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CUOQ - LANGIS AREA, MATANE AND MATAPEDIA COUNTIES

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GEOLOGICAL EXPLORATION SERVICE

ROBERT BERGERON, Director

GEOLOGICAL REPORT 121

CUOQ-LANGIS AREA

MATANE AND MATAPÉDIA COUNTIES

by
N.C. Ollerenshaw

QUEBEC

1967

THE UNIVERSITY OF CHICAGO
DEPARTMENT OF CHEMISTRY
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Tight, overturned fold in a limestone-shale sequence of the Matane River Group, in a roadcut about half-mile northwest of the bridge at Rivière Matane.

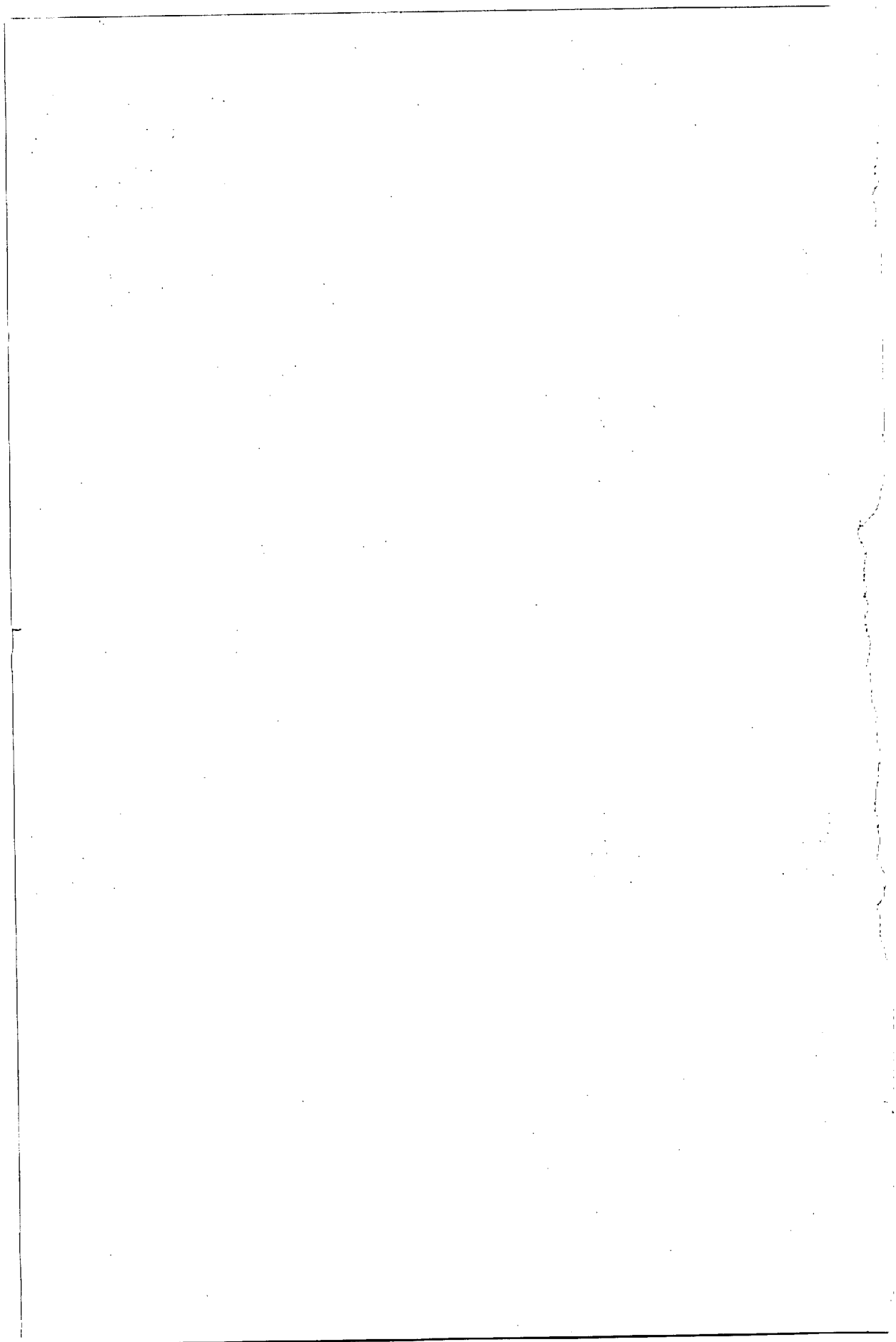


TABLE OF CONTENTS

	<u>Page</u>
INTRODUCTION	1
General statement	1
Location and area	2
Access	3
Field work	3
Compilation and laboratory work	4
Acknowledgements	4
Previous work	5
GENERAL GEOLOGY	6
General statement	6
Table of formations	8
Cambro-Ordovician	9
The Quebec Complex	9
The age of the Quebec Complex in northwestern Gaspé	10
The age of the Quebec Complex in Cuoq-Longis area	16
The Matane River Group	18
General description	20
The slate sequence	20
Kamouraska facies	30
General	30
Distribution	32
Internal stratigraphy	37
External stratigraphy	38
Lithology	40
Origin of the Kamouraska facies	50
The Shickshock Group	56
General	56
Problems and history of interpretation	56
The Lake Matapédia/Shickshock mountains relationship	60
General stratigraphy of the Shickshock Group	63
The Lake Matapédia facies	65
The Lake Matapédia area	65
Stratigraphy	65
Lithology	70
The Shickshock Mountains area	83
Stratigraphy	83
Lithology	85
The Duvivier facies	87
Stratigraphy	87
Lithology	88
Environment and conditions of deposition of the Shickshock Group	89
Provenance	89
The nature of the depositional environment	91
The nature of the source area	92

	<u>Page</u>
Pre-Silurian unconformity	94
Silurian	95
The Awantjish Formation	95
Stratigraphy and lithology	95
Paleontology and age	95
The Incognito conglomerate	96
The Val Brillant Formation	102
Stratigraphy and lithology	102
Paleontology and age	109
The Sayabec Formation	110
Paleontology and age	110
The Saint-Léon Formation	111
Stratigraphy and lithology	116
Paleontology and age	121
Devonian	122
Cape Bon Ami Formation	123
Stratigraphy and lithology	123
Paleontology and age	126
Grande Grève Formation	128
Stratigraphy and lithology	128
Paleontology and age	128
York River Formation	129
Stratigraphy and lithology	129
Paleontology and age	135
STRUCTURAL GEOLOGY	139
General	139
Faults	141
Folds	142
The Shickshock Group	142
The Matane River Group	145
The Silurian and Devonian	145
Joints and cleavage	146
The structural relationship between the Shickshock mountains and Lake Matapédia	147
The structural relationship between the Shickshock Group and the Matane River Group	147
Summary structure of the Shickshock Group	147
PHYSIOGRAPHY	151
Physiographic divisions	151
The Shickshock mountains	151
The dissected upland	153
Drainage	153
Lakes	155
Structural-lithologic control of topography	156
Peneplanation	157

	<u>Page</u>
Glacial modification	158
Drainage development	158
The problem of Matane/Matapédia relationships	159
The problem of Matane development	160
ECONOMIC GEOLOGY	162

APPENDICES

A Systems of classification and nomenclature used	166
B Kamouraska facies - Section at Goupil village	168
C Composition of the phenoclasts in the common type of Kamouraska limestone conglomerate	171
D Age determination of Shickshock Group metamorphism	173
E Evidence of tops in the Shickshock Group at Lake Matapédia	174
BIBLIOGRAPHY	175
ALPHABETICAL INDEX	190

TABLES

1 Kamouraska quartzite analyses	50
2 Estimated mineralogical composition of typical Shickshock Group volcanics at Lake Matapédia	70
3 Estimated mineralogical composition of typical Shickshock Group arkose at Lake Matapédia	75
4 Percentages of CaO, Na ₂ O and K ₂ O in Shickshock Group volcanics	94
5 Chemical analysis of Val Brillant sandstone from the Langis-Tamagodi outlier	103

ILLUSTRATIONS

Maps

- No. 1570 - Geological map, Cuoq-Langis area, including
 cross-section of the region..... (in pocket)
- No. B-842- Composite columnar and cross-sections of
 the Shickshock Group at Lake Matapédia ... (in pocket)
- No. B-844- General geological map of the Shickshock
 Group and of associated formations (in pocket)

Figures

	<u>Page</u>
1 - Matane River Group - broad lithologic differentiation	19
2 - Schematic structure sections of the Shickshock mountains	58
3 - Schematic diagram of the probable depositional environment of the Shickshock Group	90
4 - Distribution of the <u>Etymothyris</u> and <u>Amphigenia</u> zones in the York River Formation of the Lake Casault syncline	133
5 - Schematic interpretation of the general structural position of the Shickshock Group	143
6 - Physiographic divisions of the Cuoq-Langis area	150
7 - Drainage pattern of Cuoq-Langis and the surrounding area	154
8 - Suggested changes in the drainage pattern of Northwestern Gaspé	161

Plates

Frontispiece - Fold in the Matane River Group	II
I-A Ptychoparioid trilobite cranidium, Matane River Group	14
-B Algal limestone phenoclast, Kamouraska conglomerate ..	
II-A Probable worm castings, Matane River Group	15
-B Worm castings or burrows, Matane River Group	
III-A Laminated slates, Matane River Group	23
-B Laminated slates, Matane River Group	
IV-A Calcite vein, Matane River Group	28
-B Calcite vein, Kamouraska conglomerate	
V- Section of Kamouraska facies at Goupil	29
VI-A Kamouraska quartzites	33
-B Stratification in the Kamouraska facies	
VII-A Stratification in the Kamouraska facies	34
-B A lens of Kamouraska quartzite	

	<u>Page</u>
VIII- Bedding in limestone conglomerate	35
IX-A Kamouraska-type phenoclasts in slate	36
-B Intraformational conglomerate, Matane River Group	
X-A Kamouraska limestone conglomerate	41
-B Kamouraska limestone conglomerate	
XI-A Kamouraska limestone conglomerate	42
-B Folded phenoclast in Kamouraska conglomerate	
XII-A Kamouraska limestone conglomerate	43
-B Kamouraska limestone conglomerate	
XIII-A Basal volcanic contact at Lake Matapédia	67
-B Pillow lavas on the shore of Lake Matapédia	
XIV-A Amygdaloidal pillow lavas at Lake Matapédia	76
-B Pillow structures (Shickshock Group)	
XV-A Crossbedding in Shickshock Group arkose	78
-B Red slate conglomerate bed, Shickshock Group	
XVI- Close-up of the Incognito conglomerate	97
XVII-A Val Brillant cliffs of the Langis-Tamagodi outlier ...	98
-B Bedding in the Val Brillant sandstone	
XVIII-A Fragments in Val Brillant sandstone	99
-B Piercement extrusion structure, Val Brillant sandstone	
XIX-A Piercement extrusion structure, Val Brillant sandstone	100
-B Convolute bedding, Val Brillant sandstone	
XX-A Possible bubble-pits, Val Brillant sandstone	107
-B Small protuberance on a bedding surface	
XXI-A Probable fossil trails, Val Brillant sandstone	108
-B Probable fossil trails	
XXII-A Bedding in the Saint-Léon Formation	112
-B Possible load or flow casts	

	<u>Page</u>
XXIII-A Coarse, possibly deltaic Saint-Léon sandstones	113
-B Saint-Léon section on the Truite river	
XXIV-A Pseudoconglomerate in the Saint-Léon Formation	114
-B Pseudoconglomerate in the Saint-Léon Formation	
XXV- Macerated plant fragments, Saint-Léon Formation (?) ..	115
XXVI-A Laminated Cape Bon Ami limestones	125
-B Cleavage in Cape Bon Ami limestones	
XXVII-A Separation surfaces in York River sandstones	134
-B Cliff exposure of well-bedded York River Formation ...	
XXVIII-A Fault breccia on the Matane river	140
-B Fault breccia on the Matane river	
XXIX- The southern escarpment of the western Shickshock mountains	152

CUOQ-LANGIS AREA
MATANE AND MATAPEDIA COUNTIES¹

by

N.C. Ollerenshaw

INTRODUCTION

General Statement

The geology of northwestern Gaspé in general and the Shickshock mountains in particular has been variously interpreted on the basis of both reconnaissance and local evidence. The present study has revealed new evidence and, in conjunction with earlier investigations of adjoining areas, permits the first comprehensive appraisal of the Shickshock Mountain region.

The Cambro-Ordovician Quebec Complex² includes the Shickshock and the Matane River² Groups in the Cuoq-Langis area. The Shickshock Group (arkose and volcanics) is a local facies equivalent of an intermediate part of the Matane River Group (slates) to the northwest. The facies contact is interfingered. The Shickshock Group was probably derived from the southeast during the Cambrian, and the source area probably comprised an upfaulted block of sodic-granitic Precambrian rocks. Arkosic sediments were derived from the block itself, while basalts emanated from the fissured margin. The Shickshock Group overlies that part of the Matane River Group immediately to its north. The contact appears to be normal, essentially conformable, unfaulted and dips southeast. The basic interior structure of the Shickshock Group consists of a northern syncline and a southern anticline. Along its southern margin the Shickshock Group is brought into contact with the Silurian by the South Shickshock fault, which forms part of an extensive fault lineament, probably periodically active from early Cambrian to Devonian. Slates of the Matane River Group contain important lenses of the Kamouraska facies

¹ Corresponds to St. Vianney 22/B/11 East and West halves and part of the Sayabec 22/B/12 East half.

² New terms introduced in this report.

throughout. Derivation of the limestone conglomerates and quartzites of this facies from multiple, repeated, penecontemporaneous uplifts is suggested. An anticlinorium may occur in the Matane River Group north of the Shickshock mountains.

Middle Silurian to Lower Devonian sandstones, siltstones and limestones form a continuous, conformable succession overlying the Cambro-Ordovician with apparent unconformity. The Middle Silurian Incognito conglomerate was derived from the Shickshock Group. Penecontemporaneous deformation affected the Val Brillant Formation locally. Specimens of Linograptus posthumus posthumus from the Saint-Léon Formation, are the first linograptids of European affinity to be reported from North America.

Age determinations suggest a pre-Taconic episode of deformation, possibly in the late Cambrian. The role of Taconic orogeny is not clearly established. Structural genesis was completed in the Acadian orogeny.

The area was mapped in 1959 and 1960; some checking was done in 1961.

Location and Area

The Cuoq-Langis area includes approximately 425 square miles of northwestern Gaspé peninsula and extends from Lake Matapédia eastwards almost as far as Lake Matane. It is defined by latitudes 48°30' to 48°45' and longitudes 67°00' to 67°30', plus a small westward addition at Lake Matapédia. That part of the area lying in Matane county includes most of Cuoq and parts of Lagrange, Tessier, Saint-Denis, and Matane townships; most of Langis, and parts of Blais and Lepage townships, as well as part of the Seigneurie du Lac Matapédia are in Matapédia county.

The area is partly continuous with the Mount Logan area (Mattinson, 1964) on the east, but extends beyond this area southwards, bordering terrain which has not yet been mapped in detail. To the south, the eastern half of the Cuoq-Langis area borders the Causapscal area (Stearn, 1965), and to the north it borders the Sainte-Félicité - Grosses Roches area (Béland, 1957). On the west, the terrain is unmapped in detail. Southwestwards lies the Rimouski-Matapédia area (Béland, 1960). The Cuoq-Langis area falls partly into the broader, reconnaissance scale, Matapédia Lake area of Aubert de la Rüe (1941).

Access

The town of Amqui, about 3 miles south of the southwest corner of the area, is easily reached by the Montreal-Halifax line of the Canadian National Railways, or Provincial Highway 6. From Amqui, a paved, secondary road zig-zags northwards through the western half of the area linking Amqui with Matane, via the villages of Saint-Tharsicius, Saint-Vianney, Rivière Matane and Saint-René-Goupil. Air access to the region is provided by Mont-Joli airport, to the north.

In the settled western half of the area, good communications are provided by numerous gravel roads which usually coincide with range or lot boundaries, producing a basic rectangular pattern of northeast-southwest and northwest-southeast routes. All such routes connect with the paved Amqui-Matane highway. A private gravel road system, around the northeastern shore of Lake Matapédia, is accessible from the general road system via Amqui, Sayabec and Saint-Tharsicius. The more rugged, forested eastern half of the area has more restricted but conveniently spaced access through gravel roads, the most important of which follows Matane river. Further access is limited to trails or rough truck roads, and most traversing must be accomplished on foot.

Field Work

Contoured topographic base maps of the area, on a scale of 2 inches to 1 mile, were prepared by the Quebec Department of Natural Resources from smaller-scale provisional maps (Sayabec 22 B/12-East Half and Saint Vianney 22 B/11) compiled by the Department of Mines and Technical Surveys, Ottawa. The geological map accompanying this report is based on these maps modified by observations made in the course of field work.

Air photographs, taken in 1938, on a scale of approximately 2.7 inches to 1 mile, were obtained from the Royal Canadian Air Force. Other air photographs, on a scale of approximately 1 inch to 1,320 feet and covering the northeast quadrant of the area, were obtained in 1961 from Photographic Surveys (Quebec) Ltd. These were taken in 1952 and show the current state of the land surface more accurately and clearly.

Since much of the bedrock exposure occurs in the stream valleys, traverses were made along most of the streams. All lake margins, roads and the many trails were also traversed. Traverses were made in the interstream areas only where it was necessary to cross small divides, or where streams were more than a reasonable distance apart, or where observation of ground or aerial photographs suggested the possibility of outcrop. Pace and compass methods were used throughout, distances being

checked as frequently as possible at control points such as stream junctions. Location by this method, supported by cross-checked aneroid barometer readings for elevation, aerial photographs, and detailed topographic maps, was comparatively easy and accurate.

Compilation and Laboratory Work

This phase of the investigation was mainly carried out at the University of Toronto during the years 1959-62. Some of the samples and thin-sections from Gaspé in the collections of the Quebec Department of Natural Resources at Quebec were examined. Paleontological studies were pursued at the Royal Ontario Museum.

Chemical analyses were provided by laboratories of the Quebec Department of Natural Resources, and of the Ontario Department of Mines. A K-Ar age determination on a sample of Shickshock material was made by the Department of Mines and Technical Surveys, Ottawa.

Acknowledgements

Field party personnel during the 1959 season were Y. Couture as senior assistant; R.E. DeLong, L. Lavoie and C. Samson as junior assistants, and G. Thibeault as cook. In 1960, C. Johnson served as senior assistant; D. Carr, C. Lamontagne and A. Valliere as Junior assistants, with H. Savard as cook. Grateful appreciation for assistance is expressed to all these persons.

The writer acknowledges with gratitude the cooperation and assistance of Mr. A. Murray, of Price Brothers and Co., Ltd. (Rimouski), Mr. L.S. Lister of the Hammermill Paper Co. (Matane), and Mr. Dixon of the International Paper Co. of New Brunswick, for providing valuable information and putting road and camp facilities at the disposal of the party.

Dr. F.W. Beales of the University of Toronto supervised the office and laboratory research, visited the writer in the field, and provided invaluable guidance and inspiration. Dr. M.A. Fritz, Dr. W.W. Moorhouse, and Dr. J.B. Currie of the University of Toronto gave generously of their experience and time in discussing the various problems associated with the thesis. Dr. R.R.H. Lemon made numerous useful suggestions and provided excellent facilities in the Royal Ontario Museum. Mr. D.A. Moddle of the Assay Laboratory, Ontario Department of Mines, kindly undertook a partial quantitative analysis.

Research at the University of Toronto was greatly assisted by the National Research Council in the form of studentships over the years 1959-60 and 1960-61, plus a research grant in 1961-62.

Previous Work

Most of the previous work has touched the Cuoq-Langis area only casually as part of explorations and investigations of a more extensive nature, particularly around Lake Matapédia. Other pioneer visits were made along Matane and Causapschal rivers. The greater part of the area has, however, remained unknown save for brief reconnaissance.

The first recorded visit to the Cuoq-Langis vicinity is that of Logan (1846, p. 34) to Lake Matapédia in 1844 as part of his initial geological investigation in Canada, the exploration of Gaspé. In 1845, Logan's assistant of the previous year, A. Murray (1847), followed Matane river almost to its source, crossing en route the northern half of the area. The area was again touched briefly in 1858, by J. Richardson (1859), on his way north by canoe from the Restigouche via Matapédia and Great Metis rivers to the St. Lawrence. Logan (1863, p. 390-391) made summary reference to all the preceding work in his "Geology of Canada" and included the area on his Geological Map of Canada (1865).

A.P. Low visited Lake Matapédia in 1884. He correlated (1885 p. 16F) the strata on the east side of the lake, with the "Pre-Cambrian" Shickshock mountains, and made passing reference to the Silurian west of the lake. R.W. Ells (1885) made similar reference, probably on the basis of Low's observations, and mentioned Matane and Causapschal rivers. The work of Ells and Low is included in their geological map (1884), on one section of which the geology of the Cuoq-Langis area is outlined, on a scale of 4 miles to 1 inch. L.W. Bailey and W. McInnes (1889, p. 13M) visited the Matapédia valley and Lake Matapédia in 1888 in the course of their general reconnaissance of the region. R. Chalmers (1896, p. 86A) referred to glacial striae and the direction of ice movements at Lake Matapédia. Lake Matapédia was not visited again until A.P. Coleman's 1918-19 (1922) investigation of the glacial history of the peninsula.

In 1924, F.J. Alcock (1926b) examined geological sections along Matane and Little Matane rivers and around Lake Matapédia in connection with his investigation into the age problem of the Shickshock rocks around Mount Logan to the east. During Alcock's geological survey of the Chaleurs Bay region between the years 1928 to 1931, Lake Matapédia was again visited. In 1929, he introduced G.W. Crickmay to the Matapédia valley, a region which the latter continued to investigate alone in 1930, searching for evidence of Taconic orogeny. Reference is made to the Lake Matapédia region in Crickmay (1932) and Alcock (1935). The New Brunswick - Gaspé map compiled by Alcock (1931) illustrates the limited advance made in the geological investigation of the Cuoq-Langis area since the work of Ells and Low, and follows their 1884 interpretation exactly, on a reduced scale of 8 miles to 1 inch. A summary of the general geology of Gaspé peninsula was made by W.A. Parks (1931).

In 1937, J.W. Laverdière and L.G. Morin (1941) extended exploration slightly from the confines of Lake Matapédia and Matane river, and made a minor reconnaissance of the Langis half of the area, as part of their study of the Canadian Appalachians between Rivière-du-Loup and Matane. Aubert de la Rûe in 1938 (1941) performed a similar, slightly more detailed reconnaissance, which again included parts of the Langis area.

Observations relevant to the Cuoq-Langis area were compiled and summarized by J.A. Dresser and T.C. Denis (1944) in volume II of their "Geology of Quebec".

The most recent geological work in the area was carried out by H.W. McGerrigle as part of his general reconnaissance of Gaspé, preparatory to the compilation of the Geological Map of Gaspé Peninsula (1953), which broadly outlines the geology of the Cuoq-Langis area on a scale of 4 miles to 1 inch. Over the years 1954 to 1957, a gravity survey of Gaspé peninsula, including the Cuoq-Langis area, was jointly conducted by J.G. Tanner and R.J. Uffen (1960) of the Dominion Observatory.

GENERAL GEOLOGY

General Statement

Two major continental structural units come into contact, or nearly so, along the St. Lawrence. These are the Canadian Shield and the Appalachian Mountain System. The former is the exposed continental nucleus of predominantly granitic, Precambrian rocks. The latter comprises a vast peripheral wedge of sediments with igneous additives, formed and deformed during the Paleozoic into a great northeast-trending belt of folded, thrust, and more or less metamorphosed rocks of great structural complexity, which extends for at least 2,000 miles, from Alabama to Newfoundland, interrupted only by the Gulf of St. Lawrence.

The formation of the Appalachian Mountain System was a cumulative process, carried on throughout the Paleozoic to completion in the early Mesozoic, with many relatively localized movements of varying intensity, superimposed on a background of slowly formed, long-sustained warping of the geosynclinal floors. This promoted an ever-changing topographic and depositional surface, with variations and even reversals in the direction of sedimentation and the distribution of land and sea all combining to produce the final orogenic belt. It was in this environment of constant and sustained mobility* that the present geology of the Gaspé peninsula evolved.

*The present interpretation is based on general contemporary opinion outlined in the summary works of Kay (1942 and 1951), Eardley (1951), Clark and Stearn (1959) amongst others, superseding the early views, led by Schuchert, of more persistent conditions, in which large hypothetical geanticlines and borderlands split and bounded the geosyncline, the whole sundered by sudden, long-separated "revolutions".

Despite the continuity of deformation, at least three periods of increased or maximal tectonic activity have been demonstrated during the Paleozoic. These are the Taconic (late Ordovician to early Silurian); Acadian (Middle to Upper Devonian); and Appalachian (late Paleozoic) disturbances or orogenies.

Several salients and embayments distort the Appalachian lineament along its northeast trend. Gaspé peninsula itself forms one such salient or arc, convex northwards, with a southwesterly strike in the west and a southeasterly strike in the east, attributable to a pronounced Middle Devonian or younger cross-fold through east central Gaspé. This major cross-fold is evident on the geological map of Gaspé (McGerrigle, 1953).

Major deformation contributing to the present Gaspé succession is generally attributed to the Taconic and Acadian movements, there being little Appalachian deformation other than possible fracture and renewed fault movement. The cumulative effect of these deformations has imposed a synclinal structure on central Gaspé, passing southwards into an anticline, and cut by the cross-structure noted above. Flat-lying Pennsylvanian strata overlap the south flank of the southern anticline.

Rocks ranging in age from Cambrian or older to Pennsylvanian, plus a veneer of Pleistocene and Recent sediments, are represented in Gaspé. The affinities of the older, pre-Silurian rocks of northern Gaspé are eugeosynclinal. The rocks are predominantly graptolitic shales (now slaty) with subordinate sandstone and basic volcanics. Anomalous shallow water limestone conglomerates and quartzitic sandstones occur within the slates. The Silurian and Devonian strata represent an impure miogeosynclinal and coastal suite of sandstones, limestones, and shales associated with locally abundant volcanics and intrusives.

Volcanics, largely basalts and andesites, form an important part of the succession from probably Cambrian to the Devonian. Ultrabasic intrusions, possibly early Ordovician in age, Ordovician, Silurian, and Middle Devonian or younger granites and diabase completed the igneous activity of the region.

The Cuoq-Langis area is situated at the western end of the Gaspé salient, where the rocks trend northeast and strata of both the eugeosynclinal (Cambro-Ordovician) and younger miogeosynclinal (Silurian-Devonian) facies are in fault contact. The eugeosynclinal rocks are sharply crumpled and largely overturned and carried northwestwards by pre-Silurian and possibly Acadian movements. The miogeosynclinal rocks are rippled into less acute anticlines and synclines, and cut by several faults, all presumably of Acadian age.

Table of Formations

TIME		FORMATION OR GROUP (Thickness in feet)	DESCRIPTION	
CENOZOIC	Pleistocene and Recent		Gravels, sands, silts; boulder clay; stratified clay; boulders (erratics)	
Unconformity				
PALEOZOIC	Devonian	York River Formation (5,000+)	Feldspathic sandstone and siltstone; minor shale	
		LOWER	Grande Grève Formation (3,000-5,000)	Calcareous siltstone and silty limestone
			Cape Bon Ami Formation (?3,500+)	Argillaceous, silty limestone and calcareous siltstone
	Silurian	UPPER	Saint-Léon Formation (5,000+)	Calcareous siltstone and sandstone; minor shale, limestone conglomerate, limestone, and calcarenite
			Sayabec Formation (500+)	Fossiliferous limestone and calcareous siltstone
		MIDDLE	Val Brillant Formation (300-500)	Orthoquartzitic sandstone, dolomitic in upper part
			Awantjish Formation (100+)	Fossiliferous shale; minor conglomerate (the Incognito)
	Unconformity			
	Cambro- Ordovician	QUEBEC COMPLEX	Shickshock Group	Arkose; meta-arkose; minor slate and muscovite schist; rare chert, jasper and tuffs Basalts and metavolcanics
			Matane River Group (?)	Slates; quartzite and lime- stone conglomerate (Kamouraska facies) minor sandstone, siltstone, limestone, and calcarenite

CAMBRO-ORDOVICIAN

The Quebec Complex

The Cambro-Ordovician rocks of the Cuoq-Langis area form part of an extensive belt, 10 to 25 miles wide, that follows the south shore of the St. Lawrence from the eastern end of Gaspé southwestward for several hundred miles to Quebec City and, possibly, to Vermont. None of the existing stratigraphic divisions for this belt are correctly applicable to the rocks of the Cuoq-Langis area. A summary history of stratigraphy and nomenclature follows.

Logan (1863) established the Quebec Group to incorporate his Lévis and Sillery Formations in the vicinity of Quebec City. On the basis of work by Billings, Logan considered the Quebec Group to be of Calciferous-Chazy age. This stratigraphy was extended, primarily on the basis of lithological correlation, as far as Gaspé (where it included the Shickshock Group of this report), and the Eastern Townships by Logan, contemporary, and later workers. Ells (1883) revealed that Logan's succession was inverted and that the Lévis Formation is actually younger than the Sillery. Lapworth (1887) supported this view, confirmed the Calciferous (Beekmantown) age of the Lévis and suggested that the Sillery is Upper Cambrian.

From its inception, the Quebec Group was subjected to uncontrolled application and correlation. Ells (1889; 1892) proposed that the name should be abandoned in view of the heterogeneous, Precambrian to Upper Ordovician assemblage of rocks which it by then embraced. Ells was fairly successful, and Dresser and Denis (1944, p. 339) stated, "...the term Quebec group has been little used since 1894, except in historical references". Over the period 1894-1946 the greater part of the rocks along the south shore of the St. Lawrence, east of Quebec, previously referred to as Quebec Group, had been put into the Sillery Formation, again largely on the basis of lithology. Observations by Young (1913), Raymond (1913), and Clark (1924) around Quebec City, suggested that the Sillery grades up into the Lower Ordovician Lévis Formation and led to the general acceptance of a Lower Ordovician age for the Sillery as well. In 1946, Rasetti discredited this view and proposed that the name Sillery Formation should be abandoned. Rasetti substituted the Charny (Lower Cambrian) and Lauzon (Lower Ordovician) formations to cover paleontologically established units below the Lower Ordovician Lévis Formation. Osborne (1956) pointed out that Rasetti's Lauzon Formation may include strata of Middle Cambrian to Lower Ordovician age, and recommended that it be used as a provisional formation to cover the entire interval between

the Charny and Lévis Formations. Thus, the Lauzon has little practical value. Osborne also recommended the revival of the term Quebec Group for general use, largely as a convenience, and included the Middle Ordovician Quebec City and Citadel Formations in it at Quebec City, as had been done by some earlier workers (Logan, Ami).

Detailed studies of the Quebec Group have been limited almost entirely to the vicinity of Quebec City, and even in this best known and type locality the age and stratigraphy are still incompletely resolved.

In the absence of valid terms of stratigraphic reference and with the previously convenient "dustbin term" of "Sillery Formation" discredited, and the only available substitutes requiring paleontological evidence for their application, many recent workers (including Béland, 1957; 1960; Lespérance, 1959; 1960; Neale *et al.*, 1961; and Lajoie, 1961) following Osborne's suggestion, have turned back to "Quebec Group", simply because this is the only available pigeon-hole for the wide areas of undated rock along the belt.

Because the term "group" is now more restricted under the present rules of stratigraphic nomenclature it is proposed that "Quebec Group" be changed to "Quebec Complex", without change of definition. This permits the use of the term "group" as a subdivision of the complex and allows the introduction of the new subdivisions proposed here, namely, Matane River Group (not to be confused with the loosely defined "Matane shales") and Shickshock Group.

The correlation of strata from Quebec to Gaspé on the basis of lithologic similarity, without established continuity, was started by Logan and perpetuated by many later workers. This practice has led to confusion in an assemblage which all seem to have recognized as possessing numerous lateral and vertical changes and repetitions in lithology, and which the work of Rasetti (1946a) has shown to include Cambrian and Ordovician strata in close association. Structural complexity imposes further inconsistent variations. As Osborne (1956) pointed out, so-called "formations" cut across fault slices, often of different age. Only in cases such as the Shickshock Group, where a distinct lithological entity covers a wide, more or less continuous area, can a rock-stratigraphic differentiation hold any validity.

The Age of the Quebec Complex in Northwestern Gaspé

Northwestern Gaspé comprises the region between Lake Matapédia and the Tabletop mountains on the south and the St. Lawrence

on the north. This region is divisible into three east-west belts:

- i. The Northern belt (bordering the St. Lawrence) - occupied by a slate sequence.
- ii. The Central belt - occupied by a slate sequence.
- iii. The Southern belt - occupied by the Shickshock Group.

i. The Northern Belt

Along the south shore of the St. Lawrence, from near Matane to Marsoui, 70 miles farther east, Lower Ordovician fossils have been reported at scattered intervals by several workers, including Ells (1883) and McGerrigle (1954a). It would appear, therefore, that much of the Quebec Complex along the shore is of Lower Ordovician age.

North and northwest of the Tabletops, the southern part of the northern belt is occupied by Middle Ordovician (Normanskill) strata (McGerrigle, 1953; 1954). These Middle Ordovician rocks taper out westwards near Sainte-Anne river and have not been reported farther west except along Matane river. Aubert de la Rüe (1941, p. 15-17) mapped an area a few miles south of Matane, as Middle (?) Ordovician, on the basis of a few localized graptolites. McGerrigle (personal communication) has found Lower Ordovician graptolites close to Aubert de la Rüe's location, suggesting that Middle (?) Ordovician rocks may be of very limited extent.

ii. The Central Belt

This belt occupies an area 8 to 12 miles wide, north of the Shickshock mountains. No fossils have been located within this belt prior to the present investigation. In the east, McGerrigle (1954a, p. 24) referred to this belt as "Lower Ordovician or older", from general geological relationships. Mattinson (1964) working in the central part of the Shickshocks, suggested a Lower Ordovician (?) age. Aubert de la Rüe (1941, p. 11-15) investigated an area which includes the western part of this belt and, on the basis of lithology, made a correlation with the "Sillery" and a Lower Ordovician age. In addition, the same worker identified, on lithological evidence only, Middle (?) Ordovician rocks in the Cuoq-Langis area, near Rivière Matane village. Finally, Béland (1957, p. 2 and 4), working just east of Matane, interpreted the entire sequence of the combined northern and central belts as, "probably...of Ordovician age".

Despite the various interpretations mentioned, the central belt has not been positively dated closer than the probability that it is Cambro-Ordovician.

iii. The Southern Belt

The southern belt is essentially synonymous with the Shickshock Group. The age and structure of this group have been subjects of controversy since the earliest geological exploration. The various interpretations of age are listed below:

- a) Logan:
 - i) in 1846 (p. 30), Logan referred to the rocks of the Notre Dame (Shickshock) mountains as, "dissimilar to other rocks of the (Quebec) group, although their direction ought to put them near the top".
 - ii) In 1863 (p. 267), Logan implied the definite inclusion of the Shickshock rocks within his Quebec Group and suggested that these rocks overlie limestone conglomerates which he assigned lithologically to the Lévis Formation.
 - iii) In 1865 (Geological Map of Canada), Logan showed the rocks of the Shickshock mountains to be of Chazy age and as part of the Quebec Group.
- b) Low (1885, p. 16-19F): assigned the Shickshock strata to the Precambrian, but gave no evidence to support this claim.
- c) Ells (1885, p. 31E): assigned the Shickshock strata to the Precambrian, on the basis that they were, "so like the Pre-Cambrian, as seen in New Brunswick and other parts of Canada".
- d) Coleman (1922, p. 27): accepted the Precambrian age.
- e) Alcock (1926a; 1926b; 1926c; 1931, map): worked along the Shickshocks and on the possibly related Ladystep volcanics farther east. He concluded, particularly from evidence at Lake Matapédia, that the Shickshock Group overlies the early Paleozoic sequence to the north and is Ordovician in age.
- f) Parks (1931, p. 789): supported a Lower Ordovician (Upper Canadian) age.
- g) Jones (1933; 1934a; 1934b): correlated the volcanic rocks east and west of the Tabletops with probable "Middle Ordovician", admitted that they are certainly part of the "Quebec Group" and correlated them with the volcanics of the Shickshock mountains.
- h) Aubert de la Rûe (1941, p. 15): accepted Alcock's interpretation that the arkose and volcanics at Lake Matapédia are resting on the early Paleozoic shales and included the arkose-volcanic association "as the upper part of the Sillery formation", Lower Ordovician in age. Both the correlation with the "Sillery Formation" and the age are based solely on lithologic affinity.
- i) Dresser and Denis (1944, p. 295): stated, "The Shickshock series, while believed to be Ordovician, occupies a stratigraphic position that is not as yet definitely established".

They added (p. 296) that, "The series appears to lie stratigraphically above shales that probably belong to the Quebec group, and it underlies the Middle Silurian".

- j) McGerrigle: i) In 1950 (p. 22), McGerrigle stated, "The age of these rocks is in doubt; it has been variously placed as Precambrian, Cambrian and Ordovician".
- ii) In 1953 (map), McGerrigle assigned the Shickshock strata to a "Pre-Ordovician (Pre-cambrian ?)" age.
- iii) In 1954 (1954a, p. 20-23), McGerrigle, from investigations in the Courcelette area toward the eastern end of the Shickshock mountains, concluded that, "the Shickshock series probably is Cambrian or Precambrian", and older than the Ordovician or pre-Ordovician rocks immediately to the north. He based his conclusions in part on the relative degree of metamorphism between the two groups and, for this reason, rejected the correlation of the Shickshock Group in the Shickshock mountains with the basic volcanics at Lake Matapédia, with those within the "Quebec Group" in Saint-Denis Township about 8 miles southeast of Matane, and with those on either side of the Tabletop mountains.
- k) Béland (1957, p. 4): assigned the Group to the "Ordovician or older".
- l) Mattinson (1958; 1964) concluded that (abstract): "Despite its apparent greater metamorphism the Shickshock series is probably Ordovician in age because it overlies the Lower Ordovician (?) sedimentaries to the north with interlayering at the contact." However, overlying even definitely established Lower Ordovician does not necessarily imply an Ordovician age. Mattinson (1958, p. 226) admitted that he did not know whether or not the "Shickshock series-Lower Ordovician (?)" contact is normal or overturned. In addition, the Lower Ordovician (?) age of the underlying strata is actually no more than speculation. Further, he included the fringe of arkoses along the north front of the Shickshocks with the shale sequence, restricting the Shickshock "series" to the volcanic suite with its interior sedimentary belts. Elsewhere along the Shickshocks (for example, the Cuoq-Langis area), these same arkoses form an integral, interbedded part of the Shickshock Group and have been mapped thus (McGerrigle, 1954a; Ollerenshaw, 1961). It is probable that the interbedding referred to by Mattinson is between the volcanics and arkoses within the Shickshock Group thus defined, and does not prove interbedding between the Shickshock Group and the underlying slates.

Thus, the age of the Shickshock Group has never been positively ascertained. Its lower age limit depends on the age of the slate sequence immediately to the north (i.e. the central belt) and the stratigraphic relationships between the two units. Neither of these has been satisfactorily established. Its upper age limit depends on its relationship with the Silurian rocks on the south. Present information suggests that the two units are separated by the South Shickshock faults.

Plate I

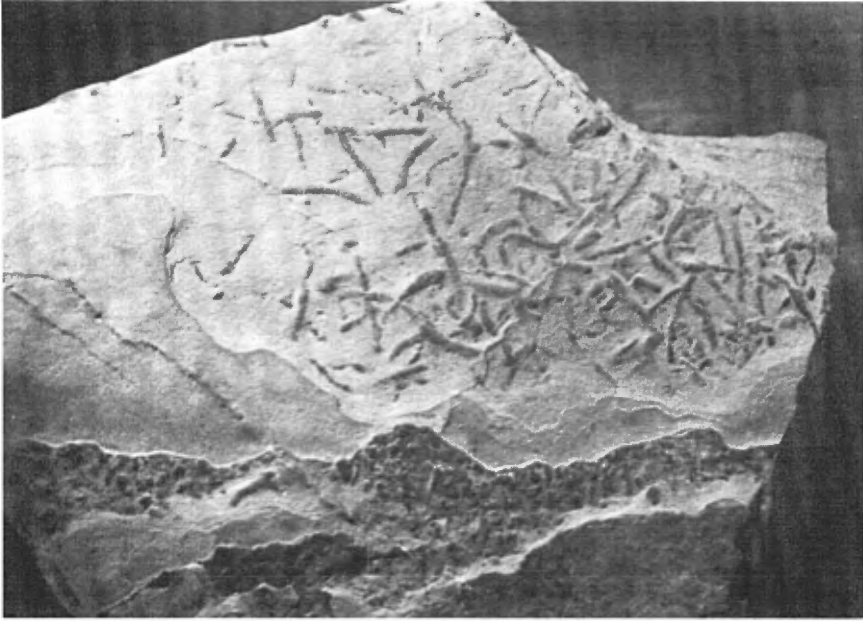


A. Part of a ptychoparioid trilobite cranium of probable Middle Cambrian age, from slates of the Matane River Group on Tremblay brook, about $\frac{1}{2}$ mile north of the Shick-shock Group. Magnification X 12.

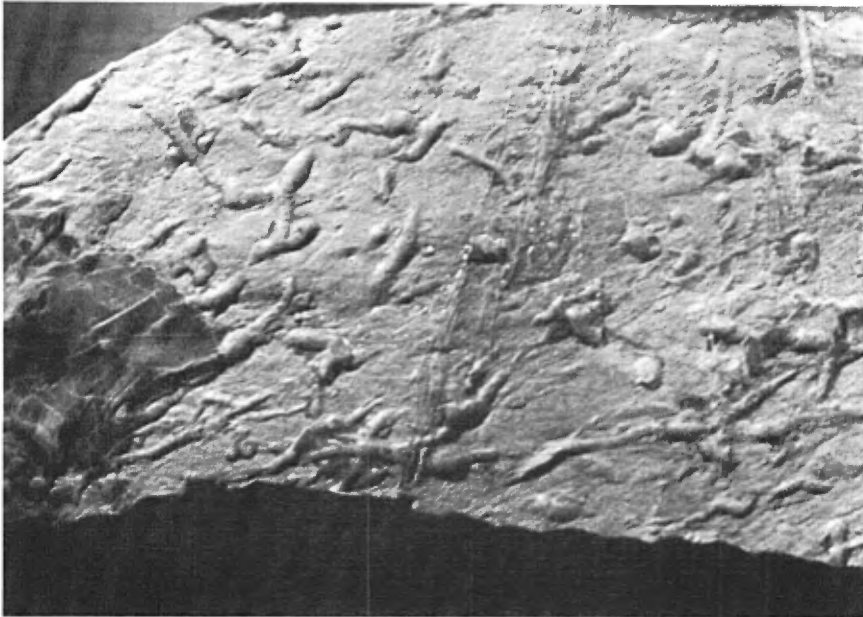


B. Algal structures in a cobble-sized phenoclast from the Kamouraska limestone conglomerate at Goupil.

Plate II



A. Probable worm castings from a siltstone layer in the Matane River Group on Tamagodi river. Note the strong resemblance to Lockeia anticostiana Twenhofel, from the Ordovician of Anticosti Island. Magnification X 1.1.



B. Worm castings or the casts of worm burrows, from the slate sequence overlying the Schickshock Group at Lake Matapédia. Magnification X 1.2.

The Age of the Quebec Complex in the Cuoq-Langis Area

The problem of age is threefold, and involves:

- a) The age of the Matane River Group.
- b) The age of the Kamouraska facies.
- c) The age of the Shickshock Group.

The only definite fossil known from the Matane River Group in the present area is an incomplete cranidium of a trilobite (Pl. II-A), found by the writer in an outcrop of dark gray slates. This cranidium was identified by the writer and confirmed by F. Rasetti (personal communication) as belonging to a ptychoparioid trilobite. Rasetti stated that, "forms of this type are most likely to be Middle Cambrian, but also occur in the Lower Cambrian. It is much less likely to be Upper Cambrian, and almost certainly not Ordovician or younger". The locality is on Tremblay brook, approximately 1 1/2 miles northwest of the northern margin of the Shickshock Group at the extreme northern edge of the area. Despite the limited nature of this evidence it constitutes the first time that evidence rather than inference is used to assess the age of these rocks. In view of the structural complexity of the Matane River Group, the evidence cannot be extrapolated too far, and an overall inference of age cannot be made. However, it is reasonable to assume, in the absence of evidence of major faulting or folding, that a band several miles wide of most probably Middle Cambrian age borders the Shickshock Group on its north side.

The writer found the pleuron of an unidentifiable trilobite in a gray slate outcrop on the road which runs northeast from Lake Matapédia toward Saint-Vianney, about 700 feet southwest of the boundary between the Seigneurie du Lac Matapédia and Langis township. The outcrop is on strike with part of the Shickshock Group.

Structures (Pl. II A and B) interpreted as worm castings or the casts of worm burrows were seen in slates along Tamagodi river west of Turtle hill, and in the slate sequence between the South Shickshock fault and the Shickshock Group at Lake Matapédia. Structures almost identical with those in Plate III-A were described and named by Twenhofel (1928, p. 99, Pl. I, Fig. 1) as Lockeia anticostiana from the Ordovician of Anticosti Island.

No other fossils were found within the slates, but several fossils were obtained from phenoclasts within the Kamouraska conglomerates, as follows:

- i. Blais township, range V, Lot 26, approximately 1,200 feet northeast of road. Kootenia cf. K. parallela^{*}, algal structures.

* Identification confirmed by F. Rasetti (personal communication).

- ii. Tessier township, range XI, lot 26, in Goupil village, 600 feet southeast of the main road. Salterella sp., algal structures (Pl. II-B).
- iii. Matane township, range XII, lot 10, approximately 200 feet northwest of road on west side of Bastien brook. Salterella sp.

In addition, concentric algal structures, 1/4 to 1/2 inch in diameter, are present in a few places within the oolitic to pisolitic matrix of limestone conglomerate outcropping 3/4 mile northeast along the ridge at Saint-Vianney (Langis township, range V, lot 32). The limestone conglomerate from which the Middle Cambrian trilobite, Kootenia cf. K. parallela, was collected has a calcarenitic matrix which resembles many of the phenoclasts in lithology. Underlying limestones are also lithologically similar to these phenoclasts. Thus, appearances suggest the possibility that the conglomerate was derived from the limestones, implying a Middle Cambrian age for these beds. The various algal and Salterella limestone phenoclasts, and the matrix algal structures at Saint-Vianney, have a Cambrian rather than an Ordovician aspect.

Further evidence on the age of the Quebec Complex, or, more specifically, the Shickshock Group, within the area was obtained by potassium-argon analysis* of a sample of muscovite, from a muscovite schist. The sample was taken from the attenuated western end of a belt of predominantly metasedimentary rocks, within the main metavolcanic sequence of the Shickshock Group, a few hundred feet east of Duvivier river, on one of its tributary streams. More details are given in Appendix D. The analysis produced a dating of 530 m.y., subject to an analytical error estimated to be within the limits of -35 m.y. In terms of the time scale by Kulp (1961) this places the metamorphism of the Shickshock Group within the range lower Middle Cambrian to early Lower Ordovician.

In view of the general supposition that the Shickshock Group was deformed and metamorphosed during the supposedly younger Taconic "orogeny", this anomalous dating from a single sample is immediately suspect. However, it takes on a more serious aspect in the light of additional evidence from the eastern end of the Shickshock Group. Separate age determinations were performed on samples of biotite and muscovite from the metamorphic aureole surrounding the ultrabasic intrusive located within the Shickshock Group at Mount Albert (Geological Survey of Canada, Paper 61-17). Both these analyses indicated a dating of 495 m.y. (or Lower Ordovician) for the aureole. The unmetamorphosed nature of the intrusive, plus the conspicuous deflection of structural axes within the

* Analysis (K-Ar No. 466) performed in the laboratories of the Geological Survey of Canada, results and discussion published in Paper 62-17, 1963.

adjacent Shickshock Group, indicate its introduction was later than the metamorphism and deformation of the latter. Thus the age determination from Mount Albert corroborates, in a relative and an absolute sense, that from Cuoq-Langis.

On the basis of these facts and assuming the K-Ar analysis to be reliable, the Shickshock Group (since it cannot be younger than its own metamorphism), does not appear to be younger than the lowest part of the Lower Ordovician, or, more probably Upper Cambrian. Evidence will be presented later in this report to show that the Shickshock Group overlies the slate sequence immediately to the north, with an interbedded, conformable, unfaulted contact, in normal superposition. The existence of probable Middle Cambrian strata 1 1/2 miles north of this contact suggests that the Shickshock Group is not older than Middle Cambrian. This conclusion is supported by the existence of a Middle Cambrian trilobite in a Kamouraska limestone conglomerate phenoclast in a sequence which is probably the strike equivalent of the Shickshock Group at lake Matapédia. Since the evidence suggests that the trilobite may well have been derived from limestones of the same sequence, the Shickshock Group is possibly, in part at least, Middle Cambrian.

On the basis of the limited paleontological evidence and the age determinations, the Shickshock Group is provisionally assigned to the Middle to Upper Cambrian period.

The Matane River Group

The Quebec Complex underlies the triangular northwestern half of the Cuoq-Langis rectangle. It consists of two main lithological units, namely, an arkose-volcanic association (Shickshock Group) forming a wide band in the southeast, and a predominantly slate association (Matane River Group) that forms the remaining and greater section to the northwest. The Shickshock Group appears to be a facies of the Matane River Group, but is of sufficient extent, thickness, and contrast to justify its separation.

The Matane River Group includes all the Quebec Complex, other than the Shickshock Group, which occurs along and in the vicinity of Matane river from the shore of the St. Lawrence to and beneath the limits of the unconformable Silurian-Devonian cover on the southeast. Its extension northeast and southwest beyond the area is not defined, and only that part of the Group included in the Cuoq-Langis area is dealt with here.

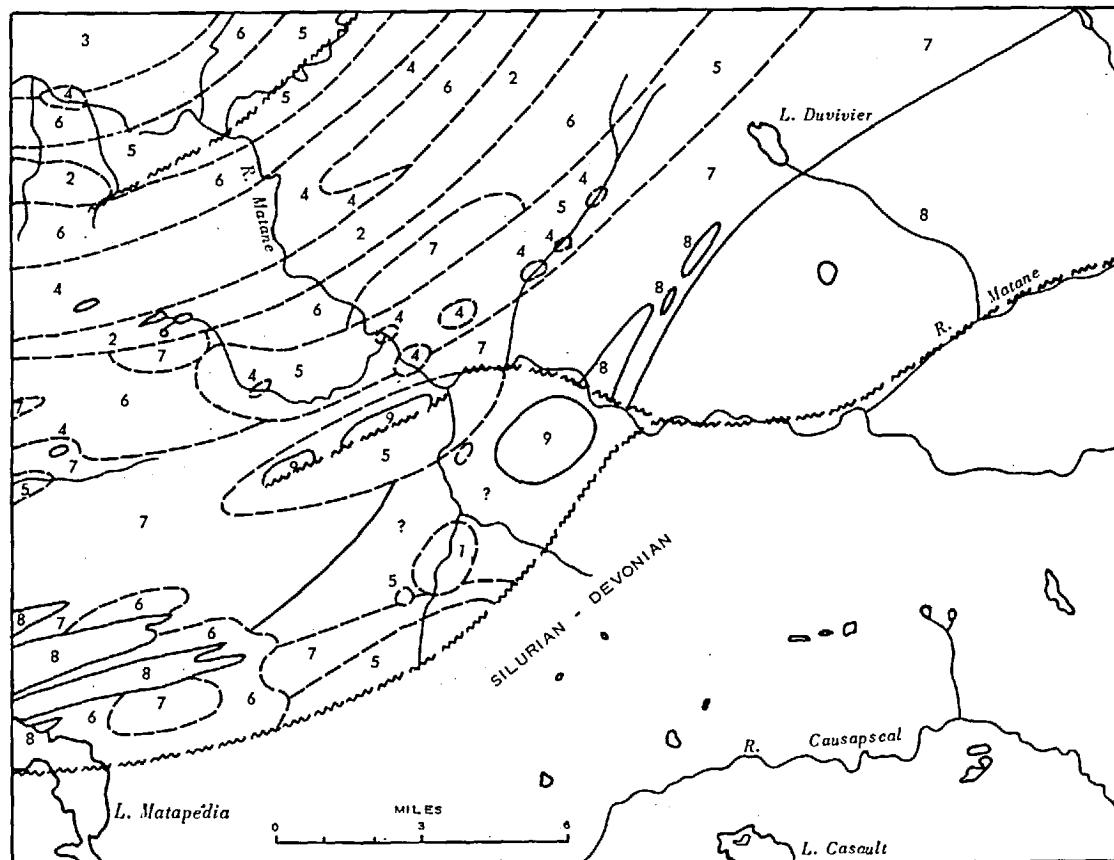
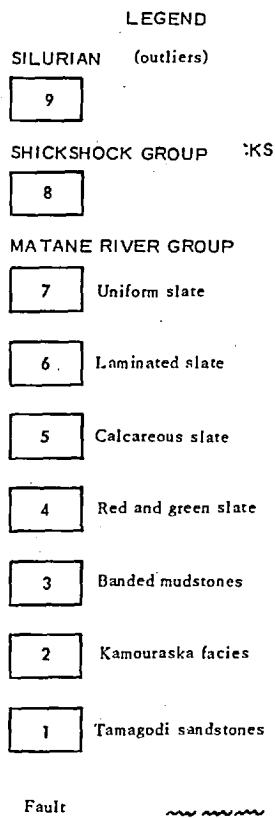


Figure 1
MATANE RIVER GROUP. BROAD LITHOLOGIC DIFFERENTIATION IN THE CUQ-LANGIS AREA

D.N.R.Q. 1965 B-643

General Description

The Matane River Group strikes essentially northeast, but in a broad, southeastwardly convex curve. Dips are typically medium to high and mainly to the southeast. Folds are generally complex, tight, and overturned to the northwest, although there are some more open, simple folds. Local shears and faults are common. The stratigraphy is obscured by excessive deformation, scarcity of fossils, repetition of lithological types, lateral variations, and by the absence of persistent marker horizons.

Figure 1 summarizes the lithological zones derived from detailed structural and lithological studies. The differentiation was based on the following properties:

- i. Color. Red-and-green slates were separated from gray slates.
- ii. Carbonate content. Calcareous slates and associated limestones were separated from non-calcareous slates.
- iii. Bedding. Slates containing siltstone or sandstone laminae or beds were separated from relatively un laminated and unbedded slates.
- iv. Facies. The limestone conglomerates and associated quartzites (Kamouraska), together forming approximately 10% of the whole, were separated from the slate sequence; also separated were some peculiar sandstones and grits with minor sandstone breccia that occur along Tamagodi river.

The zones are defined on the basis of the predominance of one property, exceeding 50% in the zones designated, and do not exclude the local occurrence of one or several of the others. They are 1-2 miles wide on the average. The typical lithology of the Matane River Group is a medium to dark gray, well-cleaved, slaty shale, commonly possessing laminae or thin layers of light-colored quartzose siltstone or fine-grained sandstone that locally are slightly calcareous. Because of the pronounced contrast between the slates and the conglomerate-quartzite association and the particular stratigraphic problems related to the latter, the two facies are dealt with separately below.

The Slate Sequence

1. Uniform slate. Most of the other lithologic divisions are simply variations of this fundamental type. In its most typical form, it is homogeneous and monotonous and consists of very finely divided material that commonly displays a pronounced orientation and aggregate extinction. It contains abundant sericite (white mica) throughout. Most of the slates contain angular quartz silt, tenors of which commonly run to 30-40% or even higher as the slates grade into siltstones. Other constituents include vague saussuritic material in some parts, local traces of chlorite and rare plagioclase.

The rock was originally a shale and was rendered slaty by mild metamorphism. It is medium to dark gray both where fresh and weathered, with a rusty brown coating common along cleavage and other separation surfaces. Cleavage surfaces are mainly parallel to subparallel to the bedding and locally have a slightly "wavy" aspect. Cleavage separation is conspicuous and ranges from 1/4 inch to less than 1/8 inch and, locally, to paper-thin.

Generally, this slate is less sericitic, and its fabric has a weaker orientation, than its counterparts within the Shickshock Group. This illustrates the gradual increase in metamorphic grade towards and into the Shickshock Group.

2. Calcareous slate. Rocks of this category are common within the Matane River Group. They form two conspicuous bands and several lesser patches, plus scattered outcrops throughout the other bands.

The calcareous slate itself differs from the uniform variety, only in its carbonate content. Beds of impure, fine-grained, gray limestone or calcareous sandstone are common; they are frequently lenticular and may occur individually, or in groups. The groups typically consist of thin-bedded alternations of limestone and slate in units several feet or even, in places, a hundred feet thick. The best exposure is in a roadcut on Highway 6 about 1/4 mile northwest of the bridge at Rivière Matane. Here, thinly interbedded limestone and dark gray slate, with a few medium and thick beds of each, form a steeply dipping succession, with a minor anticline (frontispiece) at the southeast end. Wide slate zones occur here and there and it is possible that the folded part is a faulted repetition of the northwestern half of the section. The limestones here include numerous calcarenites, some of which are oölitic. All are medium to dark gray.

Limestones also occur within the smaller calcareous slate belts south of Matane river. Thin-bedded argillaceous limestones with slate partings and interbeds occur on the south bank of the Matane, 1/2 mile or so downstream from Saint-Jean brook, and form parallel ridges on both sides of the Langis-Tamagodi Silurian outlier. These limestones form zones at least 100 feet thick. They consist of very finely crystalline to microcrystalline calcite with silt-sized, apparently authigenic quartz (and rare plagioclase) typically scattered or as rare microlaminae. They are medium gray where fresh, and light to medium gray and buff-gray weathering.

Similar limestones occur northeast of Saint-Tharsicius on the upper Tamagodi river, and at the base of a small hill about 2 miles north-northwest of Saint-Tharsicius. At these localities, the fine-grained limestones are associated with thick, sometimes massive beds of medium-

to very coarse-grained calcarenite and limestone conglomerate. The stratigraphic position and nature of the basal contacts of these limestones are unknown. It is possible (on the basis of bedding orientation) that they rest unconformably on the slates. Limestone beds are present locally along Saint-Jean brook and its tributaries, and in several outcrops on the lower Tamagodi river, about a mile south of its confluence with the Matane. Some of the limestone beds described above are highly argillaceous or very silty and sandy, and all gradations exist between limestone and slate and limestone and sandstone.

Thin-sections reveal that the calcarenitic limestones belong to the "lithocalcarenites" and "oölitic calcarenites" of Carozzi (1960, p. 255) and intermixtures of these types. The oölitic calcarenites predominate. The grains of the calcarenites consist of oöoliths, pseudoöoliths, limestone (including fragments of oöoliths and pseudoöoliths, and very finely to finely crystalline calcite) and rare, scattered quartz.

Many of the calcarenitic beds consist of silt- or fine sand-sized material but others comprise coarse and even very coarse sand-sized material, locally mixed with granules or small pebbles. In several outcrops, a gradation can be traced from these calcarenites to limestone conglomerates with a calcarenitic matrix and to those in which quartz and carbonate grains are mixed in the matrix. Similarly, calcisiltites apparently grade into quartz siltstones in some laminae interbedded with slates (for example, in the roadcut at Rivière Matane).

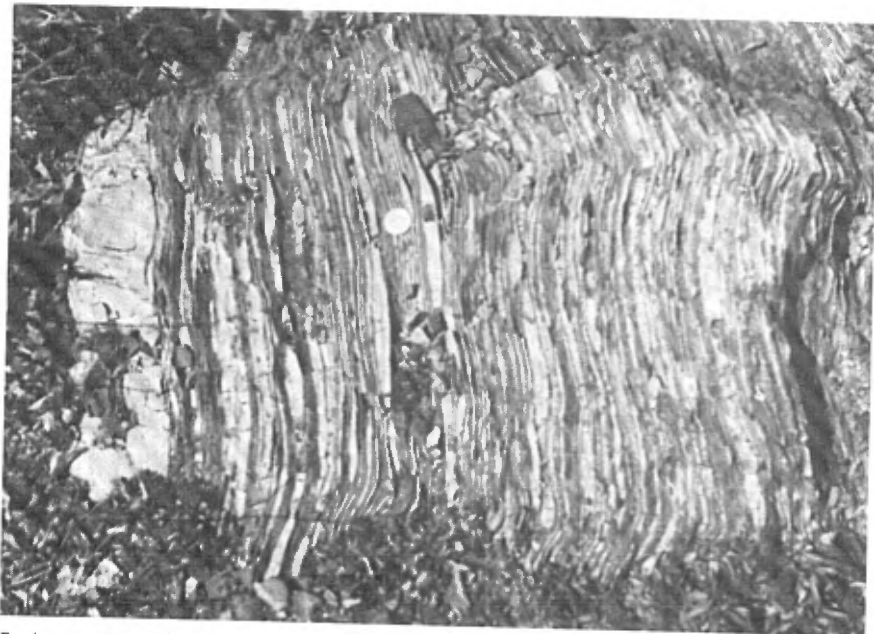
Oöoliths vary from simple oöoliths (the "superficial oöoliths" of Carozzi, 1960, p. 238) with only one envelope, to complex oöoliths with numerous (20-30 in some cases) thin concentric layers. Rare composite oöoliths occur. Nuclei include pseudoöoliths, abraded oöoliths, oölitic and pseudoölitic limestone grains, and rare quartz grains. In many oöoliths, a nucleus cannot be observed. Radial structure is commonly clearly visible, crossing the entire oöolith or, in some cases, just one thick concentric layer. Pseudoöoliths are ovoid to spherical in outline, typically cryptocrystalline or dense, and many are dark and murky. Interstitial calcite is almost invariably microcrystalline. Authigenic plagioclase is a conspicuous constituent in many cases. Pyrite occurs as fine, scattered aggregates, sometimes preferentially replacing a single concentric layer within one of the oöoliths.

An interesting feature of many of these calcarenites is the common occurrence of deformed oöoliths, indicating their plasticity after burial. A particularly interesting example of this was observed in a sample from along the road to La Coulée about 1 1/2 miles northeast of Rivière Matane. Clearly defined, undeformed, abraded oöoliths, pseudoöoliths and oölitic limestone fragments stand out against an indistinct background

Plate III



A. Layered and laminated slate-siltstone sequence of the Matane River Group on Johnson creek.



B. Layered and laminated sequence of the Matane River Group on Sabieux brook.
(The scale is a 25¢ piece.)

of strongly deformed, ellipsoidal ooliths. This rock is a mixture of relatively hard secondary calcarenitic and oolitic material, plus soft primary ooliths. In some cases the former act as nuclei for faint, deformed concentric layers of primary origin.

3. Laminated slates (Pl. III-A-B). This category includes all those slate zones in which conspicuously laminated or bedded units predominate. The layering comprises alternations of siltstone or sandstone with slate. This lithologic category forms several distinct bands and constitutes an important part of the entire slate sequence. The conspicuous lamination or bedding constitutes the only real difference from the uniform slate category and the lithologic description of the slate component will not be repeated here. The terms "laminae" and "beds" in the following description refer to the siltstone or sandstone component.

Thin laminae to very thin beds are most common; thin to medium thick beds are fairly common; thick beds are relatively rare. The relative proportions of siltstone or sandstone to slate, and the separation and concentration of the layers, are very variable. For example, the siltstone or sandstone interlayers commonly show a tendency to bunch together to form thin to thick laminated zones, separated by similar intervals of unlaminated or sparsely laminated slate.

Laminae typically consist of a quartzose, more or less argillaceous siltstone or fine-grained sandstone. Relatively slight variations, involving changes as low as 10 to 20% in the relative proportions of quartz and sericitic material, promote lamination. Laminae are composed commonly of 50 to 90% quartz; 10 to 15% sericitic material; traces to 5% of leucoxene; and rare feldspar. Calcite is present in a few cases. Clastic grains are typically angular to subangular. The laminae are light to light-medium gray where fresh, and they weather very light to whitish gray and, locally, to brown. Surfaces of the laminae are commonly uneven and undulating. In cross-section they pinch and swell laterally and many are lenticular.

Beds differ from the laminae in being generally sandstones rather than siltstones. Most belong to Pettijohn's (1957, p. 291) proto-quartzite, ranging into his subgraywacke division. Quartz content is generally high (70-85%) and feldspar content (almost entirely sodic plagioclase) is only 3%. Rock particles typically constitute 2 to 4% and are most commonly of shale and vein quartz; limestone is rare. Scattered carbonate ooliths are present in many thin-sections, and some are partly altered to quartz or chloritic material. Chlorite content is commonly from 1% to nearly 10%. Fine-grained sericitic material, locally intermixed with clay minerals, and/or saussurite, occurs interstitially in quantities up to several per cent. Calcite, commonly present as interstitial or vein material,

averages about 3%. Muscovite and lesser biotite are present locally as small shreds or flakes; they rarely form more than 1% of the body of the rock, but increase on some bedding surfaces to several per cent. Pyrite, leucoxene, zircon, epidote and tourmaline each form less than 1%. Most quartz grains display small trails of minute inclusions, and rare grains contain inclusions of rutile needles, zircon and tourmaline. The matrix generally constitutes 10% or less of the rock. The sandstones are variously cemented by silica, calcite, chlorite, sericitic clay material or by various combinations of these.

The sandstones range from very fine to medium grained. Sorting is generally moderate but may be very poor. Most grains are subrounded and almost all show moderate to pronounced strain shadows. Some ooliths are flattened and deformed, suggesting their plasticity at the time of deposition. The sandstones are commonly light-medium or medium gray, rarely almost black, and many weather very light gray to whitish, although some remain medium gray; a buff or brownish cast is general. Many beds are lenticular and some are only a few feet long. Some beds are laminated or have shale partings.

Many of the sandstones and siltstones are hard and quartzitic, whereas others, less hard, suggest normal sandstones. This difference is not an effect of metamorphism but is simply the result of the predominance of a silica or a calcite cement respectively. The silica-cemented, whitish weathering varieties, in particular, closely resemble the quartzitic sandstones of the Kamouraska and, as Section A at Goupil shows (see Appendix B), the Kamouraska passes down into the slate through a succession of quartzitic sandstone beds.

Sedimentary structures are limited in the laminated slate category. The lensing and pinching and swelling of the laminae and beds may be a sedimentary boudinage produced by compaction, or, it may be a primary depositional structure. Rare beds possess a small-scale crossbedding and vague structures resembling convolute bedding due to slump. Excellent crossbedding of normal size was observed in a laminated sandstone bed on Langis river.

On the south bank of Matane river, a mile upstream from Johnson creek, a zone of medium gray, slightly brownish gray weathering sandstone about 30 feet thick outcrops. The sandstone is in medium to thick beds and passes into slate with thin sandstone beds. The typical lithology is a calcareous, quartz sandstone, of fine to medium grain. The quartz grains are commonly rounded and poorly sorted. Rare grains of bluish quartz occur and fine-grained pyrite spheres are locally developed along laminae.

4. Red and green slates. These slates occur in three localities, the most important of which is the wide band crossing the area just south of Saint-René-Goupil, through Johnson lake. This forms a mappable unit and is referred to as the Johnson Lake band. Another band of very widely dispersed and inconsistent patches occurs near the middle of Saint-Jean brook, crosses Matane river just upstream from Rivière Matane, reappears briefly on Langis river and again just north of Inconnu brook. The third occurrence constitutes a band that crosses the Matane valley between Johnson creek and Bastien brook, extending locally to the northeast.

The red and green slates differ from the uniform gray type essentially only in color, — the red color derives from a hematite pigmentation, and the green, from reduction of the hematite. The red is a rather drab medium reddish gray or maroon. The green is a light medium or medium greenish gray. The two colors usually occur together in the same or at least adjacent outcrops, although one or the other may predominate. Patches of each color grade, laterally and vertically, into one another. The relationship strongly suggests that the green variety has in some, if not all, cases formed from the red, since it occurs in subordinate stripes and layers of variable thickness and continuity within the red, whereas the reverse was not seen. The green layers follow the planes of bedding, cleavage and, rarely, even joint surfaces, or locally cut these surfaces obliquely.

Many of the red and green slates are silty. Laminae and beds are not conspicuous although rare silty laminae or beds of gray or greenish gray slate do occur. The red and green slates are rarely calcareous, but limestone beds and thick beds of intraformational limestone conglomerate occur here and there in both. The conglomerates have a red or green slate matrix. Field relationships suggest that gray slates (typically laminated) form interbedded zones tens or even hundreds of feet thick within the red and green succession, suggesting alternations in the conditions of deposition.

Apart from being harder, the red and green slates of the Matane River Group bear a strong resemblance to the Queenston shale (Upper Ordovician) of southwestern Ontario.

5. Banded slates. Banded slates are essentially confined to the northwest corner of the area, so that the width and continuity of this belt are unknown. Minor occurrences of similar slates outcrop in places along Johnson creek. The banded slates are much more solid and less well cleaved than the typical slates. The banded slates occur in zones 2 feet to 20 feet or more thick, separated by similar thicknesses of gray slate (often laminated or bedded) and less commonly by thin-bedded limestone-slate sequences (up to about 15 feet thick) and red and green slates. The

entire succession, of which the actual banded slates constitute 40% or more, is included under this general heading.

The slates typically consist of alternating lighter (light-medium olive-gray) and darker (medium gray) layers ranging from 1/8 inch to 3 inches thick. The gray layers tend to be thinner than the lighter olive-gray. The latter commonly display thin wisps and streaks of darker, interrupted laminae. Gray layers locally consist of closely spaced laminae. In thin-section, these rocks appear to be very similar to the uniform slates, but possess a higher average quartz-silt content of up to 40%.

6. The Tamagodi sediments. Unusual sandstones outcrop in three localities along the middle section of Tamagodi river. Several poor outcrops about 1 1/2 miles downstream from Chantepleure brook consist of fine- to medium-grained, locally coarse- to very coarse-grained, calcareous, quartz sandstones. They are medium to slightly greenish gray where fresh and weather brownish gray. Beds are probably very thick or massive. Sorting is locally poor and numerous small, scattered, gray slate fragments occur. One outcrop is traversed by irregular, fractures filled with a finer, darker (probably carbonaceous) material and minor calcite, giving the rock a brecciated appearance. The absence of evidence of movement along these fractures and the fact that sand grains extend across them suggests pene-contemporaneous fracture, prior to the complete consolidation of the rock. The outcrops are about 1/2 mile apart, across the strike, and it is probable that they are individual beds rather than parts of a single wide zone of sandstone.

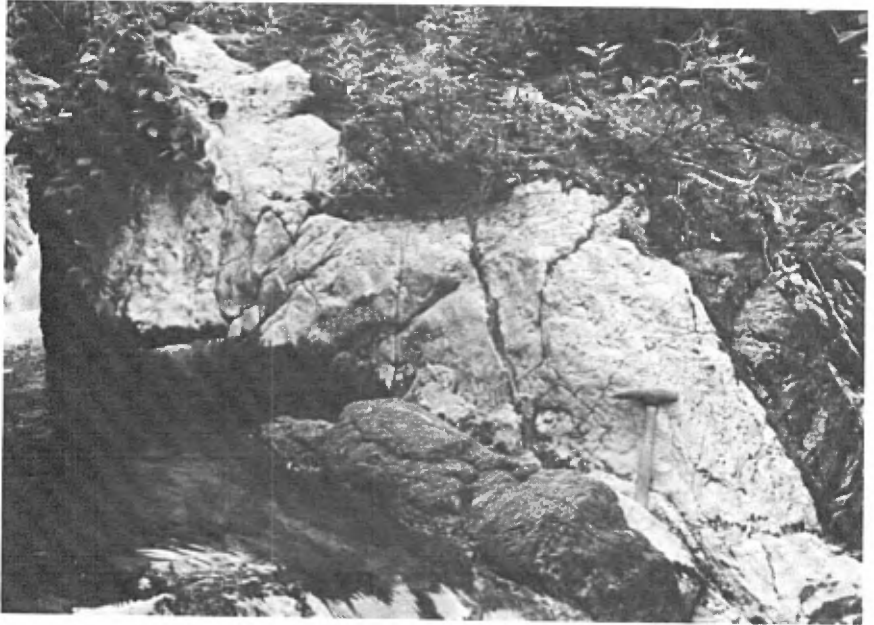
Less than 1/2 mile down Tamagodi river from the mouth of Chantepleure brook, near the South Shickshock fault, a lens of similar sandstone occurs in sheared slate. This sandstone is a poorly sorted mixture of silt- to coarse sand-sized angular to subangular quartz grains, rock fragments and minor feldspar grains. It has a greater than usual content of rock fragments (more than 15%), including chert, possible devitrified glass, andesitic material, quartzitic siltstone, slate, and vein-quartz. The slate fragments are up to 1/4 inch in diameter. This rock resembles the Shickshock Group sandstones, particularly in texture and in the nature of the plagioclase, which is commonly dusted with hematite. It also resembles the Lower Ordovician Pillar sandstones of the Sainte-Félicité and Tourelle regions. On the basis of location, composition and texture it could have been derived by erosion from the Shickshock Group.

A different sandstone occurs about one mile below Cajettan brook and about 1,500 feet east of the Tamagodi. Here, numerous large blocks and fragments of grit and minor small-pebble conglomerate occur in the valley side, and probably represent local bedrock. These rocks consist

Plate IV



A. A sheared calcite vein in the Matane River Group. Outcrop on the bank of Petite Matane river along the Saint-René-Goupil dislocation.



B. A large calcite vein in an outcrop of Kamouraska limestone conglomerate, where the Saint-René-Goupil dislocation crosses Johnson creek.



Section of Kamouraska facies at Goupil. Looking northeast.

of unsorted mixtures, mainly of quartz, with lesser plagioclase and scattered flakes and fragments of mica. The grains are generally subrounded to subangular.

Some of the Tamagodi sandstones suggest at least partial derivation from the Shickshock Group and could be either marginal sub-facies of that group or perhaps younger deposits. The grits could be a basal deposit of the Silurian.

Veins Most outcrops of slate are cut by at least a few veins of quartz or, less commonly, quartz-calcite or calcite. In the calcareous slate and limestone, calcite is the common vein mineral. Veins are typically short (a few feet long at the most) and thin (about 1/4 inch) with rare veins up to 2 inches thick. Orientation of the veins is typically random, although some veins conform to the cleavage and various joint directions. Veins are concentrated where deformation is more intense, particularly in zones of faulting. Exceptional veining occurs along the calcareous slate band of Petite Matane river following the line of the Saint-René-Goupil fault. Here, the rocks are strongly sheared and deformed and there are common calcite veins several inches thick and, locally, up to 3 feet thick. Where this zone crosses Johnson creek, there is a vein 1 foot to 2 feet thick and 20 feet long (Pl. IV A and B).

Kamouraska Facies

GENERAL

Dresser (1912, p. 14) proposed the term "Kamouraska formation" to cover an association of quartzites and limestone conglomerates in western Kamouraska, L'Islet and Montmagny counties. No specific type locality was designated, and only general reference was made to scattered occurrences. Thus, the "Kamouraska Formation" has never been thoroughly defined. Its adoption has been sporadic and its application has been inconsistent.

Aubert de la Rüe (1941, p. 13) remarked that similar rocks, occurring within the "Sillery Formation" in the counties of Rimouski and Matane, "are not a distinct formation, but merely a facies, fairly common, of the Sillery". He referred to them as, "Kamouraska-type quartzites and conglomerates". Dresser and Denis (1944, p. 339) accepted Aubert de la Rüe's interpretation and redefined the term as "convenient phase name".*

* Editor's note: The type region of the Kamouraska was mapped by Claude Hubert for the Department during the period 1961-63. Consequently, in anticipation of Hubert's results, much of the general discussion of the Kamouraska given by Ollerenshaw is omitted here.

The problematical stratigraphic position and origin of the Kamouraska facies have attracted and puzzled geologists since Bigsby (1834) first drew attention to limestone conglomerates near Quebec City. Much description and discussion of the facies are to be found throughout the literature from 1834 to the present day.

The stratigraphy of the limestone conglomerates and quartzites has been variously interpreted. Interpretation has been complicated by the tendency of several workers to consider the limestone conglomerate and quartzite as if the two lithologies were entirely divorced, despite their common association and interbedding. Further limitations have been imposed by the sporadic and local distribution of investigation, leading to local interpretation compatible with local evidence only, and the assumption by several workers that a single stratigraphic unit or formation was involved. Long range lithological correlations, particularly of the limestone conglomerates with the Lévis Formation, and of quartzites with the "Sillery Formation", or even the Potsdam (Logan, 1846; 1863; Richardson, 1859; 1870), are common in the literature, but have no stratigraphic or faunal basis in most cases.

A review of earlier work suggests that the following conclusions are fairly well established:

- 1) The limestone conglomerate and quartzite (in places a calcareous sandstone) belong essentially to one association, despite their separate occurrence locally, or the local predominance of one lithology over the other.
- 2) This association constitutes a repetitive lithological facies, not a formation, within the predominantly slate sequence of the Quebec Complex.
- 3) The limestone conglomerates of the Kamouraska facies probably range in age from at least Middle Cambrian to Middle Ordovician. The quartzite has a more restricted known range of occurrence owing to its unfossiliferous nature, but possibly covers at least the interval Middle Cambrian to Lower Ordovician.

The first mention of the Kamouraska facies in the Cuoq-Langis area was made by Murray (1847) who referred to "brecciated limestone conglomerates" along Matane river. Logan (1863, p. 264-265) commented that limestone conglomerates occur on several north Gaspé rivers, including the Matane, for several miles inland, but added that none of the exposures rival the size of those along the coast. Richardson (1859, and reported in Logan, 1863, p. 263) described the large exposures east of Grosses Roches on the shore, several miles north of the Cuoq-Langis area.

More recently, Aubert de la Rüe (1941) discussed and briefly described the "Kamouraska-type" deposits of the general region, including the Langis area. Laverdière and Morin (1941, p. 245, and mentioned in Dresser and Denis, 1944, p. 358) referred limestone conglomerates on the road between ranges XII and XIII of Tessier township (Langis area), to the Silurian Val Brillant Formation, but these are included by the present writer with the Kamouraska.

Béland (1957) mapped and briefly described numerous lenses of Kamouraska in the adjoining "Sainte-Félicité - Grosses Roches" area to the north. These lenses are related to the Kamouraska belts of the Cuoq-Langis area, striking towards them and, in one case, in direct continuity in the vicinity of Saint-Nil. Rejhon (1957) presented a discussion of the "Ordovician conglomerates near Matane".

Distribution

Within the Cuoq-Langis area, the occurrences of limestone conglomerate and quartzite, several hundred feet northwest of the road at Goupil (Tessier township, range X, lots 27 and 28), are here designated as the local type-section of the facies for the Matane River Group (Pl. V). A summary description of this section is given in Appendix B.

The Kamouraska facies constitutes less than 10% of the total Matane River Group and includes limestone conglomerates and quartzites in sub-equal proportions. Approximately 65% of the facies is concentrated in the Goupil - Langis Lake belt. This belt extends 13 miles across the area and, according to Aubert de la Rüe's map (1941), continues 5 miles or so farther to the southwest. Another wedge of Kamouraska occurs a few miles to the north of the main Goupil - Langis Lake belt, in the northwestern corner of the area. This wedge penetrates the area for 2 miles, extending east across Bastien brook, to end fairly abruptly at Johnson brook. It is actually just a part of a much more extensive zone, that continues about 12 miles to the southwest. A vaguely defined zone of smaller, more widely dispersed lenses occurs south of the main Goupil - Langis Lake belt. It includes the prominent ridge at Saint-Vianney, scattered outcrops around Rivière Matane, and numerous, small, dispersed lenses around Saint-Nil. The remaining 5% or so of Kamouraska lithology is in small, scattered lenses.

The size of individual lenses varies from a few feet up to large wedges 3 to 5 miles long, 1/2 to 1 mile wide, and 100 feet or more thick. The largest lens straddles the road dividing ranges X and XI of Tessier township. Estimates of the thickness of this lens depend on structural interpretation, but it may be several hundred feet.



A. An unusual display of bedding in Kamouraska quartzites on the northwest side of Sableux brook, Langis township.



B. Interstratified quartzites and limestone conglomerates of the Kamouraska facies, several hundred feet southeast of the road at Goupil. Note the washout structure.

Plate VII



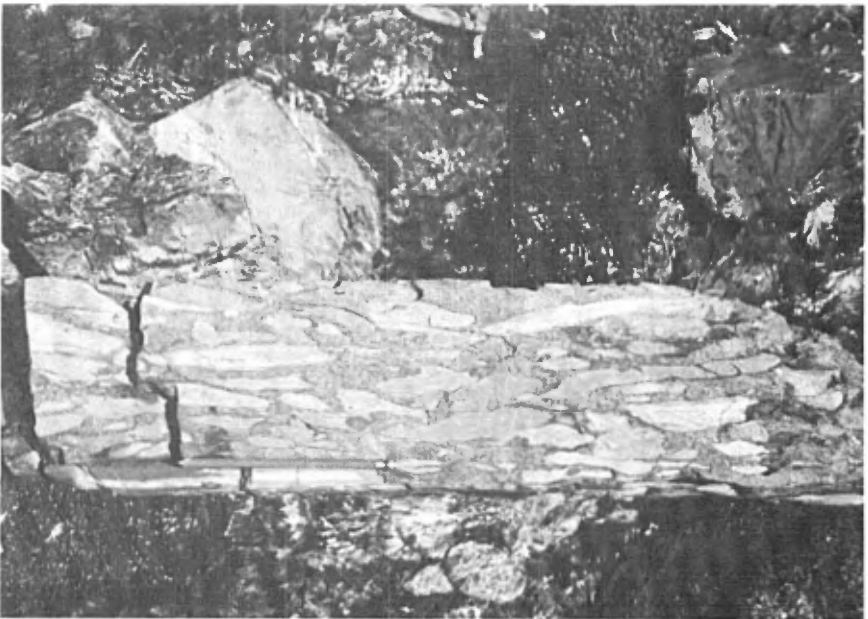
A. Interbedded, gradational association of quartzites and limestone conglomerates of the Kamouraska facies. Outcrop several hundred feet northwest of the road, about one mile southwest of Goupil.



B. A lens of Kamouraska quartzite in limestone conglomerate. Outcrop several hundred feet southeast of the road at Goupil.



A. Phenoclasts of types common in the Kamouraska limestone conglomerate, dispersed in slate, below a lens of Kamouraska facies. North bank of Matane river, just over one mile west of Saint-Jean brook.



B. Intraformational conglomerate from the Matane River Group, consisting of tabular limestone phenoclasts in a red colored matrix of silty slate. Note the moulded outlines of the phenoclasts, suggesting plasticity of the limestone at the time of deposition. The photograph is of a slab adjacent to the parent outcrop.



Uncommon example of internal stratification in Kamouraksa limestone conglomerate from a loose block beside Johnson brook.

Internal Stratigraphy

The stratigraphy within the Kamouraska facies involves primarily the relationship between the limestone conglomerate and quartzite (or its variations). Slates are commonly interbedded with the Kamouraska facies at the margins of the lenses but slate intercalations were not observed within the main interiors of large lenses.

The sections measured at Goupil (see Appendix B) serve as a useful guide to the type of stratigraphy encountered within the Kamouraska facies. The smaller section southeast of the road could be either the lateral or vertical continuation of the larger section northwest of the road, because the sections may be tectonically repeated. Sporadic outcrop indicates the possibility of an additional unknown thickness of Kamouraska (possibly more than 100 feet) above the smaller section.

The relative proportions of limestone conglomerate and quartzite vary from lens to lens. They may be sub-equal or one or the other may predominate, and minor lenses may consist entirely of one lithology. Bedding is rarely regular or rhythmic and beds generally range from several to tens of feet thick. Scattered, thin layers of one lithology in a thick unit of the other occur. Conglomerate beds have a greater tendency to be split by scattered quartzite layers than vice-versa. Some sequences (Pl. VI-B) consist of thin- to thick-bedded alternations of quartzite and conglomerate, in which the beds of conglomerate are commonly thicker than those of quartzite.

The quartzite and limestone conglomerate lithologies are typically clearly differentiated. However, beds of intermediate lithology, ranging from sandy conglomerates to pebbly quartzites, do occur locally. Phenoclasts in these intermediate varieties tend to be small and moderately well sorted. Where phenoclasts occur in quartzite zones, they tend to be restricted to definite layers or beds. Bedding contacts between conglomerate and quartzite are commonly sharply defined and gradation from conglomerate into underlying or overlying quartzite is rare. Plate VII-A illustrates a gradational sequence of conglomerates and quartzites. Many quartzite beds lens out into the conglomerate (Pl. VII-B). Variations in the size of the phenoclasts, commonly accompanied by some change in matrix proportions, produce rare stratification within the conglomerates (Pl. VIII). Such beds range from several inches to several feet thick. Major quartzite units tend to be unstratified, and broken only by joints and irregular fractures. The quartzite zone along the north side of Sableux brook is an exception in this respect. Plate VI-A illustrates the medium to thick bedding in this deposit.

Both quartzite and conglomerate are surprisingly lacking in diagnostic depositional structures. Neither display cross-bedding or graded bedding, although vague suggestions of incipient grading are rare in the conglomerate. Rare washouts occur (Pls. VI-B and VIII), apparently in the quartzite.* There is a strong tendency for the common tabular and sub-tabular phenoclasts of the conglomerate to be aligned more or less parallel to each other and the bedding (Pls. VIII-B and XI-B). An imbricate arrangement of the tabular phenoclasts is apparent locally, but the orientation is not consistent. Some phenoclasts project into the adjacent quartzite.

The smaller lenses of Kamouraska, up to a few feet thick and a few tens of feet long, tend to be more closely associated with the surrounding slate. Locally the slate forms the matrix of the conglomerate or is interbedded with the quartzite.

External Stratigraphy

Locally, at least, the relationship of the Kamouraska with the surrounding slate involves interbedding, some gradation, and conformable transition.

Owing to the difference in competence between the slate and Kamouraska lithologies, shearing effects and disruption of the slate are evident along some contacts and stratigraphic relationships are locally obscured. It is quite possible that some lenses of the Kamouraska facies have been thrust with respect to the slate.

Interbedded contact zones between the slate sequence and Kamouraska quartzite occur beneath several of the larger Kamouraska lenses. Lenses of limestone conglomerate are rare in the transition zone and the conglomerate was nowhere observed to be repetitively interstratified with the slate. The occurrence of the conglomerate tends to mark the disappearance of the slate and the beginning of the main phase of Kamouraska deposition. It obviously represents a more drastic change in the conditions of deposition.

The close relationship between slate and quartzite is further emphasized by the fairly common occurrence of Kamouraska-type quartzite within the main slate sequence. This quartzite is in thin to very thin beds that occur individually or as interbedded zones. It is possible that many of the silty, commonly quartzitic, whitish weathering laminae within the slate sequence may be finer-grained, thinner equivalents of Kamouraska quartzites.

* The attitude of the beds has not been determined with certainty.

The best and more accessible example of an interbedded contact in the Cuoq-Langis area forms the base of the hogback ridge just northeast of Goupil on the northwest side of the road (Tessier township, range X, lots 27-28) (see Appendix B and Pl. VI). Here, more than 25 thin, medium, and a few thick quartzite beds are interstratified with medium to thick, commonly laminated slate beds for at least 50 feet below the lowest bed of limestone conglomerate. The quartzite beds pinch and swell laterally and some lens out. The conglomerate makes an abrupt appearance above or in the uppermost slate bed as a local lens of medium thickness.

Conglomerate beds quite commonly make contact with slate along the margins of Kamouraska lenses and some grade into the slate. At Goupil, limestone phenoclasts are scattered in the slate for 1 foot to 2 feet below the basal limestone conglomerate bed in the small section to the southeast of the road. On a side road, between the Sainte-Paula road and Bastien brook in range XII, lot 13, Matane township, a small lens (1 foot to 2 feet thick) of pebble-sized limestone conglomerate grades into the adjoining slate through a zone of scattered limestone pebbles. On the north side of Matane river a mile upstream from the Tamagodi, a lens of Kamouraska outcrops. Near the base a slate bed about 8 feet thick lies between two beds of limestone conglomerate. Numerous rounded pebbles and cobbles dispersed throughout the slate bed (Pl. IX-A) closely resemble those of the conglomerate.

Slate beds within limestone conglomerate units are comparatively rare. One example is given above, and another was noted at Goupil. The lowest limestone conglomerate unit in the section northwest of the road (Appendix B, Section A) contains several slate beds, a few inches thick, which pinch and swell laterally. Near the top of this unit is a thick bed of conglomerate with a shaly, silty matrix and a subsidiary thin shale bed in the middle. Such mixing of shale, sandstone and conglomerate is unusual. Also, there are rare wispy streaks and wafer-thin partings of shale in a few limestone conglomerate beds.

The slate/limestone relationship is illustrated by several minor, individual occurrences of limestone conglomerate, typically only a few feet thick at the maximum and apparently intraformational in all cases. These conglomerates differ from the typical Kamouraska conglomerates in that the former consist of tabular limestone fragments of one lithology, set in a slate matrix that is commonly greenish gray. In some outcrops the moulded outlines of the phenoclasts suggests their plasticity at the time of deposition (Pl. IX-B).

On the basis of the above observations the writer concludes that:

1. The Kamouraska facies was deposited in the shale environment.

2. The influx of Kamouraska sediments was often fairly sudden.
3. The Kamouraska facies and the underlying slates are commonly conformable and, in places, interbedded.
4. Interbedding is generally between slate and quartzite; limestone conglomerate is less commonly involved.
5. In a few localities, limestone phenoclasts were deposited simultaneously with the shale, indicating gradation between conglomerate and shale.
6. Contemporaneous deformation produced minor conglomerates of intraformational aspect.
7. Minor thrusting of the Kamouraska lenses with respect to the slate may have occurred locally.

Lithology

1. The Kamouraska Limestone Conglomerates. The limestone conglomerate is slightly subordinate to the quartzite and probably forms 40 to 45% of the total Kamouraska facies within the Cuoq-Langis area. The scale of conglomerate occurrence varies from small, individual lenses only a few inches thick to beds up to tens of feet thick. Phenoclast size commonly diminishes with the size of the deposit, from predominantly cobble size with scattered small boulders and rare large boulders in the massive units, to pebble-sized material in the smaller. However, many small deposits of intraformational conglomerate do not conform to the trend and consist of fragments that are commonly several inches long.

Two basic types of conglomerate are recognized by the writer and designated "Common Type" (about 90% of the total) and "Varieties" respectively. The varieties are related to the basic type fundamentally, but differ in details of fabric and composition, probably reflecting differences in the conditions and mechanism of deposition. The varieties of limestone conglomerate include the following main sub-divisions:

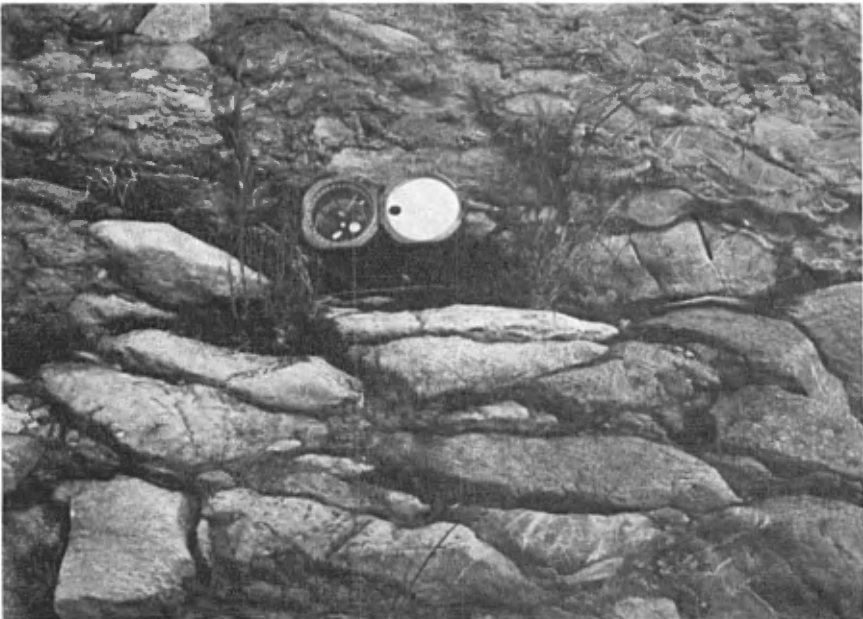
- a. Calcarenitic matrix type, usually sub-intraformational (6% or less of the total).
- b. Intraformational type (4% or less).
- c. Rounded phenoclasts in slate (1%).

A broad gradation exists between the common and varietal types. Most of the Common Type conglomerates contain at least some tabular fragments or slabs (Pl. XI-A) with more or less rounded edges, but many contain an abundance of such material and approach the intraformational type. Further, the matrices of some Common Type limestone conglomerates contain a small proportion of calcarenitic material.

Plate X

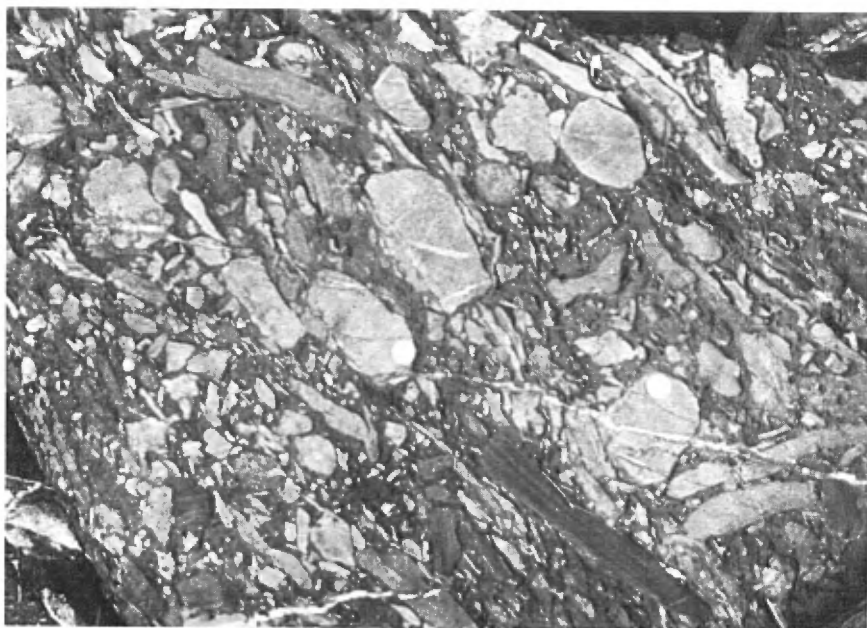


A. Kamouraska limestone conglomerate at Rivière Matane village, showing a sandstone matrix more or less entirely separating the phenoclasts. Note the coarser textured calcareous sandstone phenoclasts. The hand lens is $1\frac{1}{2}$ inches long.



B. Closely set slab-like limestone phenoclasts in a limestone conglomerate bed northwest of the road at Goupil. The slabs are oriented parallel to the bedding.

Plate XI



A. Kamouraska limestone conglomerate comprising a mixture of tabular phenoclasts and relatively equidimensional ones. The former are commonly silty or sandy and laminated, and suggest short transport. (The two coins are nickels)



B. Kamouraska limestone conglomerate northwest of the road at Goupil, containing a sharply folded, angular, calcareous sandstone phenoclast.



A. Contact between limestone conglomerate with a calcarenitic matrix and underlying calcarenitic limestones. About 2 miles northeast of Saint-Tharsicius. Note the preferential development of joints in the limestone and the close, wavy separation parallel to the bedding in both.



B. Close-up of conglomerate shown in Plate XIII-A, showing limestone, calcarenite, oölithe and siltstone phenoclasts in a calcarenitic matrix.

The types designated above show some variation in the lithologies with which they are associated. The Common Type is generally associated with quartzite or calcareous sandstone beds in the larger occurrences. Very small, scattered occurrences may be isolated in the slate, or occur in association with limestone (as in the roadcut northwest of Rivière Matane, where one or two small lenses of conglomerate are associated with calcarenitic, oblitic limestones). Limestone conglomerates with a calcarenitic matrix are invariably associated with limestone and calcarenite beds. Some intraformational conglomerates are associated with limestone beds (locally fractured) lithologically similar to the phenoclasts, and others apparently occur in isolation within the slate.

A. Common Type. The ridge on the northwest side of the road at Goupil (Appendix B and Plate V) is the type locality.

Fabric. The fabric typically consists of closely set phenoclasts which, in spite of their concentration, make relatively few contacts with their neighbours because each phenoclast is commonly surrounded by a thin layer of matrix (Pl. X-A). The matrix tends to weather in relief, sometimes excessively so, relative to the limestone phenoclasts.

The phenoclasts are commonly moderately to poorly sorted. In some beds, particularly those with pebble-sized or smaller phenoclasts, sorting of the phenoclasts improves, but there are some scattered larger phenoclasts. Pebble- and cobble-sized phenoclasts predominate with scattered small and rare large boulders. Scattered beds of predominantly small- or medium-sized pebbles also occur and rare beds of large cobble to small boulder sizes.

The largest boulder seen was at Goupil and measured 5 feet 4 inches by 1 foot 10 inches. Another boulder 4 feet 2 inches by 2 feet, and several around 2 feet by 1 foot to 2 feet, were observed nearby. Large boulders tend to be longer than thick, broadly slab-like, and subrounded; some are tabular. They occur at random in beds of pebble- to cobble-sized material and do not seem to correlate with any significant change in deposition. The largest phenoclast of oblite seen is slab-shaped and nearly 4 feet in maximum observable dimension.

The phenoclasts may be tabular or equidimensional, sub-spherical, or ovoid. Most are elongate and slab-like and sub-tabular or tabular forms are widespread and locally common. These shapes reflect the predominantly thin beds from which many of the phenoclasts were derived and also indicate the immaturity of the material. Plate XI-A shows a mixture of tabular and more equidimensional phenoclasts. The tabular or sub-tabular phenoclasts are most commonly sandstones, siltstones, and sandy or silty limestones. Occasional phenoclasts are slightly deformed and some drape

themselves around their neighbors, suggesting that they were in a semi-plastic state at the time of their inclusion in the conglomerate. Most of the material is subrounded, although subangular and rounded phenoclasts are fairly common and there are some well-rounded forms.

More than 85% of the phenoclasts consist of limestone; sandstone, siltstone, dolomite and slate are minor (see Appendix C).

Two phenoclasts deserve special mention. The first is an angular, sharply folded fragment of calcareous, fine-grained, light brownish gray, laminated sandstone (Pl. XI-B) identical to the common sandstone phenoclasts. The sharp chevron folding involved is interpreted as a tectonic rather than a slump structure, and thus would imply pre-depositional folding. The immature shape and angularity of this phenoclast suggest short transport and, therefore, folding close to the site of deposition. A calcarenite phenoclast from a conglomerate near Bastien brook consists of a fine to very coarse sand-sized mixture of limestone grains, some of which are fragments of ooliths and oolites and many of which are now superficial ooliths. This suggests repetitive conditions of oolith formation and repeated erosion in the phenoclast source area.

The matrix almost everywhere is a calcareous, locally slightly dolomitic, quartz sandstone (essentially an immature orthoquartzite). It is light gray where fresh, and deep buff-brown to whitish where weathered. Quartz typically constitutes 60 to 80%, interstitial calcite 20 to 40%, dolomite 0 to 5% and plagioclase 0 to 2%. Grain sizes range from fine to coarse. Silt or scattered very coarse sand sizes occur locally. Sorting is commonly moderate, locally poor. Rounding is typically moderate also and subangular to subrounded grains predominate. Quartz grains commonly are frosted and most are strain-shadowed. The interstitial carbonate forms a microcrystalline to very finely crystalline mosaic.

An important exception to the above generalization occurs in a conglomerate bed associated with the quartzite unit north of Sableux brook. Here, a mixture of fine quartz grains and medium to coarse grains of limestone represent a transition between the conglomerates with a calcarenitic matrix and the Common type. A similar matrix was observed about 1/2 mile southwest of Goupil.

Veins. Calcite veins 1/4 to 1/2 inch thick and usually at the most a few feet long are ubiquitous in the conglomerate.

B. Varieties. a. Calcarenitic Matrix Type. The small hill in lots 53-54, range V, Blais township, about 2 miles northeast of Saint-Tharsicius is the type locality for this variety. Another, rather different type forms part of the ridge at Saint-Vianney. All occurrences of this type are confined

to the area southeast of the Goupil - Langis Lake band of the Kamouraska facies.

Fabric. The fabric (Pl. XII) consists of closely set phenoclasts and is analogous to that described for the Common type above. Locally, the rock consists of a few scattered phenoclasts in calcarenitic limestone.

The phenoclasts are moderately sorted. At the type locality the main size range is 1/4 to 1 inch although common scattered fragments are up to about 10 inches in greatest apparent dimension. At some other localities, a larger percentage of the fragments are one to several inches long, but sizes are conspicuously smaller than those of the Common type, and the overall size range is more restricted. Phenoclasts generally constitute 65 to 75% of the volume of the rock.

Phenoclasts vary in shape from tabular, flat and platy to varihedroid, sub-equidimensional and ovoid. Siltstones tend to be particularly flat and tabular. Tabular and flat forms predominate in the sub-intraformational members of this category, such as the conglomerate forming part of the ridge at Saint-Vianney.

Sedimentary structures are few. Parallelism of the longer axes of phenoclasts with the bedding is fairly pronounced, becoming very pronounced in the sub-intraformational types. Some of the thicker conglomerate units are split at intervals of one or several feet by thin to medium lenticular beds of calcarenite, indistinguishable from the matrix in composition. Changes in phenoclast size promote subsidiary bedding in places.

Irregular, wavy separation surfaces, an inch or several inches apart, cleave the matrix of the conglomerate and the underlying calcarenite beds (Pl. XII-A) in some outcrops. Stylolitic interpenetration of several tabular phenoclasts occurs in the conglomerate at Saint-Vianney.

Phenoclasts consist predominantly of limestone (entirely so in the case of the sub-intraformational varieties) with an important element of siltstone and silty limestone. The main feature distinguishing the phenoclasts of the above variety from those of the Common type conglomerate is the shift to calcarenitic and oölitic material.

At the type locality, light to medium gray, calcarenite, calcisiltite and oölitic phenoclasts predominate. Subordinate (locally predominant) very fine-grained, gray limestone and gray, light yellow-brown weathering siltstone phenoclasts also occur. The siltstones are commonly laminated, tabular and flat. Minor constituents include peculiar, well-rounded, pebble-sized phenoclasts of coarsely crystalline, dark gray to black calcite, some of which show relict oölitic texture when etched with

HCl. Relatively rare phenoclasts include yellow-brown weathering dolomite, gray calcarenitic limestone containing scattered concentric algal structures, rare limestone conglomerate fragments of the same type as the host rock, and fine-grained, light gray limestone containing vague shell fragments and Salterella. Trilobite fragments were recovered from a calcisiltite phenoclast.

Thin-sections reveal that some of the oölite phenoclasts are laminated owing to the alternation of fine- and medium-grained oöoliths. Sorting of the oöoliths is locally poor. Many oöoliths are fairly dense and murky and are set in a cryptocrystalline calcite matrix. Phenoclasts containing lentil-shaped algal structures are very similar to those in the Common Type conglomerate except that quartz silt is absent. The patchy, rather curdled texture of these algal lentils is similar to the grumous texture of the predominant limestone phenoclasts of the Common Type conglomerate, suggesting the possibility that this limestone is also of algal origin. Carozzi (1960, p. 210) and Hadding (1958) drew attention to the possibility of an algal origin for such a grumous texture.

Phenoclasts of the sub-intraformational Saint-Vianney Ridge conglomerate consist mainly of dense limestone containing a little dispersed quartz silt. Calcareous quartz siltstone and rare fine-grained oölite phenoclasts (resembling the matrix) are less common. The restricted range of phenoclast composition is distinctive. The presence of calcisiltite grains (identical to the calcisiltite phenoclasts) in some calcarenite phenoclasts, and of calcarenite phenoclasts in some conglomerate phenoclasts, implies an environment of repetitive and "cannibalistic" erosion.

The matrix consists essentially of fine- to medium-grained calcarenite, commonly with scattered coarse sand- to granule-sized material. Oöoliths are very common and locally (as in the Saint-Vianney Ridge conglomerate) form the entire matrix. Scattered silt or sand grains of quartz locally form part of the matrix. Scattered oöoliths are broken while others are partly recrystallized. Locally, the matrix has recrystallized completely, to form a mosaic of very finely crystalline calcite. The matrix of the Saint-Vianney Ridge conglomerate is so coarse as to be in part pisolitic and contains concentric structures 1/4 to 1/2 inch in diameter, interpreted as algal. The oöoliths and pisoliths are partly and very finely recrystallized. Some have incipient dolomitization of their central parts. Laterally, the matrix of this conglomerate grades to a calcareous quartz sandstone.

The Saint-Vianney Ridge conglomerate is interesting in several ways:

- i. The oölitic, pisolitic, algal matrix indicates a shallow environment of deposition and there is a suggestion of erosion and the recycling of material.
- ii. It is close to being an intraformational conglomerate.
- iii. It shows a gradation from a quartz sand to an oölitic type of matrix.

Veins are almost entirely thin and short, and consist of coarsely crystalline white calcite. The calcite is sheared in some veins.

b. Intraformational Type. Outcrops of this variety of limestone conglomerate tend to localize in zones, but are invariably small and scattered within these zones. They occur most commonly within the Johnson Lake band of red and green slate.

Fabric. The fabric consists essentially of closely packed, flat, tabular fragments. Styloolitically interpenetrating phenoclasts occur in some outcrops. In others the phenoclasts are isolated in the matrix.

The phenoclasts are almost invariably a cryptocrystalline to very finely crystalline, light to light-medium gray, lighter gray weathering limestone. Locally the phenoclasts are stained red by dispersed hematite, which appears to spread from the red slate matrix. Some phenoclasts show a relict calcisiltite texture.

Phenoclasts are most commonly 1/2 to 2 inches long although some are several inches. Fragments are usually angular or subangular, but are subrounded in the subintraformational varieties. Some appear to have been incorporated in a semi-plastic condition, and are moulded into the surrounding slate matrix.

Thin-bedded limestones, lithologically similar to the phenoclasts, commonly outcrop in the vicinity of the intraformational conglomerates.

The matrix is 10 to 50% of the rock and consists mostly of slate, greenish gray or, less commonly, maroon. The slate is identical with the surrounding Matane River Group slate and is variably silty. In one instance, a calcarenitic matrix was derived from the same type of limestone as the phenoclasts.

c. Rounded Phenoclasts in Slate. This type is simply transitional from limestone conglomerate to slate and occurs in rare outcrops at the contacts between conglomerate and slate or very rarely within the conglomerate. Phenoclasts are of the same approximate size and

lithology as those of the neighboring limestone conglomerate. The matrix is common Matane River Group gray slate, and is locally silty or sandy.

2. The Kamouraska Quartzites. The term "quartzite" is used for convenience, as most previous workers have done, to cover all the quartz sandstones of the types commonly associated with the limestone conglomerates. Most of these sandstones are hard and siliceous and do qualify as quartzites, but others are calcareous sandstones. The difference between the sandstones is largely one of cementation.

The typical quartzite is a quartz sandstone, best summed up as an orthoquartzite, slightly immature texturally. The rock consists almost entirely of quartz. Plagioclase is rare. Minor interstitial carbonate (mainly calcite with some dolomite) is present in some samples. Carbonate content increases locally to a few per cent in the calcareous sandstones. Traces of limonite and leucoxene occur. Inclusions of zircon, rutile, and apatite were noted in the quartz of some thin-sections. Quartz grains are commonly strained and appear dusty. The size range is almost invariably fine to medium sand-size, and sorting is commonly moderate. Most grains are subrounded to rounded. Freshly broken surfaces are light to medium gray, in many cases with a brownish cast, and the rock weathers whitish with faint yellow-brown stains in places. Scattered chips up to 1/2 inch of gray slate are common.

The quartzites vary in the degree of recrystallization, and the nature of cementation. Many are simply quartz-cemented without significant recrystallization; others have been recrystallized into a mosaic of sutured grains. The subordinate calcareous sandstones consist of relatively unmodified grains in a mosaic of very finely crystalline carbonate. Gradations exist between all types. The quartzite commonly gives the impression that it has undergone a moderate degree of metamorphism. However, thin-sections indicate that the influence of metamorphism has been mild.

The calcareous sandstones are very similar to the typical quartzites and tend to occur in close association with the limestone conglomerate (probably the source of their cement) or as scattered beds. They commonly lack the massive character of the quartzite proper and display subsidiary bedding separation.

In an outcrop of Kamouraska facies on the north bank of Matane river, just over a mile upstream of the Tamagodi, a peculiar conglomeratic sandstone (or grit) takes the place of the quartzite to form several interbeds with limestone conglomerate. This rock consists of an unsorted mixture of generally angular, coarse sand to small pebble-sized quartz and rock fragments (including rare volcanics) in a calcareous matrix.

Table 1. - Kamouraska Quartzite Analyses
(Laboratories of the Department of Natural Resources, Quebec)

	Long Pilgrim Island		Langis
	No. 1801	No. 1802	VJA-52
SiO ₂	98.24	97.77	93.58
Fe ₂ O ₃	0.24	0.19	2.07
Al ₂ O ₃	1.52	1.27	1.00
CaO	0.10	0.10	
CaCO ₃			2.11
MgO	0.16	0.17	
MgCO ₃			0.40
S			0.02
L.O.I.	0.29	0.29	
Total	100.55	99.79	99.18

Several important facts emerge from a study of the quartzites. Firstly, the quartzites of the Cuoq-Langis area are essentially identical with quartzites sampled by the writer from several outcrops in Kamouraska county and elsewhere. Secondly, many of the ordinary gray sandstone beds scattered throughout the slate sequence, differ from the Kamouraska quartzites only in detail. They tend to be more calcareous and/or more argillaceous and often contain scattered ooliths. If the carbonate and argillaceous material were removed, a Kamouraska-type sandstone would generally result, although commonly coarser and less sorted. Thus, a possible local source of the Kamouraska quartzites is suggested. Thirdly, the quartz component of the typical limestone conglomerate matrix closely resembles that of the quartzites, and in places the two pass into one another laterally. The main differences are in size and sorting, the matrix quartz being slightly coarser and not quite so well sorted as that of the quartzite.

Veins of quartz are ubiquitous, generally thin (1/8-1/2 inch), and seldom more than a few feet long.

ORIGIN OF THE KAMOURASKA FACIES

The Kamouraska facies as here defined does not consist entirely of identical types, so that immediate origins may vary locally. Most earlier theories of origin invoke instability (frequently penecontemporaneous faulting) and the mass transport of material. All acknowledge the abnormality of the processes involved. Submarine landslides have been the favorite mechanism, modified and modernized recently by the introduction of

the turbidity current concept. Earthquakes have been postulated as either a major or a support factor. The shallow water origin of much of the material involved and the affinity of the deposits to beach or shoreline types have been acknowledged by some. Certain tenuous theories of origin have been proposed from time to time, such as the glacial theory and the theory of the sliding of lithified lenses. Recently, the probable poly-genetic nature of similar and possibly related conglomerate in Newfoundland has been suggested by Baird (1960).

Certain basic facts and features must be borne in mind and referred to in an interpretation of the origin of the Kamouraska facies. The involve particularly: A. Distribution, B. Stratigraphy, C. Composition and Fabric, D. General Environment.

Under each of these broad headings, some of the main points which must be considered and satisfied by any interpretation are as follows:

A. Distribution

1. The great length of the band in which this facies occurs.
2. The width of occurrence of the facies within the band.
3. The apparent occurrence of the facies below, on strike with, and above the Shickshock Group and possibly within one of the slate zones with which it is interfingered at Lake Matapédia.

B. Stratigraphy

1. The recurrent nature of the deposits.
2. The overall range of the Kamouraska facies from at least Middle Cambrian to Middle Ordovician.
3. The lenticular form of the exposures and probable deposition in lens form.
4. The considerable variation in concentration and size of lenses and in the size and proportions of the constituents.
5. The commonly conformable relationship and interbedding between the Kamouraska facies and the underlying slate.
6. The suggestion of mild unconformity between certain lenses and the underlying slate.
7. The U-shaped outline of some occurrences.
8. The close association and interbedded relationship of the quartzite and limestone conglomerate.

9. The occurrence of subsidiary bedding within continuous limestone conglomerate units as the result of variations in the size of phenoclasts or the proportion of matrix to phenoclasts.
10. The associated occurrence in many areas of intraformational conglomerates.
11. The indications of the local derivation of materials.
12. The tendency for younger limestone conglomerate beds to contain increasing proportions of younger phenoclasts, and the close correlation between the age of individual conglomerate beds and immediately underlying strata in Newfoundland.
13. The general apparent absence of suitable source limestones in place within reasonable distance of the conglomerate beds.

C. Composition and Fabric

1. The moderate to well developed rounding of much of the phenoclast material in the conglomerates.
2. The monotonous predominance of limestone phenoclasts, the relative scarcity of sandstone, and the rarity of slate.
3. The orthoquartzitic nature of most of the quartzites and sandstones, which are texturally slightly immature, but generally moderately well sorted, with subrounded grains.
4. The strong similarity between the sand grains of the quartzites, those in the matrix of the conglomerates, and those in many of the sandstones and sandy limestones of the slate sequence.
5. The conspicuous general absence of any diagnostic features and structures typical of turbidity current deposition, particularly graded bedding.
6. The washouts of some quartzite beds and locally of slate underlying the Kamouraska facies.
7. The fairly abundant general content of relatively flat, slab-like and subangular to rounded tabular phenoclasts in the conglomerates.
8. The scattered occurrence and apparently random distribution of large boulders in beds of pebble- to cobble-sized conglomerate.
9. The immense size of some included boulders.
10. The existence of minor conglomerate beds consisting entirely of tabular phenoclasts indicating an intraformational origin.
11. The fact that some gradation exists between the Common Type of limestone conglomerate and the Intraformational Type.
12. The suggestion that some phenoclasts were deposited in a semi-plastic state.

13. The moderate sorting of phenoclasts in some beds.
14. The fairly common existence of recycled limestone conglomerate phenoclasts within younger conglomerate beds of similar lithology.
15. The distribution of the conglomerate matrix, separating most phenoclasts and suggesting simultaneous sand and gravel deposition.

D. General Environment

1. The common occurrence of material of shallow water origin in both the matrix and some phenoclasts of the limestone conglomerates.
2. The evidence of penecontemporaneous deformation and erosion in the basin.
3. The fact that some bands and patches of red and green slates are associated preferentially with the intraformational conglomerates.
4. The fact that local shallow water deposition in the slate sequence is indicated by the presence of ooliths in scattered, calcareous, orthoquartzitic, sandstone beds.
5. The possibility that vulcanism (Shickshock Group) was contemporaneous with at least some of the Kamouraska deposits.
6. The probable existence of a large upfaulted, granitic, basement block (Cuoq block) forming a landmass south of the site of Shickshock Group deposition during part of the Lower Paleozoic period and apparently contemporaneous with at least part of the Kamouraska.

Interpretation

The Kamouraska facies apparently was derived from, and deposited adjacent to, multiple local uplifts within the main basin of deposition. These source areas formed transient ridges or welts within the trough in which the Quebec Complex was deposited, from at least Middle Cambrian to Middle Ordovician time. They probably had a northeast trend. The environment was unstable and the distribution and elevation of the source areas were subject to change, so that old uplifts were submerged and new uplifts formed. These changes produced some erosion and recycling of earlier conglomerates.

Evidence is inadequate to assess the relative roles of folding and faulting in the development of the source areas. Both may have contributed. Evidence from Trois-Pistoles indicates erosion of the Precambrian basement. The writer concurs with Alcock (1926a, p. 31) that variations in lithology and repetitions of the facies can be attributed to

vertical movements, such as recurrent movements along faults. Coincidence of the following features suggests that a possible platform or remnant thereof exists in the Cuq-Langis area. — Firstly, the zone of predominantly red and green slates (see Map) passing through Johnson lake, is also a zone of local intraformational conglomerate (suggesting shallowing). Secondly, this zone is bordered along its southeastern edge by a pronounced zone of limestone conglomerate and quartzite, with quartzite increasing and conglomerate decreasing outwards from it. Thirdly, a zone of dislocation parallels it just to the northwest along Petite Matane river (a possible surface expression of a previous structure?).

The uplifts formed part of a "cannibalistic" process by which the Kamouraska facies was derived and concentrated from largely unconsolidated sediments, which had just previously been deposited and formed part of the basin floor. The erosion of largely unconsolidated sediments is responsible for the restricted lithology of the Kamouraska facies and for the predominance of limestone fragments and quartz sand concomitant with the conspicuous general absence of shale, contrary to expectation in a largely shale environment. The rapid preferential lithification of the limestone beds and their sandy variants occurred, while sands and shales generally remained unconsolidated. Thus, limestone and variants were broken into fragments while sand was washed and separated from the silt and clay. Masses of limestone gravel and quartz sand were deposited along the margins of the local platforms, while the lighter fraction of silt and clay was carried away and redistributed in the deeper neighboring shale environment.

Extensive shallow water areas must have existed locally. Preferential limestone development may have occurred across the shallowing sites of the developing uplifts. This factor added to preferential lithification would explain the abundance of limestone phenoclasts. Intraformational conglomerates are related to the fundamental causes inasmuch as they probably formed where the mechanism of uplift caused local shallowing and exposed the beds to wave and current action.

The exact nature of the processes by which the Kamouraska facies sediments were derived and deposited are not established in detail. However, available evidence suggests that the following general type of processes were involved.

Material was probably brought to the margins of the uplifts by surface run-off, and reworked and sorted to a greater or lesser extent along the coastal margins. The common tabular and less rounded phenoclast material was derived from close to the margins. Much of the source limestone appears to have been thin bedded. The existence of deep waters beyond steep submarine slopes or submerged cliffs around the source areas is compatible with a fault or fold origin and would explain many of the character-

istics of the Kamouraska deposits. For example, gravel and sand detritus deposited in these deeper marginal waters would be beyond the influence of significant wave or current action. This would explain the absence of depositional structures.

The alternation of quartzite and limestone conglomerate suggests that the process of sedimentation was subject to some fluctuation. It is suggested that sand was normally swept out over the steep margins of the areas of uplift with periodic influx of mixed sand and gravel from the littoral zones or beaches farther inshore. Floods, storms and tsunamis are all possible agents in this transfer. Alternatively, seasonal changes in stream or current flow, or changes in the pattern of sediment distribution may have contributed to the formation of interbedded deposits. Some conglomerate beds may have derived as talus deposits directly from partly exposed sea cliffs. Some occurrences may even be original beach deposits, although the lack of diagnostic structures is against this. Shale deposition probably continued along the margins at all times, but was relatively too slow to contribute significantly to the succession.

The apparent absence of conspicuous source areas and suitable source limestones is readily explicable in terms of the present hypothesis. Firstly, it has been suggested above that limestone deposition may have been genetically related to the fundamental processes of Kamouraska development, through the preferential and local development of limestone across the shallowing sites of the developing uplifts. Thus, the limestones would face almost inevitable destruction in the culminating erosion. Secondly, relatively localized source areas adjacent to Kamouraska occurrences have not been carefully sought. Thirdly, source areas are not necessarily very different from the surrounding slate sequence, since thick limestone successions are not necessary, as the process outlined could cull and concentrate material from scattered limestone beds and dispersed sandy layers as it washed away vast quantities of unconsolidated mud. Fourthly, where conglomerates and quartzites outcrop at the present erosion surface, their source area may have been eroded away, if it had maintained its original relatively higher position. Conversely, source areas at the present erosion surface would be above the derived Kamouraska and the relationship would not be readily apparent. Fifthly, later deformation, imposing complex and excessive deformation on the entire succession, plus probable vertical movements on faulted boundaries of the source areas themselves, would affect the juxtaposition of source area and deposit. Finally, the angular discordance between source and product would probably not be great, particularly if normal faulting underlay the development of the uplifts. Under these circumstances, it is not surprising that ancient cliffs and shores and suitable limestone deposits have not been actually recognized.

One other factor to be considered is the preponderance of unfossiliferous limestone in the Kamouraska. The reason may be that faunal migration and colonization were hampered by the localization and scattered, changing distribution of the uplifts and the depth of the troughs separating them, so that extensive organic development was inhibited.

The Shickshock Group

General

The nomenclature of the Shickshock Group has an involved history. Early references (for example, Logan, 1846, p. 30; Murray, 1847) were simply to the "rocks" of the "Notre Dame Mountains" (later corrected to "Shickshock Mountains" - see Logan, 1863, p. 265). Later workers, including Ells (1885), Low (1885), and Alcock (1926a; 1926b) referred to the Shickshock rocks according to their supposed age. The first formal name was introduced by Crickmay (1932, p. 373) who designated the rocks the "Shickshock formation" and the section at Lake Matapédia as typical. This title did not gain general acceptance and in 1944, Dresser and Denis (p. 295-296) introduced and defined the term "Shickshock series". This term was again defined by McGerrigle (1954a, p. 18). The term "Shickshock Group" is more in accordance with the rules set out in the Code of Stratigraphic Nomenclature (1961).

The Shickshock Group can be defined as including all the volcanic and associated sedimentary rocks (predominantly arkose, with minor slate intercalations) and their metamorphic derivatives, which form the main bulk of the Shickshock mountains from the vicinity of the Tabletop mountains to Matane river, plus a small, separate wedge northeast of Lake Matapédia.

Problems and History of Interpretation

In the early days of geological investigation in Gaspé, Logan (1863) included the rocks of the Shickshock Mountains in his "Quebec Group" and interpreted the structure in relatively simple terms. He did not regard the metamorphism as a complication. Later workers became involved with various problems including the following:

1. The age of the Shickshock Group.
2. The stratigraphic relationship between the Shickshock Group and the adjacent slate sequence of the Quebec Complex.
3. The structure of the Shickshock Group.
4. The period or periods of deformation involved.
5. The relationship between the volcanics and arkose in the vicinity of Lake Matapédia and the Shickshock Group of the mountain region.

Several additional problems have stemmed from the present investigation, involving:

- i. The conditions of deposition of the Shickshock Group;
- ii. The location and nature of the source area;
- iii. The classification of the Shickshock Group sandstone.

Age. The age of the Shickshock Group has never been definitely established. A complete discussion of this problem has already been given (see Age of the Quebec Complex, above).

Stratigraphic Relationship. The Shickshock Group makes contact, along the north front of the Shickshock mountains, with the sedimentary rocks, predominantly slates, which form the remainder of the Quebec Complex. It appears to have been generally accepted that the contact dips southeast and that the Shickshock Group overlies the slate sequence. However, the nature of the contact and the orientation of the succession have been a subject of controversy. To a large extent, interpretation has been governed by opinions as to the age of the rocks concerned. The two main contentions have been that: A. the succession is normal; B. the succession is inverted.

Those in favor of a normal succession include Logan (1863), Alcock (1926a), Aubert de la Rüe (1941), and Mattinson (1958; 1964). Those in favor of an inverted succession include Ells (1885), Low (1885), and McGerrigle (1954a).

Previous interpretations of the contact between the Shickshock Group and the slate sequence range from conformable, to interbedded conformable, to faulted. The conformity of the contact along the north front of the Shickshock Mountains has been suggested by Logan (1863); Low (1885, p. 16); Alcock (1926a); Béland (1957); and Mattinson (1958; 1964). Several workers have suggested actual transition or interbedding at the contact. These include Béland (1957, p. 2) and Mattinson* (1958; 1964), McGerrigle (1954a, p. 22) considered, "either an unconformity or a fault between the Shickshock series and the Ordovician", in the Courcelette area. On his accompanying map, he favored a thrust fault.

Structure of the Shickshock Group. Logan (1863, p. 265) stated that, "The whole range appears to possess a synclinal structure with an undulation along the middle, dividing the basin into two subordinate troughs." He figured a vague cross-section of this double-synclinal structure (1865, Pl. IV, Section 10; reproduced in Fig. 2A).

* As stated above, the interbedding referred to by Mattinson may be within the Shickshock Group as defined by other workers.

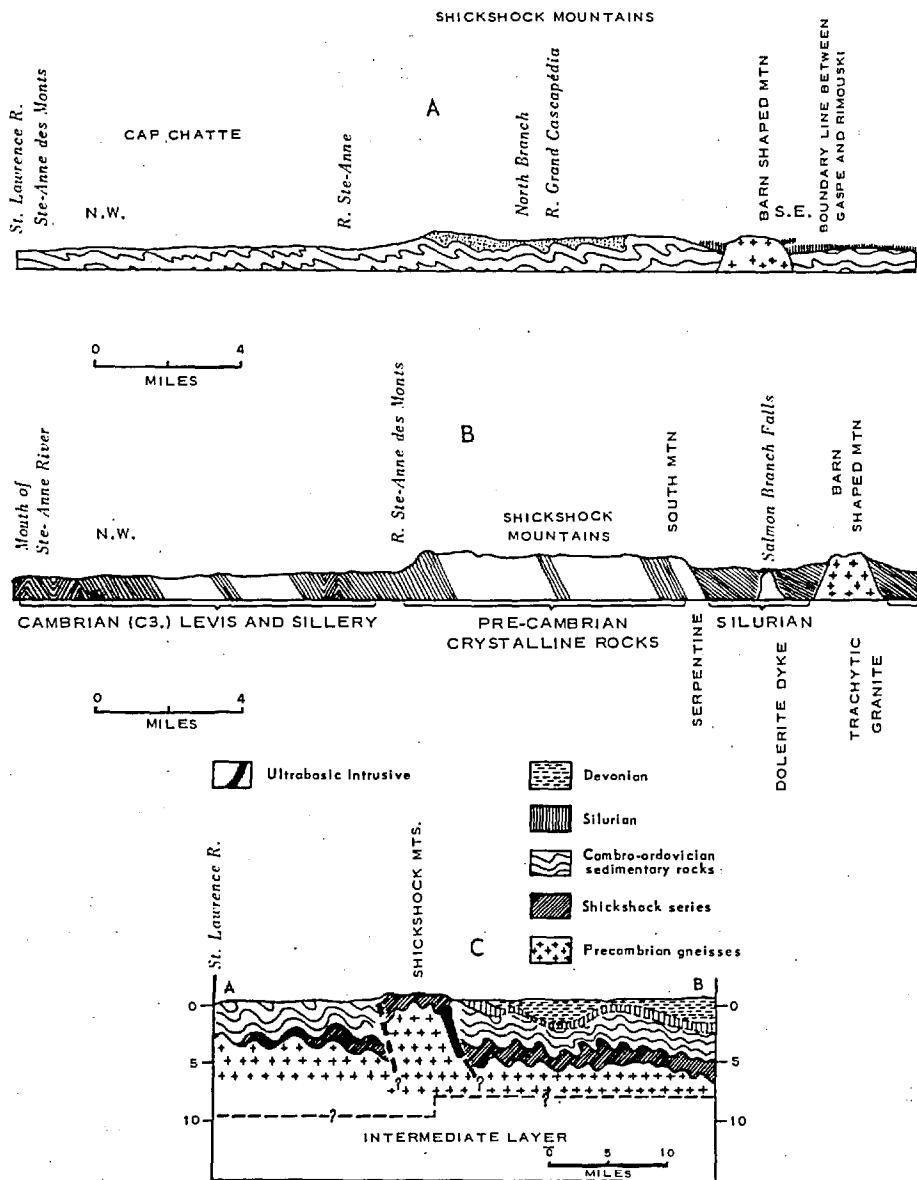


Figure 2

SCHEMATIC STRUCTURE SECTIONS OF THE SHICKSHOCK MOUNTAINS
(BY LOGAN (A); ELLS AND LOW (B); AND TANNER AND UFFEN (C)).

Ells (1885) and Low (1885) re-interpreted the structure as a great anticline overturned to the northwest (Fig. 2B).

McGerrigle (1954a) interpreted the overall structure towards the east end of the Shickshock mountains on the basis of foliation as a series of "two anticlines and two or three synclines", probably with a thrust fault underlying the entire mass.

Mattinson (1958; 1964) confirmed the existence of at least two interior folds, a northern syncline and a southern anticline, paralleling the trend of the Shickshock Group, across the main central part of the Shickshock mountains. He attributed the metamorphism and foliation of the rocks to the Taconic orogeny, but ascribed the syncline and anticline to the Acadian.

Tanner and Uffen (1960, p. 235) suggested that, "the main structural feature of the Shickshock Mountains may be a horst" (either "a true horst or an upthrust block"). This is a theoretical interpretation intended to explain the positive gravity anomaly outlined by the authors over the Shickshock mountains. Figure 2C is a reproduction of Tanner and Uffen's structural cross-section.

Metamorphism of the Shickshock Group. The influence of metamorphism on interpretations of age, structure and stratigraphic relationships of the Shickshock Group has been profound. Three main alternative interpretations of the metamorphic situation have been put forward:

- a. Differences in metamorphic grade between the Shickshock Group and neighboring strata to the north are not important.
- b. Metamorphic grade is abruptly and significantly greater in the Shickshock Group than in the slate sequence to the north.
- c. Metamorphic grade is greater in the Shickshock Group, but the increase in metamorphism is gradational southwards into the Group.

Adherents of the first interpretation believe that the succession is normal and the structure relatively simple. Adherents of the second interpretation accept the implication that the Shickshock Group is older than the rocks to the north. This acceptance, in view of the acknowledged general southeasterly dip of the contact, necessitates a reversed succession, with only two structural possibilities — either an overturned anticline, or an overthrust mass. The third interpretation is the most recent and is followed here.

Logan (1863) and Alcock (1926b) were not impressed by differences in metamorphic grade. Alcock suggested that differences are local and can be attributed to the greater hardness of the volcanics. Ells (1885), Low (1885), and McGerrigle (1954a) were much more impressed by the relative

metamorphism of the rocks involved and on this basis accepted the older age of the Shickshock Group and the overturning (Ells and Low) or overthrusting (McGerrigle) that such an interpretation required. Béland (1957, p. 3) noted that metamorphism shows indications of a gradational increase southwards into the Shickshock Group. Mattinson (1958; 1964) followed Béland's observation and stated that zones of regional metamorphism increase southwards into and across the Shickshocks.

The Lake Matapédia/Shickshock Mountains Relationship

The relationship between the Shickshock Group within the Shickshock mountains and the occurrence of arkose and volcanics at Lake Matapédia has been variously interpreted. Many workers have correlated the two occurrences as one continuous unit, while some have doubted or denied the equivalence of the two. This problem is a critical one, since one of the more important explanations of Shickshock Group stratigraphy (that of Alcock, 1926b) is based on the Lake Matapédia section. Also, the occurrence at Lake Matapédia presents, by virtue of excellent exposures and the relatively unmetamorphosed state of the rock, one of the best localities for studying the stratigraphy of the Shickshock Group (assuming the correlation to be correct).

In the early days of Gaspé geological exploration, reconnaissance was too general in nature to permit valid delimitation, but the 1864 Geological Map of Canada (Logan, 1865) showed the "altered Sillery" of the Shickshock mountains terminating westwards at Matane river. From 1884 to 1944 geological maps of the region (including Ells and Low, 1884; Alcock, 1931; Parks, 1931; Dresser and Denis, 1944) depicted the rocks of the Shickshock mountains extending in unbroken continuity as far west as Lake Matapédia. Crickmay (1932, p. 373) also referred to a continuous series of rocks from Lake Matapédia to the Tabletop mountains.

A discordant note appeared in 1953, when McGerrigle, in his Geological Map of the Gaspé Peninsula (Map No. 1000), showed the Shickshock "series" abruptly terminating at the Matane with no extension or recurrence of the series farther west. McGerrigle later qualified this interpretation (1954a, p. 18) and stated, with reference to the rocks of the Shickshock mountains and those at Lake Matapédia that,

"there is no apparent structural, and certainly no topographical, connection between the two localities. It may be that there is a stratigraphical connection, but this is at least doubtful. Certainly, the rocks included in the 'Shickshock formation' of Matapédia lake are not typical of the rocks of the Shickshock range."

Mattinson (1958, p. 77) supported McGerrigle's contention, and stated with regard to Lake Matapédia, that,

"present knowledge admits no necessary connection between the volcanic rocks there and those in the Shickshocks."

McGerrigle's (1954a) thesis opened the Shickshock problems again. Alcock's interpretation cannot be accepted until some positive evidence is put forward to show that the rocks at Lake Matapédia do in fact belong to the Shickshock Group. It is unfortunate that Alcock omitted to establish the validity of his evidence. It would appear that, despite the apparent weight of opinion in favor of continuity, no one has attempted to trace the assumed Shickshock Group between Lake Matapédia and the Matane river. The continuity was assumed by Ellis and Low (1884) and accepted without investigation by later workers prior to McGerrigle.

*Partly in consequence of the importance of the relationships of the Shickshock Group, as well as of its reputed economic possibilities, Quebec began a new investigation of the range. This was begun by McGerrigle (1954a), continued by Béland and Mattinson in 1955 and 1956 (Mattinson, 1958), and more or less completed by the present writer in 1959-61. When personnel and more material things are available a special study of the range as a whole will be made.

1. Field Mapping

The field mapping leading to the present report confirmed that the volcanics and arkose at Lake Matapédia are separated by an interval of several miles from the Shickshock Group of the mountains, and that the latter does terminate at the Matane.

2. Structure

The structural relationships between Lake Matapédia and the Shickshock mountains are fully discussed in the chapter on Structural Geology and only the main points are outlined below. The wedge at Lake Matapédia is essentially on strike with the mountains. The succession at both Lake Matapédia and the western end of the Shickshock mountains is homoclinal, dipping uniformly to the southeast although at a somewhat steeper angle in the mountains. Folds appear in the mountains farther east.

A branch of the South Shickshock fault may be responsible for the termination of the Shickshock Group at the Matane. The Lake Matapédia segment could be a fault-bounded block, downthrown slightly relative to the main Shickshock Group of the mountains. The rocks of both areas plunge towards each other according to the evidence of lineation. The plunge of the two segments could explain the break in the continuity of exposure.

* Editor's note.

Conclusion. Structural evidence in general favors the correlation of the two units.

3. Stratigraphy

At both Lake Matapédia and the western end of the Shickshock mountains, arkose and volcanics are interbedded, with the former exceeding the latter in amount. The nature and thickness of individual beds and units are comparable, with similar internal structures and characteristics. Apparently the rocks in both areas are the right way up. The present investigation has demonstrated the intercalation of numerous slate zones and beds within the interbedded arkose-volcanic sequence, particularly at Lake Matapédia and to a lesser, but locally mappable, extent at the western end of the Shickshock mountains.

Conclusion. The stratigraphy of the two units is very similar.

4. Lithology

Variations in composition, texture, color and general appearance for rocks of a given type are no greater between Lake Matapédia and the western end of the Shickshocks than they are for samples within one of the two units, and identical samples are very commonly available. Phenoclasts in conglomerate beds are derived from similar source rocks.

Conclusion. There is a definite lithologic correlation between the two units.

5. Metamorphism

The grade of metamorphism at the western end of the Shickshock mountains is comparable to that at Lake Matapédia. Change is confined essentially to mechanical effects, with only minor and incipient mineralogical reconstitution. A gradual increase in the grade of metamorphism occurs eastwards within the mountains.

Conclusion. There is no significant difference in the grade of metamorphism between Lake Matapédia and the western end of the Shickshock mountains.

6. Topography

Although the main range of the Shickshock mountains terminates unmistakably at Matane river, the abrupt appearance of a series of ridges northeast of Lake Matapédia is more closely referable to the trend and

form of the Shickshock mountain unit than to the upland, although these ridges are only one or two hundred feet above the surrounding upland. The lower relative elevation of the Lake Matapédia ridges conforms in a general way with the observed southwestward diminution of the Shickshock range.

Conclusion. Some topographic relationship does exist between the two areas, although the relationship is not strong and certainly not continuous. The break in continuity can be attributed to structural causes.

It is concluded, on the basis of the above observations, that the arkose-volcanic sequence at Lake Matapédia forms part of the Shickshock Group.

In view of pronounced lateral changes within the Shickshock Group, some comments on the above correlation are required. The correlation established is essentially between the Lake Matapédia rocks and the Shickshock Group at the western end of the Shickshock mountains. Farther east in the Shickshocks, the nature of the Shickshock Group changes considerably, owing to changes in the proportions of volcanics to arkose and in the grade of metamorphism. The change becomes marked at the longitude of Mius lake. Alcock (1926b, p. 130) noted that, whereas the arkose is more abundant than the volcanics at Lake Matapédia, the balance shifts eastwards, until, in the region of the Matane lakes, the volcanics predominate. Actually, the volcanics show little or no eastwards increase until the vicinity of Mius lake, where they abruptly increase to become predominant a little farther east, at Duvivier valley. Along the north front of the mountains the sediments thin out eastwards but less rapidly.

East of Mius lake, the Shickshock Group bears little apparent resemblance to the Lake Matapédia succession, with the exception of a narrow belt along the north front of the Shickshock mountains. However, the present writer believes his conclusions to be justified in view of the transition from the mainly sedimentary, relatively unmetamorphosed western region to the predominantly volcanic, more metamorphosed eastern region.

General Stratigraphy of the Shickshock Group

Details of stratigraphy, particularly the relationship between the Shickshock Group and the predominantly slate sequence to the north (Matane River Group of this report), and the relationship of volcanic to sedimentary rocks within the Shickshock Group, are well displayed in the Cuoq-Langis area. These details are particularly well displayed at Lake Matapédia and to a lesser but still important extent at the western end of the Shickshock mountains.

The most important features of the stratigraphy are as follows:

1. The Shickshock Group interfingers with the Matane River Group at Lake Matapédia and along the north front of the Shickshock mountains, at the western end. The interfingered zone represents a major facies boundary and the Shickshock Group is a facies equivalent of part of the Matane River Group. The Matane River Group covers a stratigraphic interval that extends above and below the Shickshock Group. Contacts between rocks of the two facies are conformable and interbedded.
2. In terms of lithology and the type of stratigraphy involved, the arkose-volcanic association at Lake Matapédia is identical with that northeast of Matane river at the western end of the Shickshock mountains.
3. There are strong indications that the succession is the right way up at Lake Matapédia and some evidence of a normal succession at the western end of the Shickshock mountains. This implies that the Shickshock Group is younger than that part of the Matane River Group immediately to the north of the Shickshock mountains.
4. A lateral facies change occurs within the Shickshock Group itself, in the vicinity of Mius lake, with volcanics predominating to the northeast and sediments predominating to the southwest. The transition between these two sub-facies is accomplished by an interfingered zone. In the sedimentary sub-facies, volcanics occur as sporadically distributed, relatively narrow and sometimes isolated units. The volcanic sub-facies is probably the innermost facies (i.e. nearest the source) of the Shickshock Group, and the sedimentary sub-facies is the marginal facies, meeting the slate facies at its outer edge.
5. The belt of sedimentaries (mainly arkose) along the north front of the Shickshock mountains is equivalent to, and a continuation of, the southwestern sedimentary sub-facies. The close, interfingering and interbedded relationship between the arkose and volcanics within this sub-facies and the transition between it and the volcanic sub-facies is evident. Thus, the stratigraphy does not support Mattinson's (1958, p. 97) contention that the arkose association along the north front of the Shickshock mountains is more closely related to, and forms part of, the slate sequence rather than the Shickshock Group. On the contrary, it is an integral part of the Shickshock Group, although of a marginal sub-facies in which sedimentaries exceed volcanics.

In addition to, and largely concomitant with, the internal facies change noted above, a conspicuous change in metamorphic grade occurs within the Shickshock Group in the Cuoq-Langis area. This adds to the difficulties of stratigraphic interpretation by creating strong apparent differences in the rocks to the east and west of Mius lake.

In view of the many differences, the writer suggests the adoption of the following two terms, to differentiate the succession for convenience of reference and description:

- a. The Lake Matapédia facies to cover all the relatively unmetamorphosed arkosic sedimentaries with subordinate, commonly purplish volcanics of the type found at Lake Matapédia, the western end of the Shickshock mountains and along the north front of that range.
- b. The Duvivier facies to cover the visibly metamorphosed "greenstone" and foliated or schistose volcanics with subordinate intercalated metasedimentary zones, of the types found in the region of the Duvivier valley and eastwards through the main range of the Shickshock mountains.

The contact between the two facies is gradational. It is less clear along the north front but probably coincides essentially with the northern margin of the main central volcanic prism (see Map). It should be noted that the grade of metamorphism increases gradually northeastwards within the Lake Matapédia facies along the north front of the mountains, as a result of the general eastward increase.

THE LAKE MATAPEDIA FACIES

The Lake Matapédia Area

At Lake Matapédia, the multiple wedges of arkose and volcanics outcrop in a triangular area that covers approximately 14 square miles. This area constitutes an excellent locality for the investigation of stratigraphy and structure, by virtue of very good exposure along the shore of the lake, the relatively unmetamorphosed state of the rocks, and the interfingering relationship between rocks of Shickshock Group and Matane River Group lithology. It is for these reasons that the recognition of the Lake Matapédia segment as a definite, if marginal, part of the Schickshock Group is so important to the study of the group as a whole.

1. Stratigraphy

The pronounced interfingering and interbedding make it difficult to establish the exact delimitation of the Shickshock Group and Matane River Group at Lake Matapédia. Throughout the main extent of the Shickshock mountains the contact is relatively abrupt and the two groups can be separated by a line on a map. However, at Lake Matapédia we are dealing with a lateral facies contact zone, and, for purposes of description, the zones of arkosic sandstones and volcanics are classed as Shickshock Group, and all the slates, above, below, equivalent to and interbedded with them are classed as Matane River Group.

Crickmay's (1932, p. 373) suggestion that the section at Lake Matapédia be regarded as typical of the Shickshock Group is endorsed on the grounds that stratigraphy and lithology can be more clearly determined here than elsewhere in the Shickshock Group. However, the fact that the Lake Matapédia facies is only a sub-facies of the Shickshock Group must be remembered.

The general relationship consists of arkose-volcanic units intertongued with slate. The individual arkose-volcanic tongues taper off until they disappear in the northeast through a combination of plunge and lensing out.

Contacts between the slate and the arkose or volcanics of the Shickshock Group are rarely seen, owing to the relatively greater erosion of the slate. However, those exposed leave no doubt of the essential conformity, interbedding and gradation of the contacts. Generally, the contacts are between slate and arkose, and slate to volcanic contacts are rare. This is explained by the fact that most volcanic units occur within the arkose tongues, rarely on their margins. The change from slate to arkose is accomplished within a few tens of feet at most, indicating the fairly sudden incursion of the arkose detritus.

At arkose-slate contacts the arkose tends to be finer-grained than usual, lower in feldspar content, and to grade into fine-grained sandstones with a variable content of argillaceous material. These sandstones are reddish or, less commonly, greenish gray. Some are still recognizably arkosic. Thinly interbedded slate (invariably reddish or greenish) and sandstone or arkose occur through a few feet at some contacts.

At the northwest end of Côté island, an exceptionally thick (100 feet or more), interbedded, transition zone outcrops. It consists of thick zones of laminated and banded medium greenish gray slates with thin interbeds and layers of fine-grained sandstone and siltstone. Each zone is separated by thick beds of greenish gray arkose and sandstone.

Red slates and the commonly associated green slates tend to occur in the gray slate sequence at, or just below, contacts with the overlying arkose; gray slate to arkose contacts are rarely observed. The slates commonly grade into red or green argillaceous siltstones and sandstones with slate interlayers in the actual contact zones.

Contacts with the slate are locally sheared. At the northwestern end of the largest island east of Val-Brillant, a few feet of slate are apparently squeezed and sheared between volcanic rocks above and arkose below. The shearing is locally quite intense, and the relationships obscure.

Plate XIII



A. A contact between volcanics and arkose of the Shickshock Group; north shore of Lake Matapédia, about $\frac{1}{2}$ mile southeast of Côté island. A thin bed of small-pebble conglomerate with a dark, chloritic matrix separates the arkose from the volcanics. The hammer head marks the contact, which is a level, fairly even surface and appears to be the right way up.



B. Pillow lavas in the Lake Matapédia facies of the Shickshock Group, on the north shore of Lake Matapédia.

Shearing and deformation again appear to be stronger than usual on the northernmost side of the ridge at the northwestern limit of the Shickshock Group. These examples are attributed to the difference in competence of the lithologies concerned, rather than to thrusting, although minor displacements may be involved.

Contacts between the arkose and the volcanics are conformable (Pl. XIII-A). The basal contacts of the volcanics possess more even and regular surfaces than the upper, while minor faulting, in some cases demonstrably contemporaneous, complicates the relationships. Contacts are best observed along the northern shore of Lake Matapédia, or locally along the Soucy road and some of the islands on the lake. The sedimentaries show very minor alteration at their contacts with the volcanics.

The thicknesses given below for the individual units are approximate only and the lateral variation and lensing of the units concerned should be borne in mind.

On the basis of the average dips of individual tongues, and assuming absence of repetition, it is estimated that the thickness from the base of the lowest arkose-volcanic tongue to the top of the last definite occurrence is about 14,000 feet. Further, if the volcanic easternmost island on Lake Matapédia is part of a lens, and in stratigraphic position, the thickness of the Shickshock Group at Lake Matapédia would be more than 16,000 feet. However, this island may be part of a fault slice and, in view of the evidence of disruption in the intervening slates, this greater thickness cannot be confirmed.

The approximate proportions of the three major lithologies involved are arkose 46%, volcanics 27% and slate 27%. This gives a ratio for sedimentaries: volcanics of about 7:3 and for arkose: volcanics of about 5:3.

The individual arkose-volcanic tongues taper off towards the east-northeast, from a maximum thickness of about 2,800 feet and an average of about 2,000 feet near the lake. One and possibly two smaller tongues occur in the upper, southeastern part of the section. The average thickness of individual arkose units within the tongues is about 400 feet, with a modal thickness of nearer 300 feet. Thickness ranges from about 100 feet to more than 1,000 feet, with about 88% of the arkose units falling within the range 100 to 600 feet. Volcanic units range from about 25 feet to an exceptional 950 feet thick, with an average and mode close to 300 feet. About 85% fall within the 100 to 450 feet range.

Most of the main arkoses are thick-bedded or massive, although strikes and dips can usually be measured. Bedding, where present,

is recognizable through contacts, color banding, size differentiation, pebbly or conglomerate beds, red slate beds, and alignment of red slate fragments. In thin-section, it is shown by size variation and by microlaminae of well-rounded, sorted, hematite grains. Color-banding consists of imperfect, irregular, commonly vaguely defined and lenticular layers of reddish purple in light brown-weathering arkose. Such layers are generally 1/2 to 3/4 inch thick and rarely several inches to several feet. The size-differentiated layers are of thin to medium thickness, and are locally graded. Granules and small pebbles are scattered in the arkose in local zones that grade into the surrounding arkose. These zones range from several inches to 12 feet or more thick. Here and there, the pebbles are concentrated to form conglomerate beds. Red slate beds, several inches to a foot or so thick, also occur locally within the arkose. Red slate fragments are common and may form zones several inches to several feet thick as well as rare beds of slate conglomerate. The orientation of these fragments is generally parallel to the bedding. Bedding shows a general increase towards the northwest margin and a local increase at contacts between the major lithologies.

Owing to the general monotony of the volcanic lithology and the limited exposure, no attempt was made to work out the details of individual flows. However, flows as thin as 8 feet were observed, and it is probable that many of the thicker volcanic units are multiple flows. Minor flow breccia marks a few interflow contacts.

The main slate units intercalated between the arkose-volcanic tongues, range from 200 feet to 1,750 feet thick, widening out towards the east-northeast to merge with the main slate sequence. Subsidiary bedding within these units is the same as the bedding within the Uniform and Laminated slate varieties of the Matane River Group to which, lithologically, they belong. The apparently lenticular units of red and lesser green slate that occur at contacts with the arkose are several feet to several hundred feet thick.

Alcock (1926b, p. 130c) derived evidence of tops from structures within the volcanics at Lake Matapédia and concluded that the entire succession at Lake Matapédia is the right way up. On the broader basis now established, it is confirmed that at least 90% of the Shickshock Group at the lake is the right way up. The possibility that the overlying gray slates are similarly orientated is mildly supported by one occurrence of small-scale crossbedding.

Most of the evidence for tops is found along the shore of the lake where the rocks are best exposed. The evidence is widely distributed and is good in each arkose-volcanic tongue save one. The types of structures used to establish tops were graded bedding, pillows, contacts between

arkose and volcanics, amygdules, flow breccia, and crossbedding. Some notes on these structures are included in Appendix E.

2. Lithology

The following discussion of lithologies is based on field observations, several hundred hand specimens, and more than 50 thin-sections.

Volcanics. An indication of the composition of the volcanic rocks is given in Table 2, which is based on thin-section analysis of more than 25 typical samples. Grain counts were made on all sections to ascertain the approximate percentages of individual minerals. All amygdules, vein material, and patchy or streaky parts of the volcanics have been omitted, thereby greatly diminishing the proportions of epidote, calcite and quartz. The figures for epidote are the most seriously misleading, since no outcrop is free from this mineral and it undoubtedly occurs in tenors much higher than the 8% suggested.

Table 2. - Estimated Mineralogical Composition of Typical Shickshock Group Volcanics at Lake Matapédia

MINERAL	A	B	C	D
Plagioclase	52	52	80	100
Pyroxene	15	26	48	60
Chlorite	11	12	40	93
Very Fine Felts and Glassy Material	6	18	55	26
Sphene	4	6	20	66
Fe Oxides	4	5	20	85
Leucoxene	2	4	30	52
Epidote	2	3	8	44
Calcite	2	4	20	60
Quartz	1	5	10	20
Pyrite	tr.	tr.	tr.	40

A = Average percentage of total

B = Average percentage in rocks in which mineral occurs

C = Maximum percentage

D = Percentage of rocks in which mineral occurs

The plagioclase is mainly albite, and no plagioclase more calcic than the oligoclase-andesine boundary was observed. Plagioclase crystals are generally subhedral to anhedral, rarely euhedral, and commonly have corroded edges. Internally the plagioclase is usually clear, showing little evidence of alteration. It is well twinned on the albite and sometimes the Carlsbad laws and a few crystals display a strained extinction. Local, minor alteration to chlorite suggests preferential replacement, possibly of glass inclusions (Moorhouse 1959, p. 166).

The pyroxene is commonly augite, but some pigeonite is also present according to the low 2V. The exact proportions of the two pyroxenes have not been estimated. Crystals are generally subhedral to anhedral, less commonly euhedral, and vary in size from large crystals to microcrystalline grains dispersed in the fine plagioclase felt of the groundmass. Crystal boundaries show little evidence of reaction. Internally, strained extinction is common, and hour-glass structure is rare.

Chlorite is of ubiquitous but patchy distribution and occurs as shreds, patches and flakes. It replaces and locally forms pseudomorphs after pyroxenes, and so occurs in ophitic relationship with plagioclase. One chlorite hour-glass structure was noted.

Very fine felts, in which microlites of plagioclase occur, plus fine dust, aggregates, grains and small patches of iron oxides, chlorite and sphene, are probably devitrified and altered, originally glassy areas. Small shreds and patches of this material are locally common.

Sphene is ubiquitous and typically anhedral, and occurs as scattered very fine grains and patches or as irregular aggregates. Leucoxene is similar to the sphene in form and distribution and appears to grade into sphene in places; it is in part associated with magnetite-ilmenite (undifferentiated).

The iron oxides consist principally of hematite, with less magnetite-ilmenite. The latter forms anhedral to subhedral crystals, in part skeletal. The hematite is usually finely dispersed as dust and small grains, but forms common, conspicuous, grid-like patterns or irregular patches.

A predominantly high birefringence indicates that the iron-rich varieties of epidote are the most common. Dispersed, individual grains of epidote are typically anhedral, becoming subhedral and euhedral in veins. Calcite tends to be disseminated in irregular blebs and patches. Fine, anhedral, often roundish blebs and small patches of quartz, perhaps partly resorbed, occur in a few thin-sections. Traces of finely disseminated pyrite are common.

On the basis of composition, these volcanics may be classified as altered basalts. The sodic nature of the plagioclase suggests that they may belong to the spilite suite of soda-rich alkaline basalts.

The Lake Matapédia volcanics are typically medium to medium-dark greenish or purplish gray, or streaky mixtures of these two colors that derive from chloritic and hematitic material. The lighter "apple-green" of epidote accompanies the basic colors in many places. Weathering ranges from light to dark brownish gray, with conspicuous overtones of the original colors.

The typical volcanics are finely crystalline, but very finely crystalline and mediocrystalline types are common and some are coarsely crystalline. The last are probably flow-center material, although they strongly resemble diabase. Many of the volcanics are porphyritic. Conspicuous plagioclase phenocrysts, locally up to 1/4 inch long, are scattered in the finer groundmass. In thin-section, the orientation of the fabric is almost invariably random. Plagioclase laths, ranging from microlites in fine felts to coarsely crystalline phenocrysts, typically form the framework of the rock. Within this framework are scattered dust, crystals, grains, patches, wisps and small aggregates of other materials. Pyroxene may also form part of the framework. Relationships between the plagioclase and the pyroxene range from ophitic to sub-ophitic to entirely separated (doleritic). In some thin-sections the pyroxene is medium to coarse and dominates the texture, but generally it is sub-equal with, or lesser in size than, the plagioclase. Interstitial patches and pockets of finer felts and "glassy" material are common in the relatively coarse and fairly equidimensional fabrics. Most of the volcanics are holocrystalline; some are hypocrySTALLINE. In thin-sections of some rocks, commonly amygdaloidal, the texture is hyalopilitic, with amygdules dispersed in a microlite felt, with a "glassy" base. Devitrification has reduced all the originally glassy material to a vague mixture of microlites and alteration products.

On the north shore of Lake Matapédia, 1/2 mile northwest of the southeastern margin of the Shickshock Group, an irregular lens of scoriaceous material outcrops. This lens is 35 feet long and up to 7 feet high and is surrounded by normal volcanics. It consists of pumice fragments a fraction of an inch to several inches in diameter, set in an abundant white calcite matrix. The pumice fragments themselves consist predominantly of calcite (65%), in a framework of quartz (20%), hematite (5%), leucoxene (5%), and chlorite (5%).

Pillows are abundant in the volcanics on the islands and along the shore of Lake Matapédia. They are much less in evidence away from the lake, probably as a result of less perfect exposure rather than non-occurrence. Pillows were noted both at the base and at the top of volcanic

units. The shape of the pillows varies from vague indefinite outlines to classical. They range in size from about 6 inches to 3 feet in greatest diameter, but are mainly 1 foot to 2 feet across. They are locally amygdaloidal.

Pillow outlines are commonly accentuated by light green epidote envelopes 1/4 to 3/4 inch thick, which are locally separated from the next adjacent envelope by a thin (1/8 inch) hematitic layer, or by another layer of epidote. A further zoning occurs within some pillows. Next to the envelope, there is a darker, purplish gray layer (about 1/2 inch thick), followed towards the interior by a lighter, slightly greenish layer of similar thickness, changing to medium to dark purplish gray across the main centre of the pillow. These structures are probably the result of late stage, autometasomatic replacement, infiltration and segregation, involving particularly the iron oxides and epidote.

Irregular pockets, several square inches in surface exposure, occur between the pillows in places and contain a variety of fillings. Epidote-quartz-calcite mixtures are ubiquitous. Calcite alone is also very common; less commonly, hematite or jasper constitutes the filling. The jasper commonly forms spheroidal aggregates, which locally grade into botryoidal hematite.

Some pillow interiors are traversed by a number of shrinkage cracks, forming polygonal (generally 5- to 6-sided) systems. The cracks are commonly filled with a thin (about 1/8 inch) layer of hematitic material and have light-colored marginal zones 1/4 to 1/2 inch wide. The cracks were not observed to cross pillow boundaries.

Systems of reddish purple layers are another conspicuous feature in parts of the volcanics. Individual layers are commonly 1/16 to 1/4 inch wide. The layers are arranged in close, sub-concentric rings around the margins of ellipsoidal areas that are several inches to about one foot in diameter. The layers bifurcate and anastomose to some extent. In thin-section, the reddish purple layers show an increased concentration of interstitial hematite, apparently at the expense of chlorite. The interstitial hematite content ranges from 10 to 20% in these rings. These structures commonly appear to demarcate incipient pillows, but can be related locally to shrinkage crack systems.

Amygdules are locally abundant in the volcanic rocks. Calcite, chlorite and quartz (chalcedonic) are the main amygdule fillings, with lesser epidote and hematite. Any one of these minerals may form the entire, or a predominant part of an amygdule, or be accessory to any or all of the others in 2-, 3- or even 4-component mixtures, with the exception that hematite-epidote associations were not observed. One component usually

predominates locally. Accessory components tend to be distributed around the margin of an amygdule. The diameters of the amygdules range from less than 1 mm. to more than 1/2 inch. The shape is almost invariably spherical or sub-spherical and shows no sign of distortion due to mechanical deformation. Vesicles are rare and can usually be attributed to reincarnation through the leaching of carbonate from amygdules.

Thin, short veins are commonly and widely distributed throughout the volcanics, but veining is nowhere excessive. Veins range from microscopic to an exceptional 1 inch thick, and most are 1/8 to 1/2 inch thick. Quartz is the most abundant vein material, with lesser epidote and calcite. Various combinations and proportions of these three constituents may occur. Minor hematite veins and chlorite veins occur, and hematite is accessory to quartz and calcite in places. All the veins suggest cavity or fracture fillings, although epidote appears to be locally replacive. One calcite vein with included angular fragments of volcanic rock was observed. Orientation of veins is essentially random, although there may be a broad parallelism in particular outcrops and veins locally follow joint trends. Quartz veins may follow a different trend to calcite in the same outcrop. Epidote displays the most irregular distribution and exceeds quartz in volume if the ubiquitous streaks, "schlieren", patches, and pillow envelopes are included loosely as veins. Small radial growth structures of epidote occur on some surfaces.

In marked contrast to the Duvivier facies farther east, the volcanics of the Shickshock Group at Lake Matapédia show no signs of foliation or metamorphism, which cannot be attributed to autometamorphic alteration, other than the development of some strain and minor and local incipient cataclastic texture.

Sedimentary rocks. The sedimentary rocks are predominantly arkosic sandstones, with minor and local conglomerate, red slate, and tuffs and rare greenish gray slate, green chert, and jasper. From what is known of the environment, the composition, the source rock index, and their general characteristics, the sandstones at Lake Matapédia are best described as a poorly sorted, sodic arkose, straddling to some extent the textural boundary between Pettijohn's (1957) arkose and feldspathic graywacke, but otherwise conforming to the popular concept of an arkose, with its genetic implications.

a. The typical arkose. The typical arkose consists of a coarse-grained mixture of quartz and pink and white feldspar, with finer interstitial material, some of which is finely divided white mica. Traces of red iron oxides are common and the rock is locally calcareous. Table 3 shows the average mineralogical composition as calculated by grain counts of 15 representative thin-sections.

Table 3. - Estimated Mineralogical Composition of Typical Shickshock Group Arkose at Lake Matapédia

Mineral	Average Percentage	Range in Percentage
Quartz	42	28-60
Feldspar	35	20-45
White Mica	8	3-15
Carbonate	5	0-15
Sphene	3	2-4
Chlorite	2	1-5
Fe Oxides	2	1-4
Epidote	1	0-2
Lithic Fragments	1	Tr.-2
Mica	1	0-1
Pyrite	Tr.	Tr.
Leucoxene	Tr.	Tr.
Apatite	Tr.	Tr.

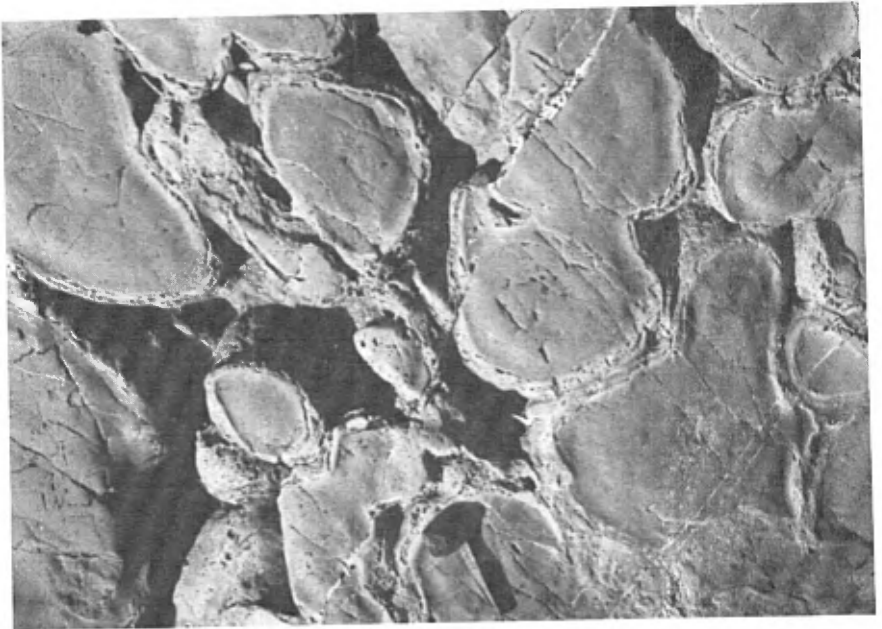
The quartz grains are mostly strain shadowed to a greater or lesser extent, and their edges are commonly corroded by carbonate. No secondary overgrowths were observed. Some grains contain inclusions of apatite or zircon. The feldspar is predominantly (at least 60%) plagioclase of albite composition; 30% is untwinned, altered feldspar. A minor percentage (about 10%) of perthite and microcline also occurs. Perthite and microcline were positively identified in only about half of the thin-sections. Plagioclase appears to grade from fairly clear, well twinned forms through vaguely twinned intermediate types to the untwinned, altered, material of dubious identity. White mica is the chief alteration product and the feldspar grains are locally penetrated and etched by carbonate.

Following Moorhouse (1959, p. 82) the term "white mica" is preferred to the more specific terms such as sericite, in the absence of definite evidence of composition. White mica forms the predominant intergranular material. Carbonate also occurs, locally attaining proportions of 5 to 10%. The carbonate is mainly, if not entirely, calcite. A total of 70% of the thin-sections contained little or no carbonate, although Alcock (1926b, p. 130c) reported a calcareous cement in all the thin-sections he studied. Sphene is another constituent of the matrix and is probably mainly an alteration product. Sphene occurs in scattered anhedral grains, small cloudy aggregates or as replacement intergrowths in some plagioclase grains, preferentially replacing alternate twins. Leucoxene is closely related to the sphene in places.

Plate XIV



A. Pillow lavas of the Shickshock Group on the north shore of Lake Matapédia, showing amygdaloidal tops.



B. Pillow lavas of the Shickshock Group on the north shore of Lake Matapédia, showing epidotitic envelopes.

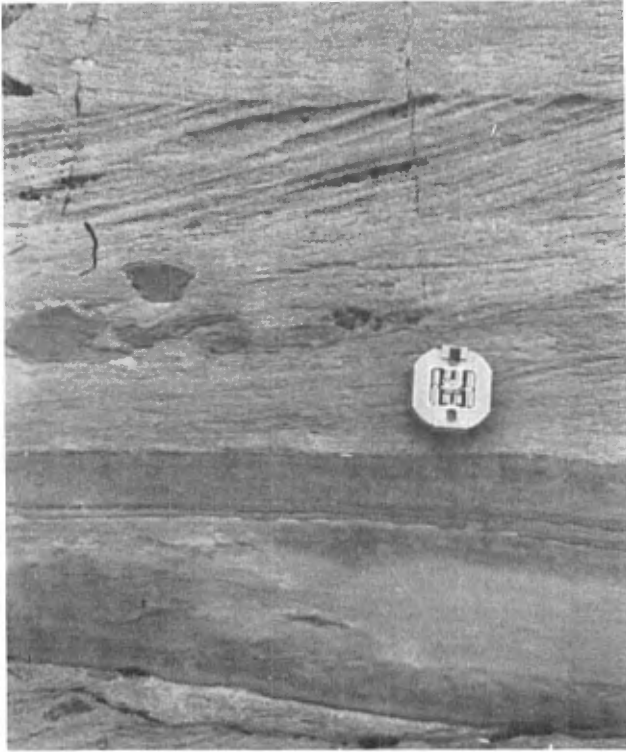
Chlorite controls to a large extent by its presence, absence and proportions, the color of the rock. With a content of about 1%, the rock is a light, slightly greenish gray; it changes to a light-medium greenish gray with 3%, a medium greenish gray with 5% and dark gray-greens with 10%. The typical, lightish colored arkoses of the Lake Matapédia facies contain less chlorite than is normal for the sedimentaries of the Duvivier facies. However, even within the Lake Matapédia facies (particularly close to the Duvivier facies) common varieties have a higher chlorite content. Chlorite occurs as an alteration product, in small discrete patches, or associated with the white mica. The red iron oxides commonly compete with the chlorite as the dominant rock pigment. Much of the iron oxide is hematite, typically occurring as small, well-rounded, sorted, detrital grains, that may be dispersed or concentrated into thin layers or single-grain laminae. Hematite dust also occurs.

Epidote is not a conspicuous constituent of the arkose and occurs as small grains or aggregates in the intergranular material. It is largely, if not entirely, a replacement product derived from the associated volcanics through permeation and infiltration from numerous vein systems. It may also be in part the product of mild metamorphism.

Scattered, small flakes of muscovite and, less commonly, of green biotite are present. The muscovite is largely a secondary growth from the white mica; the biotite is detrital. Several different types of rock fragments occur in the arkose, although the fragments are not common, and consist mainly of crystalline plagioclase (albite) with a little quartz locally. Sutured mosaics of strained quartz (probably vein material) are common. Less common are fragments of a fine siltstone (mainly quartz with some plagioclase), and there are rare basic volcanic fragments.

Surface weathering largely eliminates the chlorite pigments leaving quartz, white-weathered feldspars, and white mica with a scattering of pink feldspars to give an overall light yellowish brown or yellowish gray color. Hematite locally produces a reddish purple color on both fresh and weathered surfaces. Quite commonly the light yellowish brown and yellowish gray hues commingle with the reddish purple in streaks, patches, or imperfect layers.

The typical arkose is a poorly sorted mixture of silt-sized (or finer) to coarse or very coarse sand-sized material. In general, it is coarse grained. Arkoses with the greatest amount of matrix commonly have some cataclastic texture. Most of the arkoses are bound by recrystallization of the matrix. Grains are predominantly subangular to subrounded; some grains are angular and larger grains may be rounded or even well rounded.



A. A rare example of crossbedding in Shickshock Group arkose, on the north shore of Lake Matapédia near the northwestern margin of the group. Note the red slate bed near the bottom of the photograph and the red slate fragments near the middle.



B. Bed of exceptionally rounded red slate fragments in arkose of the Shickshock Group on the north shore of Lake Matapédia near the northwest margin of the Shickshock Group. Note that the top of the bed is at the top of the photograph, so that the conglomerate shows a reverse grading. Note also the imbrication of the fragments, suggesting current flow from the right (south or southwest).

Depositional structures are limited in occurrence and variety. Graded bedding is most important and is widely distributed. Crossbedding is rare (Pl. XV-A).

b. Varieties. This category covers sedimentaries that differ from the typical arkose in degree rather than in fundamental characteristics. It includes two main groups; firstly, varieties based on textural differences, and, secondly, varieties based on changes in mineralogical proportions.

1) Textural Varieties

i. Varietal Arkoses of the Northwest

In addition to minor variations in the size and sorting of the component particles, a general change in these properties occurs from southeast to northwest across the Shickshock Group at Lake Matapédia. With increase in sorting and a decrease in average grain size the arkose of the northwest is commonly moderately sorted to sorted and fine to medium grained. Hematite layers and laminae also appear to be more common in the northwest.

ii. Conglomeratic Arkoses and Conglomerates

Granule- and pebble-sized phenoclasts are locally dispersed in the arkose, producing conglomeratic arkose zones that grade into the surrounding arkose. These zones cover thicknesses of up to about 12 feet. Locally, the pebble-sized material is concentrated to form sandy conglomerates or true conglomerates, typically in beds several inches to one foot or more thick. The pebbles are small (mainly 1/4 to 3/4 inch in greatest length), well-rounded ovoid to sub-ovoid, and commonly slightly flattened. They are closely set in a matrix of typical arkose, although there are few pebble to pebble contacts.

Pink phenoclasts predominate. Lithologies noted include: common feldspathic, granitic and quartz; less common red slate and red sandstone; rare very fine-grained to dense, medium greenish gray, light-weathering siltstone. Along the southeastern margin of the Shickshock Group at Lake Matapédia, a moderately well-sorted conglomerate with slightly larger than average phenoclasts outcrops. Phenoclasts in this zone are up to 2 inches long for the igneous material and several inches for the red siltstone. Phenoclast size tends to diminish northwestwards across the Group and conglomerates and pebbly arkose die out in that direction.

Ten thin-sections of phenoclasts from various beds and zones were examined. Feldspathic phenoclasts were found to consist of 90 to 100% plagioclase (albite), with minor perthite and microcline. Even the potassium feldspar is more or less albitized, showing that not all the plagioclase is primary and suggesting alteration in the phenoclast source area. Accessory hematite, chlorite, saussurite and white mica occur, with a little epidote

in some thin-sections. The plagioclase is in coarse to very coarse anhedral crystals forming fairly equidimensional interlocking mosaics, commonly with white mica, chlorite, hematite or very fine, vague granulated material marking intercrystal boundaries. The crystals are typically dusty and grade from clearly defined albite twinning to untwinned varieties of low refractive index, some of which display a relict perthitic or microcline structure. The pink color of feldspar phenoclasts is caused by dispersed dust, trails, and fine patches of hematite. Alteration, particularly of the untwinned feldspars is conspicuous, and both sericitization and saussurization have taken place. Some of the phenoclasts are slightly to excessively fractured internally, with more or less finely comminuted intercrystalline material and a cataclastic texture. Because this deformation is greater in the phenoclasts than in the surrounding matrix in the conglomerates, and does not transgress the phenoclast margins, it is interpreted as indicative of tectonism in the phenoclast source area.

Granitic phenoclasts are very similar in all respects to the feldspathic phenoclasts described above, with the addition of 40% to 50% anhedral quartz. Accessory hematite, plus traces of leucoxene, magnetite and rare green biotite occur. The feldspar is largely, if not entirely albite, rendered pink by hematite dust. One example of a chessboard twin was noted, and appears to be entirely albite, possibly replacing microcline. The microcline was apparently sericitized before albitization, whereas the original albite was not sericitized.

Siltstone phenoclasts of the rare, very fine to dense, greenish gray variety consist of angular fragments of quartz and subordinate plagioclase, in a finer-grained, chloritic matrix, with dispersed hematite dust, locally concentrated into cloudy patches.

The igneous phenoclasts in the conglomerate are classified on the basis of present composition as albitites (feldspathic) and quartz albitites (granitic). Relict structures suggest the original presence of potassium feldspars, whereas saussurite suggests more calcic original plagioclase. These facts imply the possibility of an ancestry within the diorite-syenite range. The writer compared the conglomerate samples collected by McGerrigle (in collections of the Quebec Department of Natural Resources), and found them identical in hand specimen and thin-section with those of the Lake Matapédia facies.

2) Compositional Varieties

Local changes in the proportions of the mineralogical components such as a relative increase in the percentage of quartz, decrease in the percentage of feldspar, or increase in the matrix, produce local variation to feldspathic sandstones and feldspathic graywackes.

At contacts between the arkose units and underlying slates, different sandstones commonly take the place of the arkose. These are fine to very fine grained and usually reddish gray, but with some greenish gray and some interbanding of the two colors. Small-scale crossbedding is rare. These basal sandstones are finer grained, better sorted, apparently less feldspathic, and more conspicuously and thinly bedded than the typical arkose. They represent a transition between the slate and the arkose.

Changes in the arkose immediately overlying volcanics are pronounced and involve texture, composition and bedding. At one locality, thinly-layered to laminated, calcareous siltstone to fine-grained sandstone, with 5 to 30% hematite, takes the place of the arkose. In places, the carbonate content rises to as much as 55% to form layers of silty limestone. At another locality, the sedimentary rock overlying the volcanics resembles the varietal arkose of the northwest margin, but is still finer-grained and more chloritic and hematitic. The sedimentaries overlying volcanics locally display an increase in quartz and epidote veining for several feet above the contacts, suggesting deposition prior to the complete solidification of the lavas. Changes below volcanic units are minor and involve the contamination of the matrix.

Above volcanic units, the sedimentaries tend to be finer grained than usual, conspicuously layered and laminated, and to contain a greater content of detrital hematite and possibly carbonate. These differences may obtain for several feet. Below volcanics, sedimentaries show considerable local increase in chlorite for a distance of 1/2 inch and, uncommonly, several inches from the contact.

c. Other sedimentary rocks. The typical and varietal arkose association described above constitutes an estimated 90% or more of the total sedimentaries within the Shickshock Group at Lake Matapédia. The remainder consists of very different red slate, chert, and tuff.

Red slate warrants particular attention in view of its distribution, the nature of its occurrence and its implications as to the environment of deposition and paleogeography. It has been noted above that red slates tend to occur at contacts between the Matane River Group slates and overlying arkose of the Shickshock Group. Locally, green slates are associated with the red or may take their place in the vicinity of some contacts. Northwestwards across the Shickshock Group at Lake Matapédia, thin to medium beds of red slate appear rarely within the arkose and increase in abundance in that direction to become fairly common near the northwest margin.

The red slate within or at contacts with the Shickshock Group is typically more silty than its counterparts in the Matane River

Group and locally grades into argillaceous siltstone or very fine-grained sandstone. Fragments of red slate are commonly and widely distributed in the arkose of the Shickshock Group. These fragments are typically thin and subangular to subrounded tabular pieces, ranging in size from a fraction of an inch to several inches or, rarely, to a foot across. They may be scattered in ones and twos, or in relative abundance locally. No green or gray slate fragments were seen. Along with the increased occurrence of red slate beds, the fragments are more abundant and more concentrated towards the northwest and locally form red slate conglomerates (Pl. XV-B).

Red slate beds often lens out laterally into the arkose, in some cases possibly by washout. For example, a 10-inch-thick bed near the northwest margin terminates abruptly with a jagged edge, suggesting that it was virtually torn apart. In another locality, numerous fragments of red slate occur over an interval of 4 to 5 feet. Their orientation is random, suggesting deposition under violent, turbid conditions. These fragments vary in size from scarcely visible pieces to an exceptionally large block about 2 feet across by at least 6 inches thick. This large block has a very irregular and splintered margin. The indications are that the red slate beds are torn apart and redistributed by wave and/or current action. Local evidence suggests that disintegrating mud-cracked layers have contributed fragments.

Light green chert occurs in 1/4- to 3/4-inch layers in a few places within the arkose and is usually associated with tuffs. As noted above, small pockets of jasper lie within the volcanics. Common fragments and blocks of jasper, up to more than a foot square, in the float around Lake Matapédia, suggest the existence of jasper beds or lenses. The jasper is usually faintly laminated and is almost invariably traversed by thin milky quartz veins and veinlets.

Three separate examples of tuff were recognized in thin-section. All contain a mixture of sedimentary and volcanic material and are classified as hybrid-lithic tuffs. Minor crystal material is included in two of the three and original glass shards may be represented by alteration products such as chlorite.

One tuff consists of silt-sized, angular, commonly sharp, fragments of quartz, hornblende, chlorite (after mafic minerals), cherty (possibly devitrified) material, and microcline, with interstitial chlorite and dispersed calcite. Thin alteration rims of prehnite surround most of the fragments. The second tuff resembles a breccia in hand specimen and consists of angular fragments, ranging up to 1/2 inch in maximum diameter. The fragments comprise fine quartzose sedimentaries and stray shreds of volcanics (apparently incompletely consolidated lava at the time of incorporation), in a more or less finely comminuted silty matrix. Most of the

fragments are recrystallized and altered to some extent, the alteration mainly involving epidotization. This rock may be a lapilli tuff of explosive origin. The third tuff resembles a chloritic siltstone, with scattered, patchy fragments of volcanics and peculiar, zoned, subhedral to euhedral quartz crystals. The zoning consists of suborientated inclusions, principally chlorite. These quartz crystals are unstrained, although one displays a strained, possibly detrital center, and may be authigenic.

d. Veins and metamorphism. Veins are common in the Shickshock Group sedimentary rocks at Lake Matapédia, but are usually short (a few feet) and thin (1/4 to 1 inch). Quartz and mixtures of quartz and a dark green chlorite are the commonest and most widely distributed types of vein. Subordinate veins of calcite, epidote, chlorite, or variable mixtures of quartz, calcite and epidote also occur. Quartz-feldspar veins, so common in the Shickshock Group of the mountains, were not observed here. Veins commonly follow joint directions, particularly the northwest-southeast trend, but are also commonly random and crisscrossed. Rare veins follow bedding surfaces. Chlorite is much more in evidence here than in the veins that traverse the volcanics, and epidote much less so.

Metamorphism is restricted to local and relatively minor mechanical effects, imposing little mineralogical change on the sedimentary rocks other than the development of white mica and epidote. Deformation is mainly very weak and is manifested in strain effects, which, however, do not seem to affect all the grains in any one thin-section. Some plagioclase grains are cracked and bent and there are local cataclastic textures involving minor granulation. Locally, incipient fabric orientation is noticeable and an incipient schistosity affects the finer matrix. Such foliation generally parallels the bedding. An incipient fracture cleavage is developed locally with wavy separation surfaces, 1/2 inch to 2 inches apart, which coincide with the strike of the bedding but cut it obliquely.

The Shickshock Mountains Area

This portion of the Lake Matapédia facies includes that part of the Shickshock Group at the western end of the mountains, extending from Matane river to the vicinity of Mius lake, plus a narrow predominantly sedimentary strip along the north front of the mountains proper.

1. Stratigraphy

General.- The Lake Matapédia facies is transitional to the Duvivier facies along its inner margin and transitional to the slate facies (Matane River Group) on its outer margin.

An alternation of slate and arkose-volcanic tongues similar to that at Lake Matapédia is well displayed along the northern margin of the westernmost end of the Shickshocks. Farther northeast, along the north front of the mountains and within the main body of the Lake Matapédia facies in the vicinity of Cuoq brook, there are no mappable units of slate, but minor slate beds and zones are widespread. The absence of major slate intertongues along the rest of the north front of the mountains, both within the Cuoq-Langis area and northeastward, is attributed to a combination of stratigraphy, structure and erosion.

The minor slate units and beds are scattered sporadically throughout the Lake Matapédia facies and even occur in the transitional Mius Lake region. Several slate beds are interbedded with the arkose along the southern escarpment of the Shickshocks and are exposed along Cuoq brook. Thin slate interbeds were observed along Mius Lake brook, about 1/2 mile east of the lake. Numerous minor layers and scattered beds outcrop on the stream that flows east into the Matane, southwest of Lake Leclercq and along the base of the north front in that locality.

Relationships.- Actual contacts between the major arkose-volcanic and slate units are not clear in the Shickshock mountains. However, in many places the concealed interval is slight and the contact zones appear to be conformable. The slate is disrupted locally, but there is no significant evidence of fault or unconformity along the contact zones. Local, conformable interbedding, involving thin slate beds in arkose, is exposed along the valley of a small stream that cuts the north front of the mountains about 3/4 mile west of Lake Leclercq. There is no doubt that the interzones and interbeds of slate are primary stratigraphic features representing interfingering between two facies.

Very few contacts between the arkose and volcanics are exposed. All contacts observed showed the same characteristics as at Lake Matapédia and all were conformable. The strike of both arkose and volcanics is consistently northeast. The main volcanic core of the mountains splays and lenses out into the arkose northwards and southwestwards, suggesting that the main volcanic source fissures lay along the south side of the Shickshock mountains, mainly east or northeast of the Cuoq-Langis area. The arkose-volcanic relationship is obviously an interfingered one.

Thicknesses. - In view of the great general and local variations in thickness in these interlensing, intertonguing rocks, precise measurements are meaningless. However, estimated thicknesses of the main units are given and are derived by weighted averages of dip readings across the units involved.

The Shickshock Group is estimated to be about 15,000 feet thick along the line of Cuoq brook (Cross section B-B₁ of main map). As the dip is still southeast where the South Shickshock fault cuts off the Group, and in the absence of recognized folding within the Group, this is a minimum estimate. The band of Lake Matapédia facies along the north front, west of Lake Leclercq, is estimated to be 3,000 to 4,000 feet thick.

Within the Lake Matapédia facies, volcanic units thin rapidly to thicknesses of a few hundreds or even tens of feet and lens out. The arkose units separating the volcanics are up to several thousand feet thick. The main slate intertongue, along Rouge brook, is 1,500 to 2,000 feet thick. The minor slate units range from thin beds a few inches thick to units 10 to 30 feet thick and possibly up to 100 feet in rare cases. The approximate lithological proportions are arkose 65%, volcanics 30%, and slate 5%, giving a ratio of sediments to volcanics of 7:3 and of arkose to volcanics of 13:6.

Bedding structures are basically the same as those at Lake Matapédia, except that conglomerate beds are less common.

Tops.- Evidence of tops was much less convincing in the Shickshock mountains than at Lake Matapédia, but in all cases indicates a normal succession, younger towards the southeast. Several examples of graded bedding occur along Cuoq brook. Along the north front, less than one mile east of Duvivier river, volcanics of the Duvivier facies overlie arkose with a fairly level contact, compatible with the extrusion of lava over a flat sea-floor. In view of the observed situation at Lake Matapédia, where basal volcanic contacts are generally level and upper contacts usually irregular, this is accepted as evidence that the beds here too are the right way up.

2. Lithology

Volcanics.- The volcanic rocks belonging to the Lake Matapédia facies of the Shickshock mountains, closely resemble those already described from Lake Matapédia. Here again, there are local occurrences of diabase, which may be material from the centers of thick flows rather than intrusive. The main exposures of this type are along Tremblay brook and eastward.

As the Lake Matapédia facies passes eastwards and, along the north front, southwards towards the Duvivier facies, the effects of metamorphism are increasingly apparent in both the fabric and mineralogy of the rock. For the most part, these changes involve a breaking down of the primary igneous mineralogy and textures. Mineralogical changes are manifest primarily in the elimination of pyroxene, the alteration of plagioclase, and the gradual development of amphibole, chlorite and epidote. Cataclastic textures become common and the original ophitic, sub-ophitic,

and doleritic textures give way to disorganized fabrics, with anhedral grains and incipient fibrous and patchy textures.

The most conspicuous general changes in the transition from volcanics of the Lake Matapédia facies to those of the Duvivier facies include the following.- Hematite is replaced by magnetite-ilmenite, so that reddish purple disappears and the greens of chlorite, amphibole and epidote dominate; also there is an increase in magnetism. Porphyritic volcanics disappear through the conversion of euhedral, lath-shaped phenocrysts of plagioclase into anhedral, granular and finer material. Pillow structures become less common and amygdules are commonly stretched. As the above changes occur, the rocks pass from recognizable volcanics into "greenstones". The change is gradational but irregular through a zone in which old and new are sporadically distributed.

Sedimentary rocks.- The sedimentaries of the Lake Matapédia facies in the Shickshock mountains, strongly resemble those at Lake Matapédia. As in the volcanics, differences in mineralogy and texture become apparent in the arkose towards the Duvivier facies.

Typical arkoses conform essentially with the types described from Lake Matapédia. One difference is the limited local increase in the content of perthite and distinct microcline. Also, although veins essentially correspond with those at Lake Matapédia, quartz-chlorite veins are less common whereas common veins of quartz and pink or white feldspar appear. Mattinson (1964) identified this feldspar as potassium feldspar and attributed its origin to potash-bearing solutions circulating during metamorphism. A few veins are entirely of this feldspar. Quartz-epidote and epidote veins are also quite common and, while some are fracture fillings, others contain relict detrital grains of quartz and feldspar and appear to be metasomatic (possibly deriving from solutions from the lava flows).

Varieties conform essentially with those described from Lake Matapédia. Beds and lenses of conglomeratic arkose and small-pebble conglomerate are fairly common at the western end of the mountains, near the southern escarpment. Occurrences were also noted in the northeast corner of the area, along the streams flowing east into the Matane. Towards the Duvivier facies the arkosic sedimentaries change, primarily as the result of changes in the matrix, involving an increase in the content of chlorite and/or epidote by the alteration of the finely comminuted material. This produces a darkening of the rock to medium or dark greenish gray. Medium to very coarse sand-sized grains of quartz and feldspar (commonly pinkish plagioclase) are scattered throughout this finer-grained, darker matrix. In places the fabric has a preferred orientation. In addition, beds of siltstone or fine-grained sandstone become more common and beds generally are thinner (mainly thin to medium). Sorting in these

finer-grained beds generally improves to moderate or good. These changes probably result from differences in the environment of sedimentation around the main volcanic region, the increase in regional metamorphism southwards and eastwards, and possible contamination of the sediments by volcanic material.

Slates constitute the main variety of sedimentary rock associated with the arkose in the Lake Matapédia facies of the Shickshock mountains. These are essentially of the "Uniform" Matane River Group type and include both gray and lesser red slates in the main interzone along Rouge brook. Gray and lesser greenish gray slates form the thin beds and minor zones within the main part of the facies. Along Rouge brook, several thin, lenticular layers of arkose were observed within the slate, and the red slates coarsen locally into red siltstones or even fine-grained sandstones with a hematite cement (up to about 25%). These beds suggest transition to the arkose. Although red slate fragments are also common here in the arkose, red slate interbeds were nowhere observed. Unlike the succession at Lake Matapédia, all beds and zones of slate in the arkose appear to be gray or greenish gray. Those slates interbedded with the darker arkose near the Duvivier facies are moderately to strongly magnetic.

THE DUVIVIER FACIES

Stratigraphy

Metavolcanics form the bulk of the Duvivier facies. Metasedimentary rocks occur in two main bands and in a few small, scattered lenses. The segregation is not perfect, and small areas of volcanics occur within the main sedimentary zones and vice-versa. One of the metasedimentary bands is near the centre of the Duvivier facies and cuts across the Cuoq-Langis area from the northeast to southwest, just east of Duvivier river. This is the Mount Oest band of this report and is the southwestern continuation of the Tag Brook band of Mattinson (1964). A second, or South Boundary band, occurs along the southern flank of the mountains and is continuous with the Lake Matapédia facies to the southwest. To the northeast, this band probably is represented by the Weir Brook band (Mattinson, 1964).

Thicknesses.- The average width of the Duvivier facies is about 4 miles, and the estimated minimum thickness is about 12,000 feet. This, plus the 4,000 feet or so of Lake Matapédia facies sedimentaries along the north front, gives a minimum thickness of about 16,000 feet for the overall Shickshock Group at the eastern edge of the Cuoq-Langis area. Erosion and faulting may have reduced the thickness by several thousand feet.

The Mount Oest band varies in width from 2,000 to 4,000 feet and in thickness from about 1,500 to 2,500 feet. The South Boundary

band is 1,500 to 3,000 feet wide and has a minimum (faulted) thickness of 2,000 to 3,000 feet. Within the Duvivier facies the ratio of volcanics and sedimentaries is 4:1. As in the Lake Matapédia facies, bedding is commonly thick or massive, but thin to medium beds are more common than at Lake Matapédia and laminated rocks occur locally.

Lithology

Several hundred hand specimens and more than sixty thin-sections of Duvivier facies rocks were examined.

Volcanics.-- The volcanic suite of the Duvivier facies consists of metabasalts or "greenstones", some of which are amphibolitic. It is not proposed to give a detailed description of these rocks as a comprehensive study of the northeastward continuation of the Duvivier facies has been prepared by Mattinson (1964).

The incipient breakdown of the original mineralogy and textures, noted in the volcanic suite of the neighboring Lake Matapédia facies, gives way to mineralogical reconstitution in the Duvivier facies. An imperfect, progressive southwards and eastwards increase in metamorphic grade, continuing that noted from the Lake Matapédia facies into the Duvivier facies, is apparent within the Duvivier facies. On the basis of the fabrics related to this increase, the metavolcanic rocks of the Duvivier facies are divisible into three main categories:- 1) a zone of "solid" metavolcanics, with relict primary and cataclastic features, showing incipient recrystallization without important fabric orientation; 2) a zone in which the primary features have been completely obliterated, the rock is partly reconstituted and has an orientated fabric; 3) a zone in which the rock is completely reconstituted and has a complete fabric orientation with incipient to complete schistosity.

The rocks are typically medium to dark gray-green or bluish green, relieved by the lighter green of epidotitic layers, lenses, patches or veins. They are commonly moderately to strongly magnetic. Pillow structures were observed at several localities, but are generally rare. Segregated masses of epidote are common and may be in layers, producing a local banding, or in lenses up to several feet thick and tens of feet long. The composition of these masses is typically that of epidosite, with about 55% epidote and 45% quartz. Scattered masses of the epidosite contain spherulitic to rod-like quartz (locally with calcite), about 1/16 to 1/4 inch in diameter, suggesting original amygdaloidal material or some fortuitous form of segregation.

The rocks of the most highly metamorphosed, southeastern part of the Duvivier facies are largely amphibolitic and belong to the

Albite-Epidote-Amphibolite facies. They typically consist of 40% or more of prismatic, actinolitic hornblende, about 20% of predominantly anhedral albite, 15 to 20% epidote, and 5 to 10% of flaky chlorite, with accessory amounts of iron oxides, sphene, quartz, leucoxene, pyrite and, locally, calcite. Mattinson (1964) noted that, whereas the volcanics belong to the Albite-Epidote-Amphibolite facies, the associated sedimentaries belong to the Greenschist facies. He interpreted this apparent anomaly as the result of the great differences between the original mineralogical assemblages concerned, which led to an upgrading of constituents in the sedimentaries and a downgrading in the volcanics, with either or both failing to reach equilibrium. Veins in these volcanics are essentially the same as in the volcanics of the Lake Matapédia facies, although hematite is not a vein mineral here and chlorite commonly forms veins consisting of harsh fibres.

Sedimentary rocks.- Many of the sedimentaries of the Duvivier facies are very similar to the varietal arkosic sediments of the Lake Matapédia facies where it passes into the Duvivier facies, but display textural and mineralogical changes consistent with the increased (to Greenschist) metamorphism. Fabrics generally show an increased orientation and parallel alignment of constituents. The fine-grained, medium to dark greenish gray varieties studded with coarse to very coarse sand-sized pink or white relict grains (usually plagioclase, rarely quartz) still occur. Many of the larger grains are augen-shaped.

In the Mount Quest band, the above types are supplemented by quartzose and feldspathic muscovite, or muscovite-sericite schists, some in an incipient stage of development only. Such rocks probably reflect the local increase of original argillaceous material as well as the increasing metamorphism (see Appendix D). In the northwest part of the Mount Quest belt, laminated varieties of sandstone occur locally. Recrystallized quartz-plagioclase layers alternate with micaceous layers in these laminated rocks, suggesting a transition between the arkose and muscovite schist. A thin-section of a micaceous layer from one of these rocks revealed about 20% of green biotite and about 15% of muscovite.

ENVIRONMENT AND CONDITIONS OF DEPOSITION OF THE SHICKSHOCK GROUP (Figure 3)

The following discussion and interpretation is mainly based on the Lake Matapédia occurrence of the Shickshock Group.

1. Provenance

The general angularity of the grains, poor sorting and the mineralogical composition (particularly the high content of feldspar), indicate an essentially primary cycle sandstone, texturally and mineralogically immature. It is also indicated that the source area of the arkoses

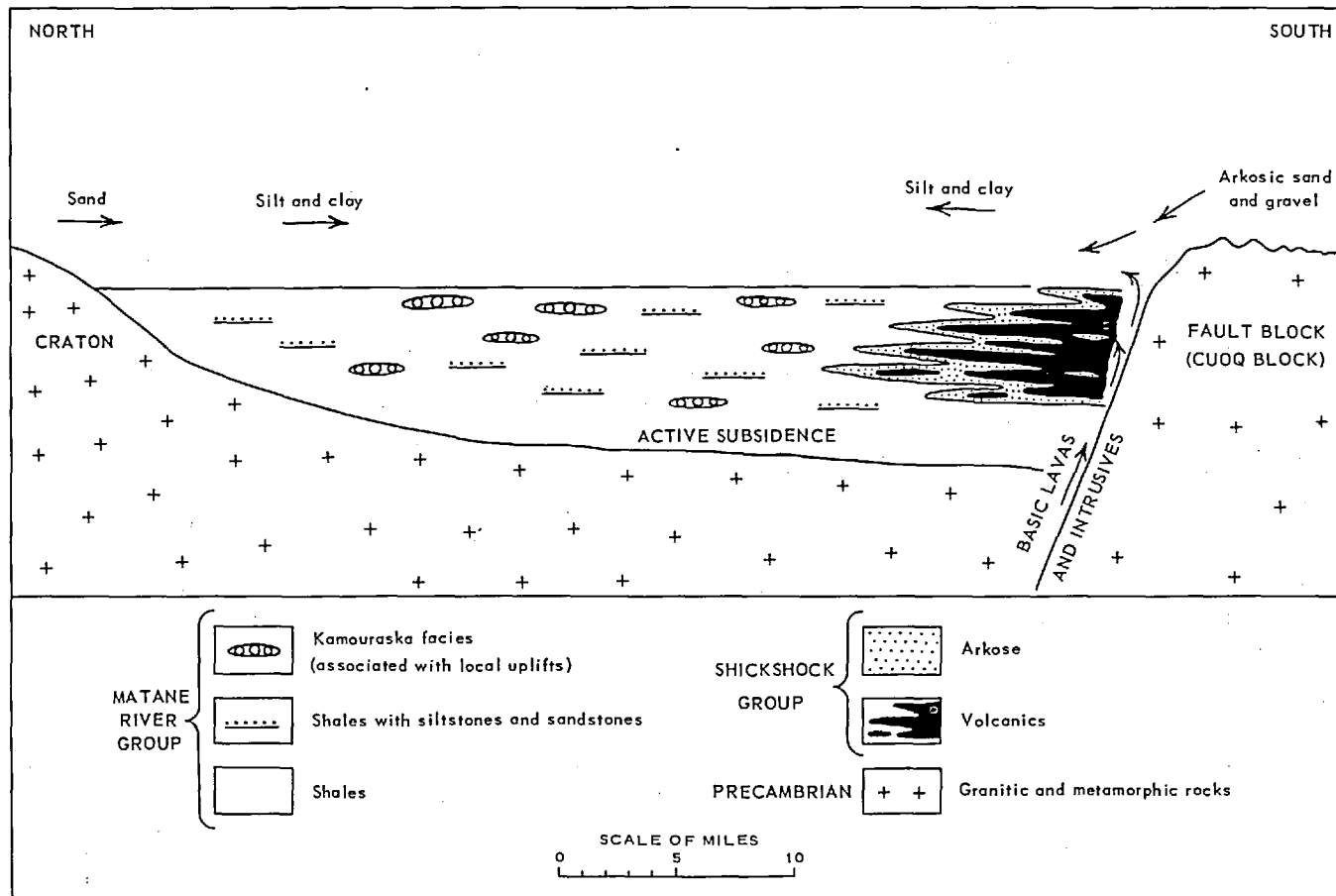


Figure 3

SCHMATIC DIAGRAM OF THE PROBABLE DEPOSITIONAL ENVIRONMENT OF THE SHICKSHOCK GROUP

and other sedimentary rocks of the Shickshock Group lay to the southeast and that deeper waters lay to the northwest.

Evidence in support of this view includes the fact that grain size and the abundance of phenoclasts and conglomerate beds increase towards the southeast. In addition, slate beds in the arkose increase in number towards the northwest and the arkose-volcanic sequence tongues out in that direction. Finally, rare examples of crossbedding and imbricate phenoclasts suggest current flow from the south or southeast.

The limited and peculiar sodic-granitic composition of the rocks from which the Shickshock Group sedimentaries have in large part been derived, from Lake Matapédia to Lake Cascapédia (Mattinson, 1964; McGerrigle, 1954a, p. 20), implies a more localized source area than the Canadian Shield, which must surely have supplied detritus in greater variety. Also, the Canadian Shield is generally acknowledged to have been supplying a preponderance of clay and fine detritus in the Lower Paleozoic. The coarse (up to pebble and cobble size) sedimentary rocks of the Shickshock Group lie at present about 50 miles from the Canadian Shield. Folding and possible thrusting have probably shortened the original distance of separation by several miles at least. Further, the interval between the Shickshock Group and the Canadian Shield is occupied by a predominantly shale sequence, part of which was deposited during the deposition of the Shickshock Group. Finally, consideration of grain angularity and of phenoclast transport and distribution lead to the conclusion that the source area was not far from the site of deposition.

Field relationships indicate that the volcanics were also derived from the southeast. The overall distribution of the volcanics suggests a wedge, thickest in the southeast and splaying out northwestwards into a series of individual, more or less widely separated tongues.

2. The Nature of the Depositional Environment

The Shickshock Group sediments were deposited simultaneously with volcanic eruptions, the lavas probably emanating from submarine fissures along the margin of the sediment source area.

The Group appears to have been deposited under shallow water conditions, possibly involving extensive tidal flats. The outer, northwestern margin shows evidence of deposition within the reach of current and possibly wave action, in the crossbedding and red slate conglomerate (Pl. XVI) composed of water-rounded phenoclasts in imbricate orientation.

Periodic migration of the strand line produced intertonguing of shale and arkose-volcanics along the northwestern margin. Penecontempo-

raneous fragmentation of red slate beds and rare mud-cracks in a red slate bed emphasize the at least temporary shallowness of the environment.

It has been established that the Shickshock Group sandstone is an arkose, deposited under shallow water conditions and its characteristics are not consistent with those theoretically or empirically associated with turbidity current deposition. For example, even the graded bedding locally displayed by the arkose occurs in thin zones within otherwise thick or massive beds of arkose and appears to reflect temporary fluctuations in the carrying strength of the medium of transport. It does not form distinct, differentiated beds, indicative of a separate and individual incursion of sediment of the turbidity current type. Nevertheless, many features of the arkose suggest some correlation with turbidity flow and the graywacke environment of deposition. This correlation probably involves the properties of a high energy level and excessive turbulence.

The unsorted nature and relatively structureless state of the arkose suggest that the original sediment must have been deposited very rapidly, while the apparent volume of deposition implies an extremely high load. These features denote an abnormal medium of deposition, capable of picking up and carrying very high, mixed loads for a short period and mass dumping them in an unsorted condition. In the shallow water environment suggested here, the only likely medium of deposition seems to be tidal waves or storm action. This inference is supported by the known association of local **volcanic activity** and faulting. The violent energy of these waves would facilitate the garnering of vast quantities of beach, littoral, and even land, material.

3. The Nature of the Source Area

A study of the literature on the environment of arkose deposition reveals generalized conclusions that such deposits are largely post-orogenic and occur in two main forms:

- i. Basal or residual blanket deposits.
- ii. Wedge-shaped deposits.

The wedge-shaped deposits are frequently cited as associated with, and adjacent to, strongly positive, block faulted, granitic source areas (Krumbein and Sloss, 1951, p. 364; Dapples, Krumbein and Sloss, 1953, p. 298-299; Heinrich, 1956, p. 123). And, there are indications that the Shickshock Group deposits fit this pattern.

Both volcanics and sedimentaries appear to have been derived from the southeast and there is evidence to suggest that the source area had a faulted margin. The volcanic source must have been between the source

area of the sediments and their depositional site and was probably submarine. The fairly even and extensive lateral distribution of the volcanics, without evidence of concentration into local centers is indicative of fissure eruptions located on the boundary of the sediment source area.

The large South Shickshock fault lies on the southeast side of the Shickshock Group in the probable general vicinity of the original fracture zone. In addition, the temporary, local appearance of a block of sodic granitic rock, necessary to produce the sediments of the Shickshock Group, is most easily and convincingly explained by a faulted block uplift.

The name Cuoq Block is proposed for the hypothetical source of the Shickshock Group sedimentary rocks. The Block is assumed to have covered a minimum length of about 100 miles. Its width probably was not great. It is unlikely to have extended farther southeast than the edge of the site of deposition of the Macquereau Group in southeastern Gaspé, which, by virtue of its similar lithology and probable age, could be the equivalent of the Shickshock Group on the opposite side of the block (Alcock, 1935, p. 11).

The mineralogical immaturity of the Shickshock Group arkose points to the outstripping of chemical weathering by mechanical erosion and deposition. It is probable that, following the suggestions put forward by Krynine (1935) in Mexico, a high relief rather than a dry or arid climate may be responsible for this feature.

Arkosic sediments commonly are derived from a granitic source (Dapples et al., 1953), and the Cuoq Block appears to have been almost entirely of highly sodic, granitic (albitic) composition, according to the ubiquitous and predominant albite in the feldspar. Similar areas of granite containing sodic plagioclase are known from the Canadian Precambrian Shield (Moorhouse, personal communication), such as the Porcupine-Malartic area. The albitic character of the basic lavas within the Shickshock Group suggests that the Cuoq Block and Shickshock Group may form part of a minor sodic province.

The age of the Cuoq Block rocks can only be inferred as Precambrian or Lower Cambrian. The duration of the block as a positive source area lies somewhere within the limits of Lower Cambrian (because the Shickshock Group is not older than the Middle Cambrian) to Lower Silurian (because Upper Llandovery strata were deposited across its site in a striking reversal of areas of deposition and erosion). The presence of Upper Ordovician sedimentary rocks over parts of central and southern Gaspé indicates that the Cuoq Block may have disappeared by the end of the Middle Ordovician. The deformation and incipient cataclastic texture of some phenoclasts from Shickshock Group conglomerates indicate some deformation of the Cuoq Block rocks prior to their erosion.

The depositional area must have formed a relatively narrow, elongate basin or trough between the Cuoq Block on the south and the craton on the north, with the former contributing coarse-grained detritus through vigorous erosion, and the latter supplying essentially finer-grained material.

On the basis of mineralogy, texture, structures and general relationships, the volcanics of the Shickshock Group qualify as spilites according to the definitions outlined by Turner and Verhoogen (1960). The plagioclase is almost invariably albite, commonly clear and well twinned, with no indication of a secondary origin.

Semi-quantitative chemical analyses (prepared by the Ontario Department of Mines) of the volcanics of the Lake Matapédia and Duvivier facies are given in Table 4 and compared with analyses of average basalts and spilites. Each analysis is based on 20 random and widely separated samples.

Table 4. - Percentages of CaO, Na₂O and K₂O in Shickshock Group Volcanics, Compared to Average Spilites and Basalts

Constituent	Shickshock Group Lake Matapédia Facies	Volcanics Duvivier Facies	Average Spilite (Sundius, 1930)	Average Basalt (Daly, 1933)
CaO	4.75	6.28	6.89	8.9
Na ₂ O	3.62	2.16	4.93	3.2
K ₂ O	0.23	0.24	0.75	1.6

While neither sample can be called "soda rich" in an absolute sense, the low potash, low lime and high ratio of soda to potash conform with the attributes of a spilite.

Pre-Silurian Unconformity

The Silurian-Quebec Complex contact was not seen in the Cuoq-Langis area. However, a considerable break in deposition, with at least some erosion, is probable between the two units. Circumstantial but convincing evidence indicates that the erosion followed a period, or periods, of folding and that the contact is an angular unconformity.

Here, and in general in northern Gaspé peninsula, there is no real evidence that the unconformity is Taconic. There is some evidence of Pre-Taconic deformation in the region, and it may be that the pre-Silurian unconformity derives from a combination of pre-Taconic and Taconic movements.

SILURIAN

The Silurian Formations are essentially confined to the vicinity of the major fault zone and consist of discontinuous slices and patches, in which the stratigraphy is masked by structural complexity and sporadic exposure. The stratigraphy is particularly complicated along Matane river by local overturning and the probable existence of subsidiary blocks or slices. As a result, a wide variety of rock types are represented here and formation identification is locally uncertain in the absence of fossils. All known local Silurian Formations are represented in the area and, in addition, there are displaced boulders of a conglomerate, unknown in place but almost certainly of local derivation, for which the informal term "Incognito conglomerate" is here proposed.

The Awantjish Formation

This formation was established by Béland (1960, p. 3) for a succession of shales and siltstones underlying the Val Brillant Formation several miles west of Lake Matapédia. It is the oldest known Silurian Formation in the Lake Matapédia region. Only two minor occurrences of this formation were seen in the present area.

Stratigraphy and Lithology

Limited exposure and uncertain stratigraphic relationships preclude valid estimates of thickness. No contacts of this formation with others are exposed.

The occurrence west of Truite river is most probably part of a fault slice. Here, the rock consists of a medium olive-gray, calcareous, fossiliferous shale with scattered lenses up to 6 inches thick of argillaceous, medium- to coarse-grained, gray, shelly limestone. The outcrop in the Langis-Tamagodi outlier is calcareous, medium to dark olive-gray, very fossiliferous shale, with scattered short, thin lenses of fine-grained, dark olive-gray to gray argillaceous limestone, containing a few fossils. Thin scattered lenses in the shale are so fossiliferous as to be virtually coquinas with argillaceous matrices. Brachiopods predominate and lie both parallel to, and across, the bedding. Detrital biotite flakes are common in the shale.

Paleontology and Age

a. Occurrence West of Truite River

Identification by A.J. Boucot:

Resserella sp.

Lissatrypa? sp.

Atrypa "reticularis"
Mesodouvillina? sp.

Gastropod

Identification by Writer:

Pentamerus cf. P. oblongus

Ptychophyllum? sp.

Dicaelosia bilobus

Zygobolba cf. Z. decora

Plectodonta cf. P. transversalis

Crinoid

Coelospira "hemisphaerica"

Trilobite

Tentaculites sp.

b. Occurrence West of Tamaqodi River

Identification by A.J. Boucot:

Chilidiopsis? sp.

Mesodouvillina? sp.

Drummockina sp.

Atrypa "reticularis"

Strophonella cf. S. euglypha

"Coelospira"? sp.

Resserella sp.

Atrypella? sp.

Identification by M.J. Copeland:

Zygobolba anticostiensis

Identification by Writer:

Coelospira "hemisphaerica"

Trilobite

Dicaelosia bilobus

Conularia sp.

Plectodonta cf. P. transversalis

Coelograptus aff. C. problematica

Monograptus cf. M. undulatus

Bryozoa

In Boucot's opinion, the presence of Resserella and Atrypa "reticularis" in both collections indicates an Upper Llandovery (C₃ or younger) to Lower Ludlow age. The Zygobolba indicate a Lower Clinton or Llandovery age according to the zones defined by Ulrich and Bassler (1923) and corresponding zones embracing the top of the Gun river and base of the Jupiter Formations on Anticosti island. Monograptus cf. M. undulatus supports an Upper Llandovery age.

The Incognito Conglomerate

Scattered conglomerate boulders occur on the southern shore of Lake Matapédia and less commonly on the islands. They form part of the local drift cover, but their restricted concentration around the lake and the fact that their phenoclasts are almost entirely of Shickshock Group volcanic and arkose material, of the type and metamorphic grade found at Lake Matapédia, points to their local derivation. Despite the absence of outcrop, the geological implications of this conglomerate are too

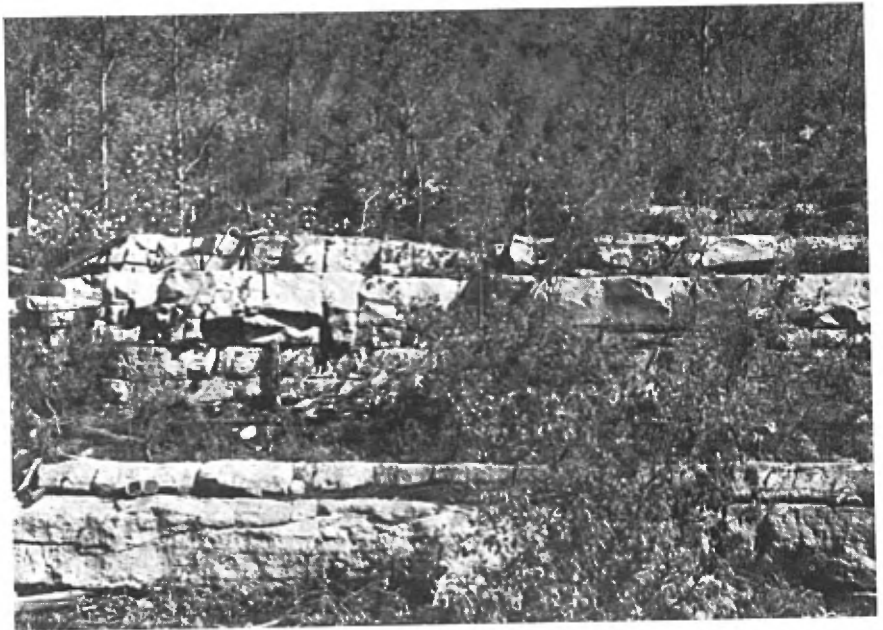


Close-up of Incognito conglomerate. Boulders of Shickshock Group arkose (light) and volcanics (dark), in a calcareous, fossiliferous, sandstone matrix. The small white patches are corals. (The scale is a dime).

Plate XVII

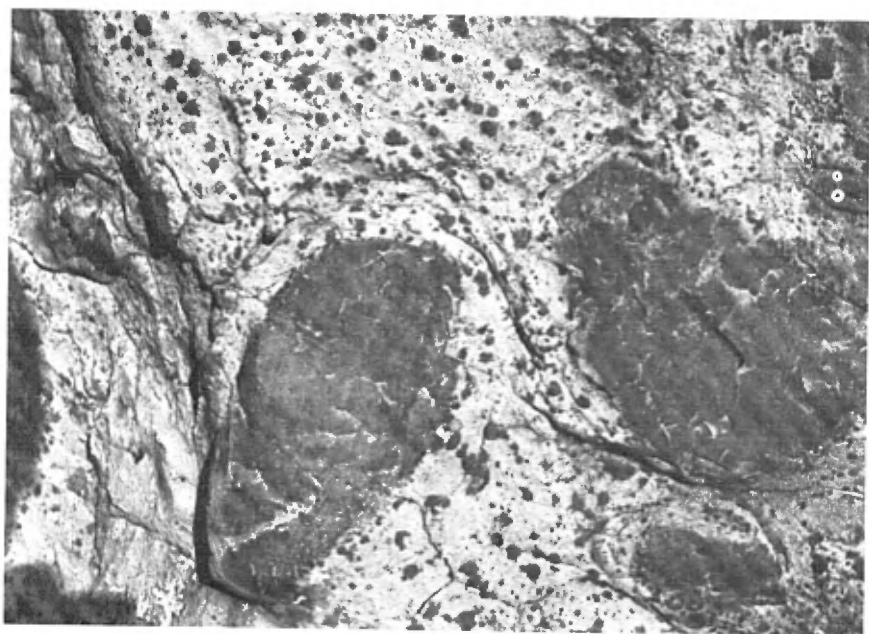


A. Looking east at the cliffs of Val Brilliant sandstone on the northwest margin of the Langis-Tamagodi outlier.



B. Looking south at medium-bedded Val Brilliant sandstones on top of the Langis-Tamagodi outlier.

Plate XVIII



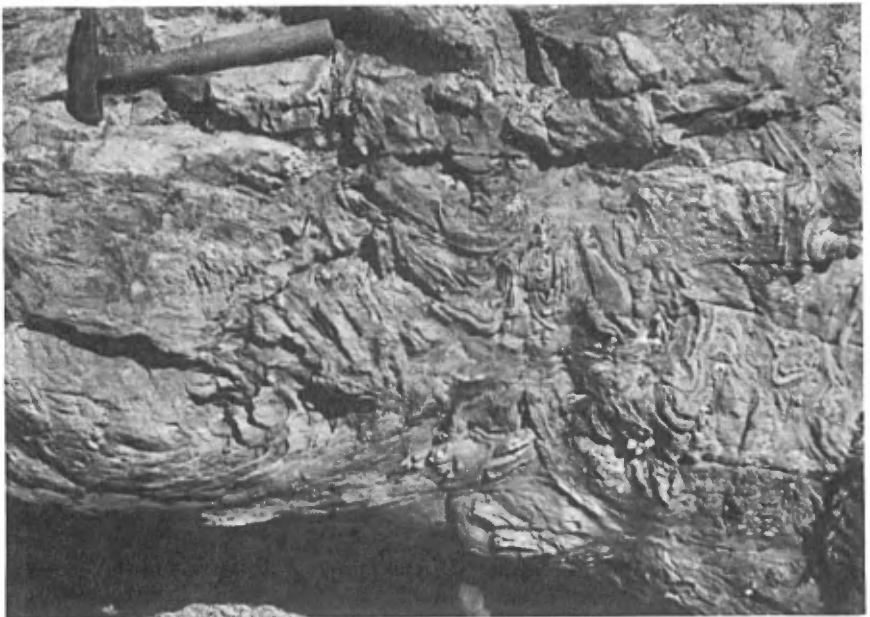
A. Langis-Tamagodi outlier. Fragments of faintly laminated, light red sandstone in a matrix of white, red-spotted sandstone.



B. Langis-Tamagodi outlier. Close-up of piercement-extrusion structure. This is capped by undisturbed beds.



A- Langis-Tamagodi outlier. A piercement-extrusion structure, showing slightly darker (reddish) sandstone filling an extrusion channel to form a short dike, in a lighter colored bed of Val Brillant sandstone.



B. Twisted and contorted convolute bedding, indicating penecontemporaneous slumping and "soft" deformation of a thick sandstone bed, overlain by undisturbed sandstone. Langis-Tamagodi outlier.

important for it to be ignored. Fossils (listed below) show the matrix to be Middle Silurian (Upper Llandovery to Wenlock). Thus, the conglomerate appears to have been deposited at some time during the Awantjish - Val Brilliant interval, either as a lateral facies of one or other of these formations or as a local basal conglomerate to the Silurian succession. It is provisionally assigned to the Awantjish Formation.

The main occurrence of the conglomerate consists of two very large boulders (approximately 16 feet by 19 feet by 7 feet, and 14 feet by 12 feet by 4.5 feet respectively) within a few feet of each other on the south shore of Lake Matapédia, about 1 1/2 miles east of Val Brilliant (Pl. XVI).

The phenoclasts are essentially of cobble to boulder size with some pebbles. Arkose blocks are up to 4 feet 2 inches by 1 foot 9 inches by 2 feet and 3 feet 6 inches by 2 feet 6 inches by 2 feet 9 inches. The largest volcanic blocks are slightly smaller. Some smaller conglomerate boulders consist entirely of pebble-sized phenoclasts. The phenoclasts are mainly rounded to subrounded, although some are well rounded and others, subangular. Some of the largest blocks are quite angular and a few still possess original joint surfaces. Sorting is poor. The phenoclasts are commonly separated by the matrix. A few of the smaller phenoclasts consist of quartz. Rare phenoclasts of a green cherty material and fine-grained, light-medium gray quartzite were also observed. There is little evidence of bedding other than a slight parallelism of many phenoclasts. This parallelism and the size of the boulders suggest that locally the conglomerate was up to at least 10 feet thick.

The matrix (25-30% of the rock) consists of a poorly sorted, very calcareous, coarse-grained sandstone (including particles of quartz, arkose and volcanics) and contains abundant, fragmentary, organic debris. Fossils include corals, stromatoporoids, brachiopods and bryozoa. Preferential weathering of the matrix gives the conglomerate surface a rough etched appearance.

Fossils

Identification by Writer:

Pentamerus sp.

Dicaelosia sp.

Leptaena? sp.

Bryozoa

Crinoids

Heliolites interstinctus

Favosites cf. F. niagarensis

Alveolites? sp.

Clathrodictyon aff. C. cystosum

Identification by A.J. Boucot:

<u>Atrypa "reticularis"</u>	<u>Pentamerus</u> sp.
<u>Cyrtia?</u> sp.	Dalmanellid
<u>Dicaelosia</u> sp.	Gypidulinid
<u>Dolerorthis</u> aff. <u>D. rustica</u>	
Smooth pentameroid with long septum	

The Val Brilliant Formation

The Val Brilliant Formation was established by Crickmay (1932, p. 374) who designated a section on the southern shore of Lake Matapédia (from Val-Brillant village northwest for 1 1/4 miles) as the type.

The outliers of this formation, here named Tortue Hill and Langis-Tamagodi, east and west respectively of Tamagodi river, expose better sections than the type. The formation also outcrops in the faulted center of an anticline a mile northeast of Saint-Tharsicius. A small, presumably faulted slice of Val Brilliant lithology occurs in the southwest corner of the area, associated with the Saint-Léon Formation.

Stratigraphy and Lithology

Previous workers in the area proper have confused Kamouraska and Val Brilliant strata in two or three instances. The thickness of the Val Brilliant is estimated to be 300 to 500 feet. The cliff section along the northeastern margin of the Tortue Hill outlier exposes about 135 feet of sandstone. West of Tamagodi river (Pl. XVII-A), cliffs expose nearly 100 feet of sandstone and a few hundred additional feet outcrop sporadically across the ridge behind.

The Langis-Tamagodi Outlier.- This northeast-southwest trending outlier is tongue-shaped and is unequally divided by the valley of Petite Langis river. In this outlier, several hundred feet of sandstone of typical Val Brilliant composition are overlain locally by an eroded remnant of light-medium brown dolomitic sandstone grading to sandy dolomite. The dolomitic zone is up to about 20 feet thick and is patchily distributed along the southeast margin of the outlier. It may represent a part of the dolomitic transition between the Val Brilliant and Sayabec Formations, remarked west of Lake Matapédia by Lajoie (1961, p. 55-58). This would imply that the Val Brilliant here, underlain as it is by the Awantjish, may be nearly completely exposed.

The typical sandstone is composed almost entirely of quartz, more or less quartz-cemented. Local layers or patches are slightly calcareous, and minor, dispersed traces of hematite are common. A local increase in porosity accompanied by decrease in cementation suggests a greater

original distribution of calcite. Rare surfaces are coated with a white, powdery calcareous residue. A chemical analysis of this sandstone is given in Table 5.

Table 5. - Chemical Analysis of Val Brilliant Sandstone
from the Langis-Tamagodi Outlier

<u>Constituent</u>	<u>Percentage</u>
Silica (SiO ₂)	97.58
Iron sesquioxide (Fe ₂ O ₃)	1.72
Alumina (Al ₂ O ₃)	0.16
Magnesium carbonate (MgCO ₃)	0.08
Calcium carbonate (CaCO ₃)	0.05
Sulfur (S)	0.01
Total	99.60

The sandstone is mainly fine to medium grained, changing locally to medium or coarse grained. Scattered granules and small pebbles occur in a few layers. Minor layers of conglomeratic sandstone occur not far below the dolomitic beds. The coarser-grained sandstones locally have a sugary appearance. The sandstones are moderately to well sorted but scattered coarser grains are common. The degree of sorting diminishes abruptly in many of the coarse-grained layers. These layers are intercalated with well-sorted, finer-grained sandstone. Grains are typically rounded to well rounded. The sandstones belong essentially to Pettijohn's (1957) orthoquartzite category.

The sandstone weathers whitish, commonly with reddish spotted, streaked or stained areas and less commonly with light yellowish brown discoloration. Where fresh it is essentially whitish, but ranges to light gray or brownish gray.

The red coloration varies in intensity from pale pinks to brick reds. It displays variable distribution, concentration, and form, as follows:

- a) A whole bed may be red, or just part of it.
- b) Laminae, particularly within crossbedding, are commonly red.
- c) Red spots and blotches are common, and formless red patches occur locally.
- d) Many of the red spots are spherical. They are commonly 1/4 to 1/2 inch, less commonly one inch, in diameter.
- e) Dendritic red patterns occur on some bedding surfaces.

- f) Locally, only the bedding surfaces are stained, either superficially, or to an inch or so above and below the surface.
- g) Many surface groovings (fossil trails?) are preferentially red.
- h) Scattered carbonate veins are red.
- i) Organic remains are commonly preferentially stained red and many possess small peripheral red "haloes". This is possibly correlated with the localized migration of calcite from the fossil.
- j) Reddish beds and laminae are commonly involved in penecontemporaneous deformation.
- k) Scattered sand-sized clastic grains of hematite occur and locally act as nuclei to the red spots. Thin-sections reveal that a fractional content of hematite within the cement provides the pigment.

The evidence suggests a detrital source for the hematite pigment and its early redistribution after deposition prior to complete consolidation. Plate XIX-A shows red fragments in a differently colored matrix, suggesting that the fragments were already stained when incorporated in the matrix. Also, the fragments appear to have been incorporated in a semi-plastic state, suggesting that coloration of the source beds must have preceded complete solidification and the penecontemporaneous creation of the mixture. The existence of undeformed red spots in the matrix proves that staining also developed after the deformation.

Beds generally range from 6 inches to 3 or 4 feet thick but may be less than 6 inches and as much as 12 feet. They are commonly marked by separations rather than by differences. Plate XVIII-B depicts an atypical sequence in which the beds are of fairly regular medium thickness. Subsidiary layering commonly occurs within the thicker beds and locally includes both rhythmic lamination (commonly one grain thick) and broader repetitions of laminated and unlaminated zones. Crossbedding is common. It is usually differentiated by coarser laminae or by reddish or pinkish hematitic staining of surfaces or layers.

The most striking feature of the Langis-Tamagodi outlier is the abundant evidence of penecontemporaneous deformation. This deformation appears to be peculiar to the Val Brillant of the Cuoq-Langis area and possibly to this one outlier. Lajoie (1961), in his study of the Val Brillant west of Lake Matapédia, made no mention of similar deformation nor is it recorded by any earlier workers. Sedimentary structures (Plates XVIII and XIX) include load casts, convolute bedding, truncated beds, slurried beds, intraformational conglomerate, piercement-extrusion structures, and sandstone veins.

These pre-consolidation structures are commonly confined to lenticular zones with undisturbed beds above, below and laterally. Deformed zones range from a single bed a few feet thick to intervals 20 to 30 feet thick. They occur throughout the lower half of the Val Brillant Formation at least. As the Formation is composed essentially of a fairly uniform sandstone the deformation structures do not always show up clearly. They are variously delimited by separation surfaces, lamination, differential weathering and the differential red coloration.

Scattered intraformational phenoclasts and, locally, conglomerates are associated with slurried beds. The phenoclasts differ little from the matrix. Their shape and rounded margins suggest incorporation in a semi-plastic state and they may be readily discerned only where differential weathering or color contrast delimits them.

In piercement-extrusion structures a sandstone bed is fissured and has all the appearance of pressure intrusion by the underlying sandstone. The margins of the fissure are turned upwards and outwards as though peeled back by the outrushing slurry from below. The underlying sandstone bed wedges up into the fissure and forms a sandstone dike less than one foot wide. This dike or fissure filling extends through the overlying fractured bed only, passing above into a slurried sandstone with sandstone phenoclasts. The lack of vertical continuity of the dikes, and the absence of evidence of dilation above the fracture channels, implies that the phenomenon essentially involved extrusion on the sea-floor. At least one fissured bed is abruptly truncated, some 25 feet laterally, so that slurried and fragmentary material above and below it merges as one unit.

The evidence suggests the fracture of a relatively coherent surface bed of sand and the accompanying disturbance of underlying water-saturated sand. The weight of the overlying bed probably provided adequate hydrostatic pressure to force the extrusion of the remobilized, hydroplastic material through the fissures to form local slurries on the surface, subsequently buried by normal sediments.

Sandstone dikes were observed only in the southwestern part of the outlier, in range V of Langis township, where they are quite common. They superficially resemble veins. Most are 1/4 to 1/2 inch thick; a few are 1 inch to 2 inches. They are of essentially the same lithology as the surrounding quartz sandstone, but can be distinguished by a difference in grain size or by relative hardness. For example, some are more friable and others more siliceous than the surrounding sandstone. They range from fine to coarse grained.

Penecontemporaneous deformation of the type outlined above is commonly associated with gravity assisted slump movements on submarine

slopes (Pettijohn, 1957, p. 189) particularly in the unstable foredeep regions of geosynclines (Fairbridge, 1946). The present case would appear to be an exception. The environment is almost certainly shallow water, while the evidence indicates periodic, localized instability with only subordinate slumping or evidence of downslope movement. Flowage appears to be random rather than directional. Such instability and the type of structures involved are consistent with an earthquake origin, probably related to contemporaneous local fault adjustments. The fault in question may have been local and minor in nature, or may have been the major South Shickshock lineament, with movements relating to the settling of the Cuoq Block.

Joints with a variety of attitudes are common in the Val Brilliant Formation and slickensides are conspicuous on innumerable joint surfaces. Although the orientation of the striation is variable, a general trend in which the striae plunge at 45° towards N.10°E. is apparent. Prominent steps at right angles to the striae indicate some reverse or thrust movement towards S.10°W., following the interpretation suggested by Billings (1954, p. 149).

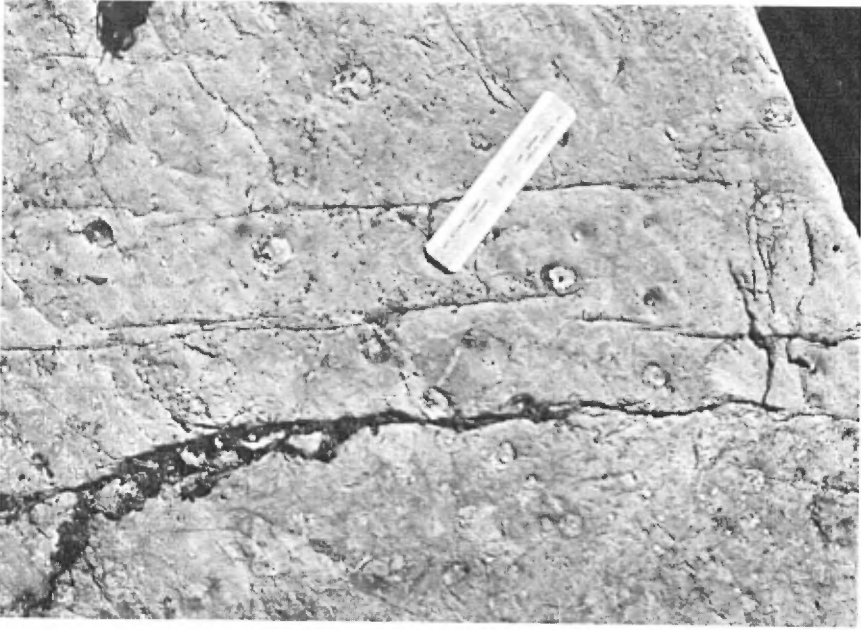
Bedding surfaces in the Val Brilliant Formation commonly display a variety of markings (Pls. XX and XXI) including the following: bubble pits (?), small lumps and curved grooves of uncertain origin, and scattered fossil trails, casts and impressions.

The Tortue Hill Outlier.- This outlier is in the northwest part of ranges I and II of Cuoq township. The foregoing description essentially fits the Val Brilliant sandstones of this outlier as well, and only the main differences will be noted here. Evidence of penecontemporaneous deformation was not observed in the limited exposures at Tortue Hill, nor was the dolomitic upper unit seen.

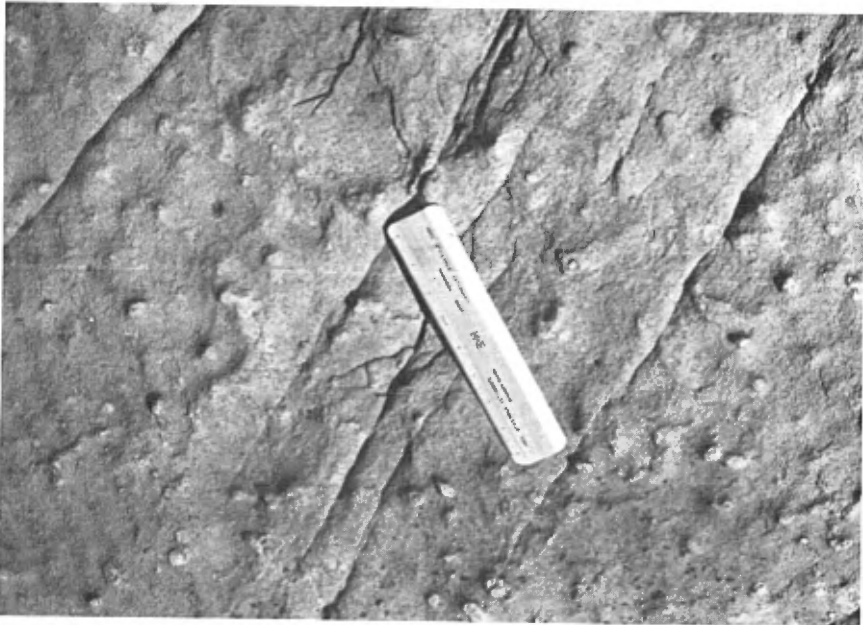
Thin zones containing scattered, sub-spherical bodies, 1/2 inch to several inches across, break the continuity of some beds. These bodies consist of light brown, friable sandstone, otherwise identical with the surrounding sandstone. They appear to be the result of differential cementation, with a calcite instead of the usual quartz cement. Some of the bodies center on a fossil fragment, possibly the source of the calcite. Calcite leaching renders the mass friable. Other subspherical to spherical bodies, several inches to one foot or so in diameter occur locally in the sandstone. Examples tested appear to be hard and quartz-cemented.

The Saint-Tharsicius Anticline. - Relatively limited exposures of hard, quartzitic sandstone, supposedly owing their increased induration to movements along the adjacent South Shickshock fault, occur on either side of Tamagodi river in range IV of Blais township. Superficially, the sandstone is more closely akin to the Kamouraska quartzite than to the normal Val

Plate XX



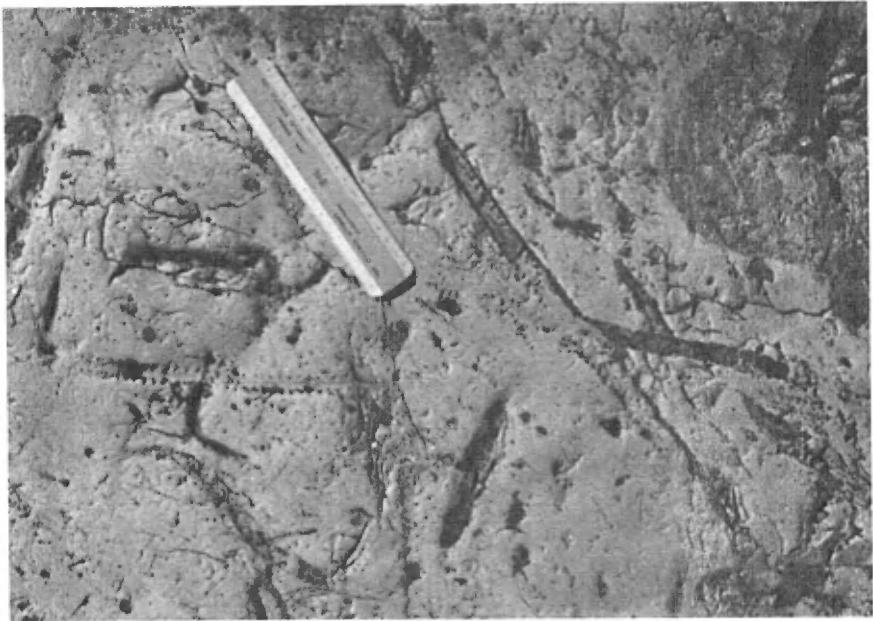
A. Possible bubble-pits on a bedding surface of Val Brillant sandstone from the Langis-Tamagodi outlier. (The scale = 6 inches)



B. A bedding surface of the Val Brillant sandstone from the Langis-Tamagodi outlier, showing small lumps of uncertain origin. (The scale = 6 inches)



A. Curving grooves, typical of many bedding surfaces in the Val Brillant sandstone, and probably the fossilized trails of some small animal, Langis-Tamagodi outlier. (The scale = 6 inches.)



B. "Tractor-tread" markings on a bedding surface from the Val Brillant Formation of the Langis-Tamagodi outlier. These marks are possibly mollusc trails. (The scale = 6 inches.)

Brilliant sandstone, but definite, if faint, lamination, crossbedding and bedding traces, and the presence of the Sayabec and Saint-Léon Formation in normal sequence points strongly to the Val Brilliant Formation.

The rock is essentially a quartz-cemented, quartz sandstone; it is fine grained, but has scattered medium grains in parts. It is light to light-medium gray or slightly brownish gray, faintly bluish in places, and weathers white on exposed surfaces and rusty brown on joints. Bedding is generally very thick to massive with local separations a foot to several feet apart. Sparkling veneers of finely crystalline quartz characterize many surfaces.

Paleontology and Age

Fossils are generally too poorly preserved in the Val Brilliant to permit their identification. The best collections were obtained from Tortue Hill; a little poor material was had from the outcrop at the Tamagodi/Matane junction.

Tamagodi/Matane

Identification by Writer:

Gastropod	
? <u>Pleurotamaria</u> sp.	
<u>Trochonema</u> sp.	Pelecypod
? <u>Cyclora</u> sp.	?Trilobite
<u>Bellerophon</u> sp.	

Tortue Hill

Identification by Writer:

<u>Dinobolus</u> sp.	Pelecypods
<u>Lissocoelina</u> sp.	?Sponge
<u>Poleumita</u> cf. <u>P. scamnata</u>	Zaphrentid corals
? <u>Homeospira</u>	<u>Stromatopora</u> cf. <u>S</u>
Crinoid	<u>constellata</u>

Identification by A.J. Boucot:

<u>Dinobolus</u> sp.	<u>Oriostoma</u> sp.
<u>Stricklandia triplesiana</u>	<u>Porpites porpita</u>
<u>Stricklandia</u> cf. <u>S. gaspiensis</u>	<u>Atrypa "reticularis"</u>
" <u>Dolerorthis</u> " <u>flabellites</u>	Sphaerirhynchid
<u>Pentameroides</u> sp.	Dalmanellid
<u>Clorinda</u> sp.	Ostracod

These assemblages have a decidedly Wenlock or Niagaran aspect, which Boucot interprets as of Upper Llandoveryan (late C₆) to Wenlock age, on the basis of an abundantly plicate Stricklandia of the gaspensis type, plus Pentameroides and Porpites. The local presence of Stricklandia triplesiana indicates a more restricted, probable Upper Llandoveryan (Upper C₆) age for part of the Val Brillant. This is the first suggestion that the Val Brillant may extend, at least locally, below the base of the Wenlock.

The Sayabec Formation

In the Cuoq-Langis area the Sayabec Formation outcrops only on Tamagodi river, just downstream from Chantepleure brook. Partial cover and deformation associated with the South Shickshock fault preclude a definite measurement, but it is estimated to be at least 500 feet thick. The upper and lower contacts of the formation are not exposed and the sporadic outcrops reveal only that there are two distinct lithological units of unknown relative proportions.

The uppermost unit includes siltstone and limestone in thin interbeds that pinch and swell slightly. The siltstone is calcareous, light-medium gray, pale yellowish brown weathering. The limestone is hard, fine to very fine grained, medium gray, light blue-gray (with patches of pale yellowish-brown) weathering. Scattered favositid corals and brachiopods occur. Some medium gray, pale yellowish brown weathering, unbedded but laminated, very calcareous siltstone outcrops nearby. This whole "upper unit" appears to represent a transition to the overlying Saint-Léon Formation.

The "lower unit" consists of a fine-grained, medium gray (fresh and weathered color), impure, fossiliferous limestone. The beds are predominantly thin, irregular and wavy and are arranged in broader, medium to thick zones. Discrete, subsidiary, lenticular laminae of pale yellowish brown weathering siltstone to very fine-grained sandstone, and layers and partings of dark gray shale are locally common within the limestone. Fragments of fossils and scattered, coarse- to very coarse-grained calcite specks stand out against the finer-grained background. The limestone gives off a petroliferous odor from freshly broken surfaces.

Paleontology and Age

Algal biscuits are locally conspicuous in the type Sayabec, but no algal structures were observed in the Tamagodi outcrops.

Identification by Writer:

<u>Conchidium</u> sp.	
<u>Leptaena "rhomboidalis"</u>	<u>Stromatopora</u> sp.
<u>Plectodonta?</u> sp.	Crinoid
<u>Favosites</u> sp.	Gastropod
<u>Syringopora</u> sp.	

Identification by A.J. Boucot:

<u>Conchidium</u> sp. (fine-ribbed)	<u>Eospirifer</u> cf. <u>E. radiatus</u>
<u>Leptaena "rhomboidalis"</u>	<u>Howellella</u> sp.
<u>Plectodonta?</u> sp.	Sphaerirhynchid
<u>Amphistrophia</u> cf. <u>A. funiculata</u>	<u>Euomphalus</u> sp.

Identification by W.A. Oliver*:

Hedstroemophyllum sp.

In view of the probable Upper Llandovery to Lower Ludlow time range of Hedstroemophyllum, the Wenlock age of the underlying Val Brilliant Formation, the Ludlow age of the overlying Saint-Léon Formation and Boucot's personal opinion that the presence of Conchidium is evidence of a Ludlow age, the Sayabec Formation probably extends from the Wenlock into the Lower Ludlow.

The Saint-Léon Formation

The Saint-Léon Formation was proposed by Crickmay (1932, p. 375-376) who cited exposures "in the Amqui River valley north of the village of Saint-Léon" as typical. Burk (1959, p. 25) criticized Crickmay's type locality on the grounds that it is of poor quality and not representative of the greater part of the formation. The present writer concurs with Burk and suggests that one of the best local sections of the Saint-Léon is exposed along Cajettan brook, in range VII of Blais township.

The main belt of the Saint-Léon Formation extends from the center of the Saint-Tharsicius anticline northeastwards, narrowing in that direction from a maximum of about 2 miles near Cajettan brook, to half a mile at Truite river, as it follows the faulted south flank of the Shick-shock mountains. As a result of the structural complexity along the Matane, slices of formations other than the Saint-Léon may be represented locally. In the vicinity of Lake Matapédia problematical rocks of uncertain affinity occur in probable fault slices and have been provisionally included in the Saint-Léon.

*United States Geological Survey.



A. A typical exposure of the Saint-Léon Formation, on Cajetan brook, showing the alternation of resistant and weathered, fissile beds.

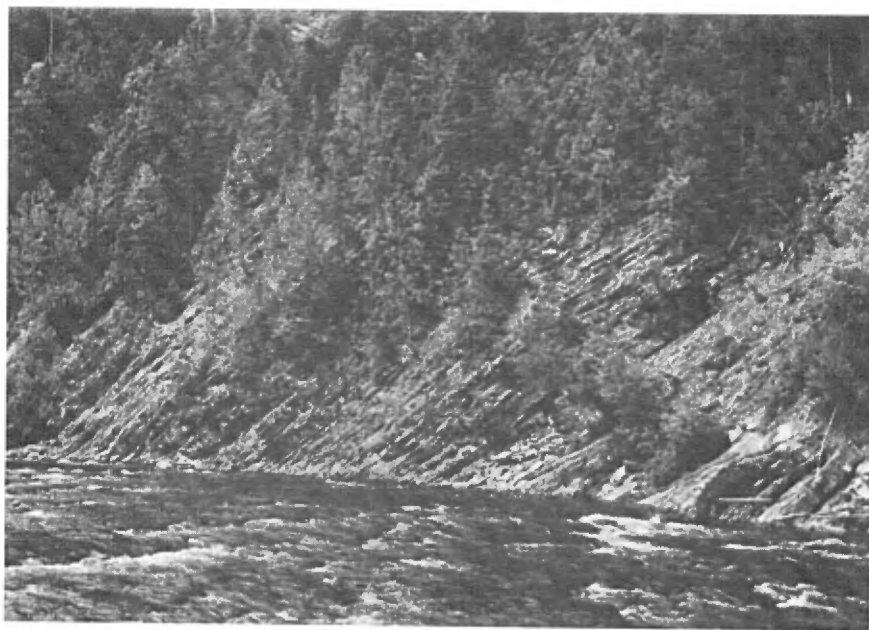


B. A loose slab of Saint-Léon siltstone by Chantepleure brook, showing possible load or flow casts.

Plate XXIII

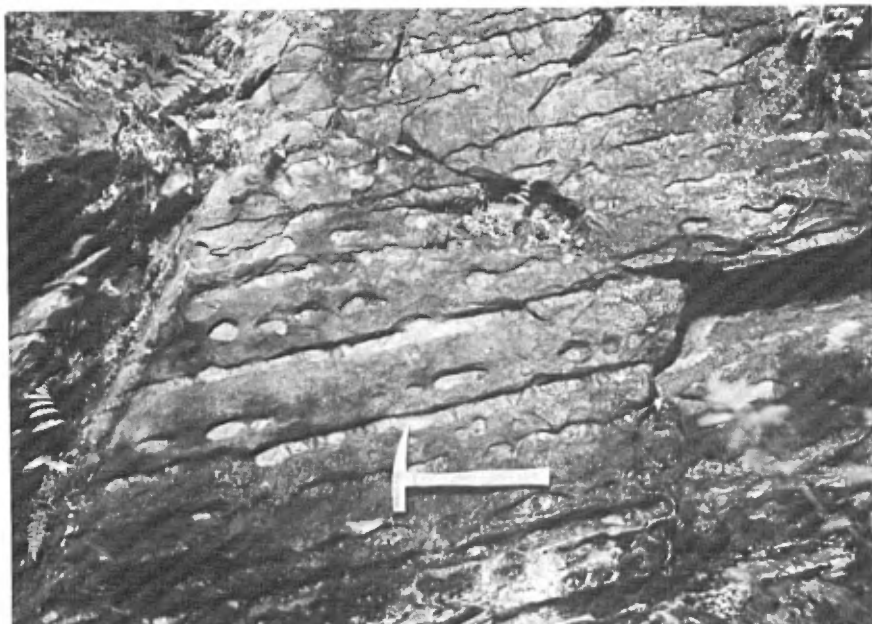


A. Bedding in coarse- to very coarse-grained, possibly deltaic sandstones from the lower part of the Saint-Léon Formation on Chantepleure brook. Note the graded bedding in the upper bed. (The scale is a 25¢ piece.)

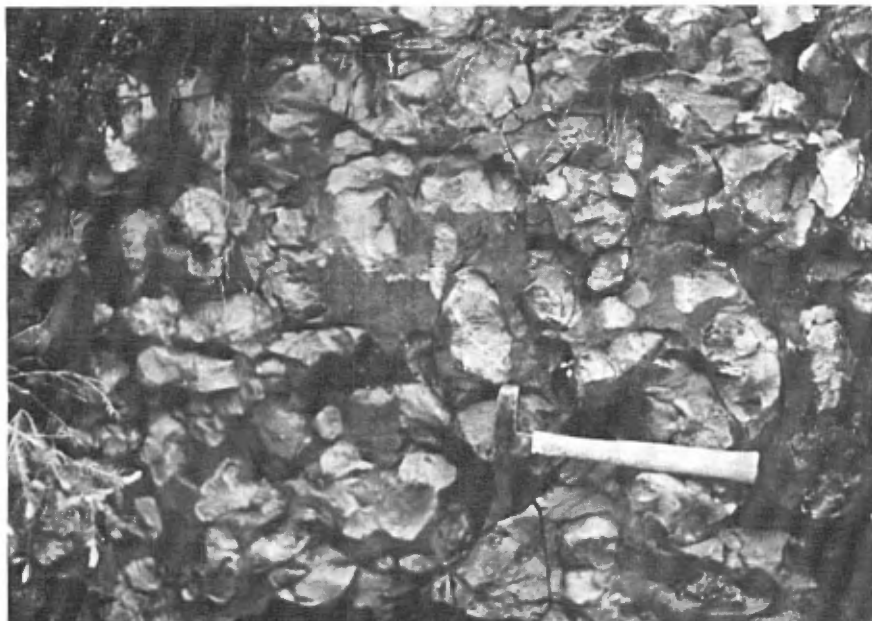


B. Thin-bedded siltstones and sandstones from the upper part of the Saint-Léon Formation, outcropping on Truite river about 2,000 feet upstream from the Matane.

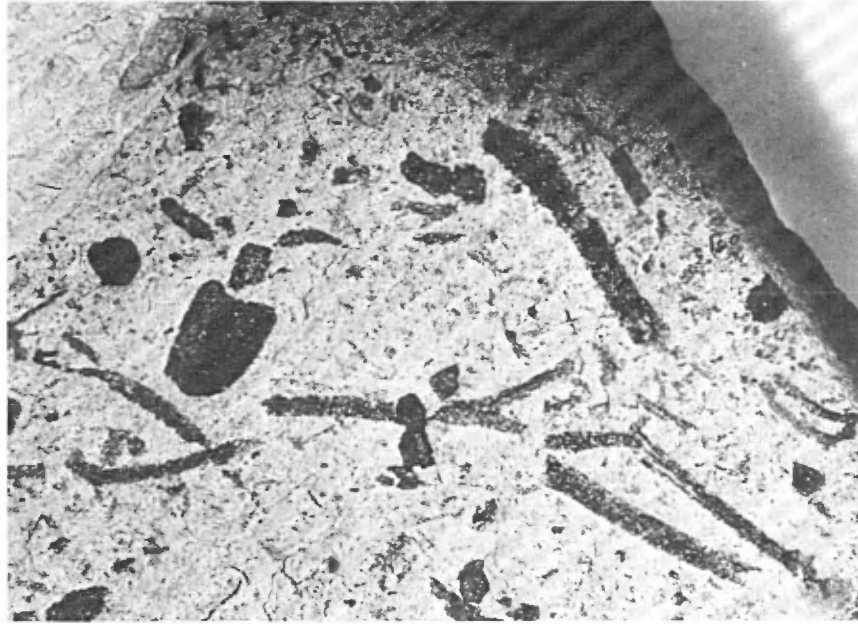
Plate XXIV



A. An incipient stage in the formation of pseudoconglomerate in the Saint-Léon Formation.



B. A more advanced stage in the development illustrated in Plate XXIV-A above; side view of a bed.



Macerated, carbonaceous plant fragments from the problematical Saint-Léon Formation (?) strata, outcropping alongside the main road, several thousand feet northwest of Saint-Tharsicius church. (Approximately natural size).

Stratigraphy and Lithology

The basal contact of the Saint-Léon Formation is nowhere exposed, although the situation on Tamagodi river suggests a conformable transition from the Sayabec Formation. The Saint-Léon is estimated to be more than 5,000 feet thick in the section along the Tamagodi, and in the incomplete Cajettan Brook section. It is not known to what extent these sections are modified by faulting.

Owing to breaks in the continuity of exposure, structural segregation, and some lithologic variation, the formation is discussed under four parts:

1. The Tamagodi-Chantepleure-Cajettan area.
2. The Matane River area.
3. The Saint-Tharsicius anticline area.
4. The Problematical Saint-Léon (?) of the Southwest.

1. Tamagodi-Chantepleure-Cajettan Area.- The best and most complete exposures of the Saint-Léon in the area occur along these three streams. The rocks are predominantly siltstones and sandstones, with some shales and minor limestones. They are commonly thin-bedded with scattered to locally predominant medium or very thin beds and a few thick beds. Within these limits, individual sections range from uniformly to more or less variably bedded. In addition, zones, up to 20 feet thick, based on variations in the distribution and concentration of particular bed sizes and relative lithologic proportions, are common. Bedding is typically marked by alternations of relatively resistant and recessive weathering layers (Pl. XXII-A). The alternations tend to be rhythmic. Many beds are not conspicuously differentiated, but are demarcated by simple separation, commonly flaggy and fissile.

The bulk of the siltstones and very fine- to fine-grained sandstones appear to differ only in grain size. They are quartzose and typically slightly (locally very) calcareous. Muscovite flakes are common on bedding surfaces. Fresh colors are light to medium greenish gray or gray, commonly showing little change on weathering, but locally changing to light shades of brownish gray to yellowish brown. These rocks are quite commonly laminated. Several zones, ranging from a few inches to 10 feet thick, of medium reddish gray, thinly separated to fissile siltstone, outcrop along Chantepleure brook. Sedimentary structures here include fairly common small-scale crossbedding, less common load casts or flow casts (Pl. XXII-B), and local internal foliation or convolute bedding.

The recessive-weathering beds interbedded with the relatively solid siltstones and sandstones, range from flaggy to fissile siltstone or

sandstone to shale. The shales are commonly silty, locally calcareous, with conspicuous muscovite on some surfaces, and are medium to dark gray or greenish gray.

Limestones are minor in the succession. They occur either as scattered individual beds, or in thin-bedded zones, from several to 20 feet or more thick. The individual beds typically are very fine-grained to dense, and light-medium gray to olive-gray. The thin-bedded zones commonly have intercalated shale layers or partings and typically consist of fine-grained to dense, light-medium to medium gray, light gray to light yellowish brown weathering limestone. Bedding surfaces are in some cases undulatory and may be marked by anastomosing shale partings. Small-scale crossbedding in one outcrop denotes the clastic origin of at least some of the limestone. Several such limestone zones occur on Cajettan brook and there is one on Chantepleure brook. A small outcrop on the small tributary of the Tamagodi between Cajettan and Chantepleure brooks yielded the only fossils from this lithology.

Also, on Cajettan brook, a bed of pebble-sized limestone conglomerate and two beds of calcarenite occur in the upstream half of the exposed Saint-Léon section. The conglomerate bed is one foot thick and consists essentially of fossil fragments, mainly 1/8 to 1/2 inch but up to 2 inches or more in maximum dimension, including crinoids, corals, brachiopods and bryozoa, in a calcareous siltstone matrix. The rock is very hard, light-medium gray, light brown-weathering, showing some coarse recrystallization and whitish calcite flecks and patches. The calcarenite beds are similar in size and composition, but finer-grained (very coarse sand size) with less organic debris.

A conspicuously different (deltaic ?) zone of sandstone (Pl. XXIII-A), probably localized and lenticular, occurs toward the base of the Saint-Léon section on Chantepleure brook, where it is approximately 400 feet thick. This sandstone is less readily discernible on the Tamagodi. The zone outcrops as a succession of sandstone ribs, each up to several feet thick, separated by concealed, weathered intervals of similar thickness. Variations in grain size, from very coarse to medium or fine, mark a medium to thin bedding in the sandstone ribs, supplemented by a general thin to very thin separation parallel to the bedding. The sandstone varies from slightly calcareous to calcareous, comprising a generally poorly sorted mixture of quartz and rock fragments with minor feldspar. The rock fragments suggest a derivation from the Quebec Complex and include basic volcanic grains. The rock is a light-medium greenish gray, weathering to a light (often slightly brownish) gray. Graded bedding characterizes a number of beds, and there is some local crossbedding.

2. The Matane River Area.- The strata occupying the narrow belt between the South Shickshock fault and the Cape Bon Ami Formation along Matane river are extremely variable lithologically. Stratigraphy is complicated by deformation and probable slicing along the fault zone, with local overturning. An outcrop of Awantjish Formation, and a small, doubtful outcrop of Val Brilliant Formation occur within the supposed Saint-Léon. In addition to strata similar to those of the first area, limestone conglomerate, pseudo-conglomerate, and rather different limestones, sandstones and shales occur locally.

Here, the best exposed and least disturbed section is on Truite river, commencing about 1,500 feet upstream from the Matane. About 560 feet of strata just below the Saint-Léon - Cape Bon Ami contact are exposed, although outcrop is sparse at the actual contact. The rocks involved are essentially thin-bedded (Pl. XXIII-B) with some very thin and rare, medium beds. They consist mainly of more or less calcareous, greenish gray siltstones and very fine- to fine-grained sandstones, with minor shale and fine- to medium-grained sandstone. The section is notable for the gradual introduction of silty, medium gray, fine-grained limestone beds of Cape Bon Ami type, and beds of siltstone and shale in which the change to Cape Bon Ami lithology is incipient. The evidence indicates a conformable and transitional relationship between the two formations.

Structures that characterize the beds include: lamination, common small-scale crossbedding, current ripple-marks (whose asymmetry indicates current flow towards the east), slump structures, convolute bedding, worm tracks, and two beds of pseudoconglomerate.

Approximately 160 feet of crumbly, cleaved, greenish-gray, silty mudstone mark the uppermost lithological unit of Saint-Léon affinity. Above this the Cape Bon Ami limestone is continuous. The contact was placed above the mudstone unit. Fossils are not conspicuous in this section, and only a few vague carbonized plant (?) laths and broken shell fragments were observed. Calcite veins, generally 1/8 to 1/2 inch wide are fairly common. The limestone beds give off a petroliferous odor when freshly broken.

Two miles east of Tortue Hill, in range III of Cuoq township, unusual rocks are exposed along a small stream flowing north into the Matane across a probable synclinal structure. Sheared, fractured limestone of Cape Bon Ami affinity, locally siliceous and with a strong petroliferous odor and rare oil globules, outcrops downstream. Farther upstream limestone and calcareous, argillaceous siltstone that strongly resemble the Saint-Léon are exposed. They outcrop in a zone which, unless it is exaggerated by faulting, must be several hundred feet thick. Locally, the limestone and

siltstone are thinly interbedded. The limestone beds are generally 1 1/2 to 2 inches and the siltstone beds, 2 to 6 inches thick. Bedding surfaces are undulatory and the limestone beds pinch and swell or form disconnected lenses laterally (Pl. XXIV). Elsewhere, bedding is not apparent and the limestone occurs as knobby nodules distributed apparently at random throughout the siltstone. These deposits form massive pseudoconglomerate beds up to at least 10 feet thick. The nodular masses in the pseudoconglomerate are mainly 2 to 5 inches in greatest diameter. They are basically sub-ovoid in shape, with undulatory, bulging and receding margins, the smooth, moulded nature of which suggests plasticity during their evolution.

Individual outcrops display progressive stages in the development of the pseudoconglomerate, from the thinly interbedded limestone and siltstone. Evidence suggests that the development is based on the thixotropic response of the unconsolidated media to penecontemporaneous earthquakes, probably related to the ancestral South Shickshock fault zone.

The limestone is generally fine grained to almost dense, with scattered coarse calcite crystals and crinoid segments and rare brachiopod fragments. It is light-medium bluish gray, weathers light gray, and is slightly recessive relative to the siltstone. Minor, very coarsely crystalline, medium gray limestone and shaly partings also occur locally. The siltstone is more or less impure, argillaceous and calcareous, generally light-medium to medium gray or greenish gray, weathering light-medium gray to buff.

Along the Matane downstream from the easternmost edge of the area, various lithologies are encountered, including ubiquitous patches of fault breccia. East of the Duvivier river, the rocks are thin- to medium-bedded siltstones of fairly typical Saint-Léon type. They are calcareous, gray or greenish gray, and locally have some small-scale crossbedding. One outcrop displays a peculiar calcite veining with layers of calcite 1/2 to 3/4 inch thick separating most beds.

One thousand feet or so downstream from the Duvivier, the south bank of the Matane exposes a faulted, apparently overturned succession. This includes zones of thinly interbedded light gray limestone and dark gray shale, and thin- to medium-bedded limestone (much of which is calcarenitic, some oölitic) with one or two medium to thick lenticular beds of limestone conglomerate. The rounded phenoclasts of the conglomerate resemble the surrounding limestone. Small-scale crossbedding occurs in several of the beds. Sporadic outcrops occur downstream to Truite river. The strata involved resemble those found in the section on the Truite, with localized areas of increased shearing or actual fault breccia.

Downstream from Truite river for more than one mile, similar lithologies and fault breccias recur. In addition, there are some local variations including a bed, at least 5 feet thick, of an unusual, impure, coarse-grained, blackish sandstone, whose fresh surfaces emit a petroliferous odor and reveal rare, very small globules of oil. This bed appears to overlie shale and siltstone. Many loose Val Brillant sandstone blocks were noted near the river in this vicinity and may indicate bedrock close by. Near the downstream end of the outcrops thin calcarenite beds appear, and the exposures end with a zone, about 120 feet thick, predominantly of limestone conglomerate, with minor calcarenites, shales and siltstones. The conglomerate consists of more or less tabular fragments, commonly with styloliticly interpenetrating margins, ranging from pebble to cobble sizes, with scattered slabs up to 2 feet by 3 inches. The phenoclasts consist of light to medium gray, commonly dense to fine-grained limestone and minor calcarenite, weathering very light yellowish brown. They are set in a sparse matrix which ranges from a fine argillaceous residue to a medium- to coarse-grained calcarenite. The angularity and shape of the phenoclasts indicates a local derivation with some penecontemporaneous erosion and recycling evidenced by a second-cycle conglomerate phenoclast.

3. The Saint-Tharsicius Anticline Area.- Several semi-concealed outcrops occur along the main road for 3,000 feet northwest of Saint-Tharsicius church. Here, fissile to shaly siltstones are interbedded with relatively solid beds of siltstone to very fine-grained sandstone. The former are impure, argillaceous, medium to dark gray, light-medium yellowish brown weathering and faintly laminated. The latter are calcareous, light gray or olive-gray, light yellowish brown weathering and locally laminated. Mica flakes are common on separation surfaces. Zones up to 20 feet thick of thin- to medium-bedded alternations of the relatively solid and fissile beds occur, separated by intervals in which one or the other (particularly the fissile) predominates.

Southwestwards, along the axis of the anticline, similar siltstones, sandstones and fissile beds occur, with minor impure limestone beds, including a 6-inch-thick lenticular layer of medium-gray very coarse-grained fragmental crinoidal limestone.

4. The Problematical Saint-Léon (?) of the Southwest.- At the southeast end of Lake Matapédia, more or less identical strata occur on either side of the lake, probably in fault slices. Their lithologic affinities include both the York River and the Saint-Léon Formations. Earlier (1961), the writer preferred a correlation with the York River. However, a third, apparently correlative, lithologic unit outcrops adjacent to the main fault, some 4,000 feet northwest of Saint-Tharsicius church on the southwest side of the main road. This latter unit is related in lithology and appears to strike into the established Saint-Léon Formation. In addition, several

outcrops in the Saint-Tharsicius anticline resemble the problematical types. Thus, although the possibility of a York River correlation is not entirely eliminated, the evidence favors uppermost Saint-Léon.

Paleontology and Age

The Saint-Léon Formation is not especially fossiliferous in the present area. Scattered occurrences of graptolites constitute the main faunal content, with rare, usually lenticular, limestone beds containing debris of corals, crinoids, bryozoa, brachiopods and, rarely, stromatoporoids. One outcrop of limestone carried a few brachiopods and trilobites. Vague carbon laths are present on many surfaces, and, locally, these occur in abundance.

From fossil localities along Chantepleure brook, the writer identified the following:

Monograptus cf. M. colonus
Monograptus cf. M. tumescens
Monograptus ultimus
Monograptus cf. M. leintwardinensis
Linograptus posthumus posthumus
Inocaulis sp.

A few poor "Monograptus" sp. were found on Tamagodi river, fairly close to the top of the Saint-Léon.

On Cajettan brook near the middle of the Saint-Léon section, Monograptus micropoma was found in a siltstone bed. A bed of fossiliferous calcirudite a short distance farther up the section contained:

<u>Alveolites?</u> sp.	Crinoids
<u>Catenipora</u> sp.	Brachiopods

Towards the closure of the Saint-Tharsicius anticline, a loose block, believed to be more or less in place, yielded several specimens, (identified by A.J. Boucot) of Conchidium sp. (coarse-ribbed).

On a small stream, just north of and parallel to Chantepleure brook, a small exposure of thin-bedded limestone contained:

Identification by A.J. Boucot:

<u>Sphaerirhynchia</u> sp.	<u>Lissatrypa?</u> sp.
Stropheodontid	<u>Howellella</u> sp. (small)

Identified by Writer:

<u>Reticularia?</u> sp.	<u>Dalmanites</u> cf. <u>D. caudatus</u>
<u>Orthoceras</u> sp.	<u>Calymene</u> sp.
<u>Phacops</u> sp.	

Roadside outcrops of problematical Saint-Léon, just east of Lake Matapédia yielded the following:

Chonetid	<u>Cyrtina?</u> sp.
Orthotetacid	<u>Polypora</u> sp.
Dalmanellid	<u>Receptaculites</u> sp.

Northwest of Saint-Tharsicius, many bedding surfaces in the roadside outcrops of the problematical Saint-Léon Formation, adjacent to the main fault, display carbon laths (Pl. XXV) which F.M. Hueber* interpreted (personal communication, 1962) as probable macerated plant fragments. Several samples of the siltstones and sandstones involved were prepared and examined for spore material, without success. This in itself is indirect evidence to support a Saint-Léon rather than a York River affinity, since spores are common in the latter.

The graptolite assemblage is typical of a Ludlow age. The Linograptus identified is particularly notable. Linograptids have rarely been reported from North America and, only from Oklahoma (Decker, 1935a) and the Yukon (Jackson and Lenz, 1962). These forms are alike, but differ from the European types recently described and revised by Boucek (1933) and Jaeger (1959). The Saint-Léon Linograptus belongs to a European, not an American species, and is the first of its kind so far recorded on the American continent. According to Jaeger, the variety identified (L. posthumus posthumus) occurs in the Middle and, more particularly, the Upper Ludlow, although on limited evidence he differentiates a more slender but otherwise identical variety which occurs in the Lower Ludlow.

The nature and stratigraphic distribution of the graptolites suggests that the zone of Monograptus nilssoni occurs near the base of the Saint-Léon and the zones of Monograptus tumescens and Monograptus leintwardinensis (including the Linograptids) towards the middle. It is, therefore, probable that the upper Saint-Léon Formation belongs to the Upper Ludlow. This interpretation is supported by the apparently continuous transition from the Saint-Léon into the Cape Bon Ami and the existence of a brachiopod fauna in the latter fairly close to the contact zone, identified by A.J. Boucot as of New Scotland (Lower Devonian) age. The Saint-Léon of the Cuoq-Langis area appears to include younger strata than the Causapsal area to the south, since Stearn (1965) reported Lower Ludlow graptolites in the upper part of the Saint-Léon in that area.

DEVONIAN

The Devonian rocks of the Cuoq-Langis area comprise a thick sedimentary sequence of impure limestones and calcareous siltstones, over-

* Paleobotanist, Geological Survey of Canada.

lain by sandstones with minor shales. Three formations are differentiated, namely, from oldest to youngest: Cape Bon Ami, Grande Grève, and York River.

Cape Bon Ami Formation

This has been extended from its type section in the Forillon peninsula across the entire length of Gaspé by McGerrigle (1953). McGerrigle summed up the lithology as, "dark silty limestone, some dark shale", a description which reflects the lithologic convergence in the formation from east to west. Russell's (1946) Forillon members merge westward into a monotonous succession of typically medium to dark gray, impure, silty to argillaceous limestone.

This westward change to a more monotonous lithology within the Cape Bon Ami is accompanied towards the western end of Gaspé peninsula by lithologic convergence between the Cape Bon Ami and the overlying Grande Grève, a fact which led Crickmay (1932) to define only one unit, the Causapschal Formation, between the Saint-Léon and the Gaspé Sandstone division in the Matapédia valley. McGerrigle (1953) and Stearn (1965) found it possible to differentiate the Cape Bon Ami and Grande Grève formations in the Causapschal area, and denied the necessity for Crickmay's comprehensive Causapschal Formation. However, Béland (1960, p. 8), working west of the Matapédia valley, mapped a "Cape Bon Ami - Grande Grève Unit", without differentiation, "... because of the local difficulty of drawing a dividing line between the two formations". In the present area, the two formations can be separated, but with increasing difficulty towards the southwest. The Matapédia valley appears to be the approximate westward limit of differentiation.

Within the Cuoq-Langis area, the Cape Bon Ami Formation occupies a band, varying from 1/2 mile to 3 miles wide, trending diagonally southwest across the southeastern half of the area. The band is widened by folds across the Truite River region, narrowed by faults in the Cajettan-Chantepleure interval and modified by folds in the southwest. It is bounded on the northwest by the Saint-Léon Formation throughout most of its extent except in the southwest, where folds bring it into contact with, and under the influence of, the South Shickshock fault. It is bounded on the southeast by the Grande Grève Formation, along a predominantly faulted contact.

Stratigraphy and Lithology

The contact between the Cape Bon Ami and the underlying Saint-Léon is at or near the Silurian-Devonian contact. In western Gaspé, Crickmay (1932) made the Saint-Léon - Causapschal contact the Silurian-Devonian boundary, but was unable to offer precise dating to prove the validity of this assumption. Further, although Crickmay stressed the

conformity of the succession, the continuity or otherwise between the two formations was not established. McGerrigle (1953) implied an erosional or non-depositional break by dating the Saint-Léon Formation as Middle Silurian and the overlying Cape Bon Ami Formation as Lower Devonian. Stearn (1959) accepted the possibility that the Saint-Léon - Cape Bon Ami contact marks the system boundary in the Causapsca area. Thus, in western Gaspé, the Silurian-Devonian boundary is arbitrarily and approximately fixed only.

In eastern Gaspé, the Silurian-Devonian boundary has been variously placed in relation to the Cape Bon Ami Formation and the underlying St. Albans Formation, largely as a result of recent changes in the definition of the formations concerned. The most recent interpretations have been made by Cumming (1959) and Burk (1959). Cumming stated that the presence of monograptid graptolites in the lowermost member of the Cape Bon Ami Formation is evidence of the Silurian age of the lower part of that formation. (Later information indicates that at least one of these monograptid species is Lower Devonian: Editors). Burk (1959) redefined the formations and boundaries in the Forillon peninsula. He believed that the lowest member of the Cape Bon Ami Formation, plus the upper part of the underlying St. Albans Formation, represents the eastern continuation of the Saint-Léon Formation. Thus, Burk has redefined the stratigraphy so that in eastern, as in western Gaspé, the Silurian-Devonian boundary is approximately at the Saint-Léon - Cape Bon Ami contact.

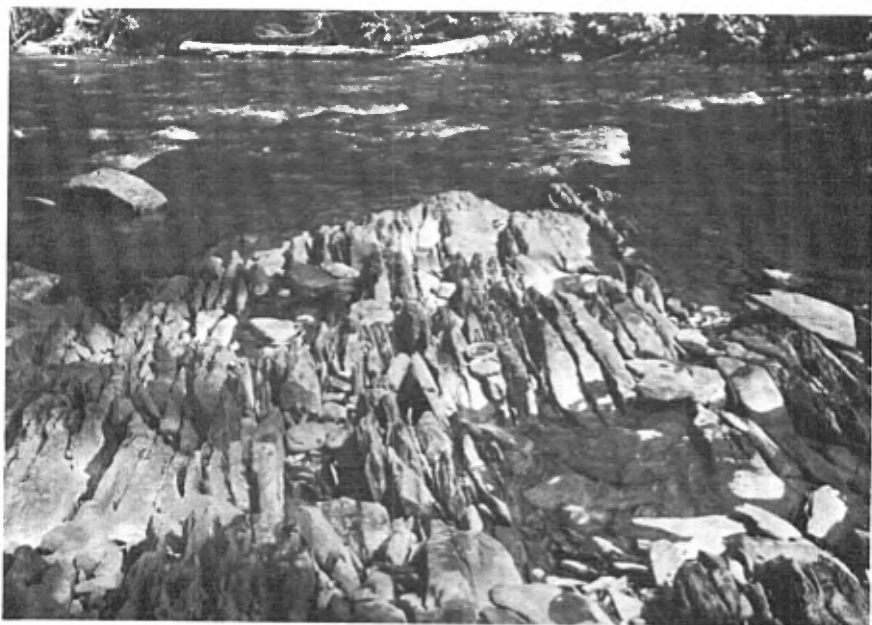
In the present area, evidence from the section along the lower reaches of Truite river indicates a conformable succession and an unbroken transition, with some interbedding, from Saint-Léon to Cape Bon Ami. Paleontological evidence from the Saint-Tharsicius anticline, indicates that beds of New Scotland (near the base of the Devonian) age occur near the base of the Cape Bon Ami. The evidence of graptolites from Chantepleure brook suggests that the middle part of the Saint-Léon Formation is of Middle Ludlow (lower Upper Silurian) age. Thus, it may be inferred that there was no break in deposition in the Cuoq-Langis area and that the Silurian-Devonian boundary must indeed be close to the formational change. In terms of stratigraphic separation of the dated beds, the Silurian-Devonian boundary is more likely to be within the Saint-Léon than the Cape Bon Ami.

The thickness of the Cape Bon Ami Formation appears to be quite variable across Gaspé. In the extreme east, on the Forillon peninsula, it is around 1,415 feet thick (based on figures given by Cumming, 1959, p. 18-19, revised according to Burk, 1959, to exclude the basal member), thickening westwards to nearly 4,000 feet at Renard river (McGerrigle, 1950) and then thinning again to around 2,000 feet at Dartmouth river, and an estimated 1,000 feet (reduced in part, at least, by faulting) in parts of central Gaspé (Carbonneau, 1959). McGerrigle (MS., 1945) estimated a

Plate XXVI



A. Laminated Cape Bon Ami limestones on the south bank of Truite river near Martelbrook. Typical cleavage is lacking, probably owing to rapid erosion preventing weathering from opening up the potential separation.



B. An outcrop on Truite river, just downstream from Chandler creek, showing the high angle cleavage typical of the Cape Bon Ami Formation.

thickness of about 3,000 feet in western Gaspé, a figure confirmed in estimate by Stearn (1965) for the Causapscal area. In the Cuoq-Langis area continuity and structural control are inadequate for an accurate measurement, but 3,000 to 3,500 feet are indicated.

Throughout the Cuoq-Langis area, the Cape Bon Ami is a fairly uniform impure limestone. It is typically argillaceous and silty. In places it is fairly hard. Thin-section and solution analyses reveal general ranges in composition of 60 to 90% for the carbonate, 4 to 40% for the quartz silt, and 5 to 10% for the argillaceous material. Typically the rock consists of silt-sized grains dispersed in very finely crystalline to cryptocrystalline calcite. Freshly broken, the rock is medium to dark gray with a faint brownish cast; it weathers to pale yellowish brown or gray. Freshly broken rock commonly gives off a petroliferous odor.

Bedding is seldom conspicuous and many exposures, even tens of feet wide, show no evidence of it. In some outcrops, fine laminae may be dispersed or grouped in bands, and are particularly visible on weathered surfaces (Pl. XXVI-A). Differential weathering, resulting from changes in the relative proportions of silt and argillaceous material, brings out local thin to medium bedding.

The most characteristic feature of the Cape Bon Ami is its fracture cleavage (Pl. XXVI-B). The few bedded occurrences of the Formation display some unusual cleavage features, including the refraction of cleavage and the dissection of some more competent beds into more or less rounded blocks suggesting "cleavage-boudinage" (Charlesworth and Evans, 1962). Additional cleavage, parallel or sub-parallel to the bedding, appears in places. The intersecting planes locally produce a disintegration into elongate fragments or, where joints are also conspicuous, a confusion of intersecting surfaces.

Joints are fairly common and include thinly spaced, sub-horizontal joints occurring in places along Truite river that are probably a type of sheeting separation (Billings, 1954, p. 121-123) due to the release of load during erosion. Thin veins (calcite-filled fractures) are present locally.

Paleontology and Age

Fossils are widespread in the Cape Bon Ami of the area but are abundant in only a few places. Brachiopods, particularly "Chonetes", are most common, with some pelecypods and lesser cephalopods and trilobites; conularia and ostracods are rare. The identifications of brachiopods in the following collections were made or confirmed by A.J. Boucot:

Lepage township, range III NW, boundary of lots 46/47A, approximately 3,100 feet southwest of range IV NW, at side of main road.

<u>Coelospira</u> <u>virginia</u>	<u>Schuchertella</u> sp.
<u>Leptocoelia</u> sp.	" <u>Chonetes</u> " sp.
<u>Spinoplasia</u> sp.	Stropheodontid

Blais township, range I, intersection of lots 44/45 with boundary road separating Lepage and Blais townships.

<u>Craniops</u> sp.	<u>Coelospira</u> sp.
" <u>Chonetes</u> " sp.	<u>Spinoplasia</u> sp.

Roadside outcrop, Blais township, range III, boundary of lots 35/36, 1,500 feet northeast of range II.

Stropheodontid

Trail, northwest side of Chandler creek, approximately 1/2 mile above its mouth.

" <u>Chonetes</u> " sp.	?Crinoid
<u>Leptocoelia</u> sp.	

Trail, northwest side of Chandler creek, approximately 4,000 feet above its mouth.

" <u>Chonetes</u> " sp.	Ostracod
<u>Leptocoelia</u> sp.	

Trail, north side of Truite river, opposite lot 21, range V, Cuog township on south bank.

Chonetid	<u>Nuculites</u> sp.
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North bank of Truite river and trail alongside, approximately one mile from eastern edge of Cuog-Lanqis area.

" <u>Chonetes</u> " sp.	Cephalopod
<u>Leptocoelia</u> sp.	? <u>Paracyclas</u> sp.
<u>Plectodonta</u> sp.	? <u>Nucula</u> sp.
<u>Conularia</u> sp.	

The above fauna is undoubtedly Lower Devonian. In Boucot's opinion the association of Leptocoelia, Plectodonta, and Spinoplasia gaspensis indicates a New Scotland age.

Grande Grève Formation

Stratigraphy and Lithology

The Grande Grève Formation occupies a belt averaging 2 miles wide in the southeast corner of the area, curving around the margin of the Lake Casault syncline. Differentiation of the Cape Bon Ami and Grande Grève lithologies is not easy here, particularly where individual outcrops are concerned. However, the latter, as a formation, is definitely harder, less argillaceous, more siliceous and silty and less well cleaved than the former. In addition, loose fragments of the Grande Grève generally weather whitish in the forest soil. Placing of the actual contact is facilitated by its predominantly faulted nature, which eliminates confusing transition.

The thickness of the Grande Grève Formation north of the Lake Casault syncline, in the Cuoq-Langis area, is estimated to be 3,000 to 5,000 feet. In the area to the south Stearn (1965) estimated a thickness of 3,600 feet, decreasing southwards to around 2,000 feet.

The Formation is poorly exposed in the area and good, continuous sections are lacking. Some of the best exposures occur along Martel brook and its main tributary. Here, the rocks are medium bluish gray, hard, commonly siliceous, and range from silty, finely to very finely crystalline limestones to calcareous or very calcareous siltstones. Bedding is not clear although the pale to medium yellowish brown or gray-brown weathered surfaces in places show a faint, thin, color lamination or, thin silty laminae. The laminae tend to be lenticular, and pinch and swell irregularly. The concentration of silty (locally sandy) layers and laminae increases towards the top of the formation, heralding the approaching change to York River sandstone deposition. Subhorizontal to low-angle joints in places give a false impression of thin bedding. Veins are of calcite and are few and thin; some contain tiny crystals of quartz. A faint petroliferous odor is given off by some of the rock when freshly broken.

Thin-sections reveal that, in addition to silt-sized clastic and minor authigenic quartz and feldspar, quartz is abundantly intergrown with calcite. These intergrowths locally form very fine-grained spherulitic structures. Most of the calcite in the rock is very finely crystalline or cryptocrystalline. Scattered, locally abundant laths of calcite (relict sponge spicules?) also occur.

Paleontology and Age

Rare, incomplete brachiopod shells were the only fossils noted. On the north shore of Gunn lake Schuchertella sp. and Leptocoelia sp. were collected. In eastern Gaspé, an Oriskany age has been established for much of the Grande Grève, and cherty limestones forming part of an undifferentiated Cape Bon Ami - Grande Grève sequence from the Neigette syncline, west of Lake Matapédia, have been similarly dated (Béland, 1960, p.9).

York River Formation

In the present area, only the lower part of the Devonian sandstone group of Gaspé peninsula occurs. This is correlated on general lithologic grounds with the York River Formation. It is preserved in a broad shallow synclinal structure which crosses the southeastern corner of the area.

Stratigraphy and Lithology

In the Cuoq-Langis area, as in north central Gaspé (Carbonneau, 1959), parts of northeastern Gaspé (Jones, 1936) and, more locally, in the adjacent Causapschal area (Stearn, 1959; 1965), the Grande Grève - York River contact is a transition zone, in which at least one major unit of Grande Grève lithology recurs above the lowest sandstone unit of York River type. This transition does not warrant separation as either a distinct formation or facies, but it does raise the problem of where to place the contact.

Following McGerrigle (1950, p. 73), who included the transitional York Lake series within the York River Formation, and Stearn (1965), the contact is placed below the lowermost sizeable and extensive unit of York River sandstone lithology. The contact can only be placed with certainty west of Causapschal river. North of the river, its position is largely assumed, owing to very inadequate exposure.

The Formation is incomplete and eroded in the Cuoq-Langis area and only a few thousand of the 10,000 to 14,000 feet estimated in this region by other workers (Stearn, 1959; Béland, 1960) remains. In addition, of the estimated 3,200 feet forming the northern limb of the Lake Casault syncline, only about 2,500 feet are exposed, owing to an extensive drift and alluvial blanket in the center of the syncline from Lake Casault eastwards.

Stearn (1965) has divided the York River Formation of the Causapschal area into three members as follows: 3. The Upper Beds, 2. The Jollet^{*} Beds, and 1. The Basal Beds.

In view of Stearn's estimate that the Basal Beds are at least 3,000 feet thick, it would appear at first sight that only the Basal Beds are exposed in the Cuoq-Langis area. However, he reported Boucot's diagnosis that the Basal Beds belong to the zone of Etymothyris, and the Jollet Beds, to the overlying zone of Amphigenia. Since the upper

* Jollet (member, beds, etc) named after the brook of that name replacing Four Mile Brook (member, beds, etc.).

part of the Cuoq-Langis succession, occupying the center of the syncline, is also referable to the Amphigenia zone, according to Boucot, it appears to be equivalent to the Jollet member. This implies that the Basal Beds thin northwards from around 3,000 feet near Causapschal, to nearer 2,000 feet in the Cuoq-Langis area, assuming both estimates to be correct.

For the purposes of description only, the York River can be divided in descending order into three units, as follows:

3. The main bulk of the York River sandstones, siltstones and minor shales, probably around 2,500 feet thick, and including a zone, in the vicinity of Lake Frenette, very similar to unit 2.
2. A unit of calcareous siltstone, reminiscent of the Grande Grève Formation but more fossiliferous; approximately 300 feet thick.
1. A basal sandstone unit approximately 400 feet thick.

These units are general subdivisions, based on the predominance of observed lithologies and are not meant to imply the exclusion of interbedding or lithologic variation within them.

Unit 1 Southeastwards, along the Range II-III road of Blais township, abundant, wispy, coarser-grained laminae of siltstone and fine-grained sandstone distinguish the top of the Grande Grève until, in lot 22, range III (a few hundred feet northeast of the road, and some 4,000 feet northwest of Causapschal river), sandstones of York River aspect outcrop. They are light-medium gray, medium gray-brown weathering, medium-grained, slightly calcareous, feldspathic and dominated by a flaggy (1 to 2 inch) cleavage. Small, dark wispy streaks, typical of the bulk of the York River sandstones, are common. Scattered brachiopods occur. These sandstones, plus a few, small, widely scattered outcrops of similar sandstone to the northeast, are considered to form the basal unit of the York River Formation.

Unit 2 Farther southeast, on Causapschal river, calcareous siltstones occur, and have been differentiated on the accompanying geological map. They are best exposed along the river in range IV of Blais township and typically consist of calcareous to very calcareous, light-medium gray, light brownish gray weathering siltstone. Bedding is not conspicuous, although irregular, lenticular laminae and thin layers of silt- to fine sand-sized material are common locally. Differential weathering produces many surfaces honeycombed with cavities 1 inch to 5 inches in diameter, or, less commonly accentuates cleavage or bedding. The cavities probably form where fossil nuclei have supplied a local increase in calcite. Many outcrops are fairly well cleaved, with separations an average of 1 inch to 3 inches apart. Most of

these siltstones resemble those of the Grande Grève and are hard and siliceous. A few are more argillaceous, more closely cleaved, and superficially resemble the Cape Bon Ami. Exposure does not permit a detailed stratigraphic analysis, but intervals of fairly uniform lithology, without clear bedding, at least 20 feet and possibly up to 60 feet thick, are indicated. Some freshly broken surfaces give off a faint petroliferous odor. Fossils are fairly common and include brachiopods, corals and bryozoa.

Unit 3 Strata of this unit are best exposed along the Causapscal and along the Grande Décharge draining Lake Casault. Along the Causapscal, in ranges V and VI of Blais township, and to the southwest in range III, there is a transition from the siltstones of Unit 2 up into the sandstones of Unit 3. This transitional zone is probably several hundred feet thick, with a wide surface expression owing to the low-angle dips. It is characterized by alternating zones of both lithologies, several to tens of feet thick and common thin layering and lamination of sandstone in siltstone and vice-versa. Zones of intermediate lithology are present and, locally, sandstones and siltstones grade imperceptibly into one another. Small-scale crossbedding occurs in some of the laminated beds. Near or at the top of the transitional zone, in lot 3, range VI, of Blais township, cliffs on the north bank of the Causapscal expose about 150 feet of impure, quartzose, calcareous, medium to dark gray, medium brownish gray weathering siltstones. These siltstones are locally laminated and form zones 12 to 20 feet or more thick of rubbly, well-cleaved and fissile material alternating with relatively competent zones.

The Grande Décharge section presents the greatest continuity of exposure available across the strike. About 500 feet of rather monotonous sandstones immediately overlying the transition from Unit 2 outcrops here.

The sandstones of Unit 3 are mainly intermediate in composition to arkose and feldspathic or high rank graywacke. Some are lithic sandstones. Quartz is the main constituent and forms 40 to 50% of the rock. Feldspar content averages 20 to 30%, with potassium feldspars and perthite predominating over plagioclase. Weathered sandstones can readily be recognized as York River by their characteristic whitish weathered feldspar grains. Rock fragments generally form 5 to 10% of the rock (locally 20% or more) and include grains of argillaceous material (now sericitic and slightly chloritic), chert, vein quartz, and rare volcanic material. Mica flakes are thinly scattered throughout the rock. Muscovite commonly makes up 5% of the rock; biotite is much less common. Some 30 to 40% of the sandstones are at least slightly calcareous. Calcite is generally a minor constituent and seldom exceeds 5%; chlorite (1-2%) is almost invariably present. Leucoxene, hematite and magnetite-ilmenite may also occur.

Very fine- to fine-grained sandstones predominate, with minor medium- to coarse-grained. The grains are moderately to well sorted. Rounding is poor and subangular grains predominate. Secondary quartz overgrowths are developed locally, where quartz grains make contact. Thus, in texture as in composition, these sandstones are immature. The siltstones of this and the other units are basically similar to the sandstones, but commonly have a much greater calcite content and little or no feldspar. Most of the sandstones are light-medium to medium greenish gray. Well weathered rock is medium brownish gray, commonly finely flecked with white feldspar.

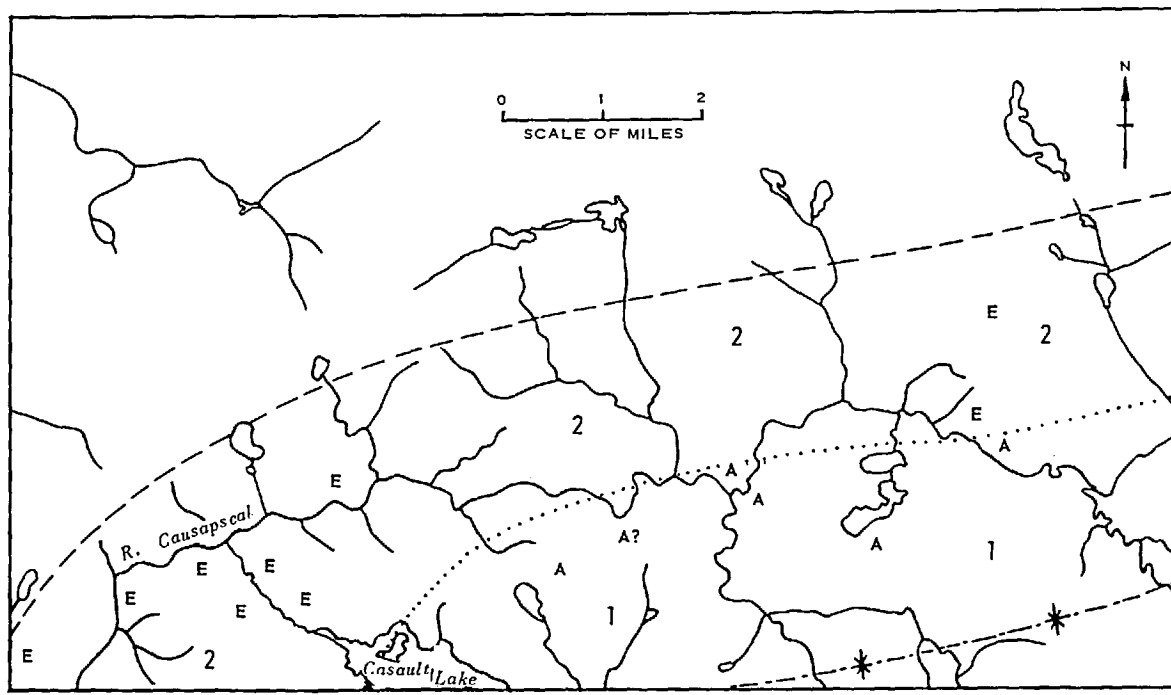
Bedding is shown by laminated zones and minor, clearly defined beds. Laminae are typically thin and faint, based on color variation, with local, lenticular, irregular or distorted laminae up to 1/2 inch or so thick, of lighter-colored, slightly coarser-grained material than usual. Scattered, medium-sized beds of medium-grained sandstone occur. Shale layers (up to 2 inches thick) or partings occur locally. They are usually fairly widely dispersed, but locally repetitively interbedded with the sandstone to produce thin to medium bedding over intervals of up to 3 feet.

A separation that is generally parallel or sub-parallel to the bedding commonly produces a thin- (Pl. XXVII-A) and less commonly a medium- to thick-bedded appearance. This may be a sheet-jointing effect. A broader zoning, based on the differential development of separation, is apparent as relatively fissile intervals alternating with more resistant and coherent intervals. The zones range from several inches to tens of feet thick, and reflect minor changes in composition (such as argillaceous content, cementation or grain size).

Scattered examples of crossbedding and asymmetrical current ripple-marks occur, the latter indicating current flow from the southeast. In several places series of curved separation surfaces resemble cross-bedding.

From paleontological evidence (see below), a line separating the Etymothyris and Amphigenia zones can be drawn through Unit 3 of the York River sequence (see Figure 4). The boundary, placed only approximately between a few scattered fossil localities, does not coincide with any recognizable immediate change in lithology. However, a thousand feet or so south of, and probably a few hundred feet above, the boundary as drawn, clearly differentiated bedding appears.

A zone of gray, calcareous siltstones, apparently only a few hundred feet thick, resembling those of Unit 2 and of the Grande Grève Formation, crosses the Causapscal river east of Frenette lake.



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LEGEND

1

Amphigenia Zone

A = Amphigenia Zone fossils

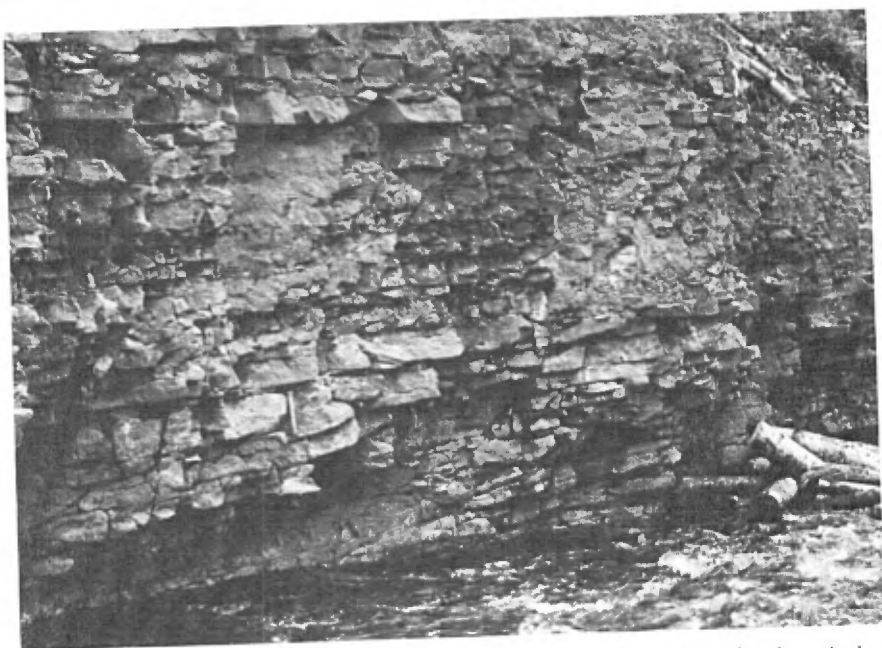
2

Etymothyris Zone

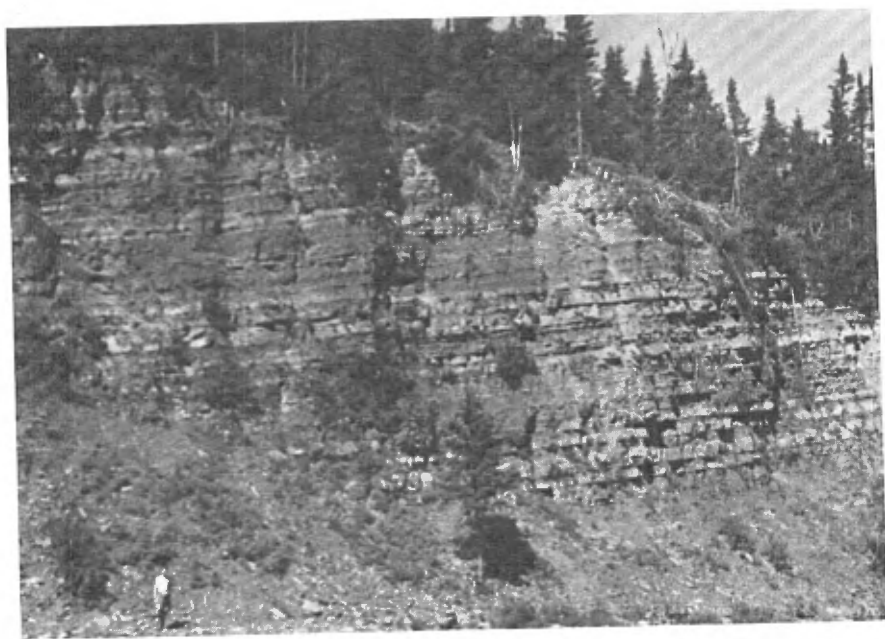
E = Etymothyris Zone fossils

Figure 4

DISTRIBUTION OF THE ETYMOthyRIS AND AMPHIGENIA ZONES IN THE YORK RIVER FORMATION OF THE LAKE CASAULT



A. An outcrop of York River sandstones on the Grande Décharge outlet from Lake Casault, showing thin separation, more or less parallel to the bedding.



B. York River sandstones on Causapsca! river. This section is probably just above the base of the Amphigenia zone and may be equivalent to the Four Mile Brook beds in the Causapsca! area. The section is well-bedded, in contrast with the underlying sandstones.

Fossils from this zone have been diagnosed by Boucot as belonging to the Etymothyris zone (close to the Amphigenia zone since they include a transitional form of Amphigenia). Small dubious outcrops of similar siltstones occur on the roads south and southwest of Lake Frenette. Fossils from this area belong to the Amphigenia zone. There is little doubt that while these siltstones represent a return (possibly an intertongue) to the Grande Grève lithology, they are an integral part of the York River Formation. York River siltstones of Grande Grève aspect are invariably fossiliferous, in marked contrast to those of the local Grande Grève Formation proper.

Paleontology and Age

The York River sandstones are the most consistently fossiliferous rocks of the area and yielded numerous collections. Brachiopods are the most important element of the fauna. Crinoid stem segments are ubiquitous. An impression of a crinoid stem, 2 feet long, was observed in the Grande Décharge section. Other fossils include corals, bryozoa, gastropods, trilobites, cephalopods, possible macerated plant debris, and probable worm burrows.

Dr. A.J. Boucot* identified the brachiopod fauna; Dr. M.A. Fritz, the bryozoa; and Dr. W.A. Oliver, Jr., the corals. The faunal lists for the various localities are as follows:

1. Causapscaal River (collections listed in downstream order, from east to west)

Lagrange township, north bank, 4,500 feet northeast of Lake Frenette.

(Etymothyris Zone)

Protoleptostrophia sp.

Amphigenia preparva

Etymothyris sp.

Rugose coral fragment

Lagrange township, north bank, a few hundred feet upstream from the Lake Frenette outlet. (Probably Amphigenia Zone)

Protoleptostrophia sp.

Eodevonaria cf. E. arcuata

Mucrospirifer sp.

Cyrtina sp.

Schuchertella sp.

Gastropod

Howellella cf. H. gaspensis

Lagrange township, 1,000 feet downstream from rapids, half mile upstream from footbridge, south bank. (Etymothyris Zone)

Cyrtina sp.

Meqanterella finksi

Etymothyris sp.

Eodevonaria? sp.

Schuchertella sp.

Plicochonetes sp.

Howellella cf. H. gaspensis

* Dr. Boucot collected additional specimens from several of the writer's localities during the summer of 1962. These have been added to the identification lists given here.

Blais township, range IV, lot 15, southeast bank.

Etymothyris sp. or Amphigenia sp.

2. Grande Décharge Section (from the base up) (probably Etymothyris Zone)

Blais township, range V, lot 11.

Eodevonaria cf. E. gaspensis Leptocoelia sp.

Blais township, range V, lot 10.

Etymothyris gaspensis Eodevonaria gaspensis

Blais township, range V, lot 10.

Etymothyris sp. Halliid corals

Blais township, range IV, lot 7. (Etymothyris Zone)

<u>Schuchertella</u> sp.	<u>Elytha</u> sp.
<u>Leptaena "rhomboidalis"</u>	<u>Costellirostra</u> sp.
<u>Etymothyris gaspensis</u>	<u>"Camarotoechia"</u> sp.
<u>Howellella gaspensis</u>	<u>Meganterella finksi</u>
<u>Eodevonaria gaspensis</u>	<u>Plicochonetes</u> sp.
<u>Leptocoelia flabellites</u>	<u>"Chonetes"</u> sp.
<u>"Leptostrophia" magniventra</u>	<u>Eurythyrid</u>
<u>Protileptostrophia blainvillei</u>	<u>Palaeoneilo?</u> sp.
<u>Cyrtina</u> sp.	Cephalopod
<u>Rhipidomelloides</u> sp.	Gastropod
<u>Atrypa "reticularis"</u>	<u>Dalmanites?</u> sp.
<u>Mucrospirifer</u> sp.	

3. South of the Causapscal River

Blais township, range IV, lot 10, on the road to Rocky Pool camp.

Etymothyris sp. Plicochonetes sp.
Howellella cf. H. gaspensis

Casault township, range VII, lot 7, 2,000 feet northeast of Lake Tremblay.

<u>Amphigenia</u> cf. <u>A. parva</u>	<u>Eodevonaria</u> cf. <u>E. arcuata</u>
<u>Howellella</u> cf. <u>H. gaspensis</u>	<u>Favosites</u> sp.
<u>Schuchertella</u> sp.	Haliid corals
<u>Leptaena "rhomboidalis"</u>	Rugose corals
<u>Atrypa "reticularis"</u>	Pelecypod

Lagrange township, track, south end of Lake Frenette (possibly displaced).

<u>Amphigenia</u> cf. <u>A. parva</u>	<u>Plicochonetes</u> sp.
<u>Eodevonaria</u> cf. <u>E. arcuata</u>	<u>Anoplia?</u> sp.
<u>Meristella</u> cf. <u>M. doris</u>	<u>Atrypa "reticularis"</u>
<u>Schuchertella</u> sp.	Chonetid
<u>Stropheodonta</u> sp.	<u>Cryptonella?</u> sp.
<u>Leptostrophia</u> sp.	<u>Zonophyllum</u> sp.
	Haliid coral

STRUCTURAL GEOLOGY

General

In recent years, the structural evolution of northern and central Gaspé has generally been attributed to the Taconic and Acadian orogenies, and Neale et al. (1961) accepted this view in their summary interpretation of the age and extent of folding in the Canadian Appalachian region.

Evidence presented in this thesis concerning the age and metamorphism of the Shickshock Group, suggests that a third or pre-Taconic period of deformation may have been involved, in the Upper Cambrian or earliest Ordovician. Such an interpretation coincides with the demonstrations by Cooke (1950; 1954) and by Riordon (1957) of a pre-Taconic unconformity separating the Caldwell Group (Precambrian or Cambrian) from the probably Middle Ordovician Beauceville Group, in the Appalachians of south-eastern Quebec.

Neale et al. (1961, p. 691-692) suggested that the Quebec Complex in Gaspé is part of a belt which had been folded only in the Taconic and which was not deformed during the Acadian. Their conclusion is based on an apparent decrease in the intensity of folding of Silurian and Devonian rocks, from south to north in the Rimouski-Matapédia region (as noted by Béland, 1960, p. 12), and the absence of deformation or recrystallization in the pre-Acadian ultrabasic pluton of Mt. Albert. However, this question is still an open one and, in the writer's opinion, the probabilities for and against Acadian folding in the Quebec Complex are about equal.

For example, the decrease may hold for the Silurian-Devonian sequence owing to northward increase in rigidity, based on lithological changes, and the possible influence of the buried Cuoq Block, but the same does not necessarily hold true for the Quebec Complex.

The "Quebec Group" in northern Gaspé has been (virtually unanimously) interpreted as consisting of numerous, tight, northeast to southwest trending folds, very commonly overturned toward the northwest. On the other hand, the structure of the Shickshock Group has consistently been a subject of controversy, with interpretations correlated to some extent with the various interpretations of its age (see discussion of the Shickshock Group above). The structure of the Silurian-Devonian sequence of western Gaspé is relatively simple and has not posed the major structural problems characteristic of the older rocks. Earlier impressions have been refined by McGerrigle (1953, map) to show a series of broad, fairly shallow anticlines and synclines, trending northeast to southwest, cut by several strike faults, at least some of which are reverse.



A. Fault breccia on Matane river along the South Shickshock fault.



B. Brecciated siltstones and shales of the Saint-Léon Formation along the South Shickshock fault, Matane river.

Local

The Cuoq-Langis area is conveniently divided from northeast to southwest into two major structural units by the large South Shickshock fault (the "Shickshock fault" of Ollerenshaw, 1961). The larger or north-western half comprises structurally complicated rocks of the Quebec Complex, contrasting with the structurally simpler Silurian and Devonian southeastern half.

Faults

The South Shickshock fault is a major fault of unknown displacement. Its surface trace trends generally N.60°E. across the Cuoq-Langis area, and it continues many miles to the northeast along the south front of the Shickshock mountains (Mattinson, 1964) with a possible continuation beyond the Tabletop mountains (Jones, 1931), and southwestwards along the north front of the Notre Dame mountains (Béland, 1960). The attitude of the fault is obscure, but it probably dips steeply to the southeast and downthrows normally in that direction. Some lateral movement is possible. Breccia (Pl. XXVIII) is found in places along Matane river and widths of several hundred feet are suggested locally. The attitude and juxtaposition of the strata suggest that subsidiary fault slices occur along the fault zone. For example, in the vicinity of Lake Matapédia and along Matane river, just east of Colline de la Tortue, the structure can best be explained by subsidiary faults, probably extensions of the main fracture. A minor occurrence of the Awantjish Formation just west of Truite river is interpreted as a local fault slice. To the west of this slice, extending almost to Colline de la Tortue, a larger associated slice of the Saint-Léon Formation incorporates part of a syncline. Local fault slices also occur along the Matane, and there is local overturning 1,000 feet or so downstream from the Matane-Duvivier junction.

For most of its extent along the south flank of the Shickshock mountains, the fault essentially parallels the regional strike. In the vicinity of the Truite-Matane junction in Cuoq township, it veers west across the strike and, although the main fault swings back southeast just east of Colline de la Tortue, a branch fault continues west along the Matane to complete the truncation of the Shickshock Group. This branch fault extends at least as far west as Tamagodi river and possibly splays out beyond into a number of lesser faults.

A branch fault, trending approximately northwest and separating the Shickshock Group on the northern shore from the Silurian on the southern shore of Lake Matapédia, has been suggested by Alcock (1926b, p. 132c) and Aubert de la Rüe (1941, p. 15). The surface trace of such a fault would be close to and approximately parallel with the southern shore,

with the downthrow on the southwest. Opposing this view, Crickmay (1932, p. 381) and Béland (personal communication, 1961) believed that the Silurian was deposited on the erosional surface of the older strata. This question is still open. The present writer prefers the fault explanation because of the apparent increase in the proportions of the Shickshock Group toward the present Silurian location west of the lake, and the probable enormity of the erosion implied. It is inferred from the similarity in elevation of the Silurian on either side of this assumed fault that it most probably occurred prior to the deposition of the Silurian. The fault topography may have been modified by erosion before the deposition of the Silurian.

Two minor normal faults, trending north, are introduced to explain the offset of Val Brillant outcrops a mile northeast of Saint-Tharsicius at the center of the Saint-Tharsicius anticline.

A fault, sub-parallel to and south of the South Shickshock fault is inferred from the scarp and drainage pattern through the vicinity of Lake Chandler. This fault marks a sudden change from Cape Bon Ami to the harder Grande Grève lithology and is held responsible for the thinness of the Cape Bon Ami Formation between Cajettan and Pinault lakes. The fault is normal, and forms a second step to the major fault.

In the Matane River Group, a zone of excessive shearing and displacement, marked by numerous thick calcite veins (Pl. IV) commonly up to one foot or more thick, is mapped as the Saint-René-Goupil fault. This can be recognized along Petite Matane river and as far southwest as Johnson creek, where it apparently truncates a wide unit of the Kamouraska facies.

The Langis-Tamagodi Silurian outlier west of Tamagodi river almost certainly owes its preservation to downthrow along a normal fault forming its southeastern margin. The structure could possibly be a small graben but is probably a single fault (see structure section C-C₁).

Minor faulting on a northwesterly trend within the Shickshock Group at Lake Matapédia appears to be along exaggerated joint surfaces.

Folds

THE SHICKSHOCK GROUP (Figure 5)

1. Lake Matapédia.- At Lake Matapédia, the Shickshock Group strikes east-northeast and dips southerly at an average of 43°. In contrast with the adjacent Matane River Group this overall southerly dip is a general and regular condition (widespread evidence of tops), not produced by overturned isoclinal folding. Nor can faulting be held responsible for the distribution.

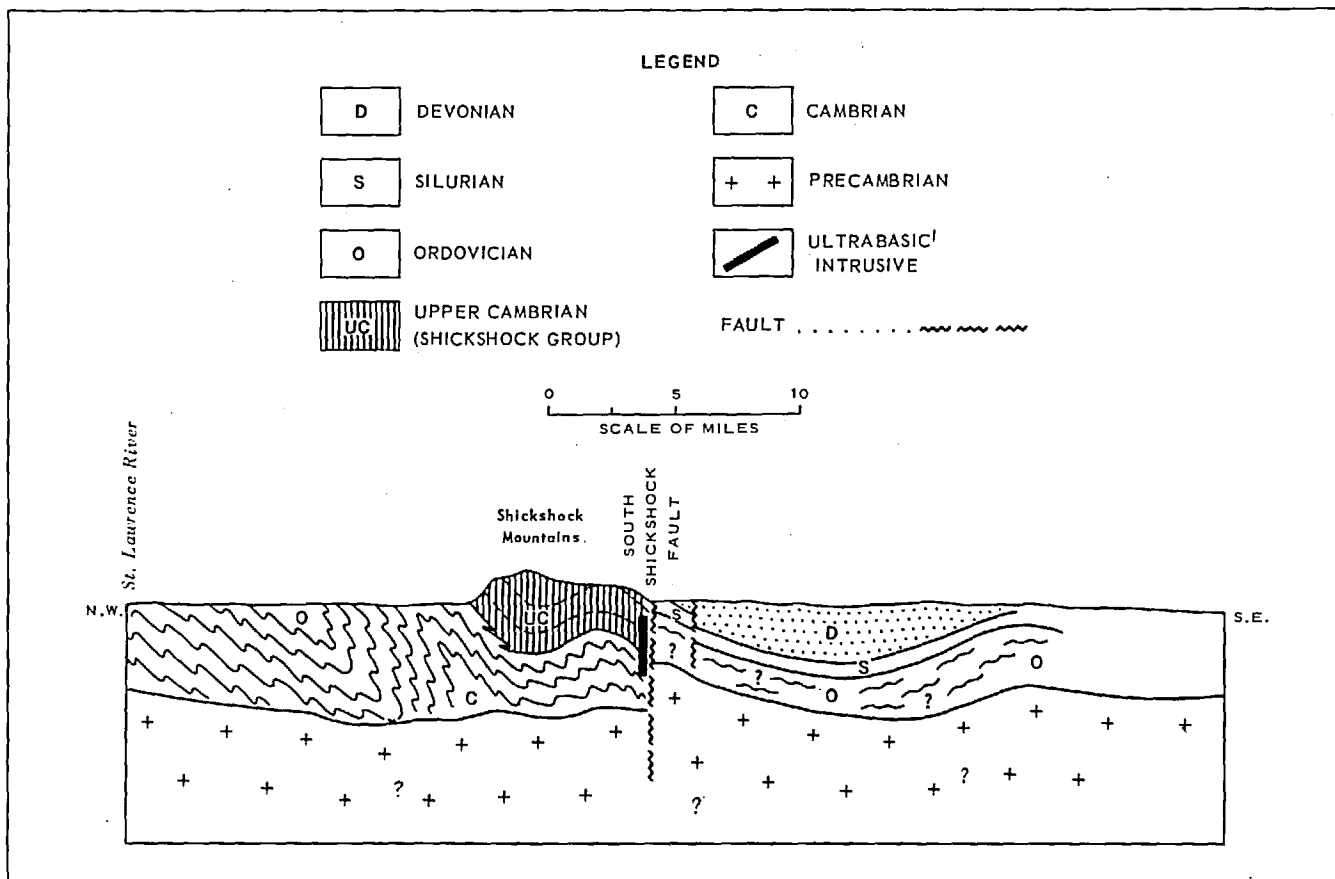


Figure 5

SCHEMATIC INTERPRETATION OF THE GENERAL STRUCTURAL POSITION OF THE SHICKSHOCK GROUP

D.N.R.O. 1965 B-843

Only along the northern contact of the northwesternmost tongue of the Shickshock Group, is shearing and disruption of the slate particularly noticeable, but even this does not suggest a major structure. Thus, the repetition of rock types in the Shickshock Group at Lake Matapédia must be attributed to stratigraphic interfingering rather than structural causes.

The tilted, homoclinal wedge of the Shickshock Group suggests the existence of a syncline to the south-southeast and an anticline to the north-northwest. However, the syncline, if it existed, has been obscured by the South Shickshock fault. The anticline is not apparent as a mappable unit either, since, towards the northwest, there is a transition from a unit of high competence (the Shickshock Group) to one of low competence (the Matane River Group shale), upon which a complex style of overturned folding has been impressed.

The average dip (43°) in the Shickshock Group at Lake Matapédia is significantly less than the average within the Matane River Group and slightly less than the average within the Shickshock Group of the mountains. The strike averages $N.62^{\circ}E.$, with 90% of the recorded readings falling between $N.50^{\circ}$ and $N.70^{\circ}E.$ The dip in the surrounding shale sequence is generally much steeper than in the Shickshock Group, although the strike is essentially parallel. This emphasizes the differential reaction of the two units to deformation. Linear structures in the Shickshock Group at Lake Matapédia plunge at 27° towards $N.70^{\circ}E.$

2. The Shickshock Mountains.- At the western end of the Shickshock mountains the structure resembles that at Lake Matapédia. The average dip is 49° to the southeast, and local evidence of tops suggests a normal succession. The wedge is truncated on the southeast by the South Shickshock fault, and dips steepen slightly towards the fault.

East of Duvivier river, two major folds appear: a syncline on the north and an anticline on the south. Neither fold is overturned and their limbs dip at medium or medium-high angles. Along Duvivier river, the structure appears somewhat complicated, possibly owing to the transition in this region from unfolded rocks on the west to folded rocks on the east. Foliation is inconsistent and several minor local folds are suggested. Local shearing prior to the metamorphism, or flow brecciation, has produced minor, indurated breccia patches. Small-scale folds are common along the south flank of the mountains near Duvivier river.

The detailed interpretation of structure in the Shickshock Group is complicated by the interfingering relationship between volcanics and sediments, by pinching and swelling, and by the lateral lensing out of the units.

THE MATANE RIVER GROUP

The recognition of actual local and regional structures within the Matane River Group is very difficult, owing to the intensity of the deformation involved. Folds are tight, locally almost isoclinal, and are generally overturned towards the northwest. Dips are generally to the southeast at medium to high angles and, locally, are vertical. In view of the pronounced curvature of the strike, the average strikes southwest and northeast of Matane river are given separately as N.50°E. and N.30°E. respectively. In addition to the general curvature of the strike, flexing and warping of the bedding is common within individual outcrops.

The folding appears to have taken place on all scales, so that regional or even local structures are masked by a profusion of lesser folds and confused by scattered areas of disruption. In addition, while cleavage is generally parallel to the bedding, it is not always so. This adds further difficulties to the interpretation of cleaved but unbedded zones of slate.

The overturned, or northwestern, limbs of small-scale anticlines appear to have a consistently steeper dip than the upper southeastern limbs where both can be observed, a condition that probably applies to the larger anticlines and synclines also. An attempt has been made to follow this principle in the construction of the cross-sections that accompany the geological map of the area.

It has been demonstrated that the Kamouraska facies is, at least locally, in stratigraphic continuity with the surrounding slates. However, the disposition and orientation of the lenticular Kamouraska masses suggest local displacement and, in view of the considerable difference in competence between the lithologies concerned, it seems inevitable that some displacement should occur.

THE SILURIAN-DEVONIAN

Most of the Silurian-Devonian sequence forms part of the northern limb of a broad, fairly shallow syncline, the east-northeast-trending axis of which crosses the corner of the Cuoq-Longis area in the vicinity of Lake Casault. On the northwest, this syncline is truncated by the South Shickshock fault. To the west it passes into the more local, northeast-trending, Saint-Tharsicius anticline, which is itself truncated on the northwest by the major fault. Still farther west, at Lake Matapédia, subsidiary fault slices of probable Saint-Léon Formation occur. One of these appears to contain the remnant of a syncline. The Lake Casault syncline plunges gently east-northeast. The Saint-Tharsicius anticline

plunges towards the southwest and is separated from its probable southwestern continuation, the Anqui anticline (Béland, 1960), by a local cross-fold.

Joints and Cleavage

Joints occur in all the rock units of the Cuoq-Langis area, but are most strongly developed in the York River, Saint-Léon and Val Brilliant Formations. The predominant present strike is northwest across the axes of folding. The development of joints rather than cleavage in many of the York River sandstones produces a second, approximately northeast, trend. Joint surfaces generally have a steep dip, with the exception of the sub-horizontal sheeting common in the York River Formation and, to a lesser degree, in the Cape Bon Ami and Grande Grève Formations.

Slaty cleavage is very well developed in the shales of the Matane River Group. Cleavage planes are commonly very close, ranging from paper-thin to 1/4 inch apart. The cleavage mainly follows and emphasizes the bedding fissility, but is locally slightly oblique. Also, a second cleavage, of the fracture type, is developed locally; it commonly strikes with the bedding cleavage, but dips in the opposite sense (usually northwest) and at a lower angle. It is locally parallel to the axial planes of small folds, or spread out as a fan cleavage. The intersection of these two cleavages produces elongate, pencil structures.

In the Shickshock Group, a schistosity is progressively developed as metamorphism increases and becomes common and well developed in the Duvivier facies. This schistosity parallels the bedding wherever the two are observed in association, a fact previously noted by McGerrigle (1954a, p. 21) and Mattinson (1958, p. 229-230). An incipient second or cross-schistosity is locally developed in the Duvivier facies. This appears to be a strain-slip schistosity, developed from minute puckering of the main schistosity, and it strikes about northwest, or at right angles to the general strike. Finally, a fracture cleavage is developed locally in the Arkose, with wavy separation surfaces 1/2 to 3/4 inch apart. This cleavage strikes with the bedding but locally dips in the opposite direction.

A fracture cleavage is common in the Silurian-Devonian rocks. It is best developed in the Cape Bon Ami and Grande Grève Formations, where the cleavage planes are typically 1 inch to 3 inches apart, but are 1/4 to 1/2 inch apart in the weathered, more argillaceous varieties. The cleavage planes commonly converge and diverge, producing a lenticular appearance. A similar cleavage is developed locally in the Saint-Léon and York River Formations, but tends to be more widely spaced and, particularly in the York River, locally disappears or passes into joints. The cleavage strikes northeast and dips at consistently steep

angles (70° to 90°). It cuts across the local folds, indicating a correlation with regional rather than local structure.

The Structural Relationship between the Shickshock Mountains and Lake Matapédia

The gap in surface continuity between the Shickshock Group of the mountains and that of Lake Matapédia is interpreted as being the result of a broad, shallow, down-warped cross-fold lying with northwest trend across the general northeast trend. This interpretation is reasonably obvious from the main geological map and is supported by plottings of lineations in the Shickshock and Matane River Groups, and of strikes in the Matane River Group and in the Siluro-Devonian succession.

The Shickshock Group plunges east-northeast at 27° at Lake Matapédia, southwest at 19° at the western end of the Shickshock mountains, and northeast at 27° east of Duvivier river. The continuity of the Group is cut by a cross-fault along Matane river and possibly cut by a cross-fault along Lake Matapédia. The South Shickshock fault bounds the southeast side of the Lake Matapédia segment, and the branch cross-fault on Matane river possibly extends along its northwest flank. This being so, the Lake Matapédia - Matane River area of the Shickshock Group and the associated Matane River Group is at least partly, and possibly entirely, bounded by faults and, therefore, could have acted as an independent block.

Structural Relationship between the Shickshock Group and the Matane River Group

The Shickshock Group structurally overlies the Matane River Group. The contact follows the north front of the Shickshock mountains and dips southeast at an angle of 40° to 50°. The contact reveals no evidence of faulting, other than minor, local disruption. On the contrary, the contact zone shows good evidence to suggest that it is normal, conformable, and interfingering.

Summary Structure of the Shickshock Group

A major object of the present survey was to ascertain the stratigraphy, structure, age, and relationships of the Shickshock Group. The evidence from the Cuoq-Langis area has been presented above. The mapping of this area constitutes the completion of recent relatively detailed mapping of the Shickshock Group (McGerrigle, 1954a; Mattinson, 1964) and the present writer is fortunate in being able to construct, for the first time, a fairly detailed map of the entire Shickshock Group and

probable equivalents, from Lake Matapédia to the Tabletop mountains (Map B-844). Previous workers have been restricted by the availability of information from specific areas with only reconnaissance information from the remainder, and this has led to a variety of interpretations.

It can be seen from Map B-844 that the Shickshock Group overlies the undivided Quebec Complex immediately to the north. The contact dips southeast to south-southeast at about 50°. Strikes are essentially parallel across this contact from one end of the Shickshock Group to the other, except northwest of Mount Albert.

The present field investigation, plus the findings of Mattinson (1964), refutes the existence of a fault contact along the northern margin of the Shickshock Group from Lake Matapédia at least as far east as the boundary between the counties of Matane and Gaspé-Nord. The existence of a thrust fault or unconformity east of this point was suggested by McGerrigle (1954a, p. 23) as a corollary of the fact that some of the zones and structures within the Shickshock Group appear to be cut off at the northern edge of the range, and of his impression that the Shickshock Group is older than the underlying slate sequence to the north. Some disruption has occurred at this contact zone along Sainte-Anne river but the present writer does not construe this as evidence of an extensive major fault. In view of the great difference in relative competency involved, some local disruption of the slate sequence at the contact is to be expected.

Further, the writer does not agree with McGerrigle (1954a, p. 23) that "some of the structures or stratigraphic belts within the Shickshock series appear to be cut off at the northern edge...". The main evidence of this is the Lake Cascapédia belt of sediments, which strikes obliquely into the contact. McGerrigle explained this apparent discordance as indicative either of thrusting or of an unconformity. Mattinson (1964) disagreed and postulated deforming forces oblique to the original margins of the volcanic prism. The present writer believes that the apparent discordance results quite simply from the dilational effects of the Mount Albert ultrabasic intrusive.

In the west, the Shickshock Group is downfaulted into discontinuity west of Matane river, and at Lake Matapédia apparently still farther downfaulted, below the present Silurian cover, with a possibly related local recurrence several miles farther west in Awantjish township. In the east, the Shickshock Group appears to taper out against the Tabletop granite intrusive. Lenses of volcanics and minor arkosic sedimentary rocks east and west of the Tabletop mountains (Jones, 1933; McGerrigle, 1953) are interpreted by the writer as probable equivalents of the Shickshock Group by virtue of their position and from suggestions of lithologic affinity (Jones, 1933; Béland, personal communication, 1961).

Along its southern margin, the Shickshock Group makes an abrupt contact with rocks of Silurian age. For most, if not all, of its extent this contact is a fault, probably normal, and has been identified as the South Shickshock fault. At Lake Matapédia the fault is separated from the Shickshock Group by a band of younger slates about one mile wide.

The Shickshock Group appears to be folded for most of its length into a northern syncline and a southern anticline. The flanks of these folds dip at 35° to 60° . Some subsidiary folds occur in the east towards Mount Albert. In the west, folds appear to die out west of Duvivier river, so that the western extremity of the prism and the isolated segment at Lake Matapédia are homoclinal and dip southeastwards. The stratigraphic relationship between the Matane River Group and the Shickshock Group and between the sedimentary and volcanic rocks within the Shickshock Group involves interlensing and interfingering. As a result, lithologic units do not always appear to be directly related to fold axes and are not everywhere symmetrically or continuously distributed around them.

Structural and stratigraphic relationships in the Cuoq-Langis area suggest that an anticlinorium occurs to the north of the Shickshock Group. This implies that the oldest rocks of this part of the Quebec Complex lie several miles north of the Shickshocks and that the succession becomes younger towards the mountains and towards the St. Lawrence. A small area of volcanics lithologically similar to the unmetamorphosed volcanics of the Western Shickshock Mountain region occurs several miles north of the Shickshocks on Gagnon brook, in Saint-Denis township. These volcanics could well mark the downfolded northern continuation of the Shickshock Group north of the suspected location of an anticlinorial axis. Such an anticlinorium would form a complement to the Middle Ordovician synclinorium of northeastern Gaspé.

Figure 6 illustrates the writer's interpretation of the structure, approximately along longitude $67^{\circ}00'$, which marks the eastern edge of the Cuoq-Langis area. The interfingered northwest margin of the Shickshock Group probably has been eroded away. A hidden unconformity might exist between the Cambrian and Ordovician. The South Shickshock fault lineament has been simplified, - e.g., some Shickshock Group may exist on its southeast side, in fault slices. Also, the displacement along the fault zone is a sum of movements, with downfaulting on the southeast most recent, but not necessarily compensating for earlier upthrow on this side as far as the basement is concerned. Compare Figure 6 with Figure 2.

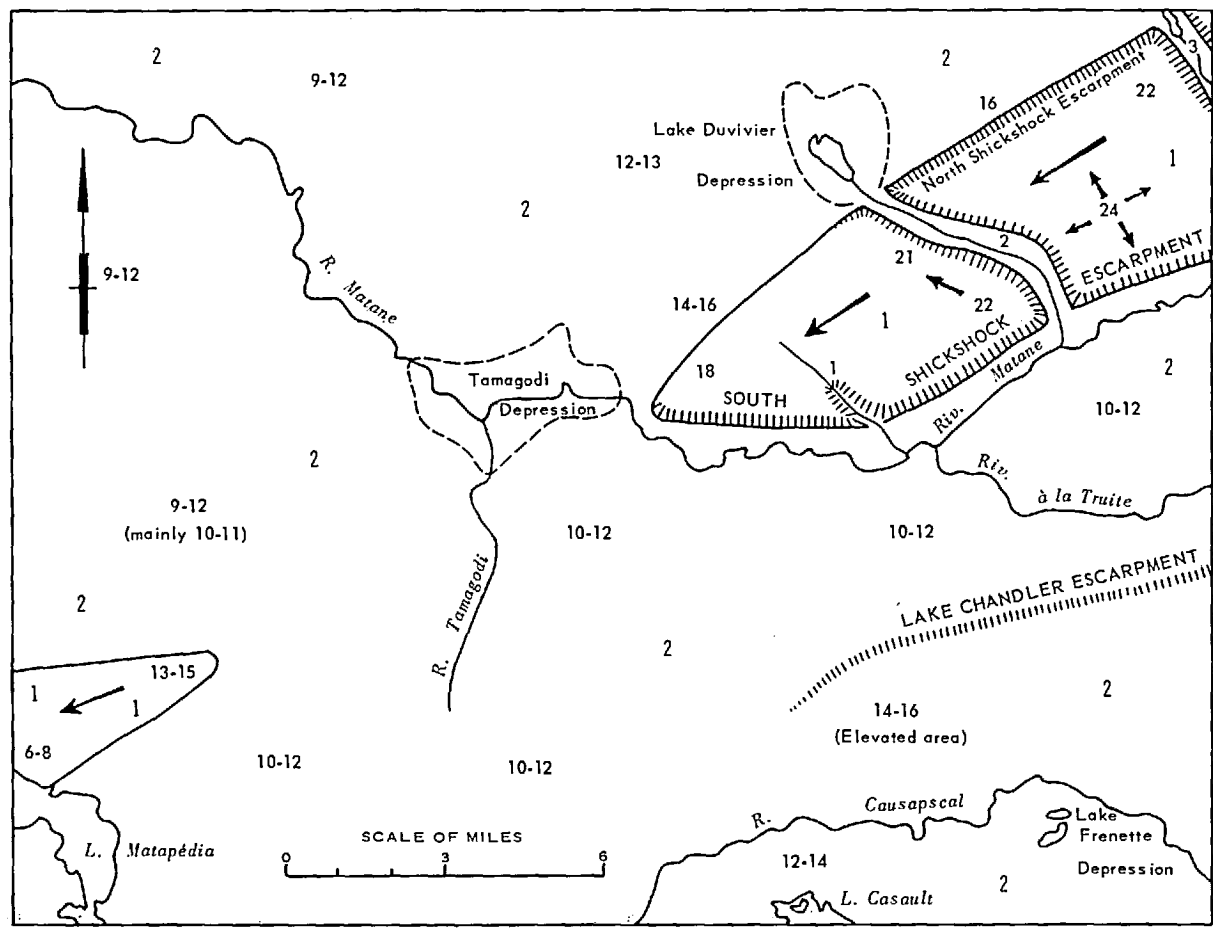
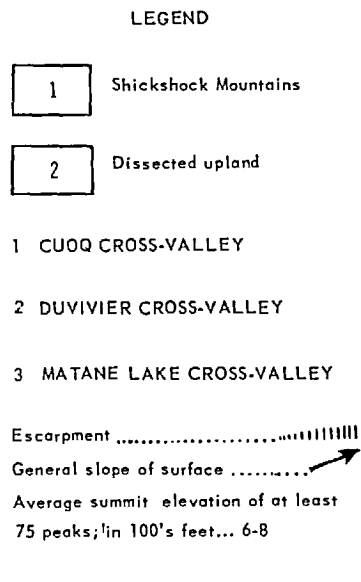


Figure 6

PHYSIOGRAPHIC DIVISIONS OF THE CUQ-LANGIS AREA

PHYSIOGRAPHY

The Cuoq-Langis area is a rugged, dissected upland or plateau, interrupted in part from northeast to southwest across the center by the westernmost extension of the Shickshock mountains. The upland surface becomes flatter and less rugged locally and slopes into a few minor depressions. The elevation of the area varies from a minimum of 150 feet above sealevel at Matane river in the extreme northwest, to more than 2,900 feet above sealevel at Mount Ouest in the Shickshocks. The Shickshock mountains stand about 1,000 feet above the general level (1,000-1,200 feet) of the surrounding upland. An active, rejuvenated drainage system is deeply incised into the upland and mountain surface. The Matane has cut a deep, arcuate, trench (east-west) across the center of the area, and the Matapédia, another (northwest-southeast) across the southwest corner.

Earlier workers (McGerrigle, 1954a, p. 10-12; Mattinson, 1958, p. 20-27), whose map-areas have straddled the Shickshock mountains farther east, have described three main physiographic divisions: 1. The Northern Upland; 2. The Shickshock Mountains; 3. The Southern Upland.

In the Cuoq-Langis area (Fig. 6) the differentiation is not so clearly defined and the uplands merge across the center. For this reason, there are here only two physiographic divisions: 1. The Shickshock Mountains; 2. The Dissected Upland.

PHYSIOGRAPHIC DIVISIONS (Figure 6)

The Shickshock Mountains

The Shickshock mountains are about 5 miles wide where they enter the Cuoq-Langis area in its northeast corner. They form a wedge which extends for about 13 miles southwest, narrowing slightly, to end near the center of the area at Matane river. More than 10 miles farther southwest along the mountain trend, separated from the mountains by an interval of upland, the thin end of a smaller Shickshock wedge appears near Lake Matapédia, projecting only a few hundred feet at most above the upland surface, and merging with the general upland level at Lake Matapédia. Summit levels decrease rapidly from 1,300 to 1,500 feet to 600 to 800 feet in this direction.

In the Cuoq-Langis area, the northern boundary of the mountains is fairly straight, whereas the southern is broadly sinuous. The southern margin forms a conspicuous escarpment (Pl. XXIX) which rises abruptly 1,400 to 1,600 feet above the main floor of the Matane valley.



The southern escarpment of the western Shickshock mountains. Looking northeast from the Tortue Hill outlier of Val Brilliant sandstone, across Mata-ne river towards the western end of the Shickshock mountains.

This escarpment diminishes gradually westwards to merge with the general upland surface. Above the escarpment the surface rises less steeply, for another 600 feet in the east and 200 feet or so in the west. The northern boundary forms a small escarpment in the Cuoq-Langis area, with a relief of 600 feet.

Two strong, northwest-southeast cross-valleys break the continuity of the mountain belt. They are deeply incised, canyon-like, and bounded by scarp-like walls up to 1,600 feet high. In places the valley floors widen to almost 1/2 mile across. The first of these valleys cuts across the northeast corner of the Cuoq area. Through it flows the upstream, southbound part of Matane river, passing en route through Lakes Leclercq and Matane (the latter just east of the area). The second valley is more than 5 miles to the southwest, and Duvivier river flows southeasterly through it. The Duvivier valley is less impressive than the Matane Lake valley and is more youthful. To the west of Duvivier valley, Cuoq brook is actively cutting another valley back across the mountains.

The Dissected Upland

There are no major differences between the northwest and southeast portions of this upland. The general summit level is between 900 and 1,200 feet, with local increases up to 1,700 feet. The Lake Chandler escarpment rises 400 to 500 feet above the general surface to the north, and parallels and faces the main southern escarpment of the Shickshock mountains 4 to 5 miles farther south and dies out westwards towards Lake Cajettan. This escarpment faces and parallels the southern escarpment of the Shickshock mountains which lies 4 to 5 miles farther north. Lake Chandler lies in a small depression at the base of this escarpment.

Drainage

Almost the entire drainage of the Cuoq-Langis area belongs to the Matane River system except in the southwest and southeast, where streams contribute to the Matapédia River system via Lake Matapédia and the Causap-scal river respectively. Separating these systems, the main east-west Gaspé watershed passes through the southern part of the area. The complete local drainage system is shown on the accompanying geological map and is summarized in Figure 7.

The drainage system is in an active stage of rejuvenated immaturity, particularly at the tributary level, where valleys are commonly V-shaped in cross profile, and have fairly steep longitudinal profiles. Drainage development in the Shickshock mountains has progressed more slowly than in the surrounding upland as a result of the relatively greater

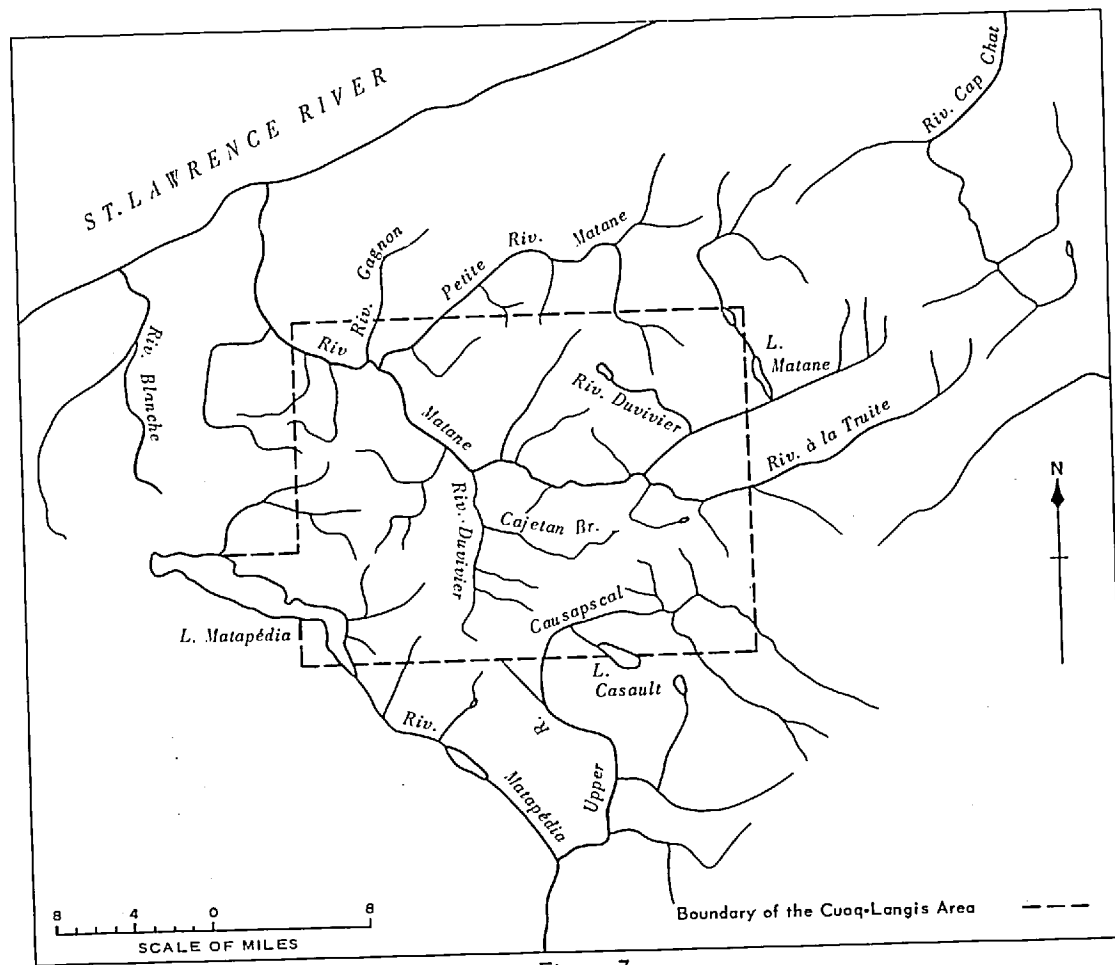


Figure 7
DRAINAGE PATTERN OF CUQ-LANGIS AND THE SURROUNDING AREA

D.N.P.O. 1965-B-843

resistance to erosion of the rocks forming the mountains. For this reason the Shickshock drainage is the most immature in the area. Waterfalls and rapids are a common feature of the mountain streams, particularly along the southern escarpment. The sub-dentritic pattern of the tributary streams shows that integration has not yet reached their level. The greatest maturity is attained by Matane river, which has reached the stage of a steep-sided, flat-bottomed, deeply entrenched valley. There are no waterfalls along its length in the area and there are few rapids.

Lakes

Lake Matapédia is the largest lake in Gaspé peninsula. It is about 11 miles long, averages 1 1/2 miles wide, and covers about 15 square miles. Originally, it was probably larger. Situated at the head of the Matapédia valley, the lake overflows southeastwards via Matapédia river. At the southeastern end of the lake, Matapédia valley is floored by an undulating blanket of drift, largely of glaciofluvial sands and gravels, and including several kame-like forms. As Alcock (1935, p. 97) suggested, this fill serves as a natural earth dam. However, several other factors may also have contributed to the lake development. For example, as the lake is along the margin of relatively flat-lying Silurian strata where they abut across the grain of the harder and more steeply dipping Shickshock Group, preferential erosion could have been a factor. Possible faulting along the lake site may have further facilitated erosion.

Several dozen small lakes occur in the area. The distribution is interesting, and reveals a strong tendency to concentrate on the more resistant lithologies. In particular, these small lakes are conspicuously concentrated on the Grande Grève and York River Formations in the southeast corner of the area. Seventy per cent of the small lakes occur here, including the not-so-small Lake Casault. Lakes in the Matane River Group are commonly associated with the Kamouraska facies. Lake Duvivier also occurs on rocks of the Matane River Group, but is a special case, where a small drainage basin has developed adjacent to the north front of the mountains, as a result of differential erosion and a probable reversal of stream flow. Several small lakes occur amongst the Shickshock summits. These have the essential appearance of cirques, complete with threshold.

Lakes Casault, Frenette, and Tremblay in the Cuoq area, lakes Causapsca and des Huit-Milles in the Causapsca area to the south, and several smaller lakes, lie in the center of the Lake Casault syncline, on the York River Formation. The structural depression has been preserved by erosion. The whole basin has a locally thick drift cover (even the islands in Lake Casault are composed, or at least crowned by drift) which has modified the lake distribution but does not appear to have been responsible for lake development.

In the extreme northeast, Lake Leclercq is a member of a lake system which includes Lake Matane and covers much of the floor of the Lake Matane cross-valley. Once again, these lakes appear to be the result of a combination of glacial erosion and deposition (glaciofluvial).

It is probable that the depression in Matane River valley at the western end of the Shickshock mountains, referred to as the Tamagodi basin, was at one time a lake. Terraces occur in places along its borders and the lower reaches of Langis river are incised. Half a mile downstream from Rivière Matane village, Matane river has cut a narrow channel through a pronounced ridge of limestone beds and there is a suggestion of a spillway channel along the northeast valley side. Plugging the channel through the ridges, by less than 100 feet, would create a lake about 5 miles long. Less than 200 feet of fill would create a lake nearer 10 miles long. It is probable that this ridge once acted as, or formed the nucleus of, an obstruction.

Very thin-bedded unconsolidated strata resembling varved clays were discovered on the east bank of the Duvivier river, a short distance upstream from the Matane. Similar deposits were found on several other tributaries of the Matane at different elevations. In all cases they are very localized and overlain by loose soil. Their exact significance is not clear, except that they are certainly lacustrine or marine. No fossils were observed. Local ponding by ice masses appears to be the most reasonable explanation.

Structural-Lithological Control of Topography

A comparison of the geological map of the Cuoq-Langis area with the topographic map and the physiographic divisions outlined above reveals the strong influence of bedrock on topography. This geological control is apparent in both the general divisions and in detailed features within them.

The north and south boundaries of the Shickshock mountains proper in the Cuoq-Langis area are of particular interest. They represent a complete reversal of conditions farther east, where the majestic northern escarpment towers above its associated trench, and overshadows the less impressive southern escarpment. In the present area, the strong southern escarpment overshadows a weak northern one, which virtually disappears west of Duvivier river. The reasons for this lie in the geology and the associated drainage development. Interbedding along the north front of the Shickshock mountains at the marginal western extension of the Shickshock Group and the relative decrease of volcanics in this direction, concomitant with a decrease in metamorphic grade, reduces the lithological contrast

between the Shickshock Group and the shale sequence to the north. Eastwards, where the interfingering Shickshock Group shale sequence margin has been eroded away, the contrast and resultant differential erosion are stronger.

Peneplanation

Several previous workers have mentioned the possibility of peneplaned surfaces within the Shickshock mountains and the surrounding uplands. Alcock (1944) related the Shickshock summits between 3,000 and 4,000 feet to a "Shickshock peneplain" of late Cretaceous or early Tertiary age, and designated the upland surface surrounding the Shickshocks the "Gaspé peneplain" of probable late Tertiary age. McGerrigle (1954a, p. 12) observed that the 3,000-foot contour in the Shickshock mountains of the Courcelette area "...is so general a marker of tops..." that it must be considered in any differentiation of peneplains and that another pronounced levelling off occurs at 2,700 to 2,800 feet. Mattinson (1964) made a statistical study of summits in the Mount Logan area and decided that, although there is a strong visual impression of summit accordance, the distribution of summit levels plotted on a cumulative curve only suggests a moderate concentration of summits between 1,800 to 2,200 feet and 2,300 to 2,900 feet. Both these surfaces slope southward and slightly to the west.

Thus, it appears that levels of summit accordance locally extend from 1,800 feet to 4,000 feet in the Shickshock mountains, covering virtually the complete range of summit elevations possible. It is apparent from this confusion that, if relict peneplanation does exist in this region, it is complex.

In the Cuoq-Langis area, the writer made a compilation of all the summit elevations from contoured maps. Simple statistical analysis and graphic representation of particular frequencies were preferred to profile or even projected profile analysis.

Cumulative frequency curves of summit elevation revealed that, in the Shickshock mountains, west of Duvivier river, 75% of summits fall within the interval 1,800 to 2,200 feet. East of Duvivier river, nearly 80% fall within the range 1,900 to 2,500 feet. Combining the two areas 60% fell within the range of 1,800 to 2,200 feet. Thus, overall analysis for the Western Shickshock mountains reveals a definite summit accordance at 1,800 to 2,200 feet, with a slight westward slope.

Analysis covering the main Dissected Upland (excluding the "foothills" adjacent to the north front of the Shickshock mountains and the elevated plateau region in the southeast) revealed that 80% of all summits fall within the interval from 900 to 1,200 feet, whereas 50% fall into the

1,000- to 1,100-foot interval (predominantly 1,100 feet). Towards the north front of the Shickshock mountains, summit levels increase from 1,400 to 1,600 feet. The elevated plateau of the southeastern part of the area was analysed in two parts, north and south, respectively, of Causapscaal river, corresponding essentially with the Grande Grève and York River Formations. North of the river, 75% of the summits fall into the 1,400- to 1,600-foot interval. South of the river, nearly 100% of the summits fall into the 1,200- to 1,400-foot interval.

In summary, evidence from the Cuoq-Langis area shows very definite summit accordance at several different levels within the area, which largely correspond to topographic divisions or subdivisions, and which have themselves been shown to be directly related to underlying lithologies. The inference is simply that degradation maintains a fairly constant surface for rocks of a given resistance, but differs between areas of different resistance. This lithological control appears to be well defined here. It is possible that a peneplaned surface is preserved in the Shickshock mountains, but, if so, it is complex, probably tilted westwards (hence the range of elevations given by various workers) and requires comprehensive statistical analysis of a regional, not local, scope.

Glacial Modification

The ubiquitous distribution and abundance of locally derived material in the surface drift proves the contribution of glaciation to the erosional sculpture and denudation of the area. However, no major erosional features attributable to ice sculpture, if such were effected, have survived. The topography is generally rugged and the valleys are V-shaped. Minor modifications are everywhere apparent and include: incipient cirque development in the Shickshock mountains; incipient smoothing and probable local deepening of the major valleys; local polishing, plucking and striating of outcrops of resistant lithologies; and distribution of erratics. It would appear, from the quality and quantity of erratics, that the well-jointed Silurian and Devonian Formations suffered particularly heavy erosion. A trend of ice movement (probably the youngest) has been established from surface striation as northwest to southeast. Evidence of this kind is particularly abundant around Lake Matapédia and, on one outcrop of volcanics, a small-scale crag-and-tail effect, involving quartz amygdules, indicates ice movement towards the northwest.

Drainage Development

The writer holds the following general views, relevant to the regional background of drainage development:

1. Drainage to St. Lawrence river and Chaleurs bay is essentially consequent, and the Matane and Matapédia systems are consequent streams.
2. The higher resistance to erosion of the Shickshock Group restricted the development of St. Lawrence drainage, permitting encroachment by Chaleurs bay drainage and migration of the watershed northwards, locally into the Shickshock mountains.
3. The stronger grain of the bedrock in the north led to the development of subsequent streams and a trellis pattern, whereas tributaries of the southern systems are more insequent in nature and dendritic in form.
4. Preferential subsequent stream development, restrictions on expansion, and intra- and inter-system captures have modified the trellis pattern and reduced the basins of the major rivers draining into the St. Lawrence.

Several suggestions have been put forward concerning the development of the Matane and Matapédia drainages. Alcock (1928; 1935) suggested that the present upper valley of Matapédia river was eroded by a river flowing north to the St. Lawrence, of which the Causapschal was a tributary. Stearn (1965) strongly refuted this hypothesis, largely on the grounds that it is unnecessary. Mattinson (1958) suggested that "flowage through the gorge now occupied by Matane Lake originally was northward". He suggested that the southward tilting of the peninsula rather than glacial deposition may have promoted the reversal of flow. He further suggested that "both the Matane and Cap-Chat rivers are probably superimposed streams which incised their canyons across the Shickshocks during a period of uplift". He rejected the possibility of stream capture, and preferred drainage reversal, on the grounds that the Matane Lakes gorge is too broad and deep for headward erosion and appears to have been "occupied by a fairly large through-going stream".

The Problem of Matane - Matapédia Relationships (Figure 8)

Figure 8 reveals the vagaries of the present drainage pattern and indicates several earlier relationships. The most striking general features are the circular drainage patterns commonly developed. Examples are the Causapschal, the Matane - Petite Matane, and the Duvivier - St-Jean systems. Similar patterns are common in acknowledged classic areas of river capture.

Apparently the upper reaches of Causapschal river constitute the original headwaters of the Matane. The Matane has all the appearance of a beheaded consequent stream. The upper Causapschal flows directly north

towards the Matane before swinging suddenly and anomalously south. A fill of 100 to 200 feet would be sufficient to divert the upper Causapschal waters via Pelletier lake into the rejuvenated but essentially misfit valley of Cajettan brook and thence down the Tamagodi to the Matane. In view of the fact that only its erosion of its own valley has lowered the river by this amount, it must at one time have flowed at or above the height of the gap and certainly towards it.

The implication of the above capture is that at this point the St. Lawrence - Chaleurs Bay watershed was originally much farther south. Unless the original watershed commenced with an extensive narrow embayment up through Lake Matapédia, the Matapédia system has captured that region too, reversing an original northwards flow, possibly through Blanche river. The pattern certainly has all the appearance of encroachment.

The Problem of Matane Development

Matane river appears to have developed originally as a straightforward consequent stream, cutting its course through the line of least resistance between the Shickshock mountains and Lake Matapédia. The Tamagodi and probable Causapschal river extensions formed its headwaters. In compliance with the grain of the country, subsequent streams developed, notably the Petite Matane to the north and the upper Matane along the southern margin of the Shickshock mountains. Brecciation along this faulted southern margin conferred a strong advantage on the latter and, even before the loss of the Causapschal headwaters, it had probably become the main, upstream portion of the Matane, converting the latter from a consequent to the composite consequent-subsequent river it is today. The upper Matane river probably included the headwaters of the present Cap Chat river at the beginning, as the cross-valleys were a later phase in the development, and the Cap Chat river would have had no access to the south.

Truite river appears to be another subsequent tributary stream. From its direction and the topography it seems evident that it formed its valley along the Lake Chandler fault and flowed originally via Cajettan brook into Tamagodi river until captured by a stream cutting back from the lower local base level of the nearby Matane River valley. Later, still more of the beheaded Cajettan brook was captured by Chandler brook.

The origin of the cross-valleys is a key to the main problem of the Matane's development. No major dislocation has been traced along them. The probable answer is suggested by the present situation at the western end of the Shickshock mountains where, from west to east, the successive stages of cross-valley development are clearly visible. In the west, Cuoq brook represents the incipient cross-valley in its early growth

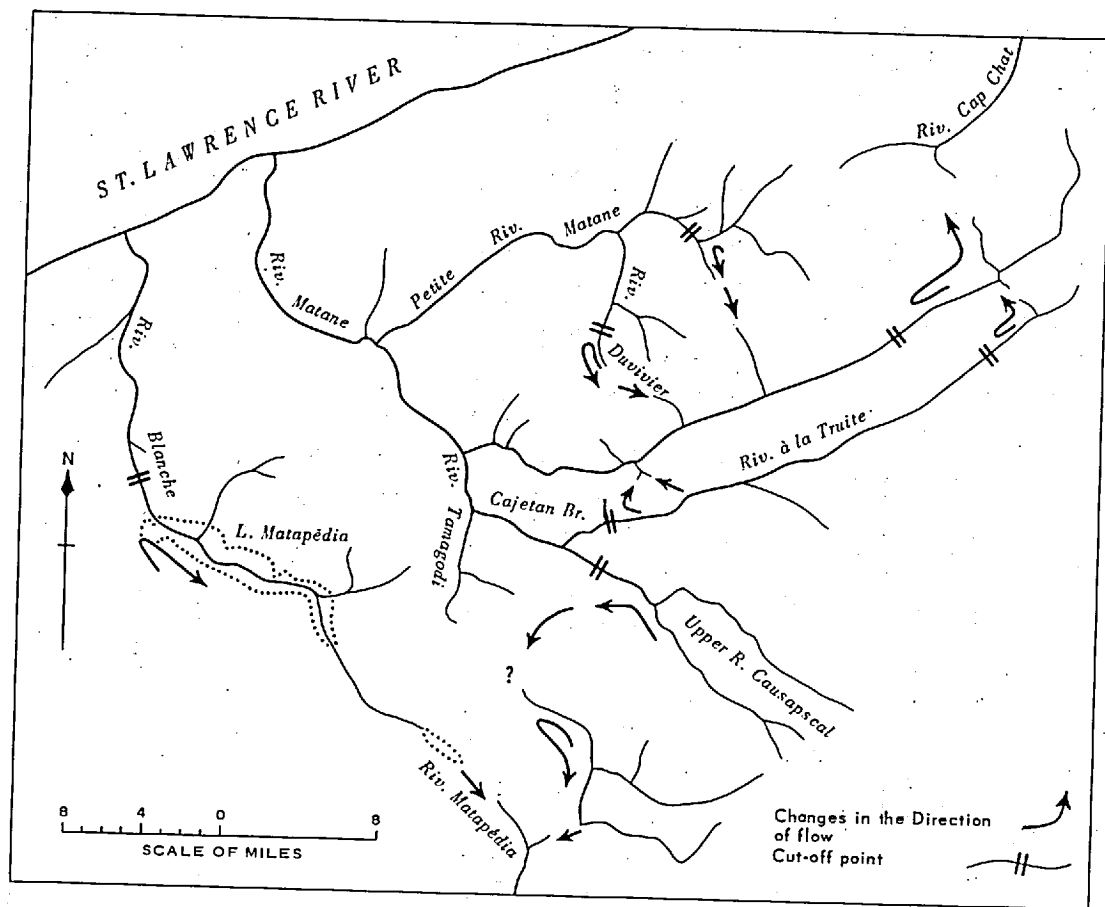


Figure 8
 SUGGESTED CHANGES IN THE DRAINAGE PATTERN OF NORTHWESTERN GASPÉ

D.N.R.Q. 1965 B-843

stage. Farther east, Duvivier valley represents an advanced stage. Farther east still, the Matane Lakes valley is the final stage.

Tributary streams, flowing from the Shickshock mountains north and south into the subsequent streams entrenched along their flanks, cut back into the mountains, as Cuoq brook is doing at present. Juxtaposition of two major local streams cutting from either side of the mountains would facilitate cross-valley growth, although one major stream would possibly suffice. In the ensuing competition for control of the developing valley victory would inevitably go to the stream with the lowest local base level. Here, upper Matane river on the faulted, more easily eroded, south side of the Shickshock mountains would hold the advantage and slow capture of the northern half of the valley would result. This appears to explain why the upper Matane flows, and since the formation of the cross-valley has probably always flowed, south.

The Duvivier cross-valley offers good evidence of the process suggested. Here, two streams probably combined, one flowing north to Tremblay brook, the other south to Matane river. Remnants of the old divide between these two streams are still visible just south of the valley center, breached by the still downcutting, southbound river. The Matane Lakes cross-valley is simply a more advanced stage of this same process, probably deepened through erosion by glaciers. Once the Matane Lakes cross-valley was established the capture of the upper Petite Matane river followed, as, at some future date, Duvivier river may capture Tremblay brook.

ECONOMIC GEOLOGY

Oil and Gas

Oil and gas possibilities are restricted to the Silurian-Devonian sequence in the southeastern half of the Cuoq-Langis area. There is minor evidence to indicate the presence of petroleum in these rocks. For example, a distinct petroliferous odor is commonly emitted from freshly broken surfaces in the Cape Bon Ami Formation and, locally, in the Sayabec Formation. In addition, several small globules of light, yellow oil were noted along the south bank of Matane river (in ranges VIII and IX of Cuoq township), in fault breccia fragments from the Saint-Léon Formation, and a small outcrop of dark gray sandstone of the same unit.

There are no obvious reservoir rocks in the area. Even the highly organic and locally reefoid Sayabec Formation limestones are commonly fine grained, contain shaly layers and partings and have only local and limited porosity.

Structural traps are the most likely potential source of oil and gas in the area. However, suitable structures appear to be rare, in view of extensive faulting and flat lying strata. The Saint-Tharsicius anticline and the local anticline southwest of Truite river are worth investigating.

In 1958, a well (Associated Developments Causapscal No. 1 Well) was drilled about 8 miles south of the Cuoq-Langis area, in the Matapédia valley. This well penetrated 4,695 feet of the Saint-Léon Formation and yielded only inconclusive evidence of petroleum prospects.

Metallic Minerals

Copper

Small flecks and stringers of chalcopyrite and bornite and small patches of malachite occur locally in small veins in the basic volcanics of the Shickshock Group on the north shore of Lake Matapédia. Calcite is commonly the gangue mineral.

In the Shickshock mountains, traces of chalcopyrite were noted in the Shickshock Group at two localities. Firstly, in a diabase intrusion on Tremblay brook, and, secondly, at a locality about 1 1/2 miles east of the Depot Jean, a few hundred feet north of the road along the north side of Matane river. Prospect pits have been dug at both of these localities.

Aubert de la Rûe (1941, p. 28) reported chalcopyrite traces and malachite stains in the Matane River Group shales about 1/2 mile south of Canton Tessier. Reports are on file with the Department of Natural Resources that traces of chalcopyrite and disseminated copper have been found in lots 31 and 32, range VI of Langis township, again in the Matane River Group.

Iron

Iron-rich jasper and hematite (commonly siliceous) are widely distributed in the basalts of the Shickshock Group on the islands and the north shore of Lake Matapédia. They occur in small patches, lenses and veins, typically measurable in inches and locally filling pockets between pillow structures in the basalt. The jasper is commonly laminated, whereas the hematite and siliceous hematite are mainly botryoidal. The exposed occurrences are too small and scattered to be of commercial value. A loose block of jasper 1 foot by 2 feet by 2 feet was found just north of the lake. The jasper was fractured and traversed by numerous white quartz veins.

Disseminated fine flecks and crystals of pyrite occur locally throughout the Shickshock Group and the Matane River Group. Rare, small lenses of finely crystalline pyrite, up to 1/2 by 4 inches, occur locally in the Matane River Group shales.

Silver

The records of the Department of Natural Resources show that traces of silver were found in an outcrop of black Matane River Group slates (some pyrite), in the south ditch of the east-west road about 1/4 mile north of Saint-Nil church. The maximum assay of 0.24 ounce of silver a ton was from minor vein material.

Non-metallic Minerals

Silica

Sandstones of the Val Brillant Formation and quartzites of the Kamouraska facies are locally potential sources of silica. Analyses of these rocks reveal silica contents of 94% (Kamouraska) and 98% (Val Brillant Formation) respectively. These percentages could be increased by careful selection. Iron contamination appears to be the main problem, owing to its patchy but widespread distribution. Some of the more favorable localities include the Kamouraska quartzites exposed along Sableux brook (Langis township, ranges IV and V, lots 5-10), and Bastien brook (Matane township, ranges XII and XIII), and the Val Brillant sandstones in Blais, Langis and Cuoq townships (see map).

Construction Materials

According to earlier reports (Alcock, 1925 and Aubert de la Rue, 1941), the Val Brillant sandstones, Sayabec limestones and Saint-Léon siltstones have all been used as building stones, particularly in the churches of the region. Future use appears to be limited, as the cost of dressing natural stone exceeds that of current synthetic building materials, so that potential uses are entirely decorative. None of the local stones are sufficiently unique or attractive to promote their export beyond the region.

Sand and Gravel

Gravel reserves are moderately good in the area but the material is generally of moderate to poor quality and commonly poorly sorted. The gravel is mainly used for road construction and maintenance. No major sand deposits are apparent. The best sands occur in the flood-plain

deposits along Matane river and consist of lithic sand in bodies that are too thin and spread out to be of significant economic value.

Sand and gravel deposits in the Cuoq-Langis area can be divided into two categories, namely alluvial and glacial.

The glacial deposits form a widespread drift cover. Much is glaciofluvial, but of an immature type, with pebbles, cobbles and small boulders set in a matrix of argillaceous sand, commonly with only minor stratification. Across the main part of the area, scattered gravel pits are found in local glaciofluvial deposits; two such pits are in range IV of Blais township, northeast of Saint-Tharsicius.

Alluvial deposits are more localized than the glacial. The best alluvial deposits occur along Matane river, from its confluence with the Truite downstream. These deposits are commonly 10 to 50 feet thick and are locally terraced. Numerous gravel pits are located along the valley and several of these are still in use. Moderate reserves still exist.

Most sands and gravels occurring around Lake Matapédia are remnants of higher lake levels but there are also glaciofluvial deposits. Several small gravel pits are found around the lake. The largest of these is on the south shore of the lake at the eastern end and displays large-scale crossbedding, suggesting a deltaic deposit. Similar lacustrine and glaciofluvial deposits occur around Lake Leclercq, in the Matane Lakes valley in the northeast corner of the area.

APPENDIX A

SYSTEMS OF CLASSIFICATION AND NOMENCLATURE USED

1) SIZE CLASSIFICATION OF DETRITAL PARTICLES

Suggested Classification of Detrital Particles as Indicated by Consensus of
Opinion of Members of Committee on Sedimentation*

<u>Millimeters</u>	<u>Inches</u>	<u>Suggested Name</u>
2048-4096	80-160	Very large boulders
1024-2048	40-80	Large boulders
512-1024	20-40	Medium-sized boulders
256-512	10-20	Small boulders
<hr/>		
128-256	5-10	Large cobbles
65-128	2.5-5	Small cobbles
<hr/>		
32-64	1.3-2.5	Large pebbles
16-32	0.6-1.3	Medium-sized pebbles
8-16	0.3-0.6	Small pebbles
4-8	0.16-0.3	Very small pebbles
2-4	0.08-0.16	Extremely small pebbles (or perhaps granules or grit)
<hr/>		
<u>Microns</u>		
1-2	1000-2000	Very coarse sand
1/2-1	500-1000	Coarse sand
1/4-1/2	250-500	Medium-grained sand
1/8-1/4	125-250	Fine sand
1/16-1/8	64-125	Very fine sand
<hr/>		
1/32-1/16	32-64	Coarse silt
1/64-1/32	16-32	Medium-grained silt
1/128-1/64	8-16	Fine silt
1/256-1/128	4-8	Very fine silt
<hr/>		
<u>Millimeters</u>	<u>Microns</u>	<u>Suggested Name</u>
1/512-1/256	2-4	Coarse clay
1/1024-1/512	1-2	Medium-grained clay
1/2048-1/1024	0.5-1	Fine clay
1/4096-1/2048	0.25-0.5	Very fine clay

* See National Research Council, Division of Geology and Geography,
Annual Report for 1941-42, Appendix G, p. 3.

2) SIZE CLASSIFICATION FOR CRYSTALLINE CARBONATE ROCKS

<u>Size</u>	<u>Name</u>
1 mm. and over.....	Very coarsely crystalline*
1/2 mm. - 1 mm.	coarsely crystalline
1/4 mm. - 1/2 mm.	medium crystalline
1/8 mm. - 1/4 mm.	finely crystalline
1/16 mm. - 1/8 mm.	very finely crystalline
1/256 mm. - 1/16 mm.	microcrystalline
Less than 1/256 mm.	cryptocrystalline (dense)

3) CLASSIFICATION OF BEDDING

<u>Size</u>	<u>Name</u>
10 feet and over	massive beds
4 feet - 10 feet	very thick beds
2 feet - 4 feet	thick beds
6 inches - 2 feet	medium beds
2 inches - 6 inches	thin beds
1/2 inch - 2 inches	very thin beds
1/8 inch - 1/2 inch	laminae
Less than 1/8 inch	thin laminae

4) CLASSIFICATION OF SANDSTONES

Unless otherwise stated, the classification proposed by Pettijohn (1957, p. 291) is followed. Note that the terms calcarenite, calcisiltite and calcilutite are used to differentiate detrital sedimentary rocks composed of sand-silt- and clay-sized clastic carbonate grains respectively.

5) STRATIGRAPHIC NOMENCLATURE

The "Code of Stratigraphic Nomenclature", proposed by the American Commission on Stratigraphic Nomenclature (1961) is followed throughout.

* Alternatively written, very coarse-grained, coarse-grained, etc.

APPENDIX B

KAMOURASKA FACIES

SECTION AT GOUPIL VILLAGE

The great lateral and vertical variations in the stratigraphy of the Kamouraska facies between different lenses or even within a single lens renders the description of a standard section impossible. However, the section given below serves as a guide to the type of stratigraphy involved, and is designated as the local type section for the Kamouraska facies of the Cuoq-Langis area. The section is described in descending order.

Location: Tessier township, range X, lot 28, approximately 400 feet north-west of road separating ranges X and XI.

<u>Unit</u>	<u>Description</u>	<u>Interval in Feet</u> (Thickness in feet)
11	Limestone conglomerate: [*] pebble- to cobble-sized phenoclasts orientated parallel to the bedding. Phenoclasts: mainly fine- to medium-grained light to medium gray, light gray-weathering limestone; minor calcareous sandstone and siltstone; rare, black, cherty slate fragments. Matrix: quartz sandstone, calcareous and dolomitic, medium grained, light gray, whitish weathering; weathers in relief.	107-111 (4)
10	<u>Quartzite</u> ^{**} : calcareous; medium grained; light yellowish gray, whitish weathering; moderately to well sorted; scattered pebble-sized limestone phenoclasts throughout, increasing over basal foot and recessive-weathering to produce a pitted surface; small scattered slate fragments; unbedded.	102-107 (5)
9	<u>Limestone conglomerate</u> : pebble- to cobble-sized phenoclasts with a bed of larger cobble-sized phenoclasts just below the middle; sandstone lenses containing scattered limestone phenoclasts occur in the upper third of the unit, which is gradational into the overlying quartzite of unit 10; a bed of calcareous sandstone, 6 inches thick, with a sharp base and pebbly, gradational top occurs above 93 feet;	90-102 (12)

* This conglomerate bed forms localized remnant patches owing to erosion, and the underlying quartzite actually caps the ridge.

** The term quartzite is used for both the typical hard, silica-cemented sandstones and their softer, carbonate-cemented varieties.

<u>Unit</u>	<u>Description</u>	<u>Interval in Feet</u> (Thickness in feet)
9	<p>phenoclasts are conspicuously orientated parallel to the bedding.</p> <p>Phenoclasts: mainly fine- to medium-grained light gray limestone with minor fine-grained calcareous sandstone; predominantly elongate to tabular in cross-section; subrounded to rounded.</p> <p>Matrix: quartz sandstone; calcareous and dolomitic; medium grained; light gray, whitish weathering; moderately to poorly sorted.</p>	
8	<p><u>Limestone conglomerate</u>: consisting predominantly of large, flattish cobble- and boulder-sized phenoclasts; conspicuously stacked parallel to the bedding and closely packed; several large boulders (including a boulder measuring 5'4" in its greatest observable dimension) occur in the conglomerate along strike from this and the adjoining units.</p> <p>Phenoclasts: consist predominantly of slightly sandy (quartz), fine- to medium-grained, light gray limestone, with minor limestone conglomerate and argillaceous, dolomitic, laminated siltstone; tabular to sub-tabular; rounded to subrounded.</p> <p>Matrix: quartz sandstone, as in Unit 9</p>	86-90 (4)
7	<p><u>Limestone conglomerate</u>: pebble- to cobble-sized phenoclasts with a bed of cobble and small boulder sizes between 73 and 75 feet; phenoclasts tend to be orientated parallel to the bedding.</p> <p>Phenoclasts: fine-grained, light gray limestones predominate, with common sandy and silty varieties (some faintly laminated), minor, scattered, small, black, cherty slate fragments and a few of limestone conglomerate; relatively flattish to tabular in cross-section; subrounded to well rounded.</p> <p>Matrix: quartz sandstone, as in Unit 9.</p>	70.5-86 (15.5)
6	<p><u>Quartzite</u>: calcareous and dolomitic; fine to medium grained; light brownish gray, yellowish white-weathering; moderately to well sorted; unbedded, apart from rare bedding traces revealed by scattered, small, recessive-weathering limestone phenoclasts; bed stands out in relief from conglomerate units; blocky fracture.</p>	69-70.5 (1.5)
5	<p><u>Limestone conglomerate</u>: pebble- to cobble-sized phenoclasts more or less orientated parallel to the bedding.</p>	68-69 (1)

<u>Unit</u>	<u>Description</u>	<u>Interval in Feet</u> (Thickness in feet)
	Phenoclasts: mainly fine-grained, light gray limestone, with scattered small pebbles of hard, ferruginous dark gray slate; mixture of equidimensional, flattish and tabular shapes.	
4	<u>Limestone conglomerate</u> : mainly pebble- to cobble-sized phenoclasts; tabular and flattish phenoclasts orientated parallel to the bedding; interbedded with minor, thin, pinching and swelling beds of gray slate (similar to that described in Unit 3 below) cleaved parallel to the bedding; a 3-foot bed of conglomerate near the top of the unit has a dolomitic, argillaceous and silty matrix, with a thin slate bed near the middle, representing a mixing of original gravel, sand and mud; local grading from conglomerate to slate suggests a normal succession. Phenoclasts: mainly fine-grained, light gray, very light gray weathering limestone, with minor similar limestone containing silt- to medium sand-sized grains of quartz; many tabular; subrounded to rounded. Matrix: quartz sandstone; dolomitic, calcareous; fine to medium grained; light gray, weathering whitish buff.	49-68 (19)
3	<u>Slate/Quartzite</u> : largely covered, but scattered outcrops account for most of the interval, comprising a succession of medium to thick slate beds alternating with thin to medium and rare thick commonly lenticular or pinching and swelling quartzite beds; slate exceeds quartzite; quartzite beds become thicker towards the top; a medium-sized lens of limestone conglomerate occurs just below the top. Slate: medium gray, weathers similar (rusty brown along separation surfaces); contains numerous fine-grained quartzite laminae several mm. apart, which pinch, swell and lens out laterally and are commonly minutely corrugated. Quartzite: silica-cemented, quartzitic sandstone; fine to medium sand-sized; light brownish gray, whitish buff-weathering and friable at weathered locally.	12-49 (37)
2	<u>Quartzite</u> : slightly calcareous and dolomitic; fine- to medium-grained; light brownish gray, whitish buff-weathering and friable at weathered surface; unbedded except for a trace of lamination in upper 6 inches; well-sorted.	9-12 (3)
1	<u>Slate/Quartzite</u> : an alternating succession of medium-sized slate beds and thin beds of quartzitic sandstone. Lithologies similar to Unit 3 above.	0-9 (9)

APPENDIX C

COMPOSITION OF THE PHENOCLASTS IN THE COMMON TYPE OF

KAMOURASKA LIMESTONE CONGLOMERATE

The various phenoclast lithologies are listed below in decreasing order of importance.

Limestone: consisting of very finely crystalline to cryptocrystalline calcite, varying from a uniform rock to a streaky, patchy to clotted texture, differentially recrystallized. Vague, relict, pelletoidal textures are visible in some phenoclasts. The rock is mainly light to medium gray, weathering light gray. It commonly has an incipient internal separation or cleavage. It is the preponderant basic type of phenoclast, but a complete variation range exists from this limestone through sandy limestones into calcareous sandstones or siltstones.

Limestone: essentially variants of the above, differing in increased argillaceous impurity, or darker color, or coarser grain size, or a minor quartz-silt content, or a combination of these properties.

Limestone: similar to the main type, but studded with fine to medium sand-sized, less commonly coarse, subrounded grains of quartz. Some examples weather buff-brown. The quartz in these phenoclasts cannot be distinguished from that forming the matrix.

Sandstone: quartzose, calcareous, and, less commonly, dolomitic; fine to medium sand-size, less commonly coarse. Light to medium gray, commonly buff-brown weathering. Some phenoclasts comprise mixtures of quartz sand and calcarenitic material, much of the latter being finely recrystallized and visible as a relict structure.

Siltstone: essentially similar to the sandstone.

Calcarenite: including both lithocalcarenites and oölitic calcarenites, plus some pelletoidal (possibly pseudoölitic) varieties. Grain size ranges from silt to very coarse sand. Color ranges from light to medium gray. In some oölitic phenoclasts the oöoliths are perfectly formed and preserved, while in others they are distorted and stretched, indicating semi-plastic deformation. "Double-yoked" composite oöoliths are visible in some thin-sections. Envelopes are thin and very abundant (commonly exceeding 20) in the oöoliths of some phenoclasts. Some lithocalcarenites, consisting essentially of limestone grains, contain scattered oöoliths or superficial

ooliths. Several phenoclasts were observed in which the very coarse sand-sized superficial ooliths resemble ostracods. Recrystallization affects the matrix more than the limestone grains or ooliths and the matrix is usually finely to very finely crystalline while the grains and ooliths are commonly cryptocrystalline.

Dolomite and Dolomitic Limestone: fine-grained; weathers buff-brown; some phenoclasts are laminated.

Limestone Conglomerate: consisting of cobble- and pebble-sized phenoclasts of material identical with the surrounding conglomerate. Only second-cycle phenoclasts were observed.

Slate: hard, black and cherty, locally calcareous or ferruginous (forms small chips).

Slate: gray and very similar to that forming the bulk of the Matane River Group.

Fossiliferous Limestone: comprising several phenoclasts of algal limestone and bioclastic limestone containing Salterella. The algal limestone consists of numerous patchy, ellipsoidal areas of cryptocrystalline material. These areas display a vague concentric structure and commonly encircle nuclei of shell fragments. They contain scattered quartz silt, probably picked up in rolling. The matrix between the algal lentils is a calcarenitic quartz-silt mixture, now dense to finely crystalline and patchy.

A thin-section of one Salterella limestone phenoclast reveals a mixture of fragmentary Salterella cones set in a matrix of poorly sorted silt- to coarse sand-sized quartz grains and very fine carbonate. The quartz constitutes around 45% of the rock. Some of the quartz grains are unstrained. The quartz contains numerous inclusions, among which are apatite, tourmaline, zircon and rutile.

Siltstone: quartzose, fine-grained, and medium reddish gray.

Intraformational Conglomerate: comprising tabular fragments of gray limestone in a matrix of the same material, suggesting fracture prior to complete consolidation.

Limestone: pure, whitish, medium-grained.

Granodiorite(?): represented by one small fragment of intergrown quartz and plagioclase; possibly vein material.

APPENDIX D

AGE DETERMINATION OF SHICKSHOCK GROUP METAMORPHISM

Method - K-Ar analysis of muscovite.

Laboratory - Geological Survey of Canada

Geological Survey of Canada Sample No. - GSC 61-184

Sample Collected By - N.C. Ollerenshaw, 1961.

Field No. - NCO-16-2

Location - Cuoq township, Matane county, Quebec, from outcrops along the stream flowing southwest from Mt. Ouest into Duvivier river, about 500 feet northeast of the latter. The co-ordinates of the locality are Lat. 48°40'52"N., Long. 67°04'20"W.

Description

The source rock is a muscovite schist of an unusual sedimentary and metamorphic composition and texture. It was derived by regional metamorphism from a feldspathic graywacke, by partial recrystallization of an incipient cataclastic texture. It is a medium to dark gray rock, lightened parallel to its finely plicated schistosity by an abundance of large, thin, secondary, anhedral muscovite crystals, ranging up to 5 mm. or more in length. Across the plication, these crystals form sharp folds (many of which are sheared) in an irregular, disrupted distribution. Parallel to the plication they have a braided appearance and twist sigmoidally, so that although their extremities parallel the wavy planes of schistosity, their centers are slightly oblique. The muscovite has grown from an extremely fine-grained sericitic matrix in which finely recrystallized quartz predominates, and through which are scattered coarser lenticular grains of sheared plagioclase (oligoclase ?), with lesser quartz and minor apatite. Accessory hematite, tourmaline and numerous tiny, secondary, euhedral garnets occur, with traces of epidote.

Technical

The rock was crushed and pulverized and a muscovite concentrate made from the minus 60 mesh (0.2 mm.) fraction.

Discussion

Analysis produced an age for the development of the muscovite, calculated to be 530 m.y.†, the estimated analytical error of 35 m.y. This date is considerably older than the generally accepted date for the Taconic orogeny. If it is correct, the Shickshock Group was metamorphosed around the Upper Cambrian period (in terms of Kulp's 1961, time scale), and must itself be Upper Cambrian or older.

Several factors should be considered with regard to possible errors in the dating. These are:

1. The analytical error may be larger than expected.
2. Contamination may have occurred and the sample of muscovite may have included fragments or nuclei of older muscovite or have absorbed old argon during growth.
3. The current time scale may be incorrect.

All these factors are possibilities rather than probabilities, and could apply to any such age determinations.

APPENDIX E

EVIDENCE OF TOPS IN THE SHICKSHOCK GROUP AT LAKE MATAPIEDIA

1. Graded Bedding is the commonest structure indicating tops, and occurs in scattered layers, typically only a few inches thick.
2. Crossbedding was observed only at the northwestern limit of the Shickshock Group (Pl. XVI-A).
3. Pillow structures were used wherever their dimensions were clearly exposed in section, following Wilson (1942, p. 62-64) and Billings (1954, p. 77-78).
4. Amygdules were observed, in rare instances, to be concentrated at the tops of pillows or near the tops of volcanic units. They were used as supporting evidence in the determination of tops.
5. Flow breccia occurs locally, but was almost invariably impossible to interpret, owing to its vague distribution and relationships.
6. Contacts between the volcanics and the arkose were of some use in the interpretation of tops.

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ALPHABETICAL INDEX

	<u>Page</u>		<u>Page</u>
Air photographs	3	Charlesworth, H.A.K. -	
Alcock, F.J. -		Ref. to work by	126
Ref. to work by .. 5,12,53,56,59,60		Chert	82
61,63,69,75,93,141,155,157,159,164		Chlorite	71,77
American Commission on Stratig-		Clark, T.H. -	
raphic Nomenclature	167	Ref. to work by	6,9
Arkose	62,65,66,68,74	Coleman, A.P. -	
77,79,81,84,85,86,92,93,101		Ref. to work by	5,12
Aubert de la Rüe, E. -		Cooke, H.C. -	
Ref. to work by	2,6,11,12	Ref. to work by	139
30,32,141,163,164		Copeland, M.J. -	
Bailey, L.W. -		Ref. to work by	96
Ref. to work by	5	Copper	163
Baird, D.M. -		Couture, Y. -	
Ref. to work by	51	Senior assistant to author ...	4
Beales, Dr. F.W. -		Crickmay, G.W. -	
Acknowledgement to	4	Ref. to work by	5,56,60,66
Béland, J. -		102,111,123,142	
Ref. to work by .. 2,10,11,13,32,60		Cumming, L.M. -	
61,95,123,139,141,142,148		Ref. to work by	124
Billings, E. -		Currie, Dr. J.B. -	
Ref. to work by	9	Acknowledgement to	4
Billings, M.P. -		Dapples, E.C. -	
Ref. to work by	106,126	Ref. to work by	92,93
Bornite	163	Decker, C.E. -	
Boucek, B. -		Ref. to work by	122
Ref. to work by	122	DeLong, R.E. -	
Boucot, A.J. -		Junior assistant to author ...	4
Ref. to work by	95,96,102	Denis, T.C. -	
109,110,111,121,122,135,138		Ref. to work by 6,9,12,30,32,56,60	
Burk, C.F. Jr. -		Dolomite	172
Ref. to work by	111,124	Dresser, J.A. -	
Calcarenite	171	Ref. to work by 6,9,12,30,32,56,60	
Calcite	142,163	Eardley, A.J. -	
Carbonneau, C. -		Ref. to work by	6
Ref. to work by	124,129,138	Ells, R. W. -	
Carozzi, A.V. -		Ref. to work by 5,9,11,12,56,59,60	
Ref. to work by	22	Epidote	77,88
Carr, D.R. -		Evans, C.R. -	
Junior assistant to author	4	Ref. to work by	126
Chalcopyrite	163	Fairbridge, R.W. -	
Chalmers, R. -		Ref. to work by	106
Ref. to work by	5		

	<u>Page</u>		<u>Page</u>
Feldspar	75	Lavoie, L. -	
Field mapping	61	Junior assistant to author ..	4
Fritz, Dr. M.A. -		Lemon, Dr. R.R.H. -	
Acknowledgement to	4	Acknowledgement to	4
Ref. to work by	135	Lenz, A.C. -	
Gas	162	Ref. to work by	122
Geological Survey of Canada,		Lespérance, P.J. -	
Ref. to work in	17	Ref. to work by	10
Granodiorite	172	Limestone	21,37,39,40,48,55,110
Gravel	165	117,119,126,164,168,169,170,171,172	
Heinrich, E.W. -		Lister, L.S. -	
Ref. to work by	92	Acknowledgement to	4
Hematite	77,163	Logan, W.E. -	
Hueber, F.M. -		Ref. to work by ...	5,9,12,31,56,60
Ref. to work by	122	Low, A.P. -	
Iron	163	Ref. to work by	5,12,56,59,60
Iron oxides	71	Mattinson, C.R. -	
Jackson, D.E. -		Ref. to work by ..	2,13,59,60,61,64
Ref. to work by	122	86,87,89,91,141,146,147,148,151,159	
Jaeger, H. -		McGerrigle, H.W. -	
Ref. to work by	122	Ref. to work by	6,7,11,13,59
Jasper	163	60,61,91,123,124,129	
Johnson, C. -		138,139,146,147,148,151	
Senior assistant to author ...	4	McInnes, W. -	
Jones, I.W. -		Ref. to work by	5
Ref. to work by	12,129,141,148	Moddle, D.A. -	
Kay, G.M. -		Acknowledgement to	4
Ref. to work by	6	Moorhouse, Dr. W.W. -	
Krumbein, W.C. -		Acknowledgement to	4
Ref. to work by	92	Ref. to work by	75,93
Krynine, P.D. -		Morin, P.L.G. -	
Ref. to work by	93	Ref. to work by	6
Lajoie, J.R. -		Murray, A. -	
Ref. to work by	10,102,104	Acknowledgement to	4
Lakes	155	Ref. to work by	5,31,56
Lamontagne, C. -		Muscovite	25,173
Junior assistant to author ...	4	National Research Council, (Canada)	
Lapworth, C. -		Acknowledgement to	4
Ref. to work by	9	Neale, E.R.W. -	
Laverdière, J.W. -		Ref. to work by	10,139
Ref. to work by	6	Oil	162
		Oliver, W.A. -	
		Ref. to work by	111,135

	<u>Page</u>		<u>Page</u>
Ollerenshaw, N.C. -		Sandstones ..	25,27,49,66,102,103,105
Ref. to previous work	141		106,109,116,117,118,120
Obliths	22,47		130,131,132,135,164,171
Osborne, F.F. -		Savard, H. -	
Ref. to work by	9,10	Cook with party	4
		Schuchert, C. -	
Parks, W.A. -		Ref. to work by	6
Ref. to work by	5,12	Shales	117
Pettijohn, F.J. -		Silica	164
Ref. to work by	24,74,106,167	Siltstones ...	25,110,116,118,119,120
Photographic Surveys (Quebec) Ltd.	3		130,131,132,164,171,172
Plagioclase	71,72,80	Silver	164
Pyrite	164	Slate	20,21,24,26,38,39,66,68
Pyroxene	71,72		69,81,82,84,85,87,170,172
		Sloss, L.L. -	
Quartz	50,74	Ref. to work by	92
Quartzite	37,38,40,49,50	Sphene	71
	55,164,168,169,170	Stearn, C.W. -	
		Ref. to work by ...	2,6,122,123,124
Rasetti, F. -			126,128,129,138,159
Ref. to work by	9,10,16	Tanner, J.G. -	
Raymond, P.E. -		Ref. to work by	6,59
Ref. to work by	9	Thibeault, G. -	
Rejhon, G. -		Cook with party	4
Ref. to work by	32	Tuff	82
Richardson, J. -		Twenhofel, W.H. -	
Ref. to work by	5,31	Ref. to work by	16
Riordon, P.H. -			
Ref. to work by	139	Uffen, R.J. -	
Royal Canadian Air Force	3	Ref. to work by	6,59
Ruedemann, R. -			
Ref. to work by	187	Valliere, A. -	
Russell, L.S. -		Junior assistant to author	4
Ref. to work by	123	Volcanics	7,62,65,68,70,72
			84,85,88,91,92,101
Samson, C. -		Young, G.A. -	
Junior assistant to author ...	4	Ref. to work by	9
Sand	165		

