuff (map-unit B_{1D})

The metabasalt is a massive or pillowed greenstone, consisting mainly of a foliated aggregate of actinolite, tremolite, chlorite, plagioclase, (An_{30}-An_{35}), biotite, carbonate and quartz. No variolitic flows were found in it, and the pillows are normally very much flattened and deformed. Some amphibolites in which pillow structure is still clearly recognizable have been included with the metabasalts. The metabasalts resemble the tholeiitic flood basalts that occur north of the Cadillac-Larder Lake fault, and have been correlated with them on the basis of gross aspect and chemical composition (see Table 4 page 26). The amphibolite is a massive, black to dark brown, medium to coarse-grained rock, consisting mainly of hornblende, cummingtonite, plagioclase, quartz and carbonate. Schistosity is generally poorly developed. The amphibolite is gradational with the metabasalt and the two map units appear to be different metamorphic facies of the same protolith.

The ultramafic rocks are generally highly altered and represented by talc-carbonate schists. However, locally, some of the primary textures and minerals are preserved. They occur in the core of the Lac Kinojevis anticline, and along Lac Beauchastel. On the east side of Lac Kinojevis, structures similar to the polygonal suture zones of ultramafic flows (Pyke *et al.*, 1973) occur in a chlorite-talc-cummingtonite-carbonate rock. In the core of the Lac Kinojevis anticline there are a few localities where radial clusters of large bladed amphibole crystals in a carbonate-talc matrix may represent relict spinifex textures. Similar textures occur in ultramafic lavas only in the Kinojevis Group or the Malartic Group north and northeast of the area (Gelinas, 1977; Imreh, 1973) and have not been found in the Blake River Group.

The andesitic tuff is a green to black, fine- to medium-grained banded rock, consisting mainly of chlorite, actinolite, plagioclase and calcite. It includes some light coloured finely laminated layers that may represent acidic tuff. It occurs above sedimentary rocks of the Pontiac Group in the core of a synform northeast of Lac Bruyere and appears to be gradational into and intercalated with the Pontiac Group. It may be a lateral equivalent of the shield volcano complex of Dimroth *et al.* (1974).

The basic metavolcanic rocks that occur near McWatters (map-unit B_1 ? of Map 3) are also tentatively assigned to the Blake River Group and are correlated with the volcanic rocks that occur further south (map-unit B_1) because they are similar in composition, structural style and structural relationships to the rest of the basic metavolcanic rocks that occur south of the Cadillac-Larder Lake fault. They consist of massive and pillowed metabasalt in which the pillows and other primary features have been largely obscured by intense deformation and metamorphic recrystallization. They show the effects of the two major sets of folds, with earlier northerly trending folds overprinted by younger east-west folds; and they are aligned with the series of structural culminations further south in which most of the other basic metavolcanic rocks are exposed.

The metavolcanic rocks near McWatters occur in an area of very complex structure that has been studied previously by Hawley (1934) and by Wilson (1948), who outlined the existence of several important faults (Cadillac-Larder Lake, McWatters, Bowes and Rouyn-Merger faults) mainly on the basis of information from underground workings and diamond drilling. On the basis of my study of the bedrock exposures at the surface, I have concluded that much of what has been previously called andesite agglomerate and tuff (Wilson, 1962) is a polymict metaconglomerate that is intercalated with metagreywacke in which the matrix has been highly amphibolitized and chloritized. The volcanic rocks are limited to one small crescent shaped area of metabasalt south of McWatters mine shaft and another small area near the south edge of the outcrop, adjacent to the Bowes Fault (see Map 3).

These volcanic rocks probably underlie the surrounding sediments but there are no good top determinations to confirm this. The metavolcanic rocks of the Lac Kinojevis anticline have been intensively deformed and thoroughly modified by regional metamorphism which increases in grade to the south, from upper greenschist to amphibolite facies. In the southern part of the anticline the primary textures and structures are completely obliterated.

The contact between the Blake River (?) Group and the Pontiac Group appears to be conformable with the bedding in the Pontiac Group. Pillow structures which are recognizable locally in the volcanic rocks, face toward the contact. On the west side of the Lac Kinojevis anticline graded beds in the greywackes of the Pontiac Group consistently face away from the volcanic rocks, but on the east side the evidence from facing directions is partly contradictory. Although the graded beds generally do face away from the volcanics, there are a number of localities near the contact where the graded beds face toward the volcanic rocks. These changes in facing direction may be due to tight small-scale folding and to faulting in the Pontiac Group. Close to the contact there is a highly deformed zone of chloritic schist in the volcanics and locally it is difficult to decide where the volcanic rocks end and the sedimentary rocks begin. Slickensiding and quartz veining in this zone suggest that there have been fault displacements along the contact.

The Archean volcanic rocks of the Abitibi belt have been subdivided by Jolly (1975) into three petrochemical suites:

1. a lower magnesian suite
2. an intermediate tholeiitic suite
3. an upper calcalkaline suite.

The tholeiitic flood basalts that occur in the Blake River Group immediately north of the Cadillac-Larder Lake fault have been included by Jolly in his intermediate tholeiitic suite (see Fig. 4).

Jolly has reported that the tholeiitic suite is characterized by an iron-enrichment differentiation trend. Most of the lavas in it contain 10 to 20% total iron expressed as FeO. In the mafic end members the TiO_2 content ranges between 1.0 and 2.75%, MnO content ranges between 0.15 and 0.50% and the ratio $FeO_T/FeO+MgO$ is greater than .65.

Chemical analysis of five specimens from the volcanic rocks in the Lac Kinojevis anticline are presented in Table 4. Three analyses are of basaltic rocks but analyses 4 and 5 are of ultramafic rocks (Riverin, 1972). The basalts have the same distinctive chemical characteristics as Jolly's intermediate tholeiitic suite (see Table 4). Total iron expressed as FeO ranges between 9.2 and 20.4%; TiO_2 ranges from 1.6 and 2.2%, MnO ranges from .2 and .4% and the ratio $FeO_T/FeO+MgO$ is greater than .8. These chemical relationships provide confirmation for the correlation of the volcanic rocks in the core of the Lac Kinojevis anticline with the tholeiitic flood basalt sheets of the Blake River Group north of the Cadillac-Larder Lake fault; and this, in turn, supports the conclusion that the Pontiac Group, south of the Cadillac-Larder Lake fault correlates with the lithologically similar sedimentary rocks that overlie the Blake River volcanic rocks and comprise the Cadillac Group north of the fault.

The two chemically analyzed specimens of the ultramafic rocks in the Lac Kinojevis anticline (Table 4; analyses 4 and 5) have an unusually high content of MgO (21.70% and 21.63%), Ni (1020 ppm

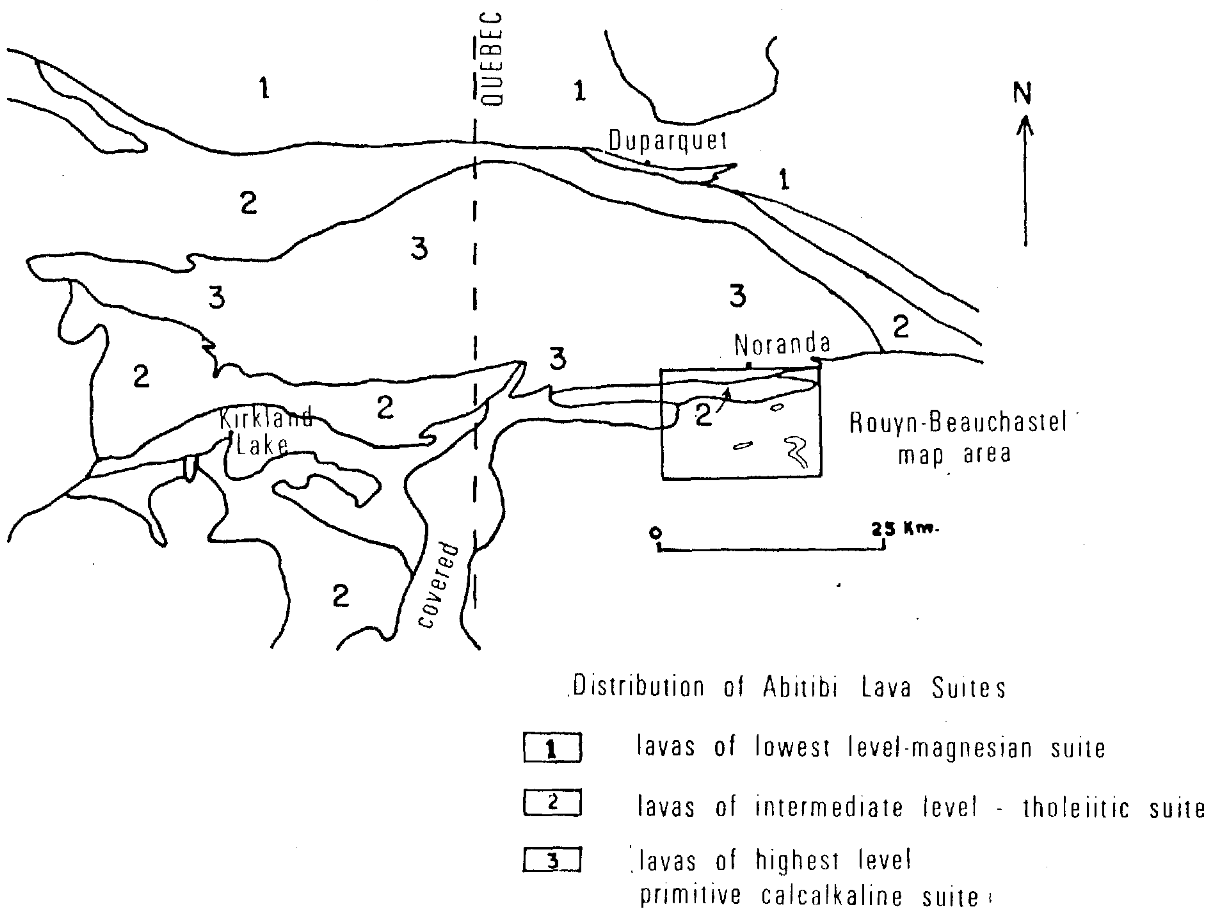


Fig. 4. Distribution of the three volcanic suites according to W. Jolly (1974) in the Abitibi rocks and the location of the area where our chemical analyses were taken.

Table 4. Chemical analyses of mafic volcanic rocks of the Blake River (?) Group (Map unit B_1) analysed by X-ray fluorescence by P. Hebert at the University of Quebec in Chicoutimi, 1972. FeO done by wet chemical analysis.

	1	2	3	4	5
SiO_2	52.10	45.18	52.61	43.58	43.91
Al_2O_3	12.45	10.91	13.62	7.32	9.42
TiO_2	2.28	1.65	1.77	0.36	0.50
FeO	12.25	17.54	8.64	7.74	8.74
Fe_2O_3	4.91	3.23	2.13	1.63	1.79
FeO_T	16.66	20.44	10.56	9.20	10.35
MnO	0.25	0.40	0.27	0.12	0.16
MgO	3.18	5.14	3.61	21.70	21.63
CaO	6.04	8.71	8.02	4.97	6.53
Na_2O	2.18	1.11	3.00	0.11	0.26
K_2O	0.91	0.18	0.25	0.0	0.0
Ni_{ppm}	9	31	43	1020	1030
Cr_{ppm}	30	51	30	2160	2220
Co_{ppm}	56	54	59	80	94
Field No.	R-4-11A	R-5-1A	R-8-2A	R-4-6A	R-4-7A
Locations	Range II	Range II	Range III	Range II	Range II
	Lot 50	Lot 49	Lot 59	Lot 50	Lot 51
	Rouyn Tp.	Rouyn Tp.	Rouyn Tp.	Rouyn Tp.	Rouyn Tp.

and 1030 ppm) and Cr (2160 ppm and 2220 ppm). These values are characteristic of Jolly's (1975) lower magnesian suite and suggest that the ultramafic rocks are probably correlative with it.

Cadillac Group

The Cadillac Group (Gunning, 1937) consists of clastic sedimentary rocks, that conformably overlie the volcanics of the Blake River Group, north of the Cadillac-Larder Lake fault, in Cadillac Township.

The sedimentary rocks of the Cadillac Group in the Rouyn-Beauchastel area are the western continuation of the Cadillac sediments of Cadillac Township. They occupy the centre of the Lac Rouyn syncline and they replace the volcanic rocks of the Blake River Group east of the hairpin bend in the Kinojevis River, presumably as a result of a facies change or folding.

In the eastern part of the area two different rock types have been distinguished in the Cadillac Group (map-unit C): conglomeratic sandstone (map-unit C_1) and greywacke (map-unit C_2) (see Plate Ib and c). Further west, in the Lac Rouyn syncline the Cadillac Group consists of rhyolite-tuff turbidite (see Plate Ia), sandstones and metapelites (map-unit C_{3A}), greywacke (map-unit C_{3B}) and volcanogenic conglomeratic sandstone (map-unit C_{3C}).

Complex folding and abrupt lateral facies changes make it difficult to estimate stratigraphic thickness. Greywacke is obviously

Plate I

a. Map Unit C_{3A}

Fine grained rhyolite tuff turbidite, showing graded bedding, with load cast. The beds are sub-vertical. (On the island in Lac Rouyn, Range VI, lot 34, Rouyn Tp.). The pen is 15 cm long.

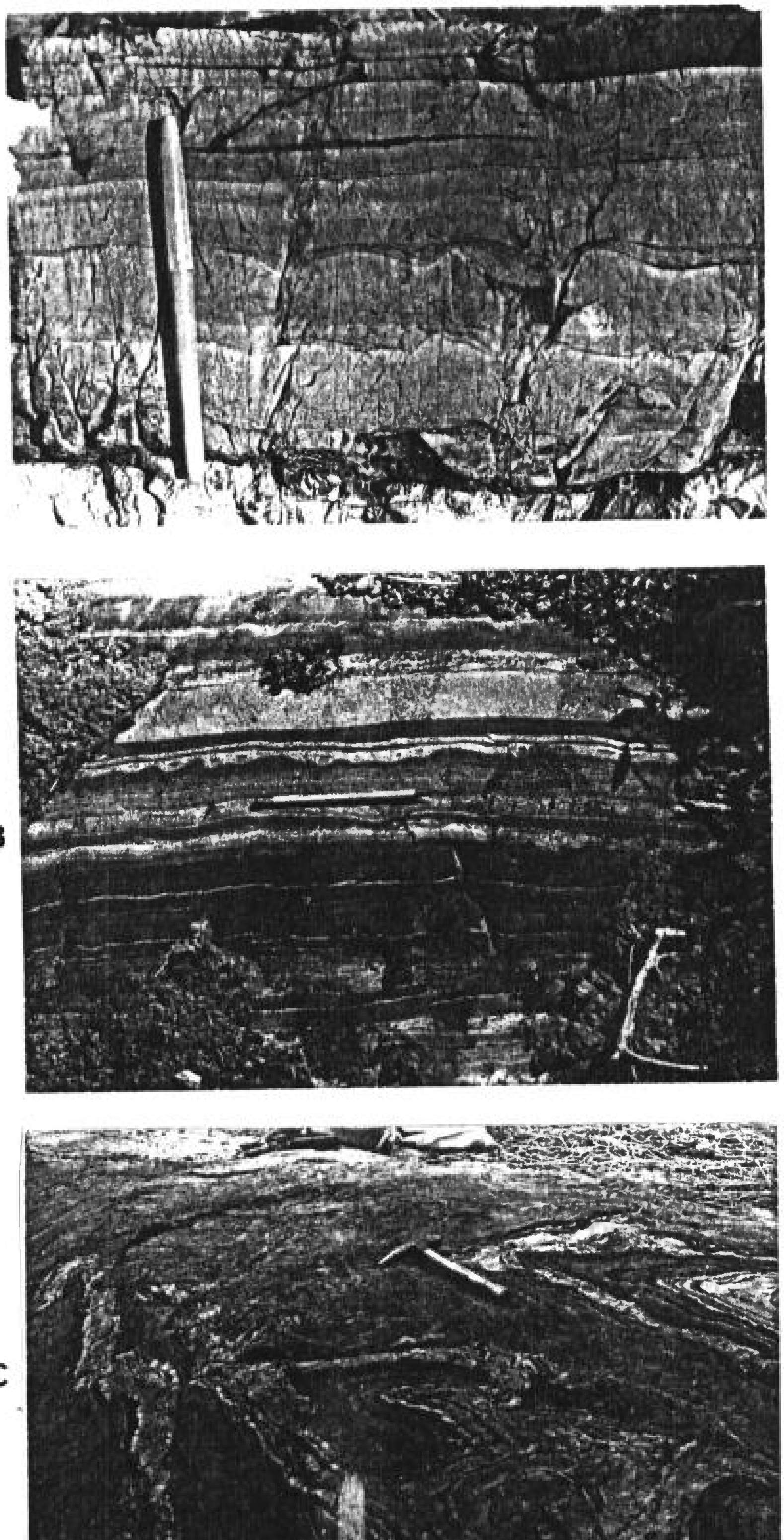
b. Map Unit C_2

Greywacke and pelite showing graded bedding, load casts and small faults which are parallel to the schistosity. (Range VII, lot 45, Rouyn Tp.). The pencil is 15 cm long.

c. Map Unit C_2

Graded greywacke and pelite are highly deformed. The beds and the fold axis are sub-vertical. The pick handle is 30 cm long. (Range VIII, lot 27, Joannes Tp.).

Plate I



A

B

C

the most dominant lithofacies, but the amount of argillaceous matrix varies greatly and locally the greywacke grades to slate. Slates are particularly abundant south of the main axis of the Lac Rouyn syncline near the junction of Lac Rouyn and Lac Routhier.

The volcanogenic conglomerate and conglomeratic sandstone occurs in the northern flank of the syncline. The rhyolite-tuff turbidite occurs in the western part of the syncline, on islands in Lac Rouyn.

The conglomeratic sandstone unit (map-unit C_1) which occurs in the eastern part of the area, between the Blake River Group and the Davidson Creek Fault, in Joannes Township, is intercalated with pillowed andesite, flow breccia and tuffaceous andesite. It is estimated to be about 100 m (300 ft) thick and consists of a medium-grained sandstone, with a low quartz content, but a high content of feldspathic and rock fragments. The clasts in the conglomeratic fraction are commonly subangular to angular, less than 50 cm long, form 5 to 60% of the rock and occur in a sandstone matrix. The pebbles or cobbles are mainly of two types: very feldspathic andesite similar to the underlying volcanics, and argillite or siltstone. There are a few rhyolite clasts but no clasts of granitoid rocks.

Most of the beds are graded, and the conglomeratic fraction at the base has an internal stratification marked by a parallel or imbricate alignment of inequidimensional clasts. The sandstone in the finer grained portion of the beds normally is finely laminated.

The most common sedimentary structures are normal or reversed graded bedding, convolute lamination and flame structures. Small erosion channels occur in the upper portion of the beds. The conglomeratic sandstone beds are commonly intercalated with fine-grained, well-bedded, finely laminated, graded siltstone.

The conglomeratic sandstones appear to have been deposited in a marine environment by powerful submarine mass flows. According to M. Rocheleau (in Dimroth et al., 1974) the clasts were probable transported mainly in suspension, but the internal lamination suggest that bottom traction was also important. Because there is a conformable relationship and intertonguing between the pillowed andesite and the Cadillac Group, and because the conglomeratic sandstones represent a flysch-type alternation of medium- to fine-grained graded sandstones with argillite at the top, it can be concluded that they accumulated as turbidite deposits in a marine environment. The nature of the clasts indicates that the source of the detritus was the nearby volcanic rocks of the Blake River Group.

The greywacke sequences which occur north of the hairpin bend of the Kinojevis River and in the vicinity of Lac Routhier (map-units C_2 and C_{3B}) are medium-grained and well bedded, with good normal graded-bedding (see Plate Ib and c). The beds vary in thickness from less than 1 cm to about 1 m but average about 1-2 cm. The pelitic fraction locally forms more than 50% of an individual bed but is highly variable. Conglomeratic lenses and layers occur locally. The main difference between the greywackes of unit C_2 and unit C_{3B} are that the proportion of pelitic material is higher in the greywacke of unit C_{3B}, and these rocks are generally finer grained and more thinly bedded. Conglomeratic lenses and layers are common in unit C_2 west of the Davidson Creek Fault and north of the Kinojevis River, but are rare in unit C_{3B}. The quartz content is low (5 to 10%) in both units and the grains are usually subrounded. Nevertheless the distinction between the two types of greywacke is not sharp and they probably grade into each other as lateral facies equivalents.

Provenance and environment of deposition

The primary structures and textures of the Cadillac Group metasediments, the nature of the clasts they contain, and the lateral facies variations in them indicate that they were deposited as turbidites, probably in a marine environment, adjacent to the shield volcanic complex of the middle part of the Blake River Group, and that they were derived from and deposited at least in part along with the shield complex of the middle part of the Blake River Group, but that they also include quartz-rich sediment that was probably derived from some other granitic source area. The volcanogenic conglomeratic sandstone are only abundant locally in the north limb of the Lac Rouyn syncline where they occur at the base of the Cadillac Group on the south shore of Lac Rouyn. They grade upward into rhyolite tuff turbidites or into the greywackes which are the dominant rock type in the Cadillac Group in the Lac Rouyn syncline. Ambrose (1941) referred to these coarse poorly sorted clastic rocks as agglomerates, but Wilson (1962) described them as conglomerates. The clasts range up to 30 cm in diameter and are variable in composition. They include basic to acidic volcanic rocks and abundant quartz-feldspar porphyries but no granitic rocks. The matrix is a medium- to coarse-grained greywacke that contain subrounded grains of quartz and albite in a schistose matrix of chlorite, carbonate, sericite, actinolite and epidote. The sedimentary textures, the variety of clast types and the subrounded quartz grains in the matrix all indicate that these rocks are conglomerates rather than agglomerates. These volcanogenic conglomerates may represent the southern edge of a thicker and more extensive deposit of acidic pyroclastic rocks, including breccias and tuffs that were described by Ambrose (1941) from the area north of Lac Routhier. A small exposure of "acidic breccia" (Ambrose, 1941) occurs along the contact with the Blake River Group in the south limb of the Lac Rouyn syncline near the west end of Lac Rouyn. It is a layer about 20 m thick that is exposed for about 40 m along strike and lies conformably between the basic volcanic rocks of the Blake River Group and the overlying rhyolite tuff turbidite of the Cadillac Group. It consists of brecciated acidic volcanic rock fragments in a grey to greenish coarse grained sandstone matrix. The fragments are subangular to subrounded and are from 1 to 3 cm in diameter. The stratigraphic tops defined by cross bedding in the black more argillaceous sandstones that are common in the "acidic breccia", is to the north; and the fragments are coarser at the base near the basic volcanic rocks than they are higher in the succession. These rocks may be a lateral equivalent of the volcanogenic conglomeratic sandstone that occurs in the north limb of the Lac Rouyn syncline.

The rhyolite tuff turbidites which occupy the core of the western part of the Lac Rouyn syncline are well exposed on the two islands in the western part of Lac Rouyn. They are dominantly very fine-grained, cherty-like, laminated and banded acidic tuffaceous sediments that weather white to pale grey, and have a conchoidal fracture; but they include interbeds of greywacke with good graded bedding. A variety of sedimentary structures is well preserved locally, and most common of which are graded beds, load casts and flame structures (see Plate Ia). Individual beds are of the order of 2 to 10 cm thick, but locally the rock is massive, light grey weathering and the bedding is outlined by concentrations of small (1 cm) black particles that appear to be fragments of mafic tuff, probably eroded from another layer.

The rhyolite-tuff turbidites are gradational upward and eastward into the greywacke (unit C_{3B}) that makes up most of the Cadillac Group in the Lac Rouyn syncline.

Chemical analyses of seven specimens of greywacke from the Cadillac Group indicate that they are derived from a basic to intermediate igneous (volcanic ?) suite and not from a granitic basement complex

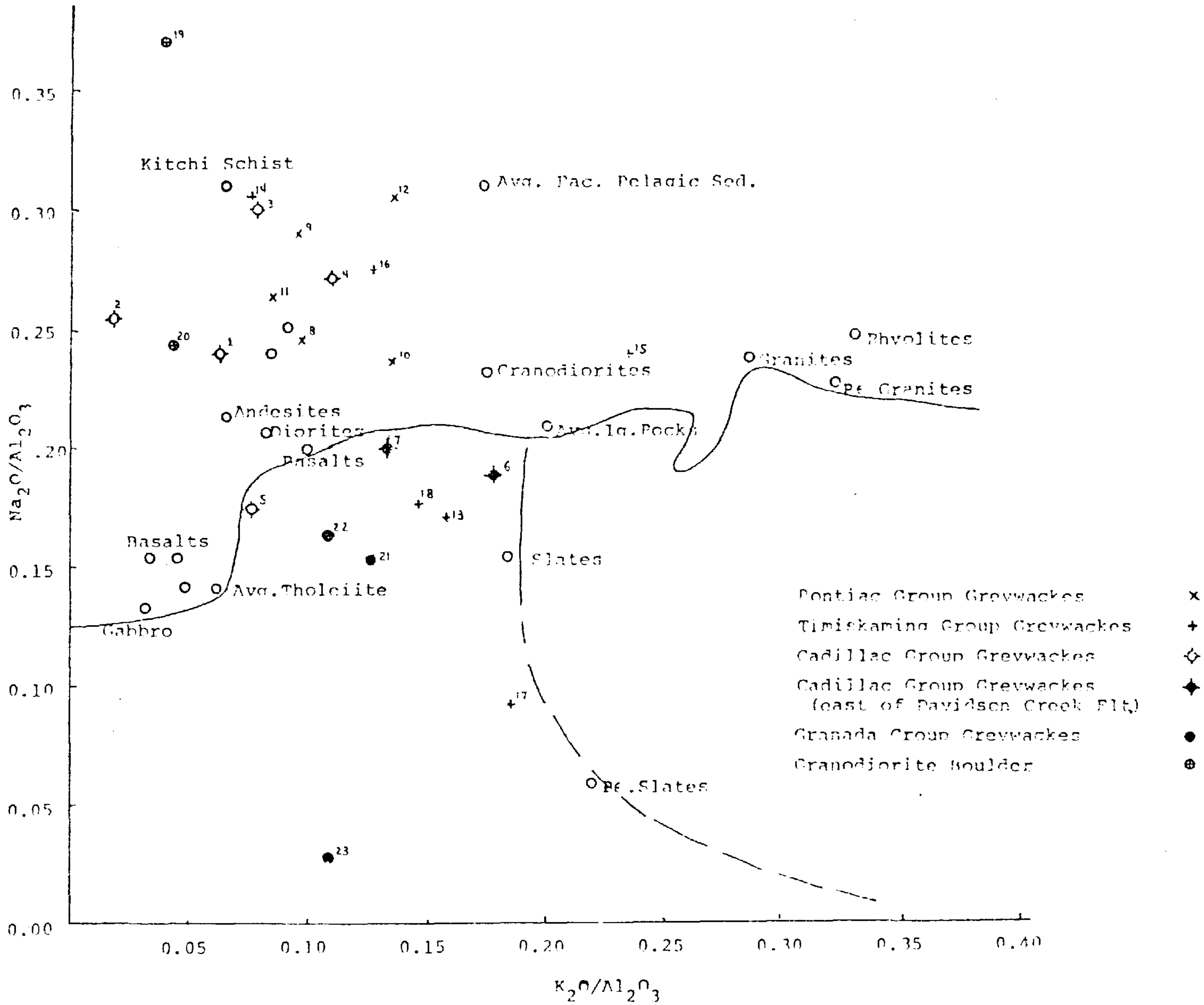


Fig. 5. Relationships between Na_2O/Al_2O_3 and K_2O/Al_2O_3 in greywackes from the Pontiac, Timiskaming, Cadillac and Granada Groups.

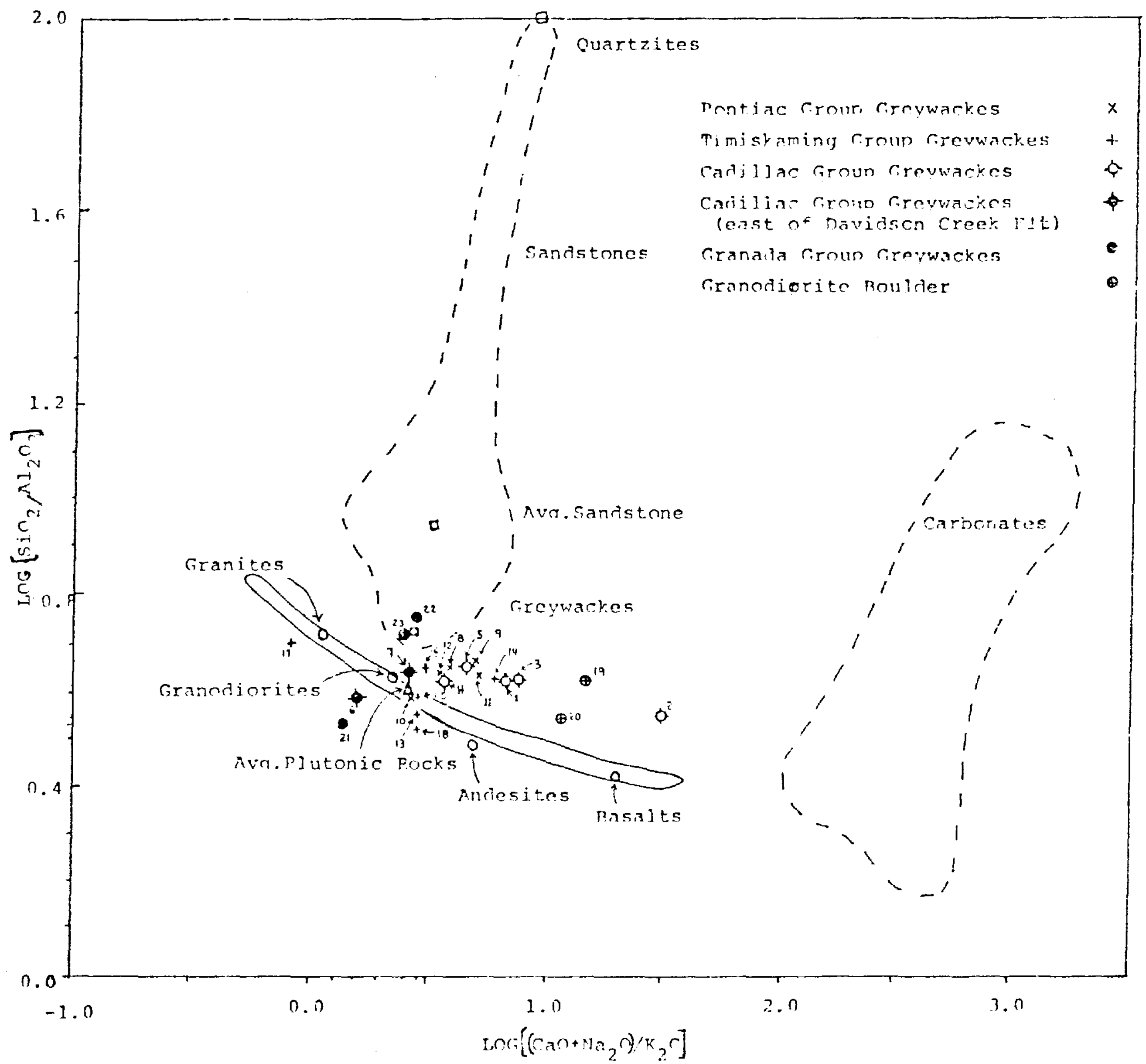


Fig. 6. Relationships between log[SiO_2/Al_2O_3] and log [($CaO+Na_2O$)/K_2O] in greywackes from the Pontiac, Timiskaming, Cadillac and Granada Groups.

Table 5. Chemical analysis of seven specimens of greywacke from the Cadillac Group analysed by X-ray fluorescence performed by F. Dunphy, Queen's University.

	I	II	III	IV	V	VI	VIII
SiO_2	64.6	59.5	59.95	63.2	65.0	66.2	65.8
TiO_2	.62	.52	.59	.62	.66	.66	.64
Al_2O_3	15.8	16.9	14.15	15.0	14.4	16.35	14.75
Fe_2O_3	3.65	4.1	6.25	5.6	4.53	6.0	5.92
MgO	2.0	2.55	5.2	3.0	2.93	3.2	3.18
CaO	2.78	4.85	3.65	1.85	2.6	1.7	2.25
Na_2O	3.8	4.3	4.25	4.05	2.5	3.05	2.93
K_2O	.99	.28	1.1	1.64	1.1	2.9	1.97
Field No.	31-1	35-7	42-1	112-5	126-4	126-5	111-2
Sample No. on Fig.	1	2	3	4	5	6	7
Locations	Range VII	Range VII	Range VII	Range VIII	Range VII	Range VII	Range VIII
	Lot 35	Lot 39	Lot 52	Lot 16	Lot 6	Lot 16	Lot 24
	Rouyn Tp.	Rouyn Tp.	Rouyn Tp.	Joannes Tp.	Joannes Tp.	Joannes Tp.	Joannes Tp.

(see Table 5 and Figs. 5 and 6).

Pontiac Group: (Map unit P)

The Pontiac Group (M. E. Wilson, 1909) occupies the southern third of the map-area, and is composed mainly of metamorphosed greywacke and argillite. It is overlain unconformably to the west, near the Ontario boundary, by the flat-lying rocks of the Aphebian Cobalt Group. To the south of the map-area, it is truncated by granitic intrusions; but it extends to the east over a distance of about 160 km to where it abuts the Grenville front. The northern limit is marked by an abrupt stratigraphic contact with the lowest bed of polymict conglomerate that defines the base of the Timiskaming Group. This contact extends across the map-area as a more or less straight east-west line from beneath the Cobalt Group near Lac Beauchastel, to the vicinity of Rivière Kinojevis where it is partly obscured by structural complications.

Only a relatively small part of the total area of exposure of the Pontiac Group lies within the Rouyn-Beauchastel area, but this part has been subdivided, in the course of this study, into three distinctive rock units. The most widespread of these is a greywacke (map unit P_1) that is more or less metamorphosed and grades southward with increasing metamorphic grade into mica schist. A distinctive monomict greywacke pebble, cobble and boulder conglomerate and conglomeratic mudstone unit (map unit P_2) occurs in the upper part of the Pontiac Group, at or near the contact with the Timiskaming Group, at two localities (south of Granada and north of Lac Beauchastel) and is easily distinguished from the polymict conglomerates of the lower part of the Timiskaming Group (map unit T_{1A}). The third rock unit (map unit P?) is only tentatively assigned to the Pontiac Group, and consists of greywacke and volcanogenic conglomerate, that is exposed near McWatters in a block that is faulted against the Timiskaming Group on the south and the "Granada Group" on the north. It resembles the rocks of the Pontiac Group that occur further south, and is underlain by meta-basalt and apparently overlain by polymict conglomerates like those in the Timiskaming Group. Thus all the rocks assigned to the Pontiac Group consist of greywacke and monomict greywacke or volcanogenic conglomerate, and all lie beneath the polymict conglomerate of the Timiskaming Group and above the basic volcanics of the Blake River Group.

The greywacke unit (map unit P_1) is a typical turbidite deposit, consisting of graded beds of medium-grained quartz-rich greywacke that range in thickness from 2 cm to 2 m, averaging about 30 cm (see Plate IIa and b). There is only minor variation in composition in the unit and no persistent marker beds have been discovered. The greywacke consists of quartz grains, rock fragments, plagioclase grains that range in composition from albite to oligoclase and are partly replaced by sericite, and a matrix of chlorite, biotite, sericite, carbonate and iron ore. Little or no potash feldspar is evident in thin section. The quartz content is variable and locally the rock almost grades into an impure quartzite, but the quartzite, does not form distinctive mappable beds (see Plate IIc). The typical rock is a graded feldspathic meta-greywacke. Although the pelitic upper portion of the graded beds is locally very thin to almost non-existent, there is a significant increase in the relative proportion of matrix toward the tops of these beds.

Primary sedimentary structures are well preserved, even with relatively high-grade metamorphism. The most common is graded-bedding marked by a very distinctly coarser quartz-feldspar-rich zone at the base which grades into a more pelitic upper zone that is locally very rich in metamorphic biotite. Other common primary structures are load casts, flame structure, small scour channels, intraformational conglomerate lenses, and ripple drift cross-lamination in sets about 2-3 cm thick. Because of the graded beds, the rocks commonly have a banded appearance and locally there is conspicuous refraction of the cleavage or schistosity across the graded beds (see Plate IIb). However, locally, the layering is difficult to distinguish, particularly where folding is intense. The typical weathering colours are dark grey to pale brown. Chemical analysis of five specimens of greywacke from this unit indicate that they are derived from a basic to intermediate igneous (volcanic ?) suite and not a granitic terrane (see Figs. 5 and 6 and Table 6).

The monomict greywacke conglomerate unit (map unit P_2) consists of subangular pebbles and cobbles, up to 80 cm long, but usually between 5 and 30 cm long, of greywacke or pelite in a greywacke matrix (see Plate IIIa and b). Wilson (1962) and Podolsky (1950) included these conglomerates in the Timiskaming Group; however they are distinctly different from overlying polymict conglomerates that are characteristic of the Timiskaming Group; and moreover, they

Table 6. Chemical analyses of five specimens of greywackes from the Pontiac Group (P_1). Analyses by X-ray fluorescence performed by F. Dunphy at Queen's University.

	I	II	III	IV	V
SiO_2	63.25	66.90	60.20	63.10	64.80
TiO_2	.52	.46	.64	.57	.53
Al_2O_3	14.30	14.10	15.30	14.50	14.80
Fe_2O_3	4.78	4.00	6.17	5.23	4.78
MgO	2.40	1.80	3.45	2.95	2.50
CaO	1.98	2.70	1.95	2.63	2.52
Na_2O	3.50	4.08	3.58	3.80	4.50
K_2O	1.39	1.35	2.07	1.23	2.02
Sample No.	124-2	88-4	126-1	1-3	126-2
Sample No. on Figs.5,6	8	9	10	11	12
Locations	Range II	Range II	Range III	Range III	Range IV
	Lot 53	Lot 15	Lot 36	Lot 38	Lot 49
	Beauchastel Tp.	Rouyn Tp.	Rouyn Tp.	Rouyn Tp.	Rouyn Tp.

Plate II

a. Map unit P_1: Pontiac Group.

Graded beds of the greywacke dip northwest and face southeast. A distinct schistosity truncates the bedding at high angle. Pick handle is 30 cm long. (Range II, lot 12, Rouyn Tp.).

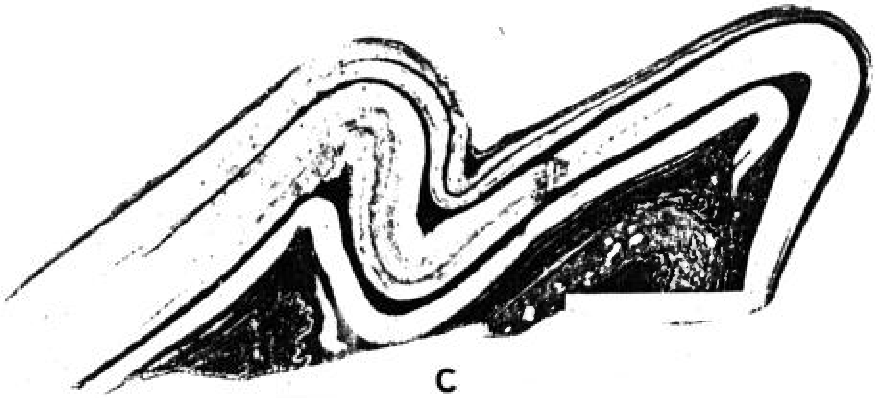
b. Detail of "a" showing refraction of schistosity in a graded bed. The base of the bed (left) is coarse grained quartzo-feldspathic greywacke with spaced schistosity. This grades in the upper part of the bed to a highly schistose micaceous pelite. Pencil is 15 cm long (Range II, lot 12, Rouyn Tp.).

c. Refolded folds of impure quartzite and mica schist from the Pontiac Group. (Range IX, lot 1, Montbeillard Tp.).

Plate II

A

B



C

are at least partly intercalated with the greywackes that are typical of the Pontiac Group. At the locality in Rouyn Township, south of Granada, the monomict conglomerate occurs as a lense approximately 900 m long and 400 m thick that is completely enclosed within greywacke typical of the Pontiac Group. Within this lens the conglomerate is intertongued with greywacke (Plate IIIa) and appears to consist of several channel fill deposits that are nested one upon the other and form a larger channel-fill deposit within the greywacke of the Pontiac Group. However, at the locality northeast of Lac Beauchastel, in Range III of Beauchastel Township, the monomict greywacke conglomerate of the Pontiac Group grades upward over an interval of 500 m of intercalated greywacke and conglomerate into a polymict conglomerate that contains pebbles, cobbles and boulders of acid volcanic and hypabyssal intrusive rocks that elsewhere are characteristic of the conglomerates of the Timiskaming Group. This gradational contact has been taken as the boundary between the Pontiac Group and the Timiskaming Group. Elsewhere the contact is a sharp boundary between a polymict conglomerate above and a greywacke below (see Plate XIb). At least three lenses of well-bedded greywacke occur in the monomict conglomerate in Beauchastel Township. The upper contact with one of these is well exposed over a length of about 30 m just southeast of a diabase dyke, in lot 55, Range II. This contact is sharp and conformable with only local channelling at the base of the conglomerate (see Plate IVa and b). Near the contact the bedding is not discernible in the massive conglomerate but elsewhere there is both reverse and normal graded-bedding

Plate III

a. Map unit P_2: Pontiac Group

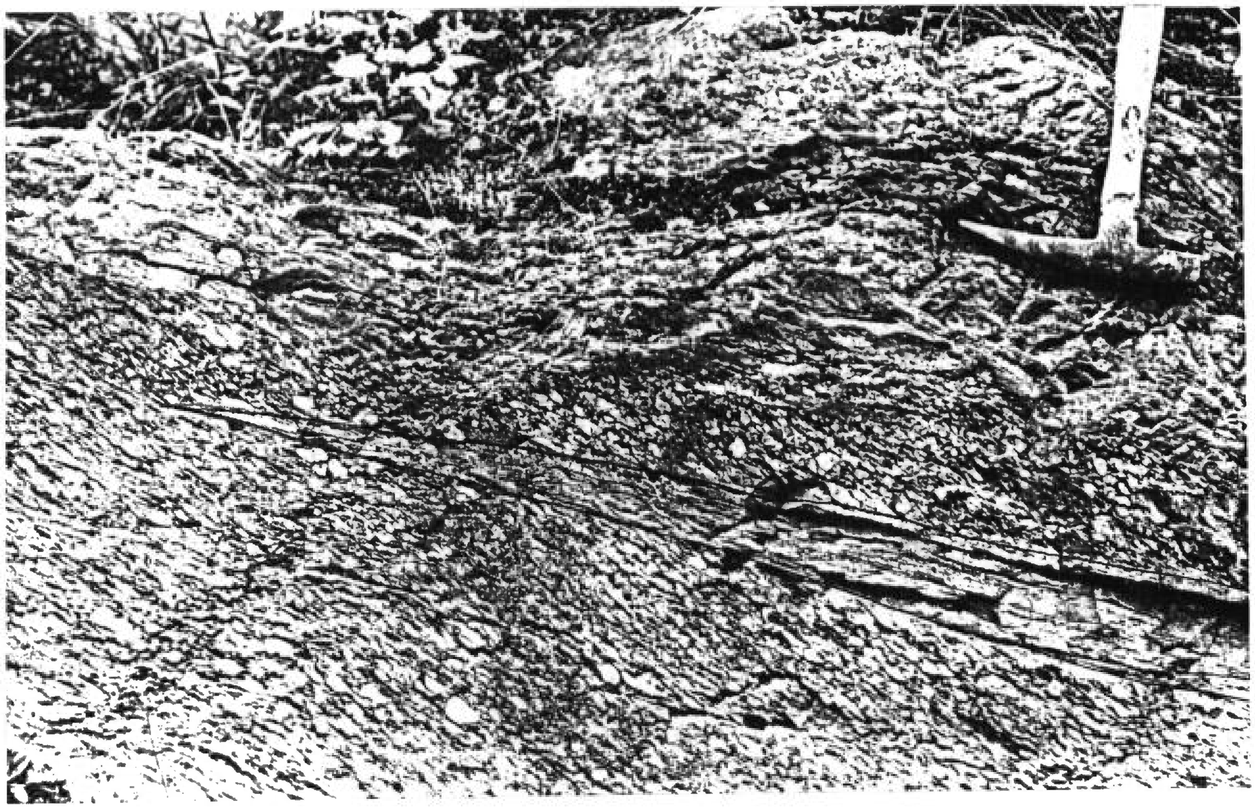
Monomict greywacke pebble conglomerate showing intertonguing with greywacke and flattening of pebbles in a foliation at a high angle to the bedding. The pick is 30 cm long. (Range II, lot 54, Beauchastel Tp.).

b. Detail of part of "a".

Monomict greywacke pebble conglomerate overlies tongue of greywacke and shows, reverse graded-bedding. Coin is 2.5 cm in diameter. (Range II, lot 54, Beauchastel Tp.).

Plate III

A



B

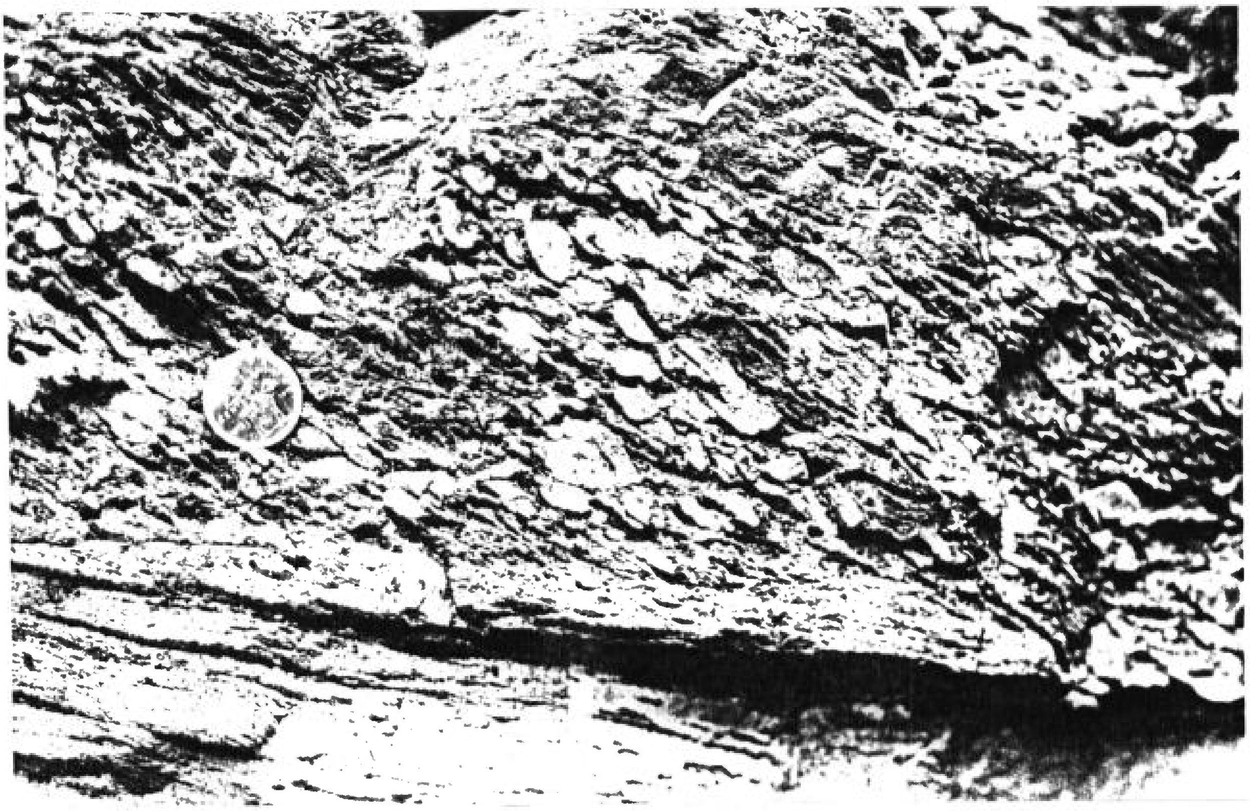


Plate IV

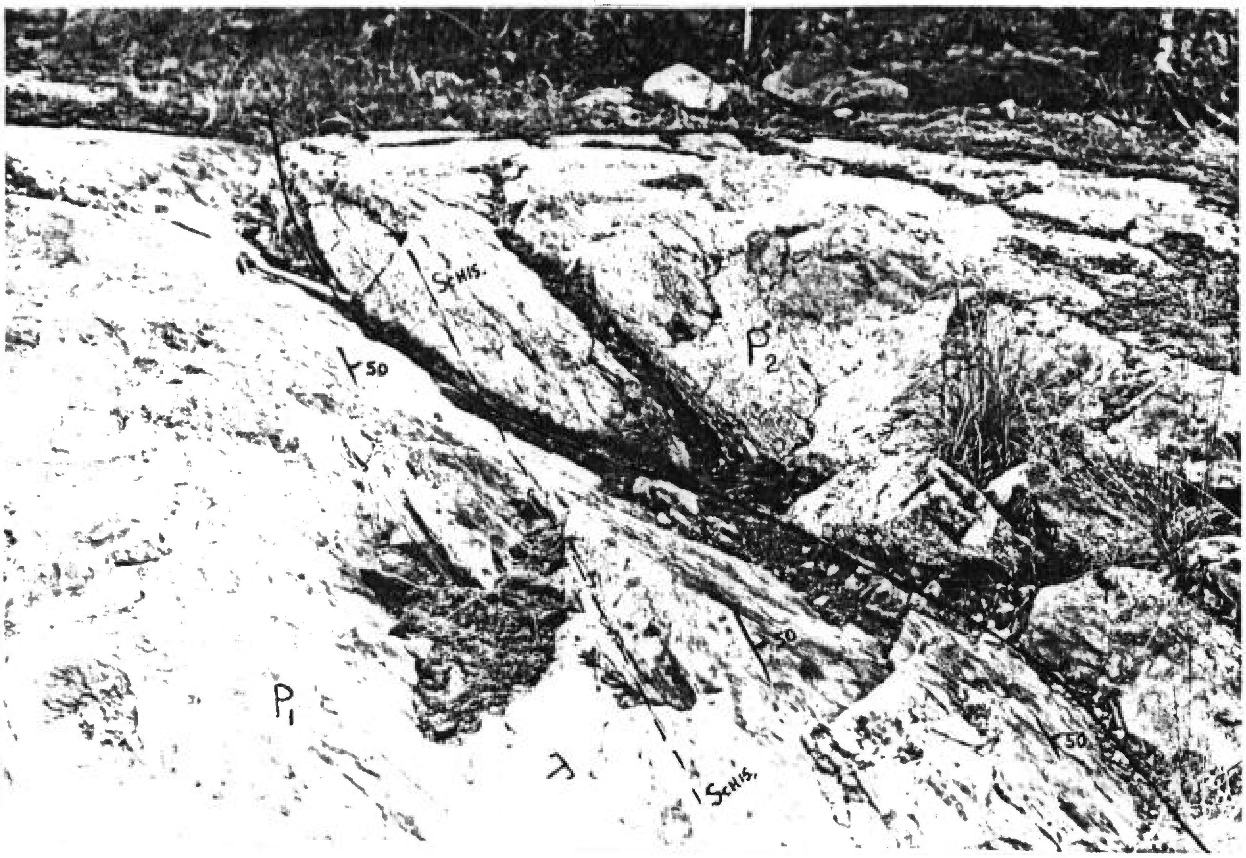
a. Contact between map unit P_1 and P_2.

Local channelling in the greywacke (P_1) filled by the monomict greywacke conglomerate (P_2). The stratigraphic top is to the right and the depth of erosion is about 1 m in the greywacke. The schistosity has the same orientation in both units. The pick handle is 30 cm long. (Range II, lot 55, Beauchastel Tp.).

b. Detail of part of 'a' showing truncation of graded bedding in unit P_1 (faces north) against greywacke of unit P_2; and continuity of schistosity (sch) across contact. The pick handle is 30 cm long.

Plate IV

A



B

(see Plate IIIb). The monomict conglomerates in the upper part of the Pontiac Group appear to represent submarine channel-fill deposits, comprising greywacke detritus eroded from the Pontiac Group further up slope in the channels.

The conglomerate and greywacke unit near McWatters, (map unit P?) which is tentatively assigned to the Pontiac Group, has been metamorphosed and contains abundant amphibole, chlorite, biotite and tourmaline, but much of the primary structure and texture is still recognizable. It consists mainly of polymict conglomerate with only minor intercalated greywacke. The greywacke is pale green, medium- to fine-grained, and highly schistose. It consists of rounded to subrounded quartz and plagioclase and some basic volcanic fragments in a recrystallized matrix consisting of chlorite, biotite, actinolite, epidote and tourmaline. Bedding is commonly recognizable, but locally obscure. The fragments in the conglomerate are well rounded to subangular and sharply to poorly defined. They are up to 5 cm long and consist mainly of acidic volcanic rocks, but include mafic volcanic rocks and granitic intrusive rocks and rarely greywacke. However, there are none of the distinctive fragments of magnetite, jaspillite and fuchsite that are characteristic of the "Granada Group" north of the Cadillac-Larder Lake fault and the lower part of the Timiskaming Group south of the fault. On this basis, the unit is tentatively correlated with the Pontiac Group rather than the Timiskaming Group; and the associated volcanics are correlated with the Blake River Group.

This correlation is consistent with the fact that these rocks occur in the north limit of the Timiskaming Synclinorium about equidistant from the axial region with the Pontiac Group and underlying mafic volcanic rocks of the Blake River (?) Group in the south limb. Moreover on both sides of the Timiskaming synclinorium the metasedimentary rocks and underlying mafic volcanic rocks form a north-south trending anticlinal structure that has been refolded about east-west axial surfaces (see discussion of geologic structure, p. 110. The inferred extension of this unit (map unit P?) along the south side of the Cadillac-Larder Lake fault westward from McWatters to Lac Bouzan is based on the logs of diamond drill holes as reported by Wilson (1962).

Timiskaming Group

Introduction

The Timiskaming Group occurs in an east-west trending synclinorium that extends across the centre of the map area and lies between the Cadillac-Larder Lake fault on the north and the top of the Pontiac Group in the south. Within this synclinorium the Timiskaming Group has been divided, in the course of this study, into four informal stratigraphic units. The lowest of these is a polymict conglomerate characterized by the occurrence of magnetite pebbles (map unit T_{1A}). It is succeeded by a greywacke unit (map unit T_{2A}), a quartz-feldspar porphyry conglomerate unit (map unit T_{3A}) and a pebbly sandstone (map unit T_{4A}) which forms the top of the Archean succession in the area.

The lower conglomerate unit which contains the magnetite pebbles (map unit T_1) has only been observed in the southern limb of the synclinorium and lies directly upon the Pontiac Group. It extends from beneath the unconformable cover of the Cobalt Group in the western part of the map area to the eastern part of the map-area where it becomes thin, and is overlapped by the overlying greywacke unit about 1 km west of the Kinojevis River.

The apparently conformable sharp contact with the underlying greywacke of the Pontiac Group (map unit P_1) has already been discussed. The contact with the overlying greywacke unit (map unit T_2) is gradational over an interval of about 8 m in which greywacke and conglomerate are intercalated. A bed of a yellowish green tuffaceous sandstone, approximately 3 m thick commonly is found at the top of the conglomerate unit.

Map Unit T_1

Map unit T_{1A} is a polymict conglomerate composed of rounded to subrounded pebbles of acid to mafic volcanic rocks, acidic intrusive rocks, greywacke and pelite, and laminated magnetite pebbles. No pebbles of jaspillite, fuchsite or variolite have been found in it. The unit is generally a framework supported, very thick bedded boulder conglomerate, 10-30 m thick, with few greywacke interbeds. Internal stratification is outlined locally by alternation of beds of finer and

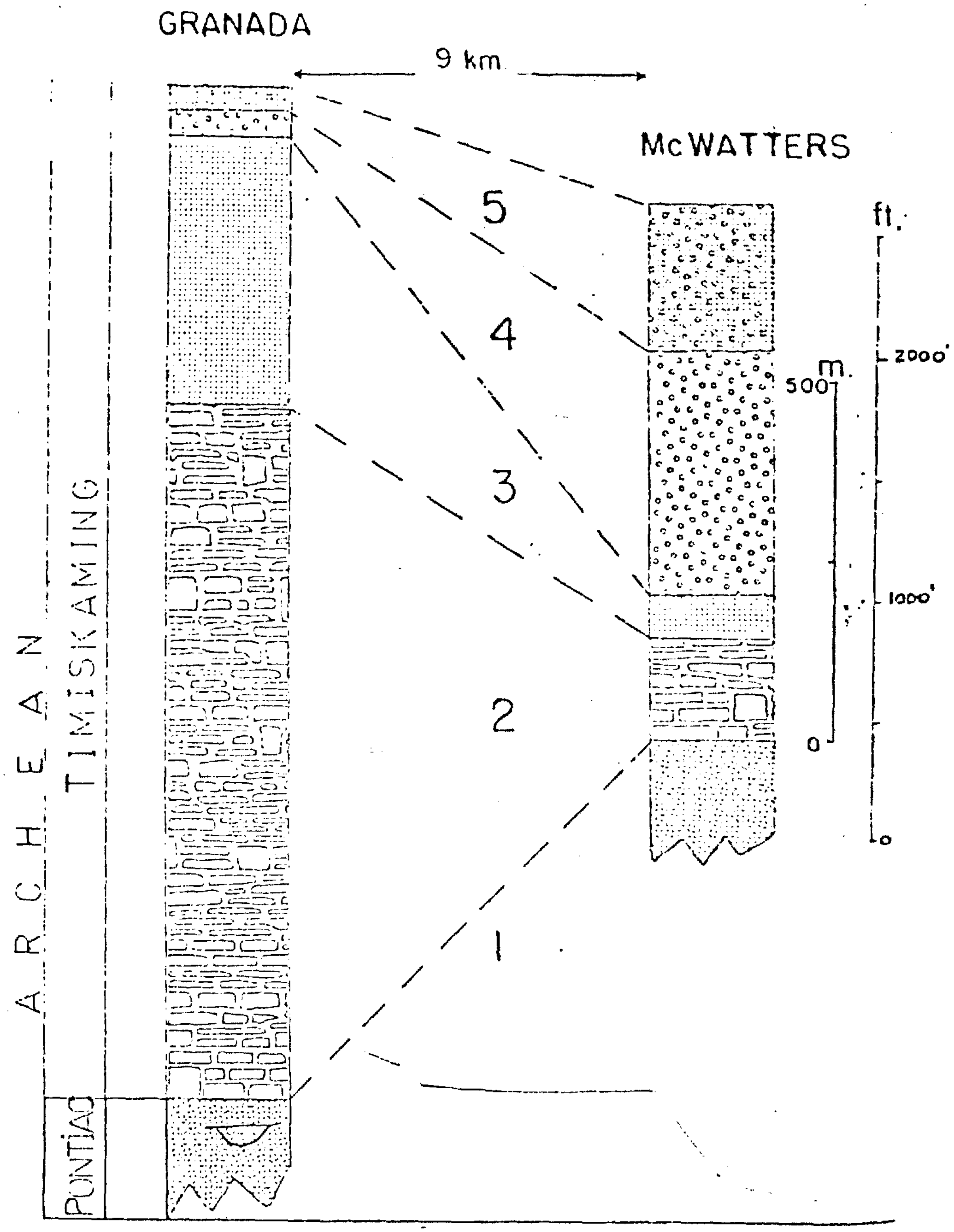


Fig. 7. Stratigraphic sections along Granada road and McWatters road showing thickness variations among units in the Timiskaming Group.

1. greywacke and greywacke conglomerate (unit P_1 and P_2)
2. polymict conglomerate with magnetite pebbles (unit T_1)
3. greywacke (unit T_2)
4. porphyry conglomerate (unit T_3)
5. pebbly sandstone (unit T_4).

coarser clasts. No regional variations in the size or composition of the pebbles have been detected. The conglomerate unit thickens from east to west. It is approximately 100 m thick south of McWatters, 250 m thick north of Lac Bruyère, and 900 m thick south of Granada (see Fig. 7). These estimates of the thickness are based on the dip of the adjacent beds and do not take into account the effect of deformation. Although evidence of the stratigraphic tops in the conglomerate is very rare, wherever observed, the conglomerate is north-facing and strikes east-west.

One of the main distinguishing characteristics of the conglomerate is the presence of pebbles of magnetite which are lacking in other conglomerates, except the one north of McWatters. The magnetite pebbles are small (usually <4 cm), tabular, and laminated, and comprise less than 1 per cent of the conglomerate in any individual outcrop. They are most common in the upper part of the conglomerate unit and generally are represented by only trace amounts in the lower part. The source of these magnetite pebbles was probably the iron formation which occurs in the Cadillac Group, about 3 or 4 km east of Joannes Township and also further east in the Cadillac Township, as well as further north in the Kinojevis Group.

The clasts in the conglomerate are very much deformed. Granodiorite, chert and acid volcanics are least deformed, but fragments of basic volcanic rocks, greywacke, argillite, and magnetite are typically flattened and molded around these more resistant clasts (see Plate Va).

The relative proportions of the different types of clasts in the conglomerate were estimated using a sampling grid technique, but no significant patterns of variation were detected from one part of the area to another. The proportion of acid volcanic rock fragments varies from 20 to 47 per cent, the sedimentary rock fragments from 10 to 37 per cent, the basic volcanic rock fragments from 5 to 35 per cent, the intrusive rock fragment from 3 to 65 per cent, the matrix comprises 5 to 25 per cent of the rock, and magnetite, chert and rare quartz clasts make up less than 1 per cent. The clasts derived from intrusive rocks are mainly of granodiorite. Chemical analyses of two boulders are given in Table 7 (p. 55). Although the clasts are generally between 5 and 25 cm in diameter some are up to 1 m long. Coarse feldspar porphyry clasts containing phenocrysts of albite up to 5 cm long have only been observed in this conglomerate unit. It does not contain any clasts of foliated granite. The matrix varies from medium- to fine-grained sandstone to sandy argillite. It is composed of detritus similar in composition to the phenoclasts. Feldspar, quartz, chlorite, biotite, muscovite, sericite and carbonate are the most common minerals in the matrix.

Lenticular beds of greywacke occur in the conglomerate and are most abundant in the thicker succession, SW of Granada village. Most of these are too small to be shown separately on the map, but the

Table 7. Chemical analyses of six specimens of greywacke from Unit T_{2A} of the Timiskaming Group (I to VI) and two specimens (VII and VIII) of granodiorite boulders in the Timiskaming conglomerate. Analysis by X-ray fluorescence by F. Dunphy, Queen's University.

	I	II	III	IV	V	VI	VII	VIII
SiO_2	59.9	63.95	57.2	62.95	69.6	56.95	66.5	62.36
TiO_2	.44	.58	.63	.57	.28	Nil	.42	.32
Al_2O_3	17.05	14.9	14.6	14.1	13.8	16.67	15.75	17.96
Fe_2O_3	4.95	5.68	7.1	5.21	3.78	Fe_2O_3: .86 FeO: 6.72	4.6	Fe_2O_3: .62 FeO: 4.24
MgO	3.25	3.98	3.95	2.9	2.45	3.22	1.8	1.45
CaO	4.9	2.05	6.02	1.75	.9	4.15	4.0	4.58
Na_2O	2.9	4.53	3.52	3.87	1.25	2.94	5.85	4.38
K_2O	2.69	1.14	3.43	1.78	2.57	2.43	.64	.78
Sample No.	104-1	94-2	71-4	126-3	60-3	HAWLEY (1932)	50-4	WILSON (1962)
Sample No. on Figs.5,6	13	14	15	16	17	18	19	20
Locations	Range IV Lot 62 Beauchas-tel Tp.	Range IV Lot 13 Rouyn Tp.	Range IV Lot 32 Rouyn Tp.	Range V Lot 49 Rouyn Tp.	Range V Lot 62 Rouyn Tp.		Range IV Lot 31 Rouyn Tp.	

Plate V

a. Map unit T_{1A}, Timiskaming Group

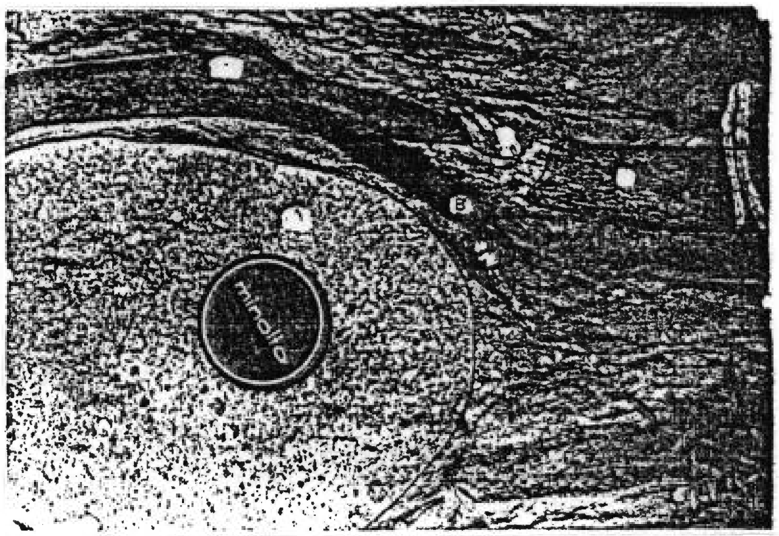
Deformed conglomerate. The felsic clasts are least deformed, and the flattened mafic clasts are bent around them. The clasts consist of: a - granodiorite, b - laminated magnetite, c - mafic volcanic rock, d - sedimentary rock with fine laminations. (Range III, lot 15, Rouyn Tp.).

b. Map unit T_{2A}, Timiskaming Group.

Deformed cross bedding. Penetrative foliation is parallel with the pencil and perpendicular to the orientation of the bedding. The top faces toward the bottom of the photograph. (Range IV, lot 31, Rouyn Tp.).

Plate V

A



B

Plate VI

a. Map unit T_{2A}, Timiskaming Group.

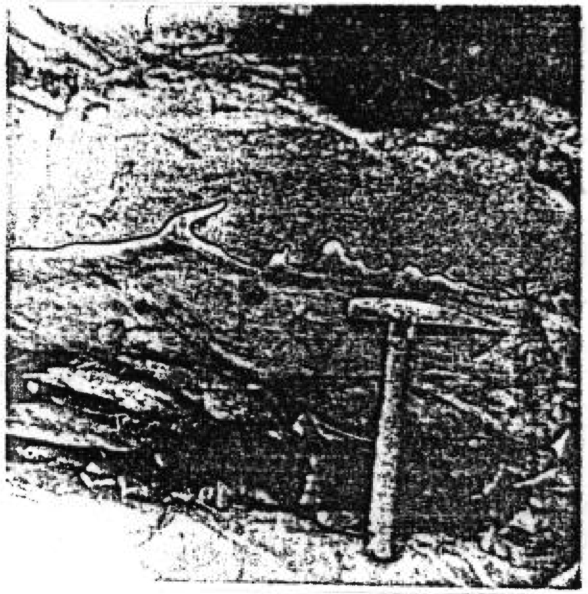
Flame structures and load casts in a graded-greywacke. The pick handle is 30 cm long. (Range IV, lot 33, Rouyn Tp.).

b. Map unit T_{2A}, Timiskaming Group.

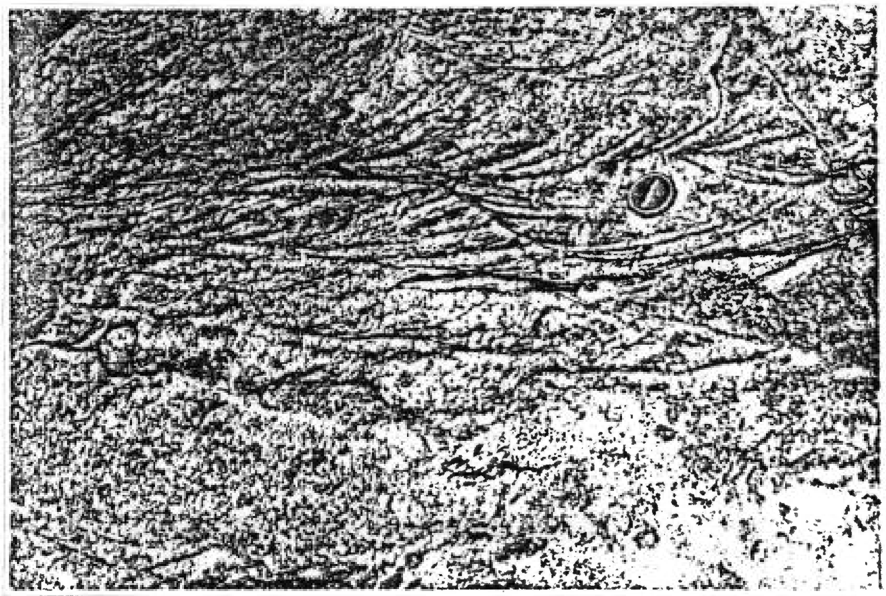
Cross lamination and rounded pebble (on the left). Same horizon as in Plate Vb, but on the flank of an isoclinal fold. (Range IV, lot 32, Rouyn Tp.).

Plate VI

A



B



large ones (map unit T_{1B}) have been shown separately from the conglomerate. The top and base of those beds are normally very sharp; the greywacke is not graded and it contains many pebbles as stringers, isolated clasts and thin pebble conglomerate beds.

After the deposition of the turbidites of the Pontiac Group (unit P_1) and the filling of the channels (unit P_2), there was a strong uplift in an area north of the Cadillac-Larder Lake fault. Erosion of earlier sediments, uncovered intrusive rocks, which contributed to the oldest conglomerate (unit T_{1A}). This appears to have accumulated as a mass flow deposit which was subsequently covered by turbidites comprising unit T_{2A}. The conglomerate with magnetite pebbles probably accumulated in a marine environment on the fore slope of a delta, which was prograding over the deeper water deposits of the Pontiac Group.

Map Unit T_2

The greywacke unit (map unit T_2) can be followed from east to west across the area in both limbs of the Timiskaming syncline. West of Lac Beauchastel it is unconformably overlain by the Cobalt Group; to the north it is truncated by the Cadillac-Larder Lake fault zone, and to the south it is underlain conformably and gradationally by the polymict conglomerate unit (map unit T_1). It is overlain conformably by a porphyry conglomerate unit (map unit T_3) along the base of which there is local evidence of erosional channelling. There are conspicuous lateral and vertical facies variation in the greywacke unit. Lenses of polymict conglomerate (map unit T_{2B}), crystal tuff and tuffaceous sandstone (map unit T_{2C}) occur within it, particularly between Lac Bouzan and Granada. Near the contact with the overlying porphyry conglomerate the greywacke grades upward into a laminated (1 mm - 3 mm) siltstone and argillite in which the thicker beds (>3 cm) shows good normal graded bedding.

The greywacke which is the predominant rock type in this unit is a well bedded, and usually well graded dark grey to brownish grey, fine- to medium-grained rock composed of alternating beds of dark grey mudstone and impure sandstone. It grades laterally in some places into a coarse sandstone. The greywacke is composed of quartz, plagioclase, rock fragments (mainly basic volcanic rocks) with a matrix of carbonate, epidote, biotite, actinolite, sericite and iron ore in variable amounts. Sedimentary structures such as graded bedding, cross lamination and slumping are very well preserved (see Plate Vb and Plate VIa and b). Chemical analyses of six specimens of greywacke from unit T_2 are listed on Table 7 and displayed in Figs. 5 and 6. They indicate that, except for one sample, the greywacke coincides in composition with a basic volcanic rock suite.

The conglomerate lenses (map unit T_{2B}) are minor in amount, but locally, such as in the area south of Granada and south of Lake Bouzan, they become very abundant. They vary in thickness from 1 m to about 50 m. The conglomerate is a polymict assemblage of rounded to subrounded clasts, averaging between 5 to 15 cm in diameter, and consisting of basic to acid volcanic rocks, greywacke, pelite, granodiorite, black chert, and small pebbles of quartz. It is typically framework supported, occurs in lenticular beds and grades laterally into sandstone. The conglomerate that occurs between McWatters and the Kinojevis River, south of the Cadillac-Larder Lake fault has been tentatively assigned to the unit T_{2B}, mainly because of its close association with the greywacke of map unit T_{2A}. However, it could belong to map unit T_{1A}, even though no magnetite pebbles have been found in it. The matrix of this conglomerate shows a conspicuous increase in chlorite content, particularly in lot 62, close to the mafic volcanic rocks. On the north side of the small anticline, south of the Cadillac fault near the Kinojevis River, the matrix contains a high proportion of chlorite and carbonate and the pebbles are extremely deformed. In the same area greywacke has been observed intercalated with the conglomerate, but it occurs as lenses which are too small to portray on the map.

The crystal tuff and the tuffaceous sandstone unit (map unit T_{2C}) occurs south and west of Lac Bouzan. It is a very distinct, dark to pale green chloritic unit, in which dark, sub-angular fragments, a few mm in diameter, occur in a chloritic and carbonate-rich matrix. The crystal fragments have been replaced by amphibole or carbonate. They commonly occur in graded beds about 5 to 20 cm thick and locally up to 50 cm thick. Although complex folding and lateral facies variations obscure the true thickness of this unit, it is estimated to be about 60 m. In thin section, this rock consists of angular fragments of basic volcanic rocks that have been replaced by actinolite, but may have originally been crystals of pyroxene. The matrix consists of quartz, plagioclase, chlorite, biotite, epidote and carbonate.

Acid tuff also occurs in association with greywacke of map unit T_2 but does not form a mappable unit. The best exposure occurs west of the cemetery in Granada where the tuff is a very fine-grained, yellow brown rock with a conchoidal fracture. It forms a unit averaging 5 m thick that is exposed along strike for 200 m. One of the main characteristics of map unit T_2 is the conspicuous lateral and vertical facies variations that occur within it. These are well displayed in the area south of Lac Bouzan, where they have been studied in detail by M. Rocheleau (in Dimroth _et al._, 1975) who has concluded that the greywacke unit in the Lac Bouzan section represents a transition between the alluvial deposit of steep sloped southerly prograding delta fan and the marine deposits of the adjacent deeper water turbidite basin.

The marine deposits are represented by greywacke turbidites that occur south and west of Granada and south of McWatters. The transitional deposits, in the intervening zone south of Lac Bouzan were considered by Rocheleau to represent the deposits that formed along the margin of a fluvial delta complex which must have been situated further north. In the transition zone south of Lac Bouzan, the conglomerates are replaced toward the south by well graded beds of greywacke showing divisions A and B of a typical Bouma sequence (Bouma, 1962).

The conglomerate occurs in units that vary in thickness from several metres to a layer consisting of a few pebbles aligned in the bedding of the sandstone. The conglomerate is not graded and does not show internal stratification. It is usually framework supported or nearly so, and is locally underlain by a cyclically bedded sandstone-argillite sequence in which the cycles are about 3 to 5 m thick. At the base of the cycle there is a pebbly sandstone or a massive, coarse- to very coarse-grained greywacke in a bed 30 cm to 1 m thick that is not graded. The top of the cycle is thin-bedded, fine-grained sandstone and parallel laminated siltstone and argillite. Some of the fine-grained beds are graded. The conglomerate is usually above the pebbly sandstone and close to the base of a new cycle. The conglomerate is matrix supported (40% or less pebbles), and is usually 50 cm thick. The sandstones interbedded with the conglomerate locally show a very crude graded bedding on a scale of 3 m, and locally there are multiple superimposed channels cut into the sandstone.

The sandstone in the Lac Bouzan section is medium- to coarse-grained; is not graded; and is lenticular. It contains channels about 50 cm deep and a few metres wide. These are lined with a pavement of lag gravel, and contain sandstone with a few trough cross beds, 10 - 50 cm thick. The sandstone lenses vary in thickness, but are normally 10 - 200 cm thick. West of Lac Bouzan, in the area south of Granada the conglomerate and the sandstone are replaced by relatively proximal turbidite deposits (Walker, 1967), comprising greywacke with good development of divisions A, B and C of a typical Bouma sequence (Bouma, 1962) coarse-grained graded greywacke above which there are parallel laminations, and then ripple-drift cross-laminations in sets from 5 to 10 cm thick. Convolute laminations and very well developed slump structures are also present. The turbidite units, which are 10 - 70 cm thick, are incised by erosional channels that locally cut through several turbidite units. These are filled with turbidite deposits, indicating that the flows depositing the turbidites were channelized.

Map Unit T_3

The porphyry conglomerate (map unit T_3) occurs in both limbs of the Timiskaming syncline over an interval of 12 km between Granada and the Kinojevis River. Measured sections show that the porphyry conglomerate is 280 m thick just west of the road south of McWatters, 145 m thick near the road to Bellecombe village, but only 17 m thick north of the Old Granada Mine (see Fig. 7).

The feldspar porphyry conglomerate is a polymict conglomerate (see Plate VIIa and b) characterized by a relative abundance (5 to 25 per cent) of feldspar porphyry clasts. These are of dacitic composition and probably were derived from the Stadacona breccia (Wilson, 1948) which has more or less the same composition. Granodiorite, greywacke and pelite, acid to mafic volcanic rocks, black chert, quartz, and locally magnetite, form the rest of the phenoclasts. The phenoclasts are subrounded to subangular, normally 5 to 25 cm in diameter and rarely up to 50 cm in diameter. They are commonly flattened or stretched. The conglomerate in the lower and middle portion is framework supported, but near the upper contact it is matrix supported with up to 50 per cent matrix and with internal stratification. It occurs in beds from 30 cm to 30 m thick that are not graded and are fairly massive. The matrix is normally a medium- to coarse-grained sandstone in which the effects of intense penetrative deformation make it difficult to distinguish the matrix from some of the phenoclasts. The matrix is composed of chlorite, sericite, carbonate,

Plate VII

a. Map unit T_{3A}: Timiskaming Group.

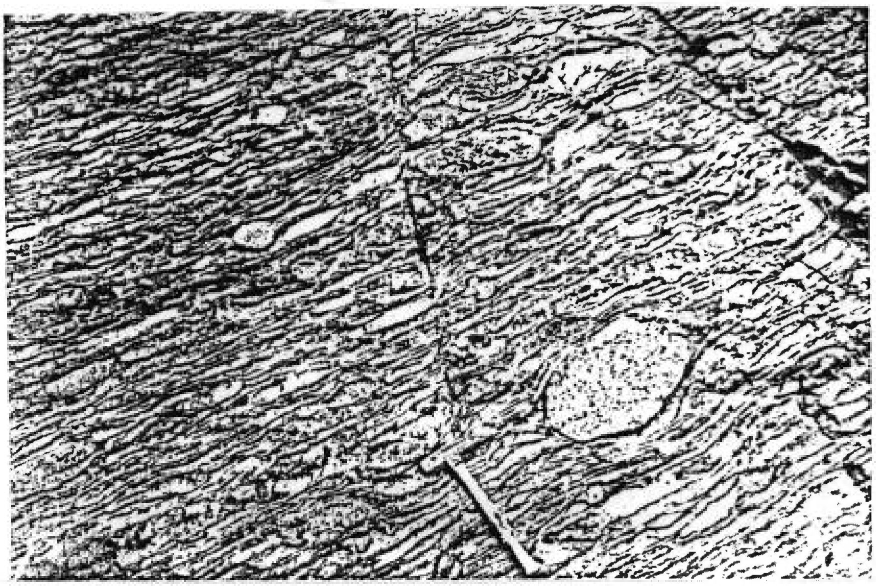
Deformed porphyry conglomerate. Granodiorite clasts are least deformed. Pick handle is 30 cm long. (Range IV, lot 48, Rouyn Tp.).

b. Map unit T_{3A}: Timiskaming Group.

Deformed conglomerate. Clasts of volcanic and sedimentary rock are flattened deformed oblate spheroids. (Range IV, lot 49, Rouyn Tp.).

Plate VII

A



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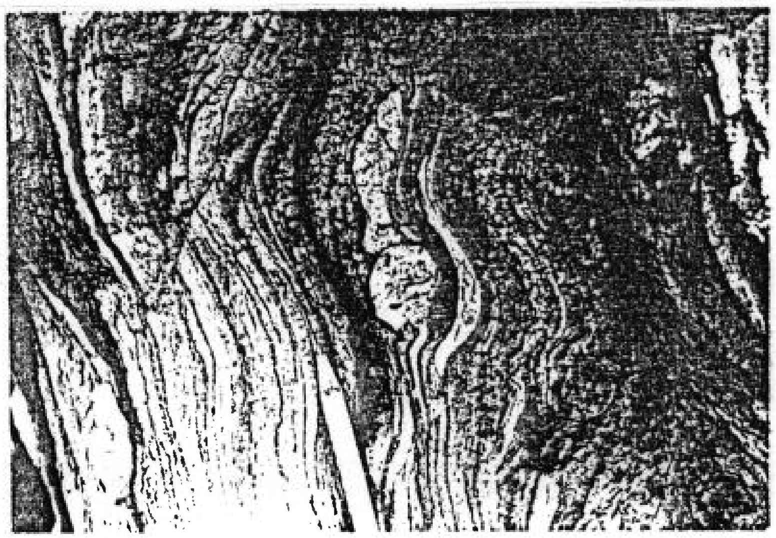


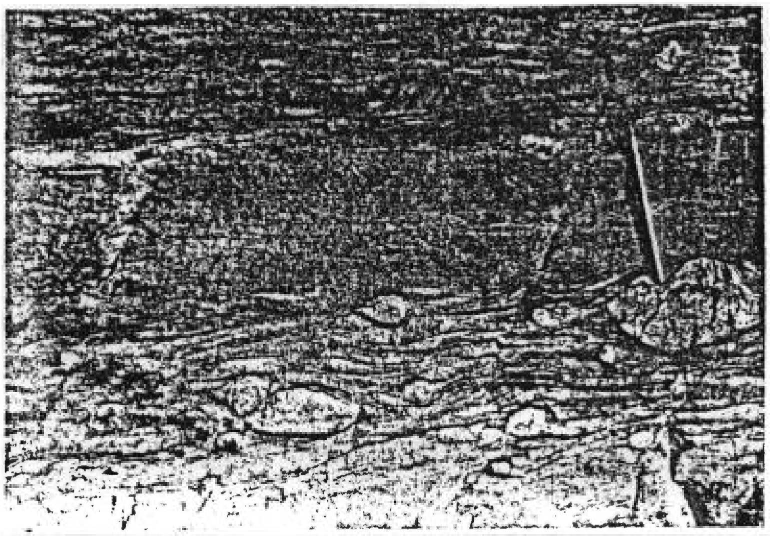
Plate VIII

a. Map unit T_{4A}: Timiskaming Group.

Pebbly sandstone with dominant feldspar porphyry pebbles. The pencil is 15 cm long. (Range V, lot 61, Rouyn Tp.).

b. Isoclinal folding in the pebbly sandstone near the main synclinal hinge. The tight fold can be outlined mainly by the thin laminations in the sandstone. The pick handle is 30 cm long. (Range IV, lot 29, Rouyn Tp.).

A



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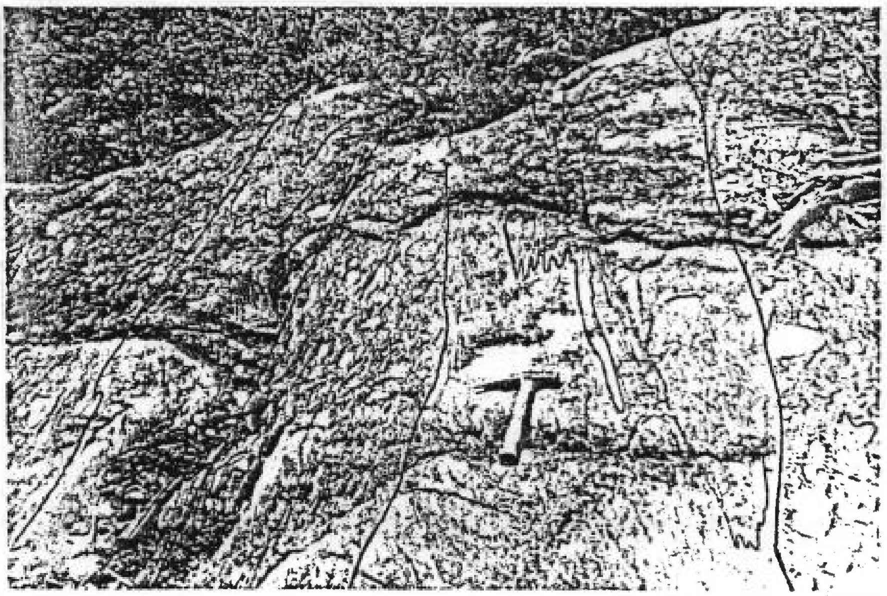


biotite, epidote, iron ores, as well as rock fragments of the same composition as the clasts.

The basal contact with the underlying greywacke unit (map unit T_2) is sharp and conformable. The upper contact with the pebbly sandstone unit (map unit T_4) is gradational through a transition zone about 20 m thick in which the conglomerate is matrix supported and is intercalated with increasing amounts of sandstone that contains lenses of conglomerate.

Greywacke which occurs as lenses (map unit T_{3B}) within the conglomerate is normally medium- to coarse-grained and massive, and occurs in beds 10 - 30 cm thick that commonly contain stringers of pebbles. The greywacke lenses are most common in the northern part of the map-area and are rare in the boulder conglomerates but more common and thinner (10 cm to 5 m) and more persistent in cobble and pebble conglomerates. Because of the intense deformation most of the primary sedimentary structures have been destroyed.

The porphyry conglomerate unit (map unit T_3) has the same characteristic as the lower conglomerate unit (map unit T_1) and therefore it too probably represents a marine deposit which formed in a southerly prograding delta fan complex.

Map Unit T_4

The pebbly sandstone unit (map unit T_4) which comprises the highest stratigraphic unit in the Archean succession in this area, occurs in the core of the Timiskaming syncline. It can be followed over an interval of 8 km from a point about 1 km west of the road to Bellecombe village eastward to the Kinojevis River. The bulk of the unit is a pebbly sandstone (map unit T_{4A}), but intercalated homogeneous sandstone, (map unit T_{4B}) is common locally, especially between McWatters road and Kinojevis River.

The clasts are rounded to subrounded and have the same range of composition as those in the unit below. The feldspar porphyry clasts are more widely dispersed than the granodiorite clasts. Greywacke pebbles, acid to mafic volcanic rocks, black chert, and quartz pebbles form the rest of the conglomeratic fraction. The pebbly sandstone is a matrix-supported mixture of pebbles, cobbles and grit (see Plate VIIIa and b). No systematic pattern of variation in the proportions of different types of clasts has been detected within the area; and no previously foliated clasts have been found in the conglomerate. The pebbles are moderately well sorted. Grading within an individual bed is not obvious, but some beds do show the upward fining of clasts. The matrix is usually a medium to coarse grained sandstone. Laminations are present locally and represent dark argillaceous material. The thickness of individual pebbly sandstone beds varies from 10 cm to 5 m. The total maximum preserved thickness of unit T_4 is about 200 m on the road south of McWatters.

The sandstone beds (map unit T_{4B}) are lenticular and are usually replaced laterally by pebbly sandstone or matrix-supported conglomerate. The sandstone is medium- to coarse-grained, composed of rounded to subrounded grains of quartz and feldspar. Chlorite, biotite, sericite, carbonate, iron ore, epidote and rock fragments form the matrix of the rock. The rock in the outcrop is pale to dark brown. The beds are 5 cm to 2 m thick and are rarely graded. Rare pebbles or cobbles occur within the sandstone, and cross beds 10 to 20 cms thick are discernible locally; but in general sedimentary structures have been destroyed by intense deformation.

The origin of the pebbly sandstone is difficult to interpret but it appears to be associated with marine mass flow deposits, and may have a similar origin.

"Granada Group" (Map unit M)

A distinctive assemblage of polymict conglomerates and greywacke turbidites, which unconformably overlies the Blake River Group along the north side of the Cadillac-Larder Lake fault, near McWatters and Granada, is referred to here, informally, as the "Granada Group". It differs markedly in terms of composition and structural relationships from the Cadillac and Pontiac Groups, which overlie the Blake River Group elsewhere; and although it bears a relatively close resemblance to Timiskaming Group, from which it is separated by the Cadillac-Larder Lake fault, it contains a distinctive conglomerate unit at the base and it is underlain by the Blake River Group, whereas the Timiskaming Group is underlain by the Pontiac Group.

Plate IX

a. Map unit M_1: Granada Group

Polymict conglomerate with pebbles of basic volcanic rock, jaspillite, magnetite, black chert, fuchsite, feldspar porphyry, sedimentary rock and granodiorite. The conglomerate is framework supported. The pick handle is 30 cm long. (Range VI, lot 51, Rouyn Tp.).

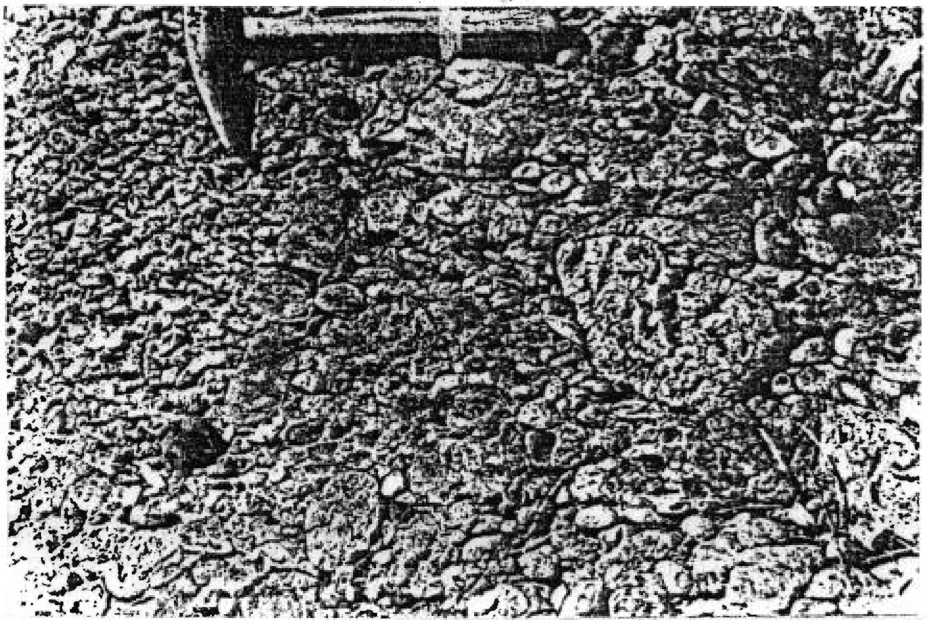
b. Same unit as above but close to the contact between Blake River Group and Granada Group. The matrix is more basic closer to the contact. The pick head is 15 cm long.

c. Large trough cross-bedding in the Granada Group. (map unit M_1).

The beds are steeply dipping to the north and the stratigraphic tops are to the south. (Range VI, lot 51, Rouyn Tp., on the northern part of the main outcrop).

Plate IX

A



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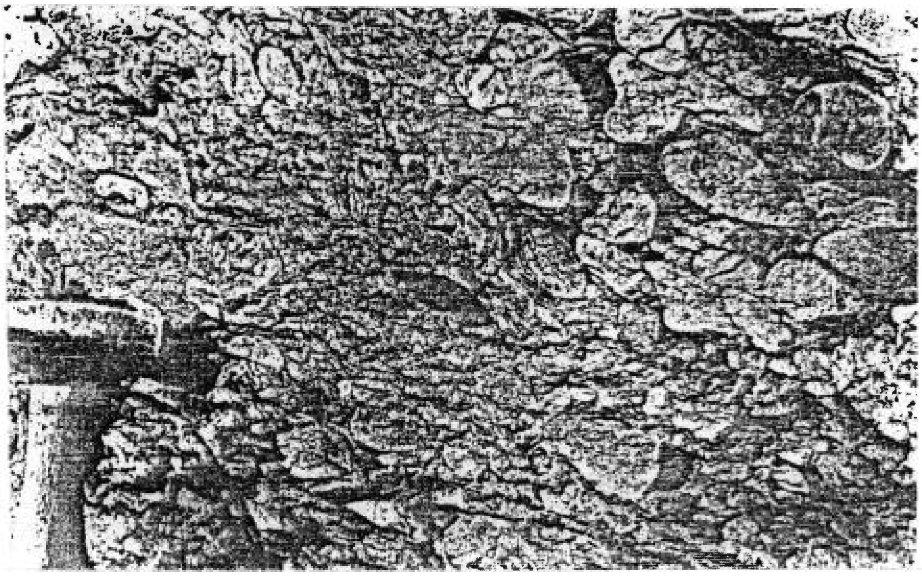


C

The "Granada Group" is probably a lateral equivalent of part of the Timiskaming Group and also the Duparquet Group, north of the Blake River Group, but until this correlation can be adequately documented it would be best to treat it as an independent informal unit.

The "Granada Group" in the Rouyn-Beauchastel area comprises two main rock units: a basal polymict conglomerate (map unit M_1) characterized by clasts of jaspillite, fuchsite, magnetite and variolitic basalt, and an overlying greywacke-sandstone sequence (map unit M_2).

The basal conglomerate consists of rounded to subrounded pebbles or cobbles of basic and acid volcanic rock, greywacke sandstone and siltstone, feldspar porphyry, quartz, magnetite, jaspillite, fuchsite, granodiorite and chert (see Plate IXa and b) that are framework-supported and occur with a matrix of medium- to coarse-grained greywacke sandstone. The phenoclasts are generally between 10 and 30 cm in diameter, only rarely up to 60 m in diameter, and are much less deformed, (except near Granada), than those in the conglomerates south of the Cadillac-Larder Lake fault. The presence of fuchsite (a chromium mica, with a typical light green colour,(see analysis on page 82) and jaspillite is characteristic of this unit. North of McWatters the proportion of mafic volcanic rock fragments in the conglomerate at the base of the map unit M_1, increases and the fragments are subangular, but fairly well sorted. Near Granada area the conglomerate is restricted to a series of lenses in the greywacke which locally lies directly on the mafic volcanics of the Blake River Group.

Individual beds of conglomerate are commonly 1 to 6 m thick, but locally are up to 15 m thick, and are separated by beds of medium- to coarse-grained sandstone, a few centimetres to about 5 m thick. The intercalated sandstone beds contain isolated pebbles, and normally are not graded. One of the main characteristics of this sandstone is the presence of cross beds in sets that are commonly 10 to 50 cm thick and locally up to 2 m thick (see Plate IXc). The paleoslope as defined by the orientation of the cross bedding is to the south and southwest.

Conglomerate overlying the sandstone commonly shows an erosional contact. Bedding is discernible in the conglomerate as a variation in clast size and rough alignment or imbrication of clasts.

In the thickest portion of the "Granada Group" just north of McWatters, the basal conglomerate grades into a medium- to coarse-grained, rarely graded sandstone (map unit M_2); but laterally this sandstone becomes a well graded greywacke. The sandstone (map unit M_2) has the same composition as the sandstone interbeds in the basal conglomerate unit. Channels cut through parallel lamination in a pebbly sandstone are filled by a polymict conglomerate, and stringers and lenses of conglomerate and trough cross beds in sets of 10 cm high are also common. In the thickest section that is preserved, the sandstone sequence is 200 m thick. The sandstone is composed of subrounded grains of quartz, feldspar, volcanic rock fragments, chlorite, sericite, muscovite and a variable amount of carbonate. The proportion of carbonate, as a late alteration mineral, increases toward the top of the unit and toward the Cadillac-Larder Lake fault. It locally forms as much as 50 per cent of the rock which then assumes a rusty brown colour.

North of McWatters, the sandstone grades rather abruptly toward the west from a medium- to coarse-grained rock with practically no graded beds, into fine- to medium-grained greywacke bed with intercalated siltstone and argillite beds showing very good graded bedding, parallel lamination and very well preserved climbing ripple drift cross laminations (see Plate Xa and b). Those greywacke were also derived from a volcanic suite as can be seen from Figs. 5 and 6 and in Table 8.

At Granada, the greywacke is highly deformed and primary structures have been partly obliterated. Adjacent to the mafic volcanic rocks the greywacke is generally massive and no bedding can be discerned directly at the contact. Differentiated crenulation cleavage parallel with the 4th schistosity (see details in chapter V on structural geology) can be traced across both rock units. Away from the contact the greywacke is well bedded, in units from 2 to 10 cm thick, with diffuse lenses of conglomerate that include the pebbles of jaspillite, fuchsite, magnetite, and variolitic basalt that are characteristic of the "Granada Group".

Plate X

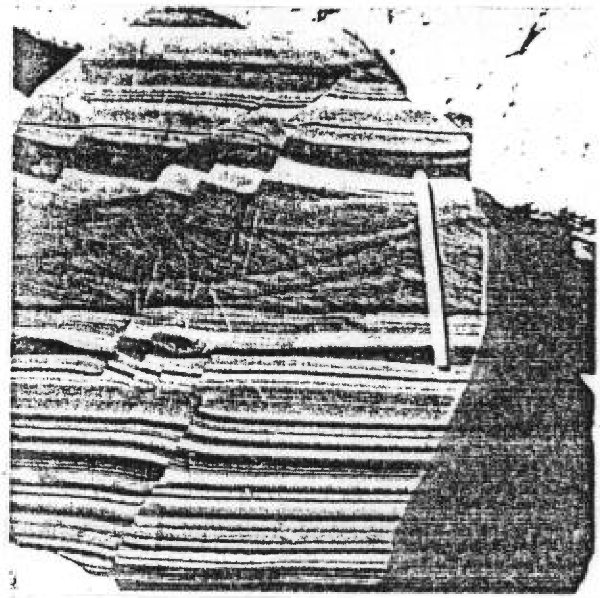
a. Greywacke from the Granada Group (Unit M_2). Showing a sequence from graded-bedding, through parallel lamination and climbing ripple-drift cross laminations to an upper pelitic unit. The match is 6 cm long. (Range V, lot 47, Rouyn Tp.).

b. Detail of 'a'.

The faulting is parallel to the northeast fault system in the area.

Plate X

A



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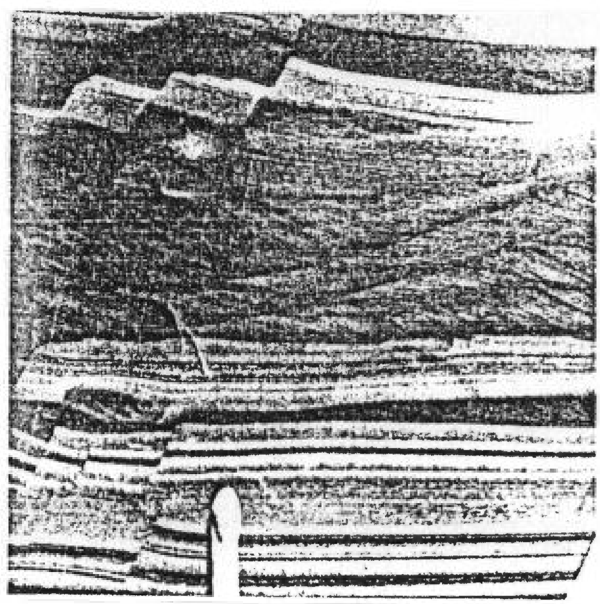


Table 8. Chemical analyses of three specimens of greywacke from the "Granada Group". Analyses by X-ray fluorescence by F. Dunphy at Queen's University.

	I	II	III
SiO_2	60.0	69.5	63.9
TiO_2	.73	.4	.54
Al_2O_3	18.2	12.0	11.8
Fe_2O_3	6.85	3.9	6.5
MgO	2.92	1.85	3.1
CaO	.45	1.68	3.0
Na_2O	2.75	2.0	.3
K_2O	2.3	1.3	1.28
Sample No.	104-7	52-6	127-2
Sample No. On Figs. 5,6	21	22	23
Locations	Range IV	Range VI	Range VI
	Lot 55	Lot 51	Lot 51
	Beauchastel Tp.	Rouyn Tp.	Rouyn Tp.

Table 9. Four electron microprobe analyses of fuchsite in the "Granada Group", performed by Dr. M. Corlett at Queen's University.

Sample No.	172-5		173-5	
	(1)	(2)	(1)	(2)
Na_2O	1.53	2.04	3.31	2.18
MgO	.45	.31	.39	.34
Al_2O_3	36.05	37.48	37.47	36.63
SiO_2	46.82	47.19	46.07	46.84
K_2O	8.28	6.95	6.44	7.71
CaO	.07	.00	.06	.08
TiO_2	.05	.05	.15	.00
Cr_2O_3	.70	.83	.44	.76
MnO	.00	.00	.03	.00
Fe_2O_3	.89	.91	.87	.81
Total wt.%	94.84	95.76	95.23	95.35

The pattern of channelling, the coarse cross bedding, and the rapid lateral variations from conglomerate to sandstone all suggest that the sediments of the "Granada Group" represent the deposits of a piedmont alluvial fan (Turner and Walker, 1973).

The Sub-"Granada Group" unconformity

A sharp contact between the basic volcanic rocks of the Blake River Group and the basal conglomerate of the "Granada Group" is exposed at several localities in the area, and there is no doubt about the existence of an angular unconformity between the two units. Wilson (1962) described an exposure of this unconformity in lot 48; Range VI in Rouyn Township, where the conglomerate shows an irregular contact with the volcanic rock, without any evidence of weathering or soil development.

The unconformity can also be demonstrated in the area about 1.5 km east of Lac Bouzan, where the bedding in the "Granada Group" strikes roughly N60E and dips to the NW but faces south. The strike is more or less parallel to the contact and truncates about 1500 m of mafic volcanic. One good exposure of the truncation of several flows was discovered during this study in lot 42, Range V, in Rouyn Township, where polymict conglomerate, exposed on the southeast side of a cliff, is about 10 to 100 cm thick, and is overlain by a graded greywacke and tuffaceous sediments in which the stratigraphic top, defined by graded bedding, load casts, faces south. The sedimentary rocks at this locality clearly truncate a massive basalt which grades upward to a variolitic pillowed flow top. At two other localities there are channels up to a few hundred feet deep eroded into the volcanic rocks and filled with polymict conglomerate. One is about 1.5 km east of Granada village and the other on the main highway about 1.5 km west of McWatters.

The Pontiac-Timiskaming unconformity reconsidered

M. E. Wilson (1943) and Podolsky (1950) have concluded, on the basis of the exposures along the east-west road south of Granada (in lot 12 of Range II), where they observed an angular discordance between a monomict conglomerate and the underlying Pontiac greywacke, that the Timiskaming Group lies with angular unconformity on the Pontiac Group. However, as was indicated above (p. 40) this conglomerate differs from those which are characteristic of the Timiskaming Group, and moreover, it is interbedded with and enclosed within greywacke typical of the Pontiac Group. Therefore, it should be included within the Pontiac Group and not taken to represent the base of the Timiskaming Group.

The same record of deformation is preserved in both the greywacke and the monomict conglomerate. The schistosity and the lineations defined by elongation of minerals or pebbles have the same orientation in both, and accordingly, there is no indication in the fabric at that specific outcrop (Plate XIa) of deformation that occurred in the greywacke before the conglomerate was deposited.

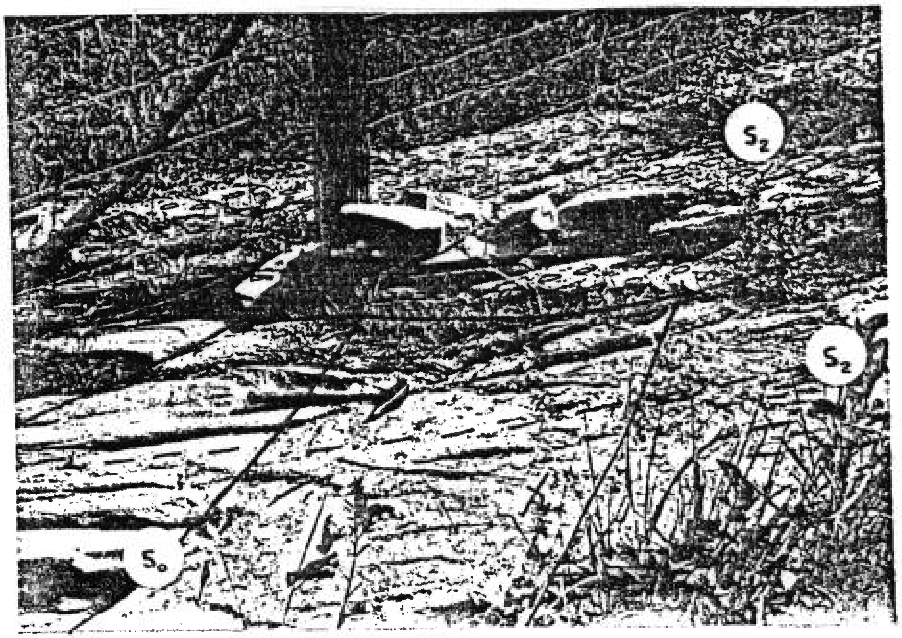
Plate XI

a. Contact between monomict conglomerate and greywacke, Pontiac Group (Range II, lot 12, Rouyn Tp.). The beds (S_o) dip to the left (south) but the stratigraphic tops are to the right. The schistosity (S_2) has the same orientation in both units.

b. Concordant contact between the Timiskaming Group (T_{1A}) and the Pontiac Group (P_1). The beds in the greywacke (S_o) are oriented east-west, facing north, (on the basis of graded-bedding) and the schistosity (S_2) runs NW-SE across both units. (Range III, lot 25, Rouyn Tp.).

Plate XI

A



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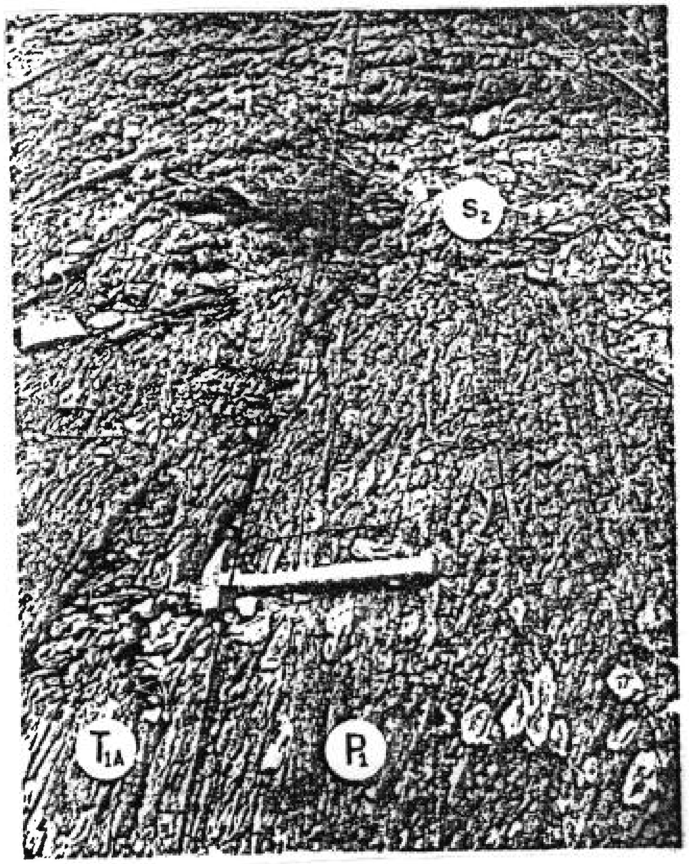


The direction of facing in the greywacke, as defined by graded bedding, is to the SE. Although there is no evidence of bedding or facing direction in the conglomerate the fact that the contact between the conglomerate truncates the bottoms of the beds of greywacke indicates either that the greywackes were overturned before the conglomerate was deposited, or else that the conglomerate or the greywacke (more obviously the conglomerate) was deposited in a channel within which individual beds onlapped the erosion surface cut into the conglomerate (see sketch below).

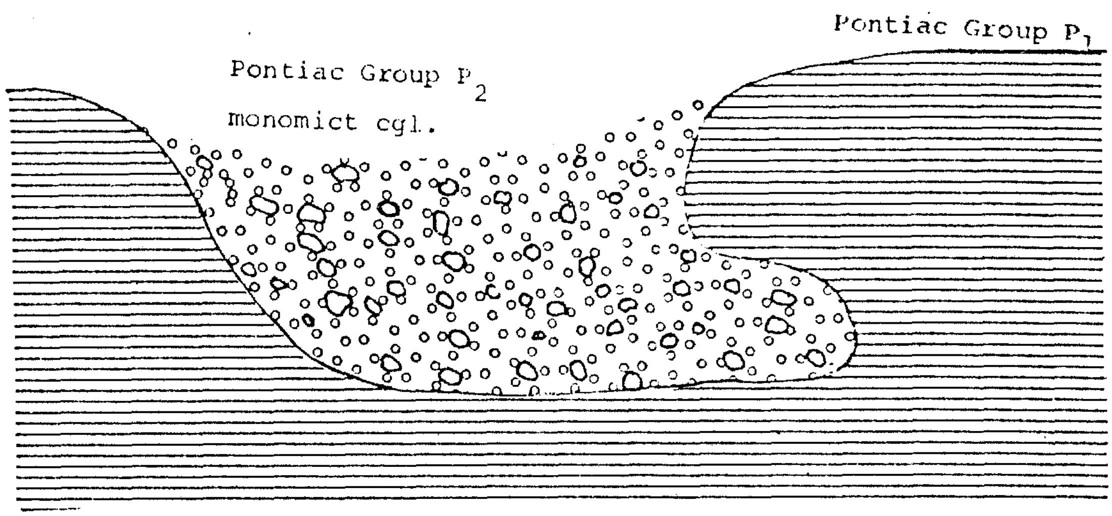


Fig. 8. Schematic cross-section of a channel showing the onlapping of greywacke beds on the conglomerate.

According to M. E. Wilson (1962) an unconformity marks the contact between the southernmost outcrop of conglomerate of the Timiskaming

Group and the greywacke of the Pontiac Group. Podolsky (1950) on the other hand concluded that there is a perfectly conformable discontinuous unit of bedded quartzose, argillaceous or sandy sediment that belongs to the Timiskaming Group and occurs underneath the southernmost outcrops of polymict conglomerate, but above the erosion surface that separates the monomict conglomerate and the greywacke south of Granada in lot 12 of Range II.

On the basis of my examination of all the exposures of the contact between the polymict conglomerate of the Timiskaming Group and the underlying greywacke, I concur with Podolsky in concluding that the contact is conformable and that the same history of deformation is recorded in the rocks that occur above and below it. The greywackes that occur below, and the interbedded conglomerates both contain primary structures indicating that all of the sequence faces north. Evidence of faulting between the polymict conglomerate and greywacke has been found locally. Slickensides, quartz veins aligned parallel with the main east-west schistosity, and small zones of carbonatized schists are common especially north of Lac Bruyère. Local erosional channelling also occurs at the base of the polymict conglomerate (map unit T_{1A}), but regionally there is no evidence of angular unconformity at the base of the polymict conglomerate (see Plate XIb).

It might be argued that an angular unconformity between the polymict conglomerate and the underlying greywacke has been obscured by transposition due to intense deformation, but the fact that the angular discordance between the monomict conglomerate and greywacke south of Granada has not been obliterated by transposition makes this argument unconvincing.

The rocks of the Pontiac Group up to within 1 km of the contact with the polymict conglomerate of the Timiskaming Group contain clear-cut evidence of north-south folds that have been refolded by an east-west folds, whereas in the Timiskaming Group and the upper part of the Pontiac Group only the east-west trending folds are evident. Transposition of the north-south structure by an east-west foliation is, as indicated above, unlikely; and therefore, the greywacke, which occurs immediately underneath the polymict conglomerate, and appears to be conformable with it, might be part of the same depositional unit as the Timiskaming Group, as suggested by Podolsky (1950); and the actual angular unconformity, if there is one, may occur within the greywacke succession further south. This possibility is very difficult to evaluate because no angular discordance has been observed within the greywacke sequence, except where the monomict conglomerate occurs south of Granada, and the only conspicuous change in the composition of the sediments is the one which occurs at the base of the polymict conglomerate which marks the bottom of the Timiskaming Group.

The polymict conglomerates of the Timiskaming Group do not occur in the core of the major east-west trending syncline which lies in the Pontiac Group some 2 km south of the base of the Timiskaming

Group, either because they were not deposited there or because they were eroded from the core of the syncline.

The Timiskaming Group is probably a lateral equivalent of the "Granada Group", which is clearly unconformable on the Blake River Group north of the Cadillac-Larder Lake fault, therefore it should also be unconformable on the Pontiac Group, south of the fault, if the Pontiac Group is indeed a lateral equivalent of the Blake River and Cadillac Groups. However, both may be parts of a wedge type deposit, in which the "Granada Group" represents an alluvial fan on older volcanics, and is replaced to the south by a more distal facies overlapping conformably the sediments of the Pontiac Group. This conformable overlap may be represented northeast of Lac Beauchastel by the contact between the monomict conglomerate (map unit P_2), the greywacke (map unit P_1) and the polymict conglomerate (map unit T_{1A}).

Thus, although several lines of evidence indicate that there is a conformable contact between the Timiskaming Group and the Pontiac Group, the presence of two channels with complex relationships, and superimposed tight folding do tend to obscure the actual contact.

STRATIGRAPHIC UNIT PROPERTIES:	PONTIAC GROUP (P1)	UPPER PART OF PONTIAC GROUP (P2) LAC BEAUCHASTEL MONOMICT CONGLOMERATE	CONGLOMERATE WITH MAGNETITE (T1)	LAC POUZAN AREA (T2A+T2B) CONGLOMERATE NORTH Timiskaming Syncline	SOUTH	PORPHYRY CONGLOMERATE (T3)	PEBBLY SANDSTONE (T4)	MCWATTERS CONGLOMERATE (M1)
Shape of strat. Unit.	Sheet	Channel	Thick lense	Lenticular	Sheet?	Fan?	Fan?	Fan?
Lower contact	Structurally conformable	Erosional channel	Sharp, conformable	Faulted	Gradational	Sharp, conformable	Gradational	Unconformity
Upper contact	Sharp, conformable	Gradational or sharp, conformable	Gradational	Sharp, conformable	Sharp, conformable	Gradational	No upper contact	Sharp, conformable
Lateral relationships	-----	Erosional truncation	On lap	Interfingering	Interfingering	Interfingering	Interfingering	On lap
CONGLOMERATE BEDS:								
1- Shape	-----	1- Channel fill	1- Lenticular	1- Lenticular	1- Lenticular	1- Thick lense	1- Thick lense	1- Thick lense
2- Dimension	-----	2- 900 m x 400 m	2- -----	2- -----	2- -----	2- -----	2 -----	2- -----
3 Lower contact	-----	3- Locally unconformable	3- Sharp, conformable. Local channelling	3- Sharp with local erosional channel	3- Sharp with local erosional channel	3- Erosional	3- Sharp with local channeling	3- Erosional
4- Upper contact	-----	4- Usually sharp	4- Sharp	4- Gradational	4- Gradational	4- Gradational	4- Gradational	4- Gradational
5- Composition	-----	5- Monomict (sediments: essentially greywacke, also pelites, siltstone)	5- Polymict (acid, mafic volcanic, granodiorite, sediments magnetite, feldspar porphyry)	5- Polymict (acid, mafic volcanic, granodiorite, sediments feldspar porphyry)	5- Polymict (acid, mafic volcanic, granodiorite, sediments feldspar porphyry)	5- Polymict (feldspar porphyry, acid, mafic volcanic granodiorite, sediments)	5- Polymict (feldspar porphyry, acid, mafic volcanic, granodiorite, sediments)	5- Polymict (aphanite, fuchsite, magnetite, chert mafic, acid volcanic, sediments, granodiorite, (feldspar porphyry)
6- Texture	-----	6- Framework supported	6- Framework supported	6- Framework supported	6- Framework supported	6- Framework supported	6- Matrix supported	6- Framework supported
7- Internal structure	-----	7- Fairly massive, not graded, rarely bedded	7- Massive	7- Massive	7- Massive	7- Fairly massive, no graded bedding	7- Fairly massive no graded bedding	7- Fairly massive
8- Shape of pebbles	-----	8- Sub-angular	8- Rounded to subrounded	8- Rounded to subrounded	8- Rounded to subrounded	8- Subrounded to subangular	8- Subrounded	8- Rounded to subrounded
9- Pebbles size	-----	9- 5 to 30cm(up to 80cm)	9- 5 to 25cm (up to 1m)	9- 5 to 15cm(up to 50cm)	9- 5 to 15cm(up to 40cm)	9- 5 to 25 (up to 50cm)	9- 1 to 15 cm	9- 10-30cm (up to 60cm)
10-Thickness of beds	-----	10-30cm - 5m	10-10 - 30m	10-30cm - 5 m	10-30 to 5m	10-30cm - 30m	10-30cm - 10m	10-50cm - 10m
INTERBEDS:								
1- Composition	1- Greywacke	1- Sandstone and turbidites	1- Sandstone	1- Sandstone and turbidite	1- Sandstone and turbidite	1- Sandstone	1- Sandstone	1- Sandstone
2- Shape	2- -----	2- Lenticular	2- Lenticular	2- Lenticular	2- Thick lense	2- Lenticular	2- Lenticular	2- Lenticular
3- Contact	3- -----	3 Erosional channel	3- Sharp and conformable	3- Sharp and conformable	3- Sharp and conformable	3- Sharp and conformable	3- Sharp and conformable	3- Sharp and conformable
4- Internal structure	4- Well graded	4 Graded bedding and parallel lamination in the turbidites	4 Graded-bedding, rare reverse grading, usually massive, amalgamated beds gravel stringers parallel and across the bedding.	4- Graded bedding rare in the east and common in the west, fairly massive, parallel lamination, trough cross lamination > 10cm., gravel stringers parallel and across to bedding.	4 Graded bedding varies rare to common, fairly massive, rare lamination, no cross lamination > 10cm Small trough cross bedding	4- Rare graded bedding Very massive, Gravel stringer parallel and across the bedding	4- Rare gradded bedding Very massive, cross laminations > 10cm, gravel stringers parallel and across the bedding	4 Rare graded bedding Fairly massive with parallel lamination cross bedding 10cm and up to 2m. Thick
5- Thickness	5- -----	5- 10 - 50cm	5- 10cm - 2m	5- 10cm - 2m	5- 5 - 30cm	5- 10cm - 5m	5- 10cm - 5 m	5- 15cm - 3m
SPECIAL OBSERVATIONS:	No marker horizons	Thick filling of a channel. Pebbles exclusively sedimentary except in the highest beds where acid volcanic starts to appear.	Great variations in thickness from east to west.	Great lateral and vertical variations of facies.	Great lateral and vertical variations of facies	Strong deformations has destroyed most of sedimentary properties	Uppermost unit observed in our area	Very big cross stratification, no graded bedding or very rare
DEPOSITIONAL ENVIRONMENT:	Submarine deposit mass flow	Submarine channel fill	Submarine fan, by mass flow deposit	Transition zone from alluvial fan to marine deposit	Submarine fan	Submarine fan?	Marine deposit?	Piedmont alluvial fan

Table 10. Resumé of the main sedimentological properties of the different units in the Rouyn-Beauchastel area.

CHAPTER IV

METAMORPHISM

GENERAL STATEMENT

Two distinct phases of metamorphism are discernible in the Rouyn-Beauchastel area: an older regional syn-kinematic dynamo-thermal metamorphism and a younger post-kinematic thermal metamorphism which is observed only in the northeastern part of the area, on the eastern side of the Davidson Creek fault. The regional dynamo-thermal metamorphism ranges from chlorite zone in the northern part of the area to biotite, staurolite and sillimanite zones in the southern part. Strong penetrative deformation continued after the onset of cooling, and retrograde metamorphism is important locally.

ISOGRADS BASED ON SPECIFIC METAMORPHIC REACTIONS

Two regional metamorphic isograds have been mapped on the basis of the occurrence of mineral assemblages which developed during the regional dynamo-thermal metamorphism: a biotite-epidote isograd in the northern part of the area and a staurolite-biotite isograd in the southern part. These isograds can be regarded as the trace of surfaces that bound masses of rocks in which the highest level attained by the prograde metamorphism can be defined in terms of the reactants and products of a specific metamorphic reaction, rather than just the first appearance of an index mineral, (Carmichael, 1970).

The metamorphic reactions associated with these two isograds

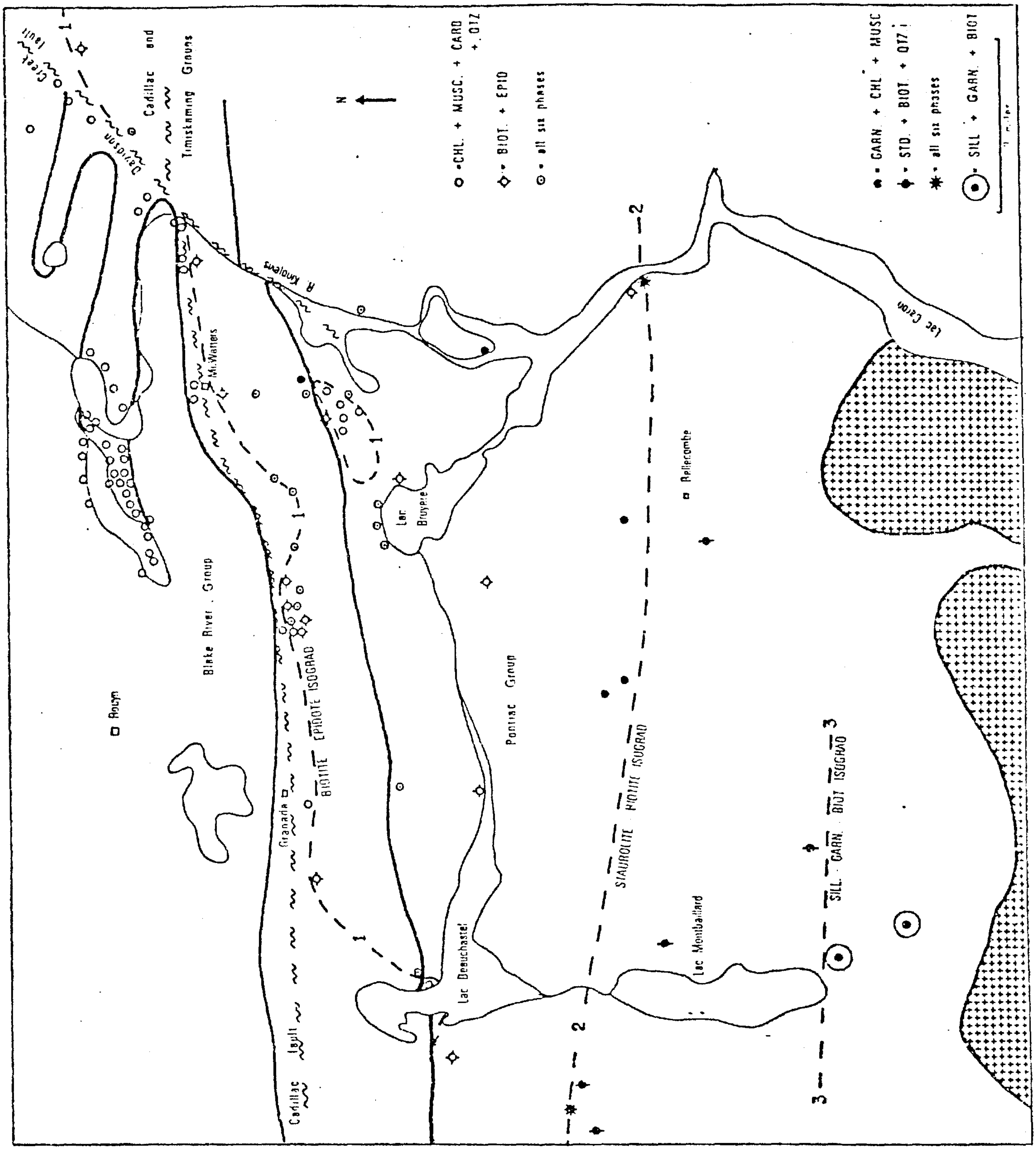


Fig. 9. Distribution of critical metamorphic mineral assemblages and metamorphic isograds based on reactions 1, 2 and 3.

are, in order of increasing metamorphic grade:

Chlorite + Muscovite + Carbonate + Quartz $\rightleftharpoons$ Biotite + Epidote + H_2O + CO_2 (1)

Chlorite + Garnet + Muscovite $\rightleftharpoons$ Staurolite + Biotite + Quartz + H_2O (2)

Hollister (1969) has mapped an isograd based on reaction (1) in the Kwoiek area of British Columbia, and Carmichael (1970) has mapped an isograd based on the second reaction in the Whetstone Lake area of Ontario.

THE BIOTITE-EPIDOTE ISOGRAD (reaction (1))

The biotite-epidote isograd cuts across the Timiskaming Group in an east northeasterly direction (see Fig. 9). West of Lac Beauchastel the metamorphosed rocks are covered by Proterozoic rocks of the Cobalt Group. In the northeast the isograd seems to have been offset along a system of northeasterly trending faults, including the Davidson Creek fault along which there is an apparent left-hand separation of about 1.5 mile (2.4 km) (see p. 128).

The assemblage biotite + epidote, which comprises the product of prograde metamorphism in reaction (1), is not found to the north of the isograd; and the reactant mineral assemblage, chlorite + muscovite + carbonate minerals + quartz, is not found in rocks to the south of the isograd, except where all 6 critical mineral phases occur together (see Fig. 9). Although the biotite-epidote isograd follows close to the Cadillac fault in the eastern part of the area near

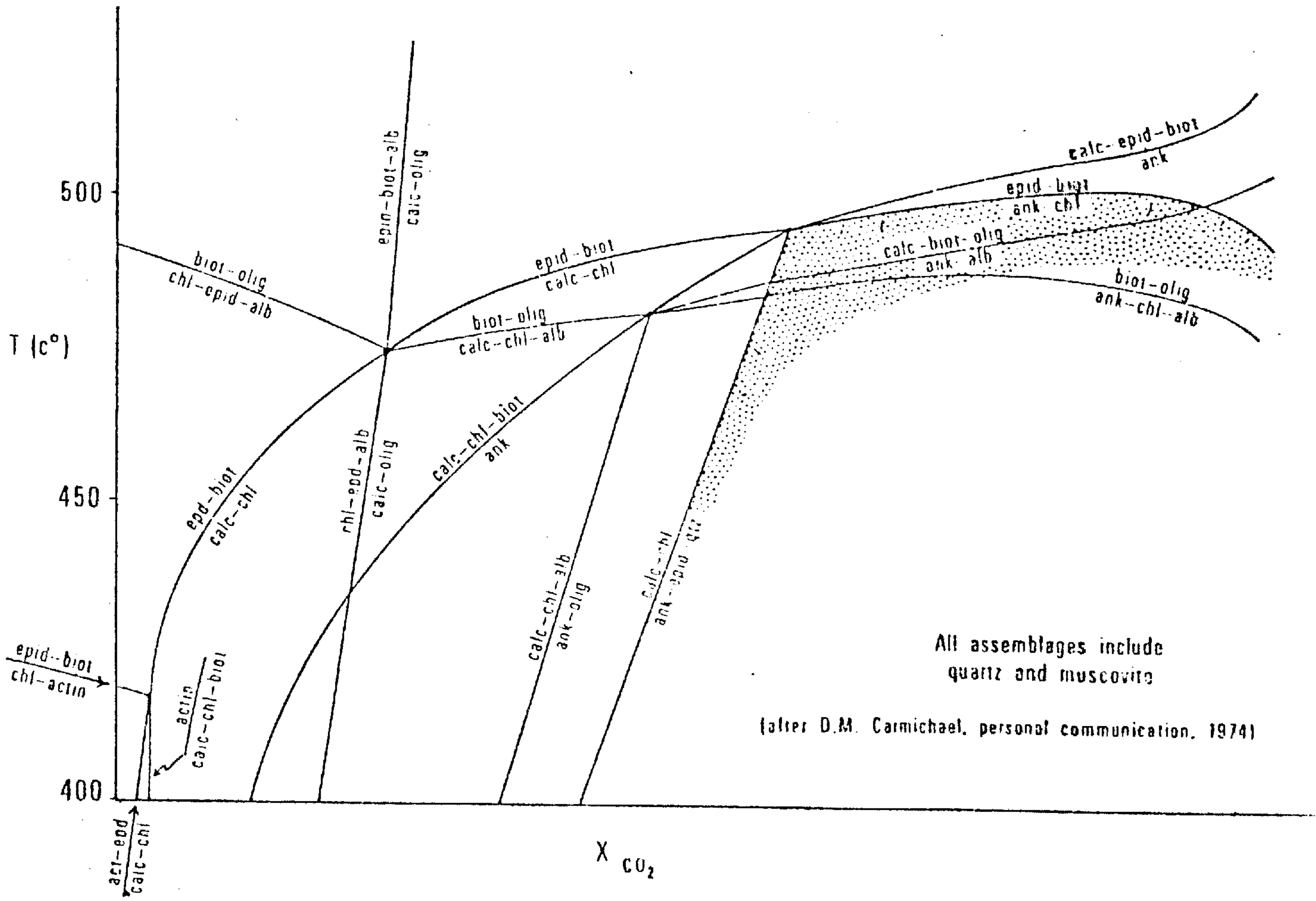


Fig. 10. Schematic $T\text{-}X_{CO_2}$ "grid" at 4-5 Kb., showing mineral equilibria in metagreywacke containing both quartz and muscovite, in the transition from greenschist to amphibolite facies.

McWatters, it diverges from the Cadillac fault in the west, and passes south of Granada village and through the northern part of Lac Beauchastel, beyond which a lack of critical data makes it difficult to locate the isograd with sufficient precision.

An important feature of the metamorphism is the occurrence of the lower grade mineral assemblage within an area of complex structure in the Pontiac Group just northeast of the Lac Bruyère. This lower grade assemblage may reflect a higher partial pressure of CO_2 that would make the reactant assemblage stable at a higher temperature for any constant total pressure (D. M. Carmichael, personal communication, 1974). This relationship can be visualized by referring to Fig. 10, a schematic $T\text{-}X_{CO_2}$ "petrogenetic grid" at about 4-5 Kb total pressure, which shows mineral equilibria in metagreywackes containing both quartz and muscovite, in the transition from greenschist to amphibolite facies.

The carbonate mineral present in the area NE of Lac Bruyère is ankerite and therefore reference should be made to the curve for the reaction ankerite + chlorite $\rightleftharpoons$ biotite + epidote which is in a significantly higher range of temperature than the curve of the reaction calcite + chlorite $\rightleftharpoons$ epidote + biotite. The composition of the chlorite, also may have affected the stability range of the reaction. The chlorites in this area have an anomalous violet or blue interference colours and therefore appear to be more Fe-rich than in the surrounding area.

Higher Fe-content in the chlorite would also make the assemblage ankerite-chlorite stable at a higher temperature (Albee, 1962). The mineral assemblages found in the lower grade rocks to the north of the biotite-epidote isograd are listed in Table 11 and those found to the south of the isograd are listed in Table 11.

Table 11. Mineral assemblages in lower grade metamorphic rocks north of the biotite-epidote isograds (all assemblages include quartz + muscovite + chlorite and plagioclase).

No. of thin sections	CARB.	EPID.	ACT.	CHLORITOID	STILPNOMELANE	BIOT.
26	X	--	--	--	--	--
16	X	X	--	--	--	--
4	X	X	X	--	--	--
2	X	--	--	X	--	--
2	X	--	X	--	--	--
2	X	X	--	--	X	--
5	--	--	--	--	--	--
2	--	X	--	--	--	--
2	--	--	--	--	X	--
4	--	X	X	--	--	--
1	--	X	X	--	X	--
1	X	--	--	--	--	X

X = Present

-- = Absent

Table 12. Mineral assemblages found in metamorphic rocks in the higher grade rocks south of the biotite-epidote isograd.

Nbr. of thin section	Qtz	Plag.	Chl.	Biot.	Musc.	Epid.	Carb.	Act.	Trem.	Hbl.	Cum.	Garnet	Talc	Anthop
6	x	x	x	x	x									
14	x	x	x	x	x	x	x							
2	x	x	x	x	x	x								
3	x	x	x	x	x	x	x							
1	x	x	x	x	-	x	-	x	-	x				
1	x	x	x	-	-	x	x	-	-	x				
3	x	x	x	x	x	-	-	-	-	-	-	x		
3	x	x	x	x	-	x	-	x						
2	x	x	x	x	-	x								
5	x	x	x	x	-	-	x	x						
7	x	x	x	x	-	x	x	x						
1	x	x	x	x	-	-	x	-	-	x				
2	x	x	x	x	-	-	x	-	-	-	x			
1	x	x	x	-	-	-	x	-	-	x	x	x		
1	x	x	x	-	-	-	x	-	-	-	x	-	x	
1	x	x	x	-	-	-	x	-	-	x	x			
1	x	x	x	-	-	-	x	x	-	-	x			
1	x	x	x	-	x	-	-	-	-	-	-			
2	x	x	x	-	-	x	x	-	x	-	-			
2	x	x	x	-	-	-	x	-	-	x	-			
1	x	x	x	-	-	-	x	x	-	x	-			
1	x	x	x	-	-	x	x	-	-	-	-			
1	x	x	-	x	x									
1	x	x	-	-	-	-	x	-	-	x				
1	x	x	-	-	-	-	x	-	-	x	x			
1	x	x	-	-	-	-	-	-	-	-	x			
1	x	x	x	x	-	-	x							
1	x	x	x	x	-	-	x	-	-	x				
1	x	-	x	x	-	-	x	-	-	x				
2	x	-	x	x	-	-	x	x						
1	x	-	x	-	-	-	-	x						
3	x	-	x	x	-	-	x			-	x	-	x	
1	-	x	x	x	-	-	x	-	-	-	x	-	-	x
1	-	x	x	-	-	-	x	-	-	-	x			
1	-	x	x	x	-	x	x	-	-	-	x			
1	-	x	x	-	-	x	-	-	-	-	x	-	-	x
1	-	-	x	-	-	-	x	-	-	-	x	-	x	
1	-	x	x	x	-	-	x	-	-	x	x			
1	-	x	x	x	-	x	-	x						
1	x	x	x	x	-	x	x	-	-	-	x	-	-	x

X: Present

-: Absent

THE STAUROLITE-BIOTITE ISOGRAD

The staurolite-biotite isograd (2), which is based on the reaction: Chlorite + Garnet + Muscovite ⇌ Staurolite + Biotite + Quartz + H_2O, runs east-west in the Pontiac Group south of Beauchastel Lake passing near the village of Bellecombe. It is approximately 4 miles north of the nearest large granitic pluton (see Fig. 9).

Table 13 shows the mineral assemblages found in the higher grade rocks above (to the south of) the staurolite-biotite isograd.

Table 13. Mineral assemblages found in metamorphic rocks south of the staurolite-biotite isograd.

No. of thin Sections	QTZ	PLAG	CHL	BIOT	MUSC	EPID	STD	HBL	GARNET
1	X	X	X	X	--	--	X	--	--
2	X	X	X	X	X	--	X	--	X
1	X	X	X	X	X	X	X	--	--
1	X	X	X	X	--	--	X	--	--
1	X	X	X	X	--	X	--	X	--
2	X	X	--	X	--	--	--	--	--

Specimens collected by M. Van de Walle, south of Lac Montbeillard, represent an even higher metamorphic grade and mark a third isograd: the sillimanite-biotite-garnet isograd, based on the reaction:

Staurolite + Muscovite + Quartz ⇌ Sillimanite + Garnet + Biotite + H_2O (3)

An isograd based on this reaction has been sketched on Fig. 9 but is poorly constrained because of the relatively few data points that are available.

The sillimanite occurs in two distinct forms: a fibrous one (see Plate XIIIb) and a prismatic one. The garnet contains inclusions of staurolite showing that the reaction is from the left to the right. The prismatic sillimanite is probably a pseudomorph after andalusite judging by the crystal shape. The prismatic crystals are up to 1 cm in diameter, and because they are more resistant they stand out on the weathered surface. Their identification is based on microscope examination and X-ray diffraction patterns. No kyanite has been observed in any of the specimens that were studied.

RETROGRADE EFFECTS AND POST-CRYSTALLINE DEFORMATION

Textural evidence of post-crystalline deformation and a retrograde metamorphism has been observed throughout the area. Kinked chlorite and biotite crystals and bent plagioclase crystals are common. Garnet and hornblende porphyroblasts commonly show evidence of rotation of inclusion traces within them, and staurolite and sillimanite are encapsulated by biotite that defines the main foliation in the rocks. Pressure shadows filled with quartz are common, and there is partial or complete replacement of biotite by chlorite, and of staurolite, plagioclase and alumino-silicates by muscovite and sericite. Those observations are similar to those made by Dimroth (1973 and 1974) who stated that the growth of the muscovitized alumo-silicate (kyanite ?)

probably was correlated with the growth of partly muscovitized sillimanite in the heterogeneous granodiorite which intruded during the latest part of the deformation. Thus, the amphibolite facies metamorphism in the southern part of the Pontiac Group is likely a very late tectonic phenomenon, and probably is related to the intrusion of large granodiorite and trondhjemite-tonalite massifs.

In the Rouyn-Beauchastel area the metamorphism in the Pontiac Group occurred in conjunction with complex superposed polyphase folding. Where the distinction between S_1 and S_2 schistosity can be made the early schistosity (S_1) defined by aligned chlorite crystals is cross cut by an axial plane schistosity (S_2) containing aligned biotite crystals (see Plate XIIa).

Post-kinematic cross-cutting biotite porphyroblasts occur roughly in an east-west trending zone in the greywacke, of the northern part of Joannes Tp., just east of the Davidson Creek fault. Although little detailed information is available on the zone it may be related to thermal metamorphism caused by a post-orogenic granite (see Plate XIIIa).

The metamorphism of the pebbles in the conglomeratic unit of the Timiskaming Group and also the pebbles from the channel fill in the upper part of the Pontiac Group is the same as that observed in the matrix. No fragments of gneiss, migmatite or other metamorphic rocks showing evidence of predepositional metamorphism have been observed.

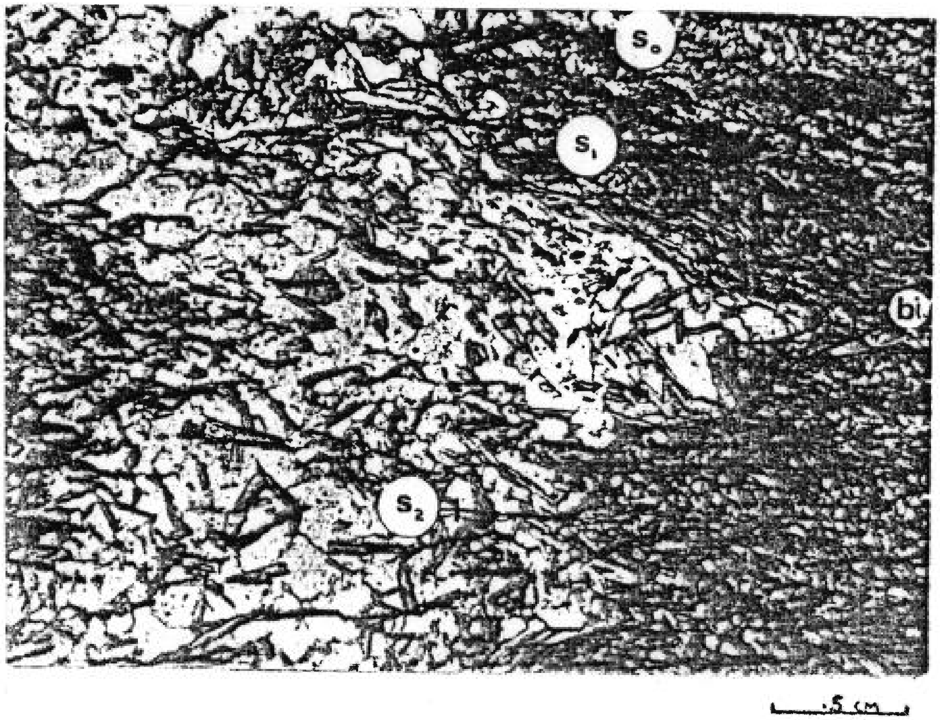
Plate XII

a. Photomicrograph of a quartzofeldspathic bed in contact with a more pelitic one. The schistosity (S_1) is defined by aligned chlorite and sericite and runs more or less N-S parallel with the compositional bearing (S_o). S_1 is refolded and cross cut by the schistosity (S_2). A biotite crystal (extreme right) is developed in the axial plane of F_2 folds. Pontiac Group (P_1), (Range IV, lot 60, Rouyn Tp.).

b. Photomicrograph showing schistosity (S_1) defined by alignment of chlorite refolded by schistosity (S_2) oriented NW-SE. Pontiac Group (P_1).

Plate XII

A



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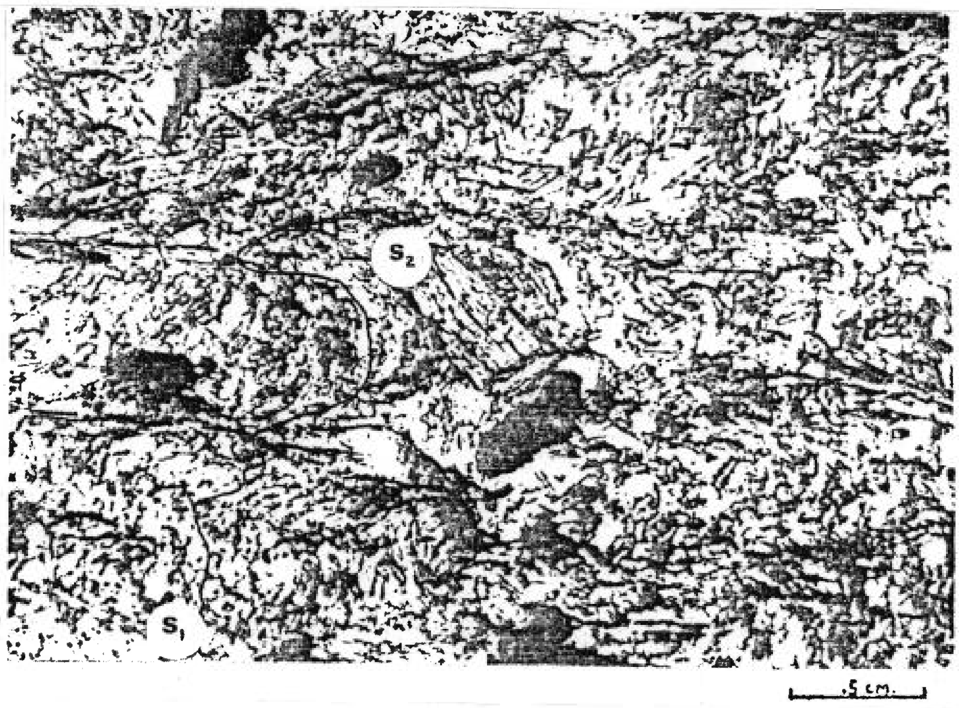


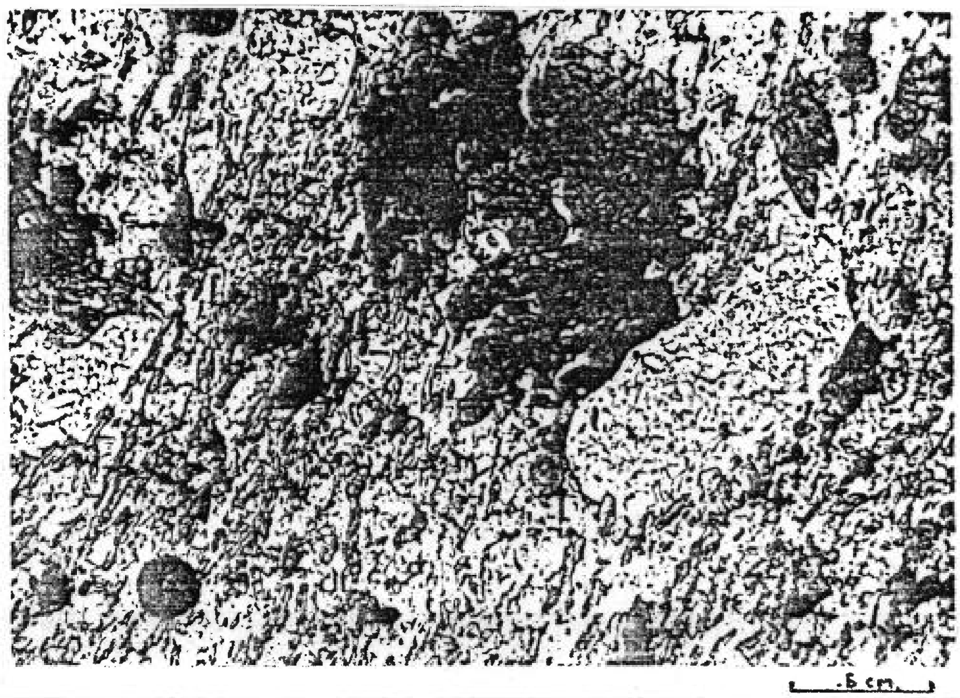
Plate XIII

a. Photomicrograph showing post-kinematic cross cutting biotite porphyroblasts in the greywacke. (Range VII, lot 16, Joannes Tp.).

b. Photomicrograph of fibrous sillimanite crystals from the Pontiac Group (P_1) south of Lac Montbeillard.

Plate XIII

A



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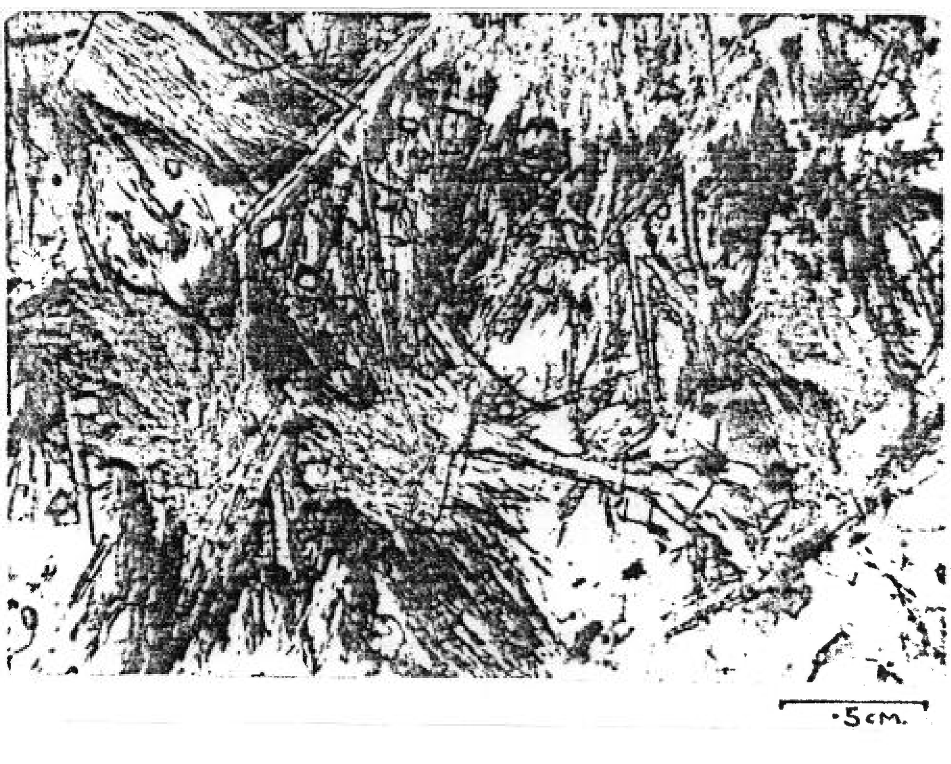


CHAPTER V

STRUCTURAL GEOLOGY

INTRODUCTION

The geologic structure of the Rouyn-Beauchastel area is characterized by complex superposed folding. The elucidation of the structural geometry has been based on the integration of the analysis of mesoscopic fabric data with the analysis of macroscopic structures outlined by the mapping of distinctive rock units.

The dominant feature of the geologic structure outlined by the mapping are two main sets of superposed folds. The younger, second, set is characterized by east-west striking axial surfaces that are not conspicuously deformed. The older, first, set, which was generally north-south striking and upright, is deformed about these east-west axial surfaces.

Both sets of large-scale folds are essentially isoclinal with almost vertical axial planes. The hinge zones are very narrow. They may be a highly schistose zone, and are commonly marked by many small-scale faults. For this reason, the hinge zones of many of the large-scale folds can be recognized only by the occurrence of oppositely facing strata. Moreover, it is commonly also difficult to determine the plunge of these large-scale folds. However, where the plunge can be established it is generally very steep. The older north-south trending fold set is overturned to the west in the southern part of the area, where it involves the Pontiac Group (P_1) and the Blake River (?) Group (B_1), but becomes vertical or slightly overturned to the east in the northern part.

The younger east-west trending set is responsible for the main structural grain discernible on the maps of the area. In the southern part it is represented by a broad synform and antiform but toward the north it forms very tight isoclinal folds.

The axial plane foliation related to both sets of large-scale folds becomes increasingly better defined with decreasing wave length of the folds. The axial surface foliation associated with the first generation of folds varies greatly in degree of development from place to place. In general, this first schistosity (S_1) is well developed in the southern part of the area, in the Pontiac Group, but is only discernible locally in the middle and northern parts of the area, and presumably was never as well developed there.

The second generation schistosity (S_2), on the other hand is discernible throughout the area. It is poorly developed in the southern part, moderately well developed in the central part, and strongly developed toward the Cadillac-Larder Lake fault where tight isoclinal second-generation folds have been recognized. Further north, near Lac Rouyn, it is moderately well developed.

A third penetrative foliation (S_3), that generally strikes northwest-southeast also occurs in the Rouyn-Beauchastel area, but is weakly developed, and no major folds are known to be associated with it.

A fourth foliation (S_4), that strikes northeast-southwest occurs in the northern part of the area. It is best developed along the Kinojevis River and near Granada village, where it is parallel with the axial surfaces of two broad antiforms that are superposed on older structures.

METHOD OF ANALYSIS

For structural analysis, the area has been subdivided into three main domains, the boundaries of which correspond with faults or contacts between the major stratigraphic units. Domain 1 and domain 2 are located south of the Cadillac-Larder Lake fault whereas domain 3 is located north of the fault. Domain 1 comprises the Pontiac Group and is subdivided into seven subdomains, the boundaries of which correspond to the surface traces of the axial surfaces of folds of the second fold set and to zones across which they change in strike. Domain 2 comprises the Timiskaming Group and is subdivided into five subdomains in the same general way. Domain 3 includes the Blake River, the Cadillac and the Granada Groups and has been subdivided into three subdomains.

The orientations of the various structural elements are illustrated with various distinctive symbols on Maps 4, 5 and 6, and are summarized in a series of equal-area lower hemisphere projections (Figs. 11, 12, 13, in pocket). At each outcrop locality which was investigated in detail during this study, the relative ages of the various structures represented were established on the basis of cross-cutting relationships following the method described by Turner and Weiss (1963). If foliations (S_1, S_2, S_3 or S_4) and lineations (L_1, L_2, L_3 or L_4) of tectonic origin exist they must be younger than primary structures, such as bedding (S_o). If two superimposed foliations appear in the same rock, the younger one (S_2) can be recognized as discrete surfaces which transect or offset the older one (S_1) and are defined by a preferred orientation of platy or tabular mineral grains, or by the axial surfaces of small folds or crenulations that have been imposed on the older foliation. The relative ages of two intersecting lineations may be established by relating each to the foliation with which it is associated (see Plate XIIa).

In the field, not all sets of S-surfaces or lineations are represented at every locality; however, on the basis of their nature, orientation, and regional relationships, correlations can be made from one locality to another, and individual fabric elements can be classified in terms of a sequence of discrete sets of foliations and lineations. For example, S_2 is a true schistosity almost everywhere, and not a crenulation, and it can be correlated from one outcrop to another with confidence.

The nomenclature used in discussing fabric elements is as follows:

S-surfaces S_0, S_1, S_2, S_3, S_4 are successively younger foliations (the suffix refers to relative age and "O" refers to primary layering or bedding).

Lineations L_E is the direction of elongation of pebbles, minerals, varioles or pillows.

Lineations L_X^Y the line of intersection of a foliation Y with a younger foliation X.

Folds F_X^Y or fold axes B_X^Y refer to structures in which X is the axial surface foliation and Y is the foliation that has been folded.

FIRST FOLD SET

General Statement

The oldest structures recognized in the Rouyn-Beauchastel area are associated with the first fold set (F_1), and are best developed in the southeastern part of the area (Domain 1), mainly in metasedimentary rocks of the Pontiac Group (P_1) and the underlying metavolcanic rocks of the Blake River (?) Group (B_1). The mesoscopic fabric elements related to these structures are an axial surface schistosity S_1, and a bedding schistosity intersection lineation L_1^O.

Surface S_1

In the sedimentary rocks of the Pontiac Group, near Lac Bruyere, S_1 is formed by a preferred orientation of chlorite and/or micas. It is commonly a well developed schistosity (see Plate XIVa) in the pelitic portion of greywacke beds, but in the quartzo-feldspathic portion, particularly at the nose of the folds, it is locally represented by a fracture cleavage which may be fanned. In the volcanic rocks of the Blake River (?) Group, (B_1) beneath the Pontiac Group, the schistosity S_1 is weakly developed, and wherever it can be discerned, it is represented by a preferred orientation of chlorite and micas in the plane of flattening of pillows.

In Domain 1, S_1 is broadly folded and trends between north-east and northwest. It is generally subparallel to the bedding S_o (see fabric diagrams for Domain 1 and subdomains 1A, 1B, 1C, 1E, 1F in Fig. 11), except in the hinge zones of minor folds where it forms an axial plane schistosity and is at high angle with S_o.

Lineation L_1

Linear structures related to the first deformation are rare and weakly developed. They are formed by the intersection of S_o and S_1, and because S_1 is generally subparallel with S_o in Domain 1, L_1^o is difficult to identify in the field except at the hinge zones of F_1^o folds, where it is well developed and is subparallel with the hinge lines. L_1^o has been identified in the eastern portion of the area in which the Pontiac Group occurs (subdomain 1A, 1B, 1C), but in the western portion it is rarely identifiable. L_1^o has been recognized locally in domain 3 and has not been recognized in domain 2.

Minor folds F_1^o

Although minor folds F_1^o are rare, they have been observed in rocks of the Pontiac Group along Lac Bruyere and Lac Kinojevis and in the Cadillac Group (see Plate Ic). Elsewhere tight folding which occurred during the development of the second set of folds (F_2) appears to have involved transposition of early foliations and lineations and to have obscured the earlier folds.

The main characteristics of the first set of minor folds (F_1^o) in the Lac Bruyere area is that they are tight to isoclinal and overturned to the west. Commonly these folds can only be recognized by sudden changes in the direction of facing of beds which have been refolded about axial surfaces parallel with S_2. East of the main anticline near Lac Kinojevis and Lac Vallet they are mainly S-shaped, whereas west of the anticline along the Lac Bruyere they are mainly Z-shaped.

Major folds F_1

Two major F_1 folds are represented in the rocks of the Pontiac Group. A major anticline, overturned to the west, occupies the area near Lac Kinojevis, Lac Vallet and Lac Bruyere. Further west, there is a major syncline between Lac Bruyere and Riviere Beauchastel, and it also is overturned to the west (see sketch on Plate XIVc).

In the eastern part of domain I, in the area between Lac Vallet and Lac Bruyere, the anticline is outlined by the crescent shaped area underlain by the metavolcanic rocks of the Blake River (?) Group (B_1). It is more or less north-south trending and has been refolded by major east-west trending younger (F_2) folds. It is noteworthy that ultramafic rocks are present only in the core of the major F_1 anticline. The geometry of the major F_1 folds is illustrated in cross section AB of Fig. 14 which has been drawn along the axial surface of the major F_2 antiform and is perpendicular to axis of the major F_1 folds.

In domain 2 near McWatters mine, and probably also further east, near Kinojevis River at Rouyn-Merger Mine, the same style of deformation seems to be represented. The mafic volcanic rocks at McWatters probably represent the core of an F_1 anticline tightly refolded by east-west trending F_2 folds. The outcrop pattern is also crescent-shaped, but the lack of definite stratigraphic facing determinations and the occurrence of faulting make it very difficult to prove that the basic structure is the same as in domain 1. However it has been observed, near McWatters, that S_1, in the nose of the F_2 folds, strikes north-south and dips to the east and this indicates that the basic structures are similar.

In domain 3 no major F_1 folds have been recognized except in the area east of the Davidson Creek fault. However, in the area between Lac Routhier and Lac Rouyn, a north-south syncline that was mapped in the pyroclastic rocks of the Cadillac Group by Ambrose (1941) could be an F_1 fold. However this north-south structure has not yet been studied in detail.

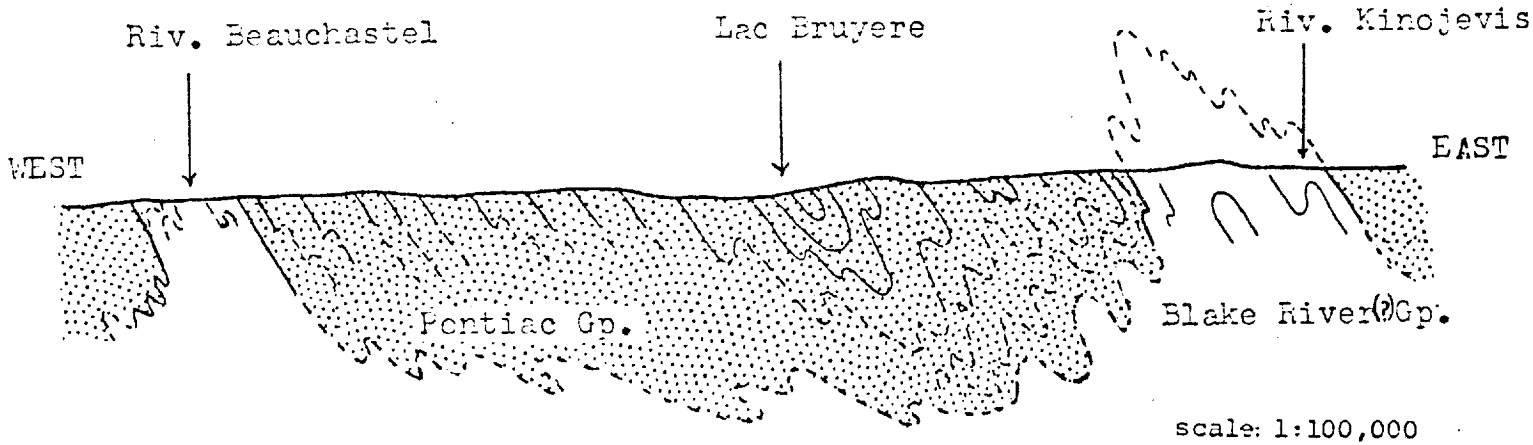


Fig. 14. Schematic cross section parallel with the axial surface of F_2 folds and perpendicular to F_1 folds.

Mesoscopic fabric

The subdivision of the area into statistically homogeneous fabric domains and subdomains that coincide mainly with the limbs of the second fold set follows from the fact that the orientation of the mesoscopic fabric associated with first set of folds (F_1) changes dramatically from one limb to another of the major folds of the second set (F_2).

In subdomains 1C and 1F, S_1 dips east to northeast forming the south limb of an F_2 synform, and L_1 plunges north-northeast; whereas in subdomains 1B and 1E, S_1 dips east to southeast forming the north limb of the synform and L_1 plunges southeast (see Fig. 11).

In subdomain 1A, S_1 strikes east-west and dips steeply either north or south, because subdomain 1A includes several tight F_2 synforms and antiforms. In the synoptic fabric diagram for domain 1 (Fig. 15) the poles to the first schistosity (S_1) are distributed along two great-circles girdles corresponding to two planes striking north-south and dipping about 40° either east or west, depending on which side of the antiform (F_4) they have been taken. The pole to the girdle dipping east is the axis about which the earliest foliation (S_1) is folded. It plunges east at about 50° and is parallel to the main preferred orientation of the lineation L_2 associated with the second fold set (F_2), and also with the preferred orientation of the long axis of mineral grains (L_e). In domain 2, the early foliation S_1 was only identified in subdomain 2A, near McWatters, where S_1 dips

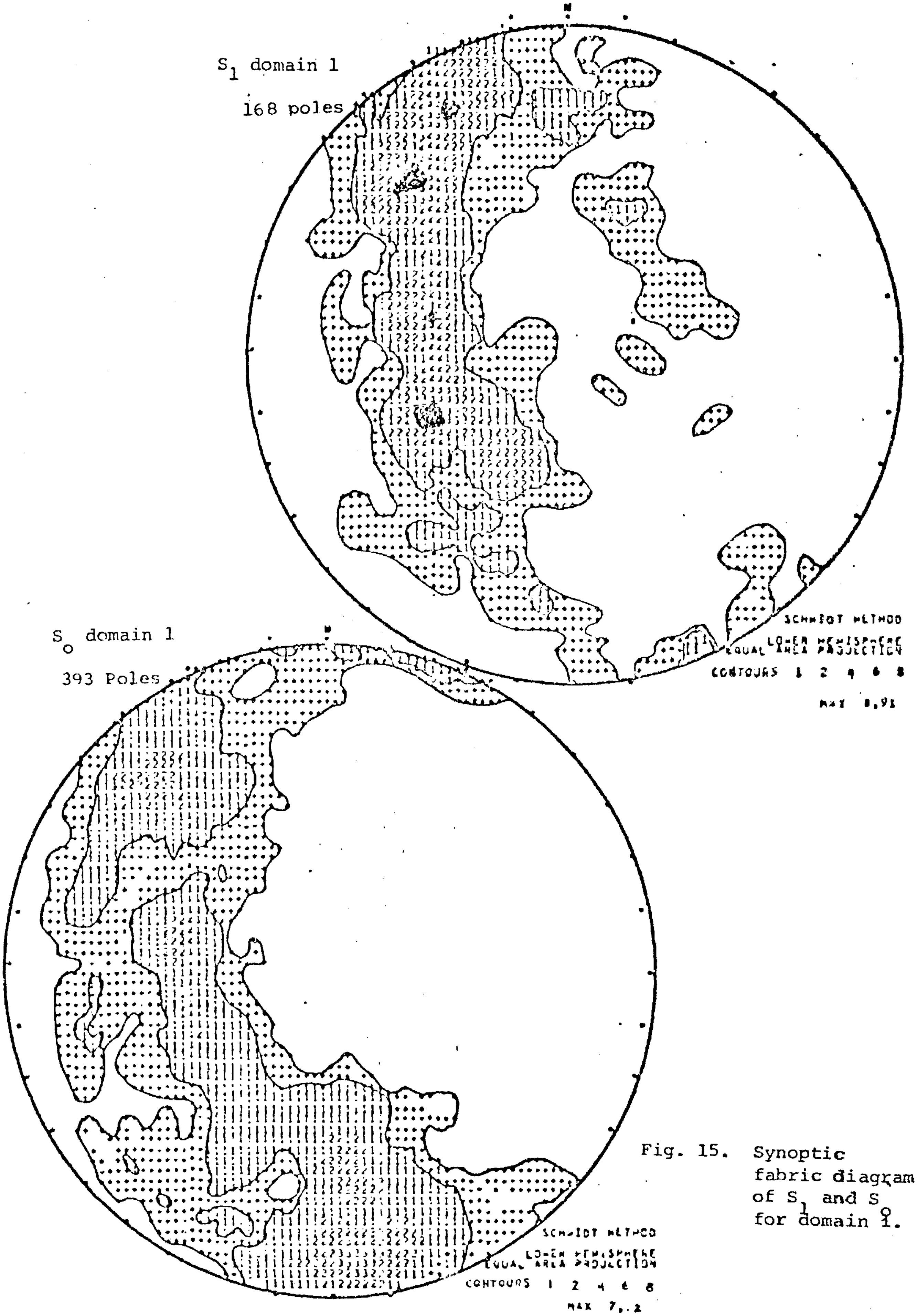


Fig. 15. Synoptic fabric diagram of S_1 and S_o for domain 1.

northeast. In domain 3, S_1 is very steep and strikes northeast in subdomain 3A and north-south in subdomain 3C.

The pattern of dispersion in the orientation of the early foliation (S_1) and of the lineation (L_1) associated with the first fold set (F_1) can be used to outline the shape and orientation of the major folds in the second fold set (F_2).

SECOND FOLD SET

General Statement

Mesoscopic fabric elements related to the second set of folds (F_2), comprise an axial surface schistosity (S_2), a lineation (L_e) marked by the long axes of minerals, deformed clasts, pillows or varioles and lineations marked by the intersection of S_2 and S_o (L_2^o) and S_2 and S_1 (L_2^1). Because S_o is generally parallel with S_1, L_2^o and L_2^1 are only rarely distinguishable from each other and therefore, they are generally referred to collectively as L_2.

The foliation S_2, the dominant penetrative foliation in the area, is generally defined by an alignment of metamorphic minerals (micas, amphibole, chlorite, sericite) but pebbles in conglomerate are flattened in the plane of this foliation (see Plate XVc), and in quartzofeldspathic rocks it is marked by a fracture cleavage or other spaced cleavage that is variable in its degree of development (see Plate XVa and b). It is common to find evidence of offsets parallel with the cleavage and quartz veins are commonly located along the cleavage (see Plate XVa).

Minor Folds F_2^o

The minor second-set folds of bedding (F_2^o) are common throughout the area, but vary in shape and size with rock type and structural position. The amplitude of the F_2^o folds varies from the order of a few metres to a few cm. The hinge zone generally is very angular in pelitic rock but more rounded in quartzofeldspathic rocks. Close to the hinge zone of a major F_2 fold, the minor F_2^o folds are tight to isoclinal with vertical axial planes. In the southeastern part of the area they generally are more open and the axial planes are steep or slightly overturned to the south, whereas close to the Cadillac-Larder Lake fault the F_2^o folds are very tight to isoclinal with a steep axial plane. The dihedral angle between the limbs usually varies from 0 to 90°. The folds are mainly of the similar type (class 2 of Ramsay, 1967).

In the Timiskaming Group, the minor F_2^o folds are well developed in the vicinity of major F_2 folds. In the main synform and the main antiform north of it they are assymetric and isoclinal. The associated parasitic folds are S-shaped of the north side and Z-shaped of the south side, and they have refolded the axial surface of F_1 folds.

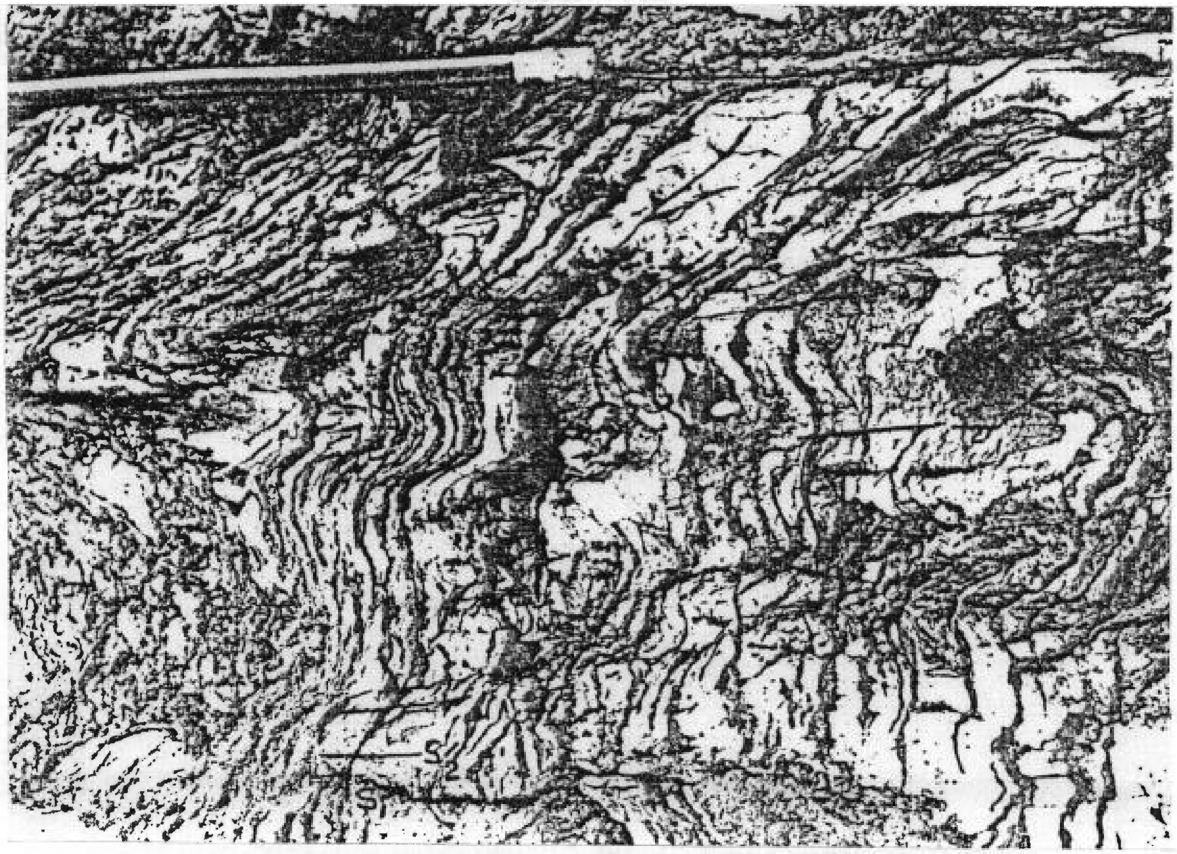
Plate XIV.

a. Well developed S_1 schistosity refolded by F_2, with S_2 as the axial plane foliation. The bedding S_o is parallel to the pencil (Range IV, lot 31, Rouyn Tp.).

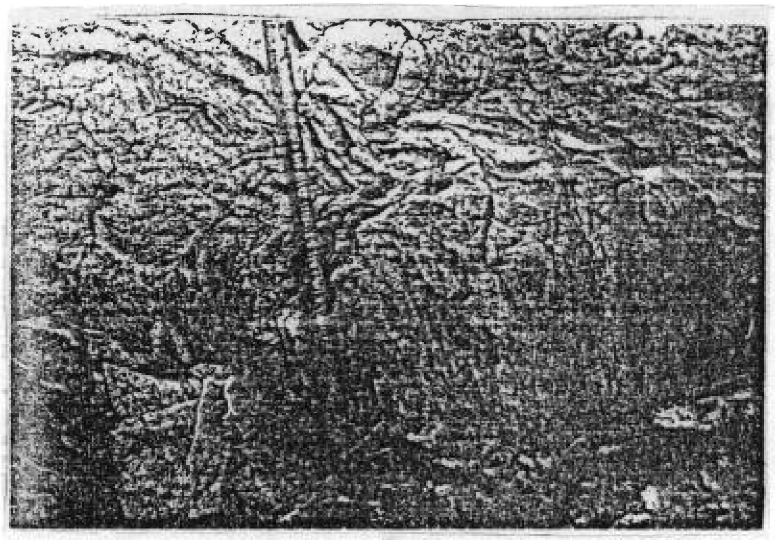
b. Subvertical F_2 fold axis in a greywacke sequence. The lineations L_2^o are parallel to the pencil and represent the intersection of S_o and S_2, an axial plane foliation (Range VIII, lot 28, Joannes Tp).

c. Plasticine model showing the major F_1 anticline in the Blake River (?) Group (in black) and the major F_1 syncline in the Pontiac Group (in white). Both have been refolded by an F_2 antiform and synform.

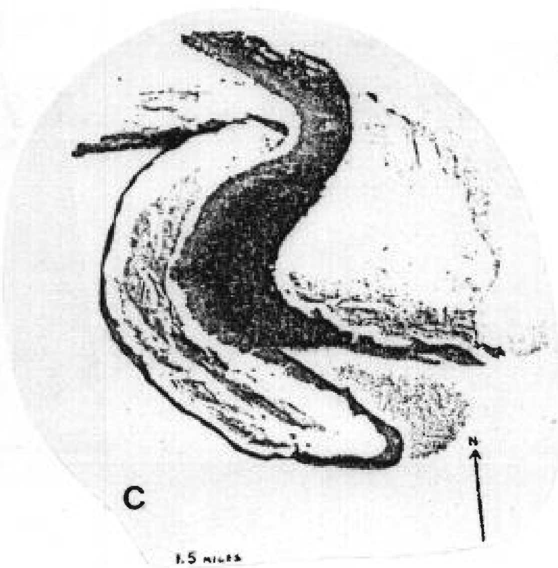
Plate XIV



A



B



C

Plate XV

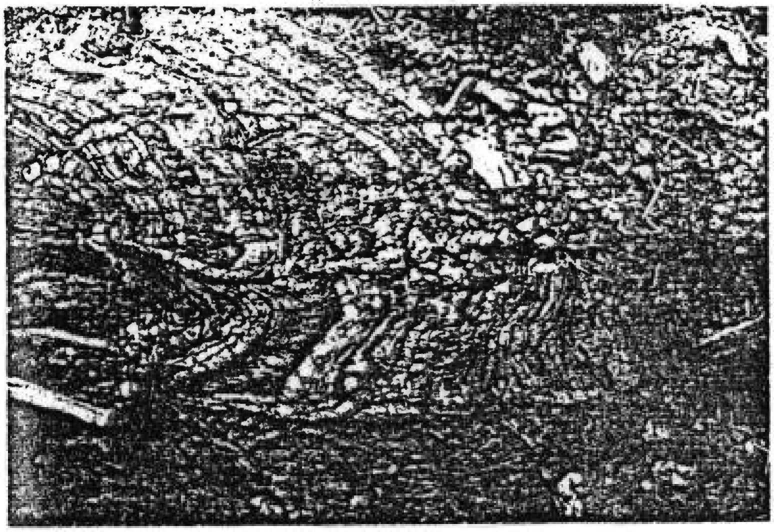
a. F_2 folds in a greywacke sequence with faulting and a quartz vein aligned parallel with the axial plane foliation S_2. The pick head is 30 cm long (Range VII, lot 51, Rouyn Tp.).

b. Spaced fractured cleavage (S_2) in the hinge zone of an antiformal syncline. The stratigraphic tops are to the right and the plunge of the fold axis F_2 is 80° to the left parallel to L_2^2 (as seen on the top of the photograph which represents a horizontal plane of the outcrop). Note the rotation of the beds and the "injection" of the pelitic material parallel to the axial plane schistosity. (Range VIII, lot 27, Joannes Tp.).

c. Refolding by F_3 of flattened pebbles (pancake shape) in the Timiskaming Group T_{1A}. The pencil is 10 cm long. (Range IV, lot 49, Rouyn Tp.).

Plate XV

A



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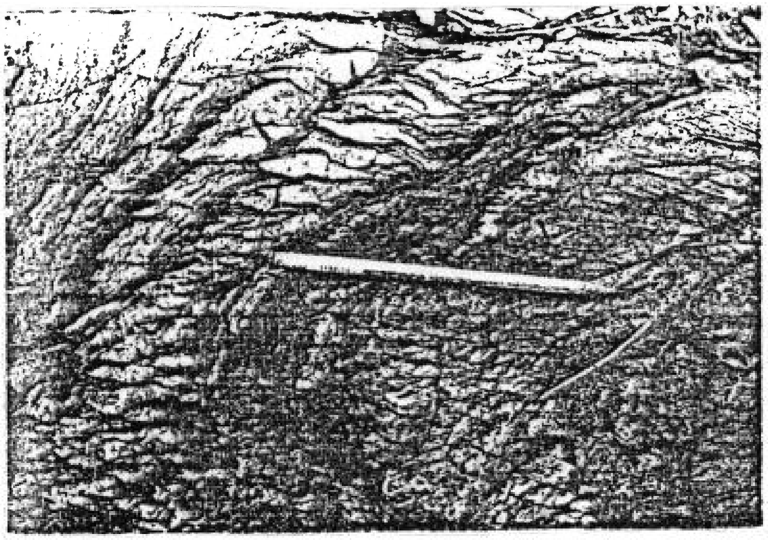

C

The mesoscopic fabric

The mesoscopic fabric associated with the second set of folds is outlined in Figs. 11, 12 and 13. In domain 1, Fig. 11, S_2 is generally east-west and vertical to steeply north dipping (see subdomains 1B, 1C, 1D, 1E, 1F). Toward the western edge of the area (subdomain 1G), near Lac Beauchastel, S_2 is east-west striking but the dip decreases gradually to about 30° north. The lineation (L_2) generally plunges moderately east or northeast, but in subdomain 1A and 1D the plunge is steeper.

In domain 2, Fig. 12, S_2 generally strikes east-west and dips about 50 to 60° north. The lineation L_2 is dispersed within the plane of S_2 but the preferred orientation is a steep northwest plunge in the same direction as the preferred orientation of the long axes of mineral grains and deformed clasts.

In domain 3, Fig. 13, S_2 also strikes east-west but dips more steeply to the north. However in subdomain 3B, S_2 strikes more northeasterly than easterly. The lineation L_2, shows the greatest plunge (very steep northwest), is parallel with the direction of elongation of pebbles, pillows and varioles, and does not have the pattern of dispersion that occurs in domain 2.

THIRD FOLD SET (F_3)

The mesoscopic fabric elements associated with the third set of folds (F_3) are an axial plane crenulation cleavage (S_3) and an intersection or crenulation lineation (L_3^2) due to deformation of the older S_2 foliation about S_3. They occur only in the northern part of the area where S_o and S_2 are essentially parallel, and they are best developed in domain 2.

The minor folds (F_3) occur only locally, are generally quite small (<1 m), open folds with an axial plane dipping moderately to steeply to the north or northeast (see Figs. 11, 12 and 13). They strike east-west in domain 1 and swing gradually to northwest in domain 2. No major folds related to the third set have been recognized.

The penetrative foliation (S_3) associated with the F_3 folds is best developed in the rocks of the Timiskaming Group as a crenulation cleavage involving the schistosity S_2. Changes in direction and amount of plunge of L_3 lineation, outline broad antiforms and synforms related to the younger F_4 folding near Granada Village and the Kinojevis River.

FOURTH FOLD SET (F_4)

The structural elements related to the fourth set of folds (F_4), are a foliation S_4, and a lineation L_4. These are fairly well developed in domain 2, mainly in the eastern part of the area in a zone running northeast-southwest parallel to Lac Vallet, and also near the Granada village. These structural elements have also been observed in the volcanic rocks of domain 3, where the foliation S_4 is not so penetrative, and also in subdomain 1A where an F_2 anticline has been refolded.

The minor F_4 folds represented on map 5 and map 6 and on Figs. 11, 12 and 13 are folds of the second foliation (F_4^2 folds). Because S_2 is more or less parallel with S_o, particularly in domain 2, they are almost equivalent to F_4^o folds. They generally plunge to the northeast at about 30°, and the axial surfaces are almost vertical. They vary in size but generally they are tight with a short flank from a few to 30 cm long.

The axial surface traces of the major F_4 folds are plotted on maps 5 and 6. The axial surface of the F_2 folds in the Pontiac Group (subdomain 1A) near the Adanac Mine is refolded in an antiform. The F_2 folds plunge 15° east, east of the F_4 antiform, and about 30° west, west of the antiform. Further south the same F_4 antiform is probably responsible for the bend in the axial surface of the major F_2 antiform and synform that occur in the Pontiac Group, and also for the change of plunge from 60° to 30° east in those major F_2 folds. In the Granada area the effect of that fourth fold set (F_4) is minor. It can be recognized by the change in the plunge of L_3 from one side of the trace of the axial plane to the other side. Further south, at Lac Beauchastel, the folding of the trace of the F_2 antiform is probably caused by this F_4 fold set.

The surface S_4 is generally weakly developed and represented by a crenulation cleavage oriented parallel to the axial planes of the F_4 folds. The foliation S_4 is locally penetrative, as, for example, near the Granada village, where S_4 forms a closely spaced differentiation crenulation cleavage. This cleavage, defined by crenulations bounded by aligned chlorite, sericite and white micas, can be observed in the sedimentary rocks near the contact with the volcanic rocks and it can be observed that it is younger than S_2 and S_3.

The lineation L_4 defined by the intersection of S_2 and S_4 is parallel with the B_4^2 axes of the minor F_4 folds.

The mesoscopic fabric associated with the F_4 folds is well developed in the northern part of domain 1, in domain 2 and in the eastern part of domain 3. It can be seen from the individual fabric diagrams in Figs. 11, 12 and 13 that the general strike of S_4 is northeast-southeast and the dip is steep to the northwest. The surface S_4 does not seem to be folded by any later deformation. The diagrams show very good concentration of poles except in areas where kink bands are superimposed on the fabric as in subdomain 2B.

The lineation L_4 plunges generally between 20 to 40° to the northeast, except in areas of complex structure in subdomain 1A. In domain 2, L_4^2 trends generally northeast and plunges northeast, whereas in domain 3 it generally trends more northerly and plunges more steeply (about 50° north).

Small <u>kink bands</u> are common in the eastern part of the area near the Kinojevis River, but also occur less commonly in the rest of the area. They strike from north 20° east to north 45° east and locally a conjugate more or less east-west set striking also occurs. Although the kink bands strike parallel to S_4, locally it can be observed that S_4 is deformed by the kink bands.

FAULTS

Two major fault systems are present in the area: an east-west system represented mainly by the Cadillac-Larder Lake fault, and a younger northeast-southwest system represented mainly by the Davidson Creek fault. There is also a conjugate shear fracture set related to this second system, and this is oriented northwest-southeast.

The Cadillac-Larder Lake fault (Wilson, 1962; Ambrose and Gunning, 1939) is marked by a rusty weathering ankerite-talc-chlorite schist and varies in width from 30 m to about 200 m. There is an increase in degree of deformation close to the fault zone. The folding becomes tighter and the schistosity S_2 strongly developed. Data from diamond drill cores and underground openings indicate that the fault dips about 70° north and is a reverse fault (Wilson, 1962). According to M. E. Wilson an overturned anticline in the volcanic rocks of the Blake River Group has been thrust over an adjacent syncline in the sedimentary rocks. The present study does not provide a reliable basis for a detailed analysis of the history of the Cadillac-Larder Lake fault, but the history is probably complex. Faulting may have commenced with normal displacements during the formation of the Blake River volcanic complex to the north, and may have been reactivated later, among other times, during deposition of the Timiskaming Group and "Granada Group" (see Chapter 3, p. 13 for stratigraphic and sedimentologic evidence).

In the McWatters area the fault lies more or less in a transition zone between the fluviatile sediments that lie to the north, and the marine volcanic rocks and turbidites with which they are interfingered to the south. It seems clear that the sedimentation was controlled by faulting, and that the antecedent of the Cadillac-Larder Lake fault was probably a part of a regional fault system, separating the emergent volcanic complex to the north from the turbidite basin to the south.

The Davidson Creek Fault

The displacement along the second system of faults varies from a few cm to about 1.5 km. Only the larger components of the main system of northeast-southwest trending strike-slip faults or of the conjugate system northwest-southeast striking faults have been mapped. The northeast-trending set generally have a left-hand strike-separation, whereas the northwest set is generally right-handed and almost vertical. These faults offset the Cadillac-Larder Lake fault.

The main north-east southwest trending fault is the Davidson Creek fault. Cooke (1931), Hawley (1934), and Ambrose and Gunning (1939) have all interpreted it as a left-hand fault with a strike slip of approximately 1.5 km based on the horizontal separation of the contact between the Pontiac and the Timiskaming Groups, on the contacts of a granite in an area just north of our map area, and also on the separation of some diabase dykes. Gunning (1941) suggested that the west side of the fault had been elevated about 2 miles (3 km) relative to the east side. Hawley and Cooke also suggested a large vertical component of displacement, but with the southeast side upward relative to the northeast side. From the present study there is no direct structural evidence on which to base a reliable estimate of the vertical component of displacement on the Davidson Creek fault, but it can be noted (see page 93) that the metamorphic grade is higher on the east side than on the west side, and also, that on the east side there is a post-kinematic thermal metamorphic overprint that is lacking on the west side. This suggests that the east side is probably displaced up relative to the west side.

According to Gunning (1941), the faults of the northeast fault system are later than and offset the auriferous veins. Gunning suggested that these faults were probably initiated during the period of mineralization. Gunning showed that in the Cadillac area there are tiny leaves of gold extending into minute fractures that are parallel with the oblique northeast or northwest fault system.

CHAPTER VI

ECONOMIC GEOLOGY

The Rouyn-Beauchastel includes part of a regional zone of gold mineralization associated with the Cadillac-Larder Lake fault, and is close to the important base metal sulphide deposits of the Noranda camp. Mineral production in the Rouyn-Beauchastel area has been restricted to gold and silver from the McWatters mine and the Granada mine. However, the mineral potential of the area is high as it can be seen from the number of small mines or mining properties (Adanac, Canadian Astoria, Clerno, Rouyn-Merger) in the area.

From our study, four structural features seem to be closely related to the occurrence of the gold-silver deposits:

1. North-south trending F_1 anticlines;
2. Culminations marked by the superposition of F_2 folds, that trend east-west, are associated with L_2 intersection (S_1/S_2) lineations that are very steep to vertical.
3. Faulting parallel with the S_2 foliation and carbonatization associated with it, and
4. A fourth set of folds (F_4), that trend northeast-southwest.

It is well known that the gold deposits occur close to the fault zone within the wallrock that has been altered to ankerite-carbonate-quartz-talc-chlorite rock, as at McWatters, or else close to a syenite porphyry, as at Granada mine.

The question of the source of the gold is still a major problem. Wilson (1962) suggested that, at Granada, the syenite porphyry is not the source of the gold but that the veins occur near or in the syenite because it was more competent and fractured more easily during the development of the east-west folds (F_2 folds) than the Timiskaming sediments into which it was intruded, and that the mineralized veins were localized by dilatancy in the brittle fractured syenite.

Ultramafic metavolcanic rocks which occur in the core of an early (F_1) anticline in the eastern part of the area (see p. 110) may provide an answer to the question of the source of the gold mineralization. While this paper was in preparation, Pyke (1975) demonstrated that in the Timmins area the source bed for the gold mineralization could be the ultramafic rocks; and that the combination of carbonatization and intense deformation are also important factors in the deposition of the gold.

The detailed relationships in the Rouyn-Beauchastel area between gold mineralization and ultramafic volcanic rocks is not clear, but the structural data suggested that known mineral deposits are aligned across the dominant east-west trend of F_2 folds in more or less north-south trending zones along with older F_1 anticlines that contain ultramafic rocks in the core and therefore the occurrence of mineralization can be correlated with early (F_1) structural culminations.

On the other hand it is noteworthy that the ore from the

Granada mine was from the upper portion of magnetite-pebble bearing conglomerate unit (map unit T_{1A}), and that magnetite pebbles also tend to be concentrated in the upper portion of the formation. The McWatters mine is located where the conglomerate is a fluvial (map unit M_1) type deposit, at the limit between fluvial sediments in the north and marine sediments in the south. Detailed study of the provenance and gold content of the magnetite pebbles with more detailed study of their environment of deposition (channel fill?) may lead to another explanation for the concentration of gold at the Granada mine and at McWatters mine.

CHAPTER VII

A TENTATIVE HISTORY OF THE TECTONIC EVOLUTION OF THE ROUYN-NORANDA AREA

On a broad regional scale, the Archean paleogeography of the area can be interpreted in terms of volcanic terrain in the north, represented by the Blake River Group, and a southward transition into a marine sedimentary basin, containing clastic detritus derived from the north and represented by the Pontiac and Timiskaming Groups (see also Table 14). Dimroth (1975b) has concluded that the volcanic pile apparently was built southward in successive steps. During the earlier stage of evolution, as the Kinojevis Group was deposited, most of the volcanic rocks were extruded in a deep marine environment and consisted of a vast, thick sheet of pillowed basalt that interfingered to the east with a shield volcanic complex. Later a thin sheet of basalt, the basal variolitic unit of the Blake River Group, erupted to the south of the Destor complex, and a complex system of overlapping shield volcanoes grew upon this base to form the main part of the Blake River Group. Some of these emerged at the end of the main phase of the Blake River volcanic activity, and shed fans of conglomeratic turbidite that were composed exclusively of volcanic fragments and were mostly andesitic, to the south where they formed the basal conglomeratic sandstone of the Cadillac Group in Joannes Township (see page 30) Some volcanism was contemporaneous with sedimentation, as shown by the rhyolite tuff intercalated in the turbidite at Lac Rouyn, by andesitic flow breccias interfingering with the Cadillac sediments in Joannes

Township, and by the tuff marker in the Timiskaming Group (Map unit T_{2C}). Somewhat later the volcanic chain emerged with its large hypabyssal synvolcanic plutons and shed debris southward to form the turbidites of the upper part of the Pontiac Group, the Timiskaming Group and the Cadillac Group. There was minor volcanic activity on the emergent volcanic complex at this time, as shown by the presence of minor tuff in turbidites in the Timiskaming Group.

Proximal equivalents of the turbidite conglomerate near McWatters were deposited in fluviatile environments, and they form the "Granada Group".

It is probable that a regional fault system, ancestral to the Cadillac Fault zone, separated the volcanic chain to the north from the turbidite basin to the south.

The evolution of the Timiskaming Group in this area can be outlined in several stages.

Stage I

Southward progradation of conglomeratic volcanic debris into a marine basin off the flank of a linear volcanic complex. During the latter stage of progradation, channels cut into greywacke turbidite on the upper part of the marine slope were filled with monomict conglomerate comprising slumped sediment (Pontiac Group). This may have been a result of uplift and erosion further north (see Fig. 16).

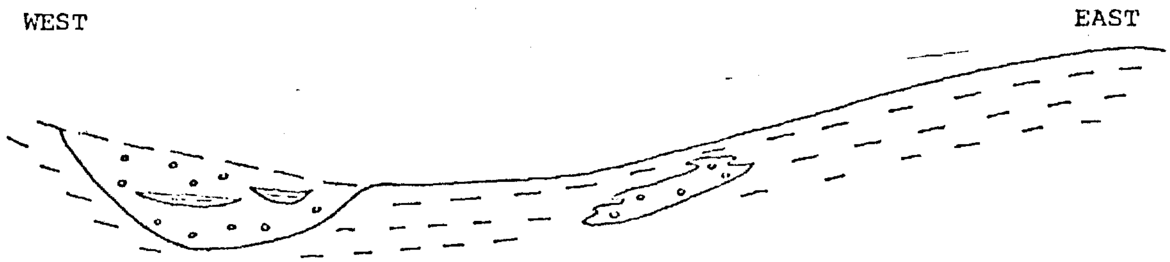

Fig. 16. Schematic section of relationships in Pontiac Group during Stage I.

Stage II

Accumulation of magnetite-bearing conglomerate (unit T_I) as mass flow deposits on a submarine fan. The upper part of the Pontiac Group (unit P_I) in the eastern part of the area, north of Lac Vallet, may be contemporaneous with the deposition of the magnetite conglomerate (T_I) and there may be some lateral intertonguing of the Timiskaming and Pontiac Groups east of Lac Vallet.

Stage III

Deposition of greywacke with minor intercalated conglomerate (unit T_2). Accumulation of sediments in the Lac Bouzan area, north of the main syncline, which were deposited in alluvial fans that graded over a very short distance to submarine fan deposits.

North	Lac Bouzan area	South
Transition zone from alluvial to marine deposits	←——————→	Submarine fan

Stage IV

Deposition of the porphyry conglomerate (unit T_3) and the pebbly sandstone (unit T_4), probably in a marine environment.

Accordingly a cross section through the sediment complex south of Rouyn-Noranda would be characterized by the relationships illustrated in Figure 17.

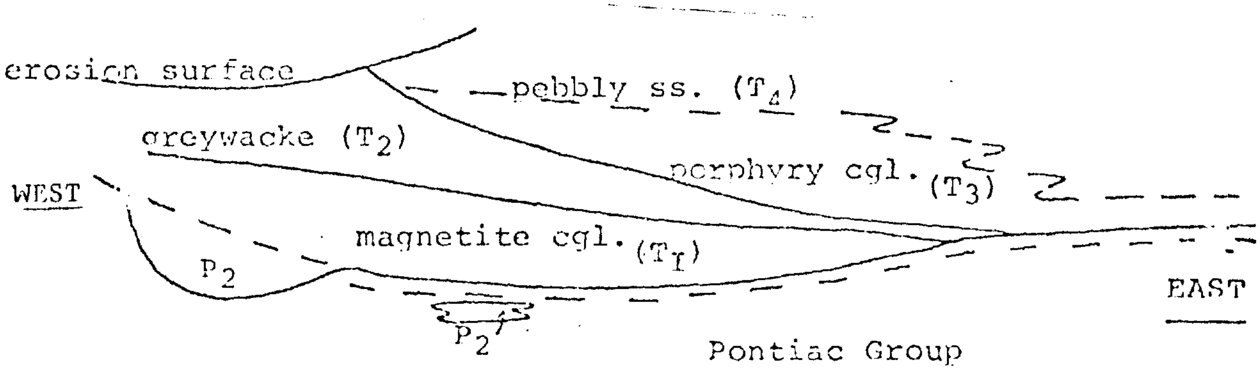

Fig. 17. Schematic cross section of stratigraphic relationships in the Timiskaming Group south of Rouyn-Noranda.

Whereas further north the relationships would be as illustrated in Figure 18.

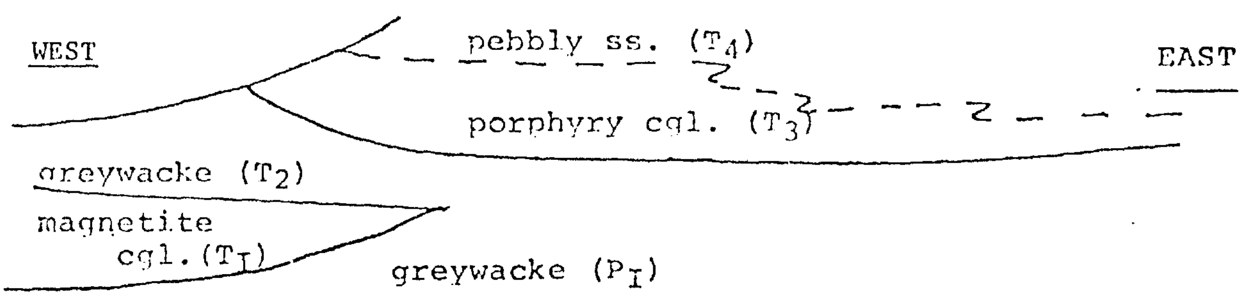

Fig. 18. Schematic relationships in Timiskaming Group showing a cross section north of Fig. 17.

Table 14. Interpretation of Sedimentary History - Cadillac, Pontiac, Timiskaming and Granada Groups.

Tectonic Processes	Timiskaming Area (Mostly Southern Part of Rouyn-Noranda Area)	Lac Rouyn-Joannes Area (Eastern Part of Rouyn-Noranda)
Beginning of uplift in volcanic zone	→	1 Joannes conglomerate deposited with
volcanism (in part sub-aerial)	→	contemporaneous volcanic rocks
acid explosive volcanism	→	2 * Tuff turbidites at Lac Rouyn
hypabyssal synvolcanic plutons unconvered	→	3 * Quartz-bearing greywacke turbidite deposited
		4 * Deposition of jasper iron formation (Inferred).
	5 * Pontiac turbidite deposited (Map unit P_1)	
	6 Slumping on slope in the Pontiac Group: cutting of channels in channels.	
	7 Filling of channels by greywacke conglomerate (map unit P_2)	
strong uplift in area north of Cadillac fault, erosion of earlier sediments.	8 Advance of oldest conglomerate unit: magnetite conglomerate (submarine fan) and Granada conglomerate (alluvial fan).	
subsidence	9 Transgression	
strong uplift north of Cadillac fault	10 Building of complex alluvial - turbidite complex of middle member (map unit T_2). Growth of alluvial fan in Lac Bouzan area.	
mafic explosive volcanism	11 * Tuff marker.	
	12 Bouzan alluvial fan expands to form the porphyry conglomerate (map unit T_3).	
	13 Retreat of the piedmont, feeding the Bouzan fan: deposition of the pebbly sandstone unit (map unit T_4).	

NOTES: * AGE - RELATIONS:

2 and 3: The tuff turbidite at Lac Rouyn probably was formed sometime during period 3 (or 1?) in a separate basin.

3-4-5: Relative ages are uncertain. In the extreme case, events 1 to 3 could perhaps even correlate with event at 9. However some sediments north of the Cadillac fault must have been present, including jasper, before event 7.

11: The tuff marker correlates with event 10. assuming that the chloritic greywacke southeast of Granada is equivalent of the tuff marker at Lac Bouzan.

1: The Joannes conglomerate is characterized by conglomerate with angular fragments. It probably was derived from erosion of a coastal or fault escarpment. No previous alluvial transport of the fragments seems possibly nor transported very long in the marine environment.

2: On basis of the transition from proximal to distal facies, it can be concluded that the tuff turbidites at Lac Rouyn were derived from the west or northwest.

3: On the basis of changes in stratigraphy at Lac Bouzan, and on the position of the tuff marker deep in greywacke turbidite sequence at Granada, it can be concluded that an alluvial fan growing into the sea south of Lac Bouzan, expanded southward and laterally. According to this basin model the alluvial fan graded into a turbidite fan, practically without transition.

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