ORDOVICIAN AND SILURIAN STRATIGRAPHY IN THE INTERLAKE AREA, MANITOBA

A Thesis

Submitted to the Faculty of Graduate Studies

in Partial Fulfilment of the Requirements

for the Degree of

MASTER OF SCIENCE

in the Department of Earth Sciences

University of Manitoba

by

John R. Cowan

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ABSTRACT

The Manitoba Mines Branch in 1969 and 1970 drilled a number of core holes in the Ordovician and Silurian strata in the Interlake Area of Manitoba. This core has provided a complete lithologic section from the top of the Middle Ordovician, Winnipeg Formation, to the base of the Middle Devonian, Ashern Formation.

Previous studies were limited to poorly exposed outcrops, and a relatively small number of quarries. Data obtained from this core permit placement of most of the strata exposed in the outcrops and quarries into their correct stratigraphic position, and define the lateral variations in both thickness and lithology of the stratigraphic units involved in this study.

The carbonate depositional environment varied from infratidal (basinal) to supratidal. Deposition is believed to have occurred primarily in an infratidal to intertidal environment on a slowly subsiding basin with numerous transgressions and regressions.

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CHAPTER I

INTRODUCTION

General Statement

Work on the Ordovician and Silurian stratigraphy in the Interlake area of Manitoba was initially confined to outcrop studies. More recently, chip samples and cored sections from oil exploration test wells have added to the subsurface stratigraphic knowledge. During the summers of 1969 and 1970, the Manitoba Mines Branch was involved in the drilling of eighteen core holes between Townships 13 to 35 and Ranges 7 West to 6 East of the Principal Meridian. The cores provide a composite for the complete Lower Paleozoic section from the upper part of the Middle Ordovician, Winnipeg Formation to the base of the Middle Devonian, Elk Point Group. The location of these core holes is shown in Figure 1.

The purpose of this thesis is to describe the lithology of the cored Ordovician and Silurian Formations. Further purposes are to establish a complete and detailed stratigraphic succession and show or determine the detailed correlation of all outcrops and type sections within the reference section, to determine any lateral changes in lithology, and to determine the environment of deposition.

Previous Stratigrathic Work and Evolution of Nomenclature

The nomenclature that has evolved from previous studies of the Ordovician and Silurian strata of Manitoba and of the Williston Basin is summarized in Table 1.

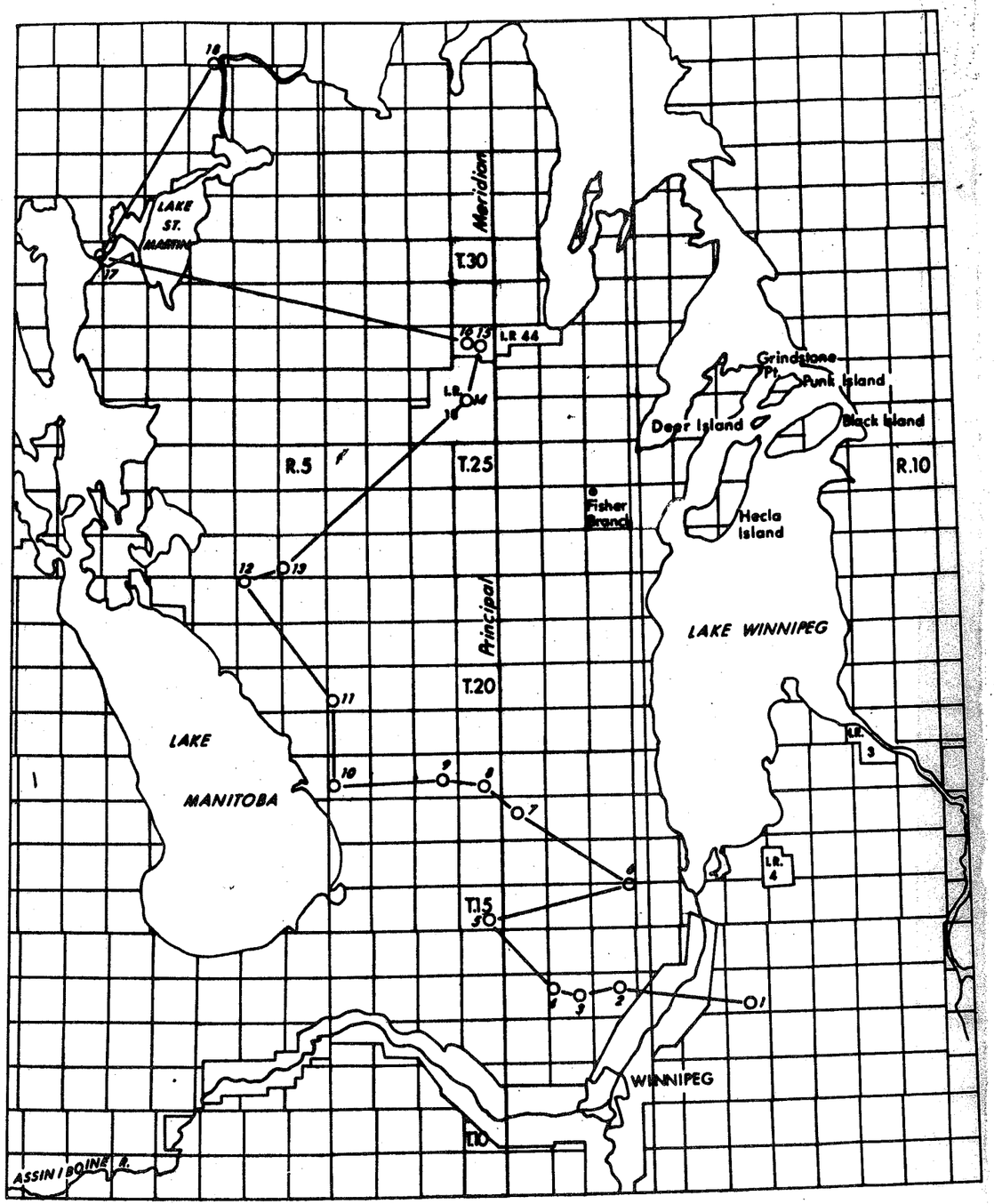
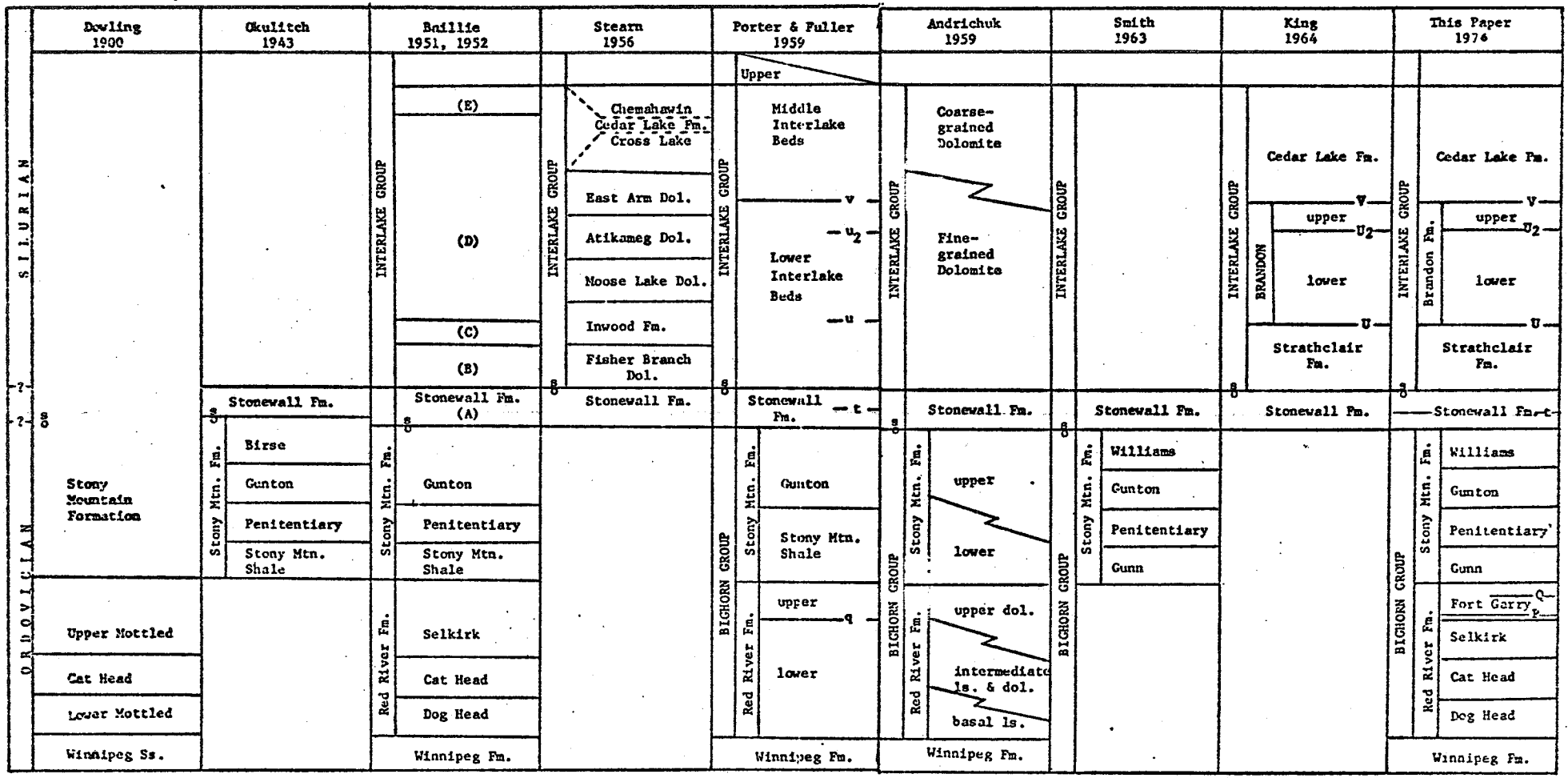


FIGURE 1

INDEX MAP

CORE HOLE NUMBER	NAME
1.	(M-3-69) Garson Quarry
2.	(M-1-70) Mulder Bros. Mowatt Farm Quarry
3.	(M-2-69) City of Winnipeg Quarry, Stony Mountain
4.	(M-1-69) Southeast Quarry at Stonewall
5.	(69-2) Woodroyd Core Hole
6.	(69-4) Petersfield
7.	(69-3) Norris Lake
8.	(M-4-69) Inwood Quarry
9.	(M-5-70) Inwood West
10.	(69-1) Oak Point Quarry
11.	(M-8-69) Lundar North Quarry
12.	(M-6-9) Mulvihill West Quarry
13.	(M-7-69) Mulvihill East Quarry
14.	(69-5) Pequis
15.	(69-6) Pequis
16.	(69-7) Pequis
17.	(LSM-13) Lake St. Martin
18.	(LSM-11) Lake St. Martin

TABLE I - STRATIGRAPHIC NOMENCLATURE



s/o indicates Silurian/Ordovician contact as proposed by various authors.

TABLE I: Table showing the evolution of stratigraphic nomenclature as applied to Ordovician and Silurian strata in the Interlake Area, Manitoba.

Dowling (1900) mapped the outcrop belt of southwestern Manitoba and named and defined the Winnipeg Sandstone, the Lower Mottled Limestone, the Cat Head Limestone, the Upper Mottled Limestone and the Stony Mountain Formation.

In 1912, Kindle proposed the name Stonewall Limestone for all of the Silurian beds occurring between the Ordovician strata on the western side of Lake Winnipeg and Devonian beds on the east side of Lake Manitoba; total thickness was estimated to be over 250 feet. He designated the quarry on the north side of the town of Stonewall as the type section for the lower portion of the Silurian beds.

Foerste (1929) revised the Ordovician succession, including Dowling's Lower Mottled, Cat Head and Upper Mottled units as members of the Red River Formation and renaming the Lower and Upper Mottled the Dog Head and Selkirk Members, respectively.

In 1943, Okulitch subdivided the Stony Mountain Formation from bottom to top into the Stony Mountain Shale, Penitentiary, Gunton and Birse Members.

Baillie (1951) proposed the name "Interlake Group" for the Silurian strata, which he subdivided into five lithologic units A to E. He re-defined and restricted the term Stonewall Formation to include only Unit A.

In his Ordovician report of 1952, Baillie assigned Okulitch's Birse Member into the Gunton Member of the Stony Mountain Formation. He sub-divided the Winnipeg Formation into two units; a basal sandstone and an upper unit of interbedded shale and arenaceous shale.

The Winnipeg Formation was subdivided by Genik in his master's thesis of 1952 into three informal units which are in ascending order: Black Island, Grindstone Point and Deer Island.

In 1955, on the basis of faunal evidence, Macauley assigned the Winnipeg Formation to the Upper Ordovician.

Stearn (1956) subdivided the Silurian outcrop section into six formations which are in ascending order: Fisher Branch, Inwood, Moose Lake, Atikameg, East Arm and Cedar Lake. On the basis of faunal studies, he placed the Stonewall Formation in the Ordovician rather than in the Silurian.

The term Bighorn Group was proposed by Ross (1957) to include the Red River, Stony Mountain and Stonewall Formations.

The Stony Mountain Shale Member of Okulitch (1943) was renamed the Gunn Member by Sinclair and Leith (1958) to conform to the stratigraphic code and to avoid nomenclature confusion that might arise from a member having the same name as the formation.

In southern Manitoba, Andrichuk (1959) in a subsurface study of the Ordovician and Silurian strata, subdivided the Red River Formation into three informal units. The upper unit consists of dolostones with minor interbedded anhydrites; the lower and intermediate units consist of limestones and limestones with interbedded dolostones, respectively. The Stony Mountain Formation was divided into Lower and Upper units, with the contact placed at a point stratigraphically equivalent to the Penitentiary-Gunton contact. He included the Stonewall Formation in the Interlake Group, and subdivided the remainder of the group into a lower fine-grained dolostone unit and an upper coarse grained dolostone unit.

Porter and Fuller (1959) also subdivided the Stony Mountain Formation into upper and lower units, correlative with the units used by Andrichuk (1959). They placed the Stonewall Formation in the Ordovician Bighorn Group, disagreeing with Kindle (1912), Baillie (1951) (1952) and Andrichuk (1959). The Interlake Group was subdivided into lower, middle and upper "Beds" on the basis of non-sequential marker beds. [1]

Smith (1963) studied the Stony Mountain and Stonewall Formations exposed in outcrops and quarries in the Stony Mountain and Stonewall areas of Manitoba. In his thesis he proposed the name Williams Member for the argillaceaous, arenaceous dolostone unit at the top of the Gunton Member. The Williams Member was included as the upper part of the Gunton Member by Baillie (1952).

In a combined surface and subsurface study of the Interlake Group, King (1964) for his master's thesis subdivided Porter and Fuller's (1959) Lower Interlake Beds into the Strathclair Formation and Brandon Formation. He also redefined Stearn's (1956) Cedar Lake Formation to include the upper portion of the East Arm Dolomite. The Cedar Lake Formation, as defined by King and as used in this report, is equivalent to the Middle Interlake Beds of Porter and Fuller (1959).

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[1] The term "non-sequential beds" was introduced by Porter and Fuller (1959, P. 160) to donote key beds which reflect an interruption of sedimentation. In this sense the key beds are not "in sequence" when considered in relation to the thick successions of dolostones. The horizons are utilized as para-time-rock markers.

McCabe and Bannatyne (1970) proposed the name Fort Garry Member for the uppermost dolomitic beds of the Red River Formation; these beds had not previously been recognized in outcrop. Andrichuk (1959) included these beds as the upper dolomite unit in the subsurface but thought they represented a facies equivalent of the Selkirk Member.

This thesis incorporates the findings of many previous workers. Discrepancies, where they exist, are described in chapter 2. It agrees with Baillie (1952) concerning the stratigraphy of the Winnipeg and Red River Formations. The Fort Garry Member of the Red River Formation, which was named by McCabe and Bannatyne (1970), is included. This work agrees with Smith (1963) in his designation of the Stony Mountain and Stonewall Formations. King's (1964) designation of the Silurian strata is incorporated. The non-sequential beds described by Porter and Fuller (1959) were seen in the core and are included in this work.

Method of Study

This project consisted of a study of cores from eighteen core holes in the Interlake Area of Manitoba (Figure 1). The total footage cored was 4648'8" with almost one hundred percent recovery. The core was logged by the author and descriptions are included in Appendix I. Folk's (1959) and Payne's (1942) classifications were used in the description of limestones and dolostones, respectively. Etched sections, cut perpendicular to bedding, were examined by the author under a binocular microscope. Dolomite and calcite, where intermixed, were differentiated by staining with alizarine red (Friedman, 1959).

Residue studies were carried out by the author on all formations except

the Winnipeg and Stony Mountain; data for the residues in the Stony Mountain Formation are included in Smith (1963). Ten to forty gram samples were taken every five feet, except for the Red River Formation, where samples were taken every ten feet. Samples were dissolved in dilute muriatic acid, the percent of insoluble residue calculated and described. Representative samples were X-rayed by the author to determine the mineralogy. The results of this study are listed in Appendix II.

Lithologic strip logs were compiled for each of the core holes, and from these, correlations were made for all Ordovician and Silurian strata. Correlation of the Ordovician strata was based on lithology; correlation of Silurian strata was based on lithology and the non-sequential marker beds of Porter and Fuller (1959). A stratigraphic cross-section (Figure 2) was prepared showing these correlations and indicating lateral variations in thickness and lithology of the various strata in the study area.

No new paleontological studies were carried out during this project. The publications of Jones (1891), Tyrrell (1892), Kindle (1914), Okulitch (1943), Baillie (1951 and 1952) and Stearn (1956) supply complete faunal lists.

Acknowledgements

The research for this thesis was done in the Department of Earth Sciences of the University of Manitoba during the 1969-70 academic year and during the summer of 1970.

The author is indebted to Professor E. I. Leith and Dr. H. R. McCabe for the guidance, suggestions and constructive criticisms they provided throughout the term of work.

The preliminary lithologic studies and field work were sponsored by the Geological Services Branch of the Manitoba Department of Mines Resources and Environmental Management.

CHAPTER 2

STRATIGRAPHY

General Statement

The area of study is located on the northeast flank of the Williston Basin, a major tectonic feature which underwent more or less continuous subsidence throughout Ordovician and Silurian time. This pattern of subsidence was the principal factor controlling the nature and distribution of the Ordovician and Silurian strata in Manitoba.

Limestones and dolostones are predominant throughout most of the Ordovician-Silurian section, except for the basal Ordovician Winnipeg Formation which consists of quartzose sands, shales and arenaceous shales. The strata dip gently and fairly uniformly to the west-southwest at about 10 feet per mile. The only anomalous areas are in the vicinity of the Lake St. Martin crypto-explosion structure (McCabe and Bannatyne, 1970) and in the vicinity of Highrock Lake, where a Precambrian window exposes rocks that indicate the possibility of a second crypto-explosion structure.

The contact between the Silurian Interlake beds and the overlying Ashern Formation of probable Middle Devonian age is an angular unconformity, considering the overall basin structure. In Manitoba, there is little evidence of any angular discordance despite the development of extensive breccia beds at the contact. All the Upper Interlake Beds were removed from the study area during the period of later Silurian - early Devonian uplift and erosion.

Ordovician Stratigraphy

Winnipeg Formation

The Winnipeg Formation was not cored completely because of jamming problems arising from the poor consolidation of the sandstone. The maximum thickness obtained was the top fifty-nine feet in hole number 6.

The cores consist of shale beds, two inches to six feet thick, interbedded with arenaceous shale and argillaceous sandstone; contacts between beds are gradational. Colors range from light greenish grey to reddish brown with minor green patches (Plate I A and I B, respectively). The sand grains are well rounded, pitted, frosted, fine to medium grained and consist of quartz. The sand occurs both as disseminated grains and as one-half inch lensoid concentrations in the shale. Some beds have up to eighty percent sand lenses with paper thin shale bands separating the lenses. The disseminated grains commonly comprise less than five percent of the rock. Randomly oriented, dark brown, chitinous, brachiopod bioclasts and phosphatic oolites occur sparsely throughout the shale beds.

These beds comprise the upper sandstone and shale of the Winnipeg Formation and correlate with the Upper Unit of Baillie (1952). Data from nearby wells indicate that the remainder of the formation consists of clean quartzose sandstone. Baillie (1952) found this lower sandstone unit exposed at Black Island (Section I) and Punk Island (Section 2).

The Winnipeg Formation overlies the Precambrian surface (Baillie, 1952). The apparently conformable contact between the Winnipeg Formation and the overlying Dog Head Member of the Red River Formation is placed at the base of the first dolomitic limestone bed, correlative to that found at Grindstone Point, Deer Island and Punk Island (Baillie, 1952).

Red River Formation

For this report, the Red River Formation is considered to consist of four members, which are in ascending order: the Dog Head, Cat Head, Selkirk and Fort Garry (Figure 2). This formation consists essentially of two different lithologic types reflecting two distinctly different depositional environments. Mottled dolomitic bioclastic limestone is the predominant lithologic type comprising most of the Dog Head and Selkirk Members and occurring to a lesser extent in the Cat Head Member. The second lithologic type, represented by the Fort Garry Member, consists predominantly of lithographic to sublithographic dolostone.

Dog Head, Cat Head and Selkirk Members

The massive thick-bedded dolomitic limestone of both the Dog Head and Selkirk Members is a brachiopod crinoid biomicrite with a minor amount of interbedded brachiopod crinoid biosparite. Horn corals, gastropods, cephalopods, bryozoans and trilobites are less common. Fossil content in the rock ranges from ten to seventy percent, averaging about forty percent. The fossils are fragmented and usually randomly oriented.

Dolomite content ranges from ten to forty-five percent and averages about thirty percent. The dolomite occurs as finely crystalline irregular medium yellowish brown mottled areas (Plate I D and III A & B). Tubular structures, which are possibly sediment-filled worm burrows, commonly form cores for dolomitized areas (Plate III A).

The color of the dolomite patches is medium yellowish brown and the limestone is light yellowish brown (Plate III A). Hematite staining is not uncommon in both the Dog Head and Selkirk Members (Plates I E and III A, respectively).

In the vicinity of the Lake St. Martin crypto-explosion structure at hole 18 the lithology of the Selkirk Member is anomalous to the rest of the study area in that it has undergone neither dolomitization nor mottling. The predominant lithologies are brachiopod biosparite and light grey micrite (Plate III C and D, respectively). Brachiopod crinoid intrabiomicrite and intrabiosparite are present to a lesser extent. Bedding varies from massive in the biosparites and biomicrites to laminar in the micrites.

In the southeastern portion of the study area, the Cat Head Member differs from the underlying and overlying members in having a higher percentage of dolomite and chert. Dolomite content varies from approximately fifty to seventy percent (Plate II A). Chert occurs as earthy nodules and as pseudomorphic replacement of fossils (Plate II B). To the northwest, the Cat Head Member becomes an interbedded, dark grey, very finely crystalline dolostone and light grey, dolomitic, micritic limestone with chert nodules (Plate II C). Hole 16 shows a transitional facies with the dolomitic micrite and very finely crystalline dolostone, typical of the northern area, underlying the mottled calcitic dolostone, typical of the southern area. Tubular structures which are possibly due to the burrowing organisms are present in the dolomitic micrite (Plate II D).

The insoluble residue is composed of predominantly illitic clay with minor amounts of silt sized quartz found in the Selkirk Member. Chert is commonly found in the Cat Head Member to a varying degree. The percentage decreases from twenty-four percent at the base of the Dog Head Member where grey shale is interbedded with argillaceous, dolomitic limestone (Plate I C) to three percent in the Selkirk Member.

Fort Garry Member

The second major lithologic type in the Red River Formation, the fine grained dolostone, is restricted to the Fort Garry Member which consists of four separate stratigraphically continuous intervals.

The basal unit, approximately 100 feet thick, consists of dense grey and red lithographic dolostone with minor interbedded fine to medium crystalline dolostone (Plate IV D). The dolostone is often structureless, although laminar and nodular bedding is not uncommon (Plate IV A & C, respectively).

Overlying this dense dolostone interval is a seventeen to twenty-one foot interval of interbedded red and grey, partly argillaceous, cherty, vuggy, fossiliferous, calcitic, finely crystalline dolostone, medium crystalline dolostone and minor amounts of light grey, micritic limestone and shale (Plate IV E). The fossils present are tabulate corals and stromatoporoids that are not oriented in the beds. The upper contact of this zone appears to be correlative with Porter and Fuller's (1959) Q-horizon.

This interval is overlain by ten to twenty feet of light grey, dense, sublithographic dolostone.

The upper most unit of the Fort Garry Member throughout most of the Winnipeg-Stony Mountain area consists of up to ten feet of relatively pure limestone which is a light grey to white brachiopod biomicrite (holes 3 and 5). The unit grades laterally, in a north-westerly direction, to a dolomitic micrite, pinching out north of hole 7. The brachiopod biomicrite is thin-bedded (1 - 1½ inches) with the brachiopods oriented parallel to bedding. The northern dolomitic micrite is massive, having a gradational

contact with the underlying dolostone. Baillie (1952) described a calcitic dolostone exposed in the Fisher Branch area (Section 24) which he believed correlative to the Selkirk Member. This outcrop may be correlative to this upper unit of the Fort Garry Member.

In the Lake St. Martin Area (hole 18) the middle portion of the Fort Garry Member consists of coarse sand to pebble sized, angular, poorly sorted fragments of light grey sublithographic dolostone suspended in a sparry calcite matrix; this highly anomalous breccia zone could be due to solution breccia or structural disturbance associated with the crypto-explosion structure.

The insoluble residue of the Fort Garry Member, excluding chert, consists of illite and decreases from bottom to top of the member. At approximately the middle of the member, there is a thin highly argillaceous zone that is correlative with Porter and Fuller's (1959) P-horizon.

Contact Relationships

The upper contact of the Red River Formation with the Stony Mountain Formation is sharp, marked by an increase of insoluble residue, due to the change in lithology from a light grey carbonate of the Fort Garry Member to the darker grey green and red argillaceous limestone of the basal Stony Mountain Formation.

The contacts between the four members of the Red River Formation are gradational over two to five foot thick intervals, except in the southern portion of the study area, where the upper and lower contacts of the Cat Head Member are gradational over a ten foot thick interval reflecting the gradual increase in dolomitization. All the members of the Red River