THE STRATIGRAPHY OF THE INTERLAKE GROUP (SILURIAN) IN MANITOBA

A Thesis

Presented to

The Faculty of the Department of Geology

The University of Manitoba

in partial fulfillment

of the requirements for the degree

Master of Science

by

Kenneth R. King

July 1964

C O N T E N T S

LIST OF ILLUSTRATIONS

Figure

THE STRATIGRAPHY OF THE INTERLAKE GROUP (SILURIAN) IN MANITOBA

by

K. R. KING

ABSTRACT

The Interlake Group in Manitoba was examined in detail, both in outcrop and in the subsurface with correlations established between them.

The outcrop area is described according to Stearn (1956) with some revisions suggested. The Fisher Branch Formation is not a recognizable unit and the Cross Lake Member of the Cedar Lake Formation is not distinctive. Several new sections at Grand Rapids and coreholes in the northern outcrop area contain thin sand and shale beds which can be correlated with extensive subsurface markers.

In the subsurface, the Interlake Group has been subdivided by means of non-sequential marker beds, U, U_2, and V. The Lower Interlake has been subdivided into the Strathclair and Brandon Formations. The use of the outcrop name, Cedar Lake Formation is extended to apply to the Middle Interlake. All formations are essentially dolomite, but through interpretation of relict textures, establishment of sedimentary pattern, notably reef distribution, has been attained. Some reefs have considerable dimension and affected sedimentation within the formation in which they occur and in some instances, in the overlying formation.

Favourable sites for the accumulation of hydrocarbons are in porous zones and trapped at the pre-Middle Devonian unconformity.

THE STRATIGRAPHY OF THE INTERLAKE GROUP (SILURIAN) IN MANITOBA

K. R. KING

CHAPTER ONE: INTRODUCTION

General Statement

In the recent years stratigraphic studies of the Interlake Group of Silurian age have been undertaken in both the surface and subsurface. Although exposure is limited, a stratigraphic picture has been established for the Manitoba outcrop belt. The Interlake in the subsurface has been described briefly in studies which were concerned with the Lower Paleozoic as a whole, with more specific works performed in North Dakota and Saskatchewan. A problem confronted by all subsurface workers is an accurate correlation with the outcrop area. This is due to a lack of detailed work in the subsurface and the scarcity of outcrop and good sections at the surface.

It is the purpose of this thesis to establish surface-subsurface correlations by a detailed examination of both areas, as well as to reconstruct the sedimentary pattern of the Interlake Group.

Correlations as presented are based on lithology and the character of electric logs. Because of the good detailed faunal lists provided by previous workers (Baillie 1951, Stearn 1956, Brindle 1960), paleontology is mentioned only where it is felt that the information is new and aids interpretation.

Ninety-eight wells reach the Interlake Group in the subsurface of which 87 penetrate the entire interval. Cores are scarce, with only 15 wells having been cored in part. Well cuttings and electric logs are available for most wells. The well control is most extensive in the south central portion of the province, decreasing slightly to the west and is very sparse in the north. The locations of these wells in addition to the areas referred to from the outcrop portion of this thesis are in figure 1 and index map (figure 10 in pocket).

Acknowledgements

The author would like to express his gratitude to Professor E. I. Leith of the University of Manitoba, under whose supervision and guidance this thesis was prepared. The assistance and co-operation of the Geology Division of the Manitoba Mines Branch for providing information and the base map is greatly appreciated. Particular thanks are extended to H. R. McCabe, Provincial Stratigrapher, for his helpful comments and criticism.

Work was carried out under a University of Manitoba Graduate Fellowship in Geology. The author also received financial assistance from Shell Oil of Canada, whose grant provided for field expenses.

The author is also indebted to Manitoba Hydro, who granted permission to work on exposures within the

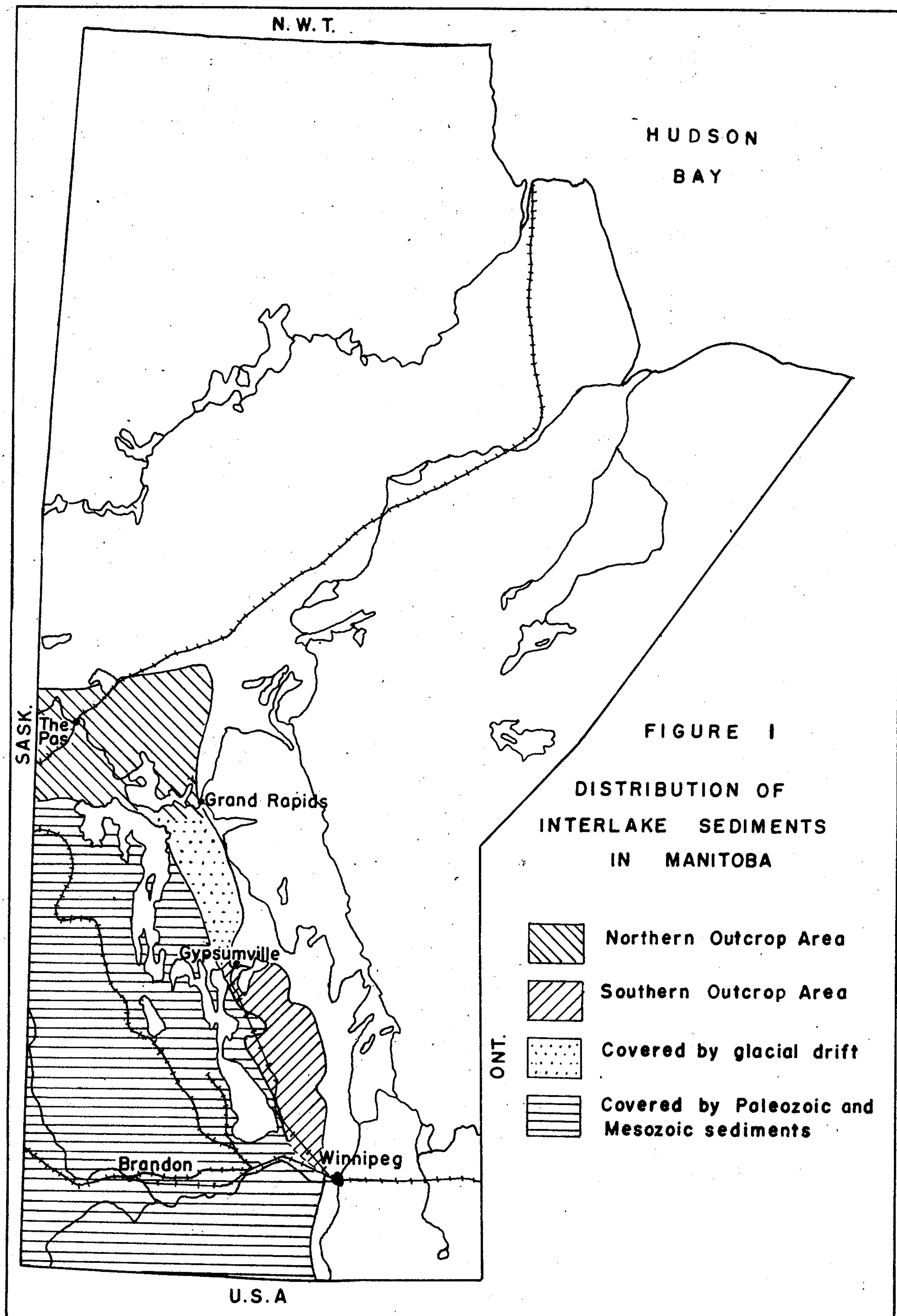


FIGURE I

DISTRIBUTION OF INTERLAKE SEDIMENTS IN MANITOBA

Grand Rapids powerdam construction site, and to Mr. L. LaChance of H.G. Acres and Co., for guidance while at the site.

Previous Work

Tyrrell (1892) was the first to consider in some detail the Silurian rocks in Manitoba and he gave an excellent account of the rocks in the Grand Rapids area, and on the east shore of Lake Winnipegosis. Whiteaves (1906) assigned a Middle Silurian (Niagaran) age to the rocks in these areas.

Kindle (1914) proposed the name Stonewall Formation for the Silurian strata at the Stonewall quarries and in the Interlake area. He established two faunal zones; the lower, *Virgiana decussata*, and the upper, *Leperditia hisingeri*. He placed the gypsum deposits at Gypsumville between these two zones. Collections of fossils from the Cedar Lake and Grand Rapids area were described by Kindle (1915).

Baillie (1951) believed that the Silurian rocks were more extensive and proposed the name Interlake Group for the strata between the Ashern and Stony Mountain Formations. This was subdivided into five lithologic units (designated by letters) and five corresponding biostratigraphic units. The lower 60 to 70 feet were designated as unit A, (analogous to the Stonewall formation) and were considered to be Lower Silurian in age with remaining overlying units as Middle Silurian.

A new subdivision of the outcrop portion of the Interlake was developed by Stearn (1956). In addition, he removed the Stonewall Formation from the Interlake Group presenting faunal evidence that it was Ordovician in age (Stearn 1953).

The subsurface was totally ignored until Kerr in 1949 gave an account as it was known at that time. With the advent of more oil and helium exploration, particularly between 1950 and 1958, considerably more information became available for study.

Andrichuk (1959), in a study of the Lower Paleozoics in Southern Manitoba, placed the Stonewall in the Interlake, and divided the latter into an upper and lower unit. This subdivision was based on grain size of the dolomite with the lower unit being finer grained than the upper and the contact between them regarded as a facies boundary.

In a regional study comprising the Lower Paleozoics of the Williston Basin, Porter and Fuller (1959), considered the Stonewall as a separate formation and subdivided the Interlake Group into three para-time-rock units, Lower, Middle and Upper on the basis of non-sequential beds.[1] The units chosen were the same as presented by the Saskatchewan

---

1. The term "non-sequential beds" was introduced by Porter and Fuller (1959 p.160) to denote 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 succession of dolomites. The horizons are utilized as para-time-rock markers.

Geological Society (1958) with the respective names, Rupert Beds, Hanson Beds, and Risser Beds.

Two additional studies, although outside the area concerned, but of immediate interest, have been performed. In Saskatchewan, Chernoff (1961) described the lithology of the Interlake Group on a three-fold subdivision using clastic marker beds. In North Dakota, Carlson and Eastwood (1962) assigned formational status to the Interlake and correlated the units of Porter and Fuller in the subsurface.

Comparison of the various terminologies developed for both the surface and subsurface is presented in figure 2.

Method of Study

In order to establish the various rock types and textures to be expected within the Interlake Group, samples were collected from sections in the Interlake region and the Grand Rapids - Cedar Lake area. In the latter region particular attention was given to new sections exposed during construction of the Manitoba Hydro powerdam at Grand Rapids. The stratigraphy as developed by previous workers was then examined in the light of the new information available. Samples gathered were examined in respect to texture and composition by means of thin sections, polished and etched sections.

Once familiar with the petrography of these rocks, an examination of the well data was undertaken. Due to the

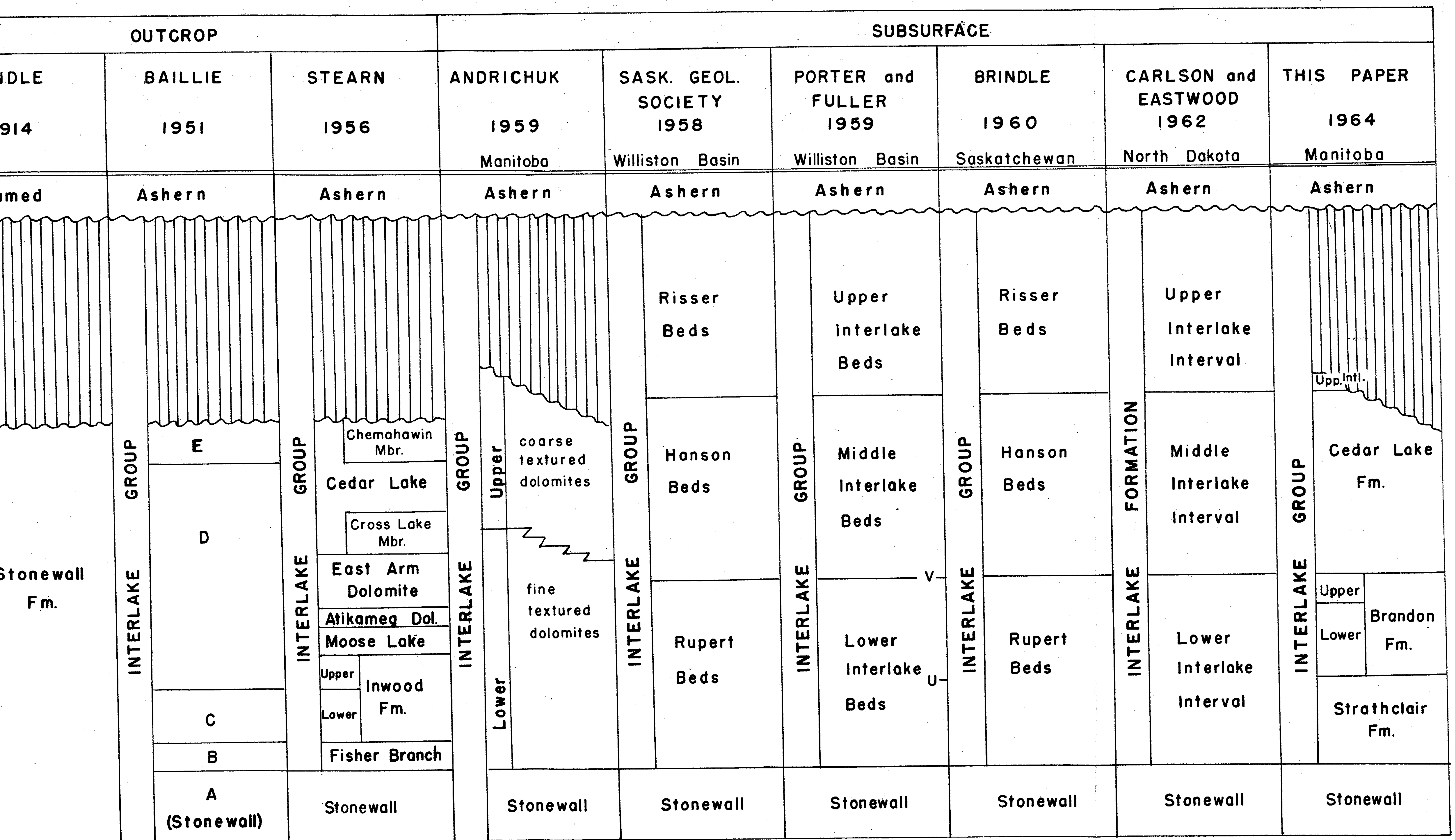


Figure 2 Comparison of nomenclature developed for the Interlake Group

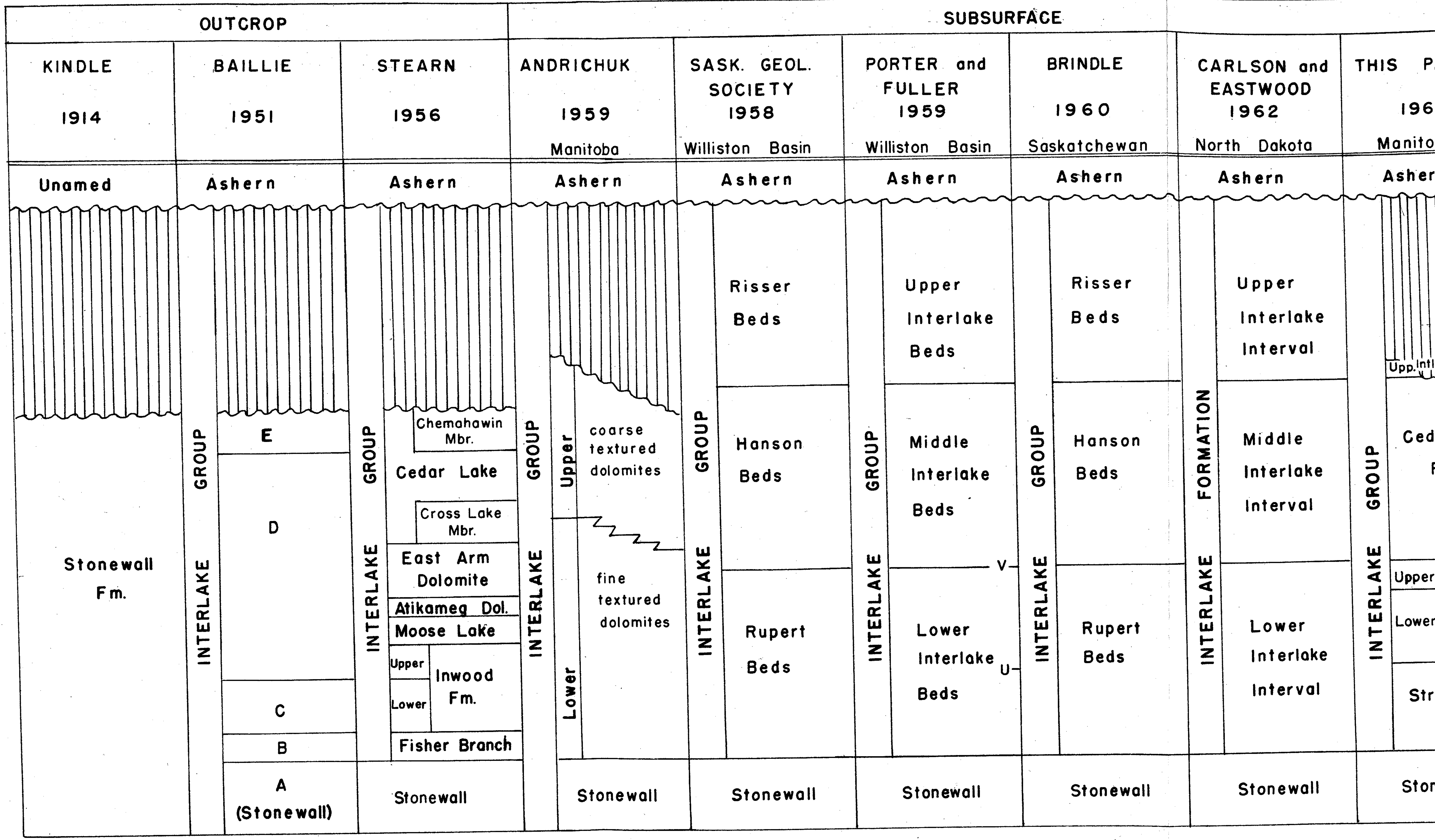


Figure 2 Comparison of nomenclature developed for the Interlake Group

scarcity of cored intervals, lithologic descriptions are mainly on well cuttings. The examination of these cuttings was done with reservation and where mixing or caving was evident, the portion affected or in some cases all the lithology of the well was disregarded. Electric logs were combined with the lithology and the group was then subdivided according to prominent deflections of the curves on either the SP Log or the gamma ray log. Wells having no electric logs could not be subdivided in this manner and in these only a general picture of the stratigraphy could be obtained.

The classification of the dolomites in the Interlake Group is based upon crystal size and shape, and recognizable relict textures. The problems faced in this classification and its interpretation are given in chapter two.

Various types of maps and cross sections were prepared to resolve correlations and to construct the sedimentary pattern.

General Stratigraphy

The rocks of the Interlake Group extend from the arcuate outcrop belt in Manitoba (figure 1) into the Williston Basin whose center lies in northwestern North Dakota. The predominant lithology is dolomite, rarely calcareous with thin non-sequential shale and sand markers. It is unconformably overlain by the early Middle Devonian

Ashern Formation and conformably overlies the Stonewall Formation, whose age once considered to be Upper Ordovician has been extended into the Lower Silurian (Brindle 1960). Fossils collected from the outcrop area have indicated a definite Middle Silurian (Niagaran) age for most of the group. Porter and Fuller (1959 p. 180) state there is a scarcity of evidence for a large faunal break and the lack of an angular unconformity between the Stonewall and Lower Interlake. They believed there was no definite evidence for the large "gap" representative of Lower Silurian time as presented by Stearn (1956). They consider the lowermost part of the Interlake Group to be Lower Silurian in age. Thus by making the Stonewall younger, and the Interlake older, a hiatus of considerable magnitude has been erased and replaced by a time break more concordant to the interpretation of regional sedimentation and tectonics.

The dolomites reflect an original carbonate shelf lithotope. Non-sequential beds are found in these dolomites and these thin marker beds represent a break in carbonate sedimentation.

CHAPTER TWO: ROCK TYPES AND TEXTURES

Interpretation of Relict Textures

In order to attempt a reconstruction of the environment of deposition for the various units, it was necessary to interpret original carbonate textures in regard to dolomitization processes. In some instances this was easily done as some rocks, although consisting entirely of dolomite have their original textures preserved.

Grain type in part determines texture, with the grains classified as either skeletal or non-skeletal. The latter group includes pellets, grapestone, mud aggregates and oolites. Descriptions of these grains are given by Illing (1954), Cloud (1962), and Purdy (1963a).

However, Purdy (1963b), indicated that all non-skeletal grains and some skeletal grains are easily capable of recrystallization into cryptocrystalline carbonate. Any grains which have attained this state can only be identified by external form, and frequently grains of different origins have the same shape. The effect of dolomitization processes are then added. Grain shape and texture can persist, although identification of individual grains becomes impossible.

In considering dolomite development in respect to original limestone textures, Thomas (1962) believes that the processes are strongly controlled by the pressure of fluids in intergranular porosity or by carbonate mud material that had a high fluid content. He indicated that dolomite preferentially occurs in open pores or in matrix material that surrounds large skeletal or non-skeletal grains, with the larger grains the last to be dolomitized. Thomas also stated that it is possible to designate the original nature of the carbonate. A cryptocrystalline - microcrystalline dolomite of anhedral grains is interpreted as derived from a carbonate mud whereas more porous granular material will give rise to a subhedral or rhombic dolomite with inter-crystalline porosity.

Drummond (1963) suggested that original carbonate grain sizes should be partially determinable up to fairly intensive stages of dolomitization. By these stages of dolomitization, the dolomite crystals will bear a direct relationship to original grain size. Thus original aphanitic rocks remain aphanitic and coarse grained rocks remain coarsely crystalline.

Criteria for similar reasoning is found within the dolomites of the Interlake Group and the evidence is for dolomitization to be a penecontemporaneous replacement process (Fairbridge 1957), with each grain replaced individually from magnesium-rich pore fluids. The smaller carbonate grains because of their larger relative surface area will be more readily replaced. If numerous small grains are present in a single area, then dolomite replacement should be a simultaneous process resulting in a very fine grained mosaic of inter-locking anhedral crystals. Because of interference from adjacent grains, the dolomite crystal cannot assume its true crystallographic shape. This constriction generally results in the grains of a lime mud assuming an anhedral shape, or at best, subhedral.

Coarser grained, poorly sorted original carbonate sediments are accompanied by larger pore spaces and subsequently less restriction on the development of dolomite crystals. Since the grains are larger, replacement processes will operate at a slower rate resulting in the occurrence of a fine to coarse crystalline dolomite (depending on the original grain size) with the euhedral crystals.

Original grain size in conjunction with porosity are considered to be the factors resulting in the relict textures preserved in the dolomites. However, several problems listed below are involved in the interpretation of relict textures;

1. If lime mud was considerably more abundant than grains, the grains tend to become obliterated in the recrystallization process. This is especially prevalent in the case of very small grains such as pellets.
2. One cannot determine if the cryptocrystalline dolomite in the interstices between relict skeletal grains represents lime mud or sparry calcite cement.
3. The development of euhedral dolomite crystals in relict skeletal grains often distorts the original grain shape.
4. The recrystallization process may be affected by pressures resulting in a false crystal development.
5. One cannot recognize primary dolomite (if it does occur).

Rock Types

Dolomites

The major rock type of the Interlake Group is dolomite. The dolomite is rarely calcitic and occasionally contains terrigenous material. They are subdivided into two major groups: A. in which relict textures are recognizable and B which consists of crystalline dolomite. Grains of both types are sized according to Leighton and Pendexter (1962)[1] and determined by visual inspection.

A. Crystalline Dolomites

1. Cryptocrystalline-Microcrystalline Dolomite

The texture consists of a mosaic of anhedral interlocking dolomite crystals less than .06 millimeters in size. Although it is difficult to identify grains less than .004 millimeters (maximum grain size of cryptocrystalline dolomite), with a binocular microscope, it is believed that compact, featureless, lithographic dolomites can be placed with assurance in this class. Most dolomites have a range in grain size from cryptocrystalline to microcrystalline and may exhibit coarsely microcrystalline grains in a cryptocrystalline groundmass (Plate I A). This texture probably formed from pellets or very fine skeletal grains in a lime mud.

---

1. Grain size classification given in appendix.

Grain shape is usually anhedral although in wholly microcrystalline dolomites a large proportion may have a subhedral form.

The grain size and texture represents an original lime mud or possible pelletal texture indicative of quiet water and a low energy environment. Stromatolitic structure was noted on the weathered surface of some cryptocrystalline dolomites. Environmental implications are similar as these organisms were restricted to protected shallow water areas.

2. Very fine - Finely Crystalline Dolomite

The grain size of the dolomite crystals of this group ranges from .06 to .25 millimeters with .12 millimeters being the dividing point between very fine and fine grained. This group may contain finer or coarser material. It is usually associated with good intercrystalline porosity.

This texture probably represents original very fine to fine grained skeletal material or grapestone. A high porosity should signify a lack of original matrix material. The texture implies deposition in slightly agitated water (Plumley et al. 1962).

3. Medium - Very Coarsely Crystalline Dolomite

The grain size of the dolomite exceeds .25 millimeters but is less than 2 millimeters. The shape of the crystals is generally subhedral to euhedral. Good intercrystalline and vuggy porosity is normally associated with this group. The original nature of the skeletal debris can often be recognized.

This group is interpreted as representing original skeletal material of comparable size. It is associated with reefal or other deposits formed in moderately or strongly agitated water.

B. Dolomites with Recognizable Carbonate Textures

1. Relict Skeletal Dolomites

This texture consists of grains of cryptocrystalline dolomite, very fine to coarse in size and exhibiting all degrees of rounding. The majority of the grains are presumed to have been derived from organisms. Some grains may be recognizable by their characteristic shape such as the brachiopods valves and crinoid columnals as illustrated in plate III A. The sorting index is variable and the grains may occur in a cryptocrystalline matrix or be accompanied by excellent intergranular porosity.

The texture and distribution of the skeletal grains is best observed in outcrop. They occur in thin to thick beds and are associated with organisms in the reef lithosome or as thin interbeds in the cryptocrystalline dolomites of the quiet water environment.

2. Relict Pelletal Dolomites

The pellets occur as silt to very fine grained, round, spherical to ovoid grains with a high sorting index. They occur in a cryptocrystalline matrix. Plate II A illustrates well sorted pellets between two intraclasts.

This texture is rarely recognizable in well cuttings.

3. Relict Grapestone Dolomites

In only a few instances was this texture recognized with any certainty. Figure B on Plate II illustrates elongate and irregular shaped grains varying from subangular to subrounded in form. The irregular form and several surface indentations suggests the original composite nature of the grains.

4. Relict Intraclastic Dolomites

The term intraclast is used here as defined by Folk (1959, 1962) to describe "fragments of penecontemporaneous carbonate sediment that have been eroded from adjoining parts of the sea bottom and redeposited to form a new sediment....".

Large tabular angular fragments of dolomite which contrast to the enclosing texture are obvious intraclasts. They generally parallel the bedding and may attain a length of several centimeters. The largest are composed of cryptocrystalline dolomite and their association with stromatoporoids suggest they have been torn from these organisms by wave action. Other intraclasts contain textures which indicate they have form penecontemporaneously. This type is illustrated in Plate II A where pellets can be identified within the intraclasts as well as in the enclosing groundmass.

With small intraclasts, a problem occurs in their recognition. They exist as cryptocrystalline grains similar to grapestone or skeletal material. Their tabular shape is the only aid to their identification but this is a weak criterion.

5. Relict Oolitic Dolomites

The oolites range in size from medium to coarse grained with minor fine grained material and are easily recognized by their spherical, sometimes ovoid shape. Their normal occurrence is in distinct beds although they may be associated with a portion of the relict skeletal material in some areas. A thin section of the oolite (Plate III B) reveals a cryptocrystalline core surrounded by a darker outer shell. The original oolitic laminations have been obliterated. The larger oolites appear to have incorporated several other oolites in their formation.

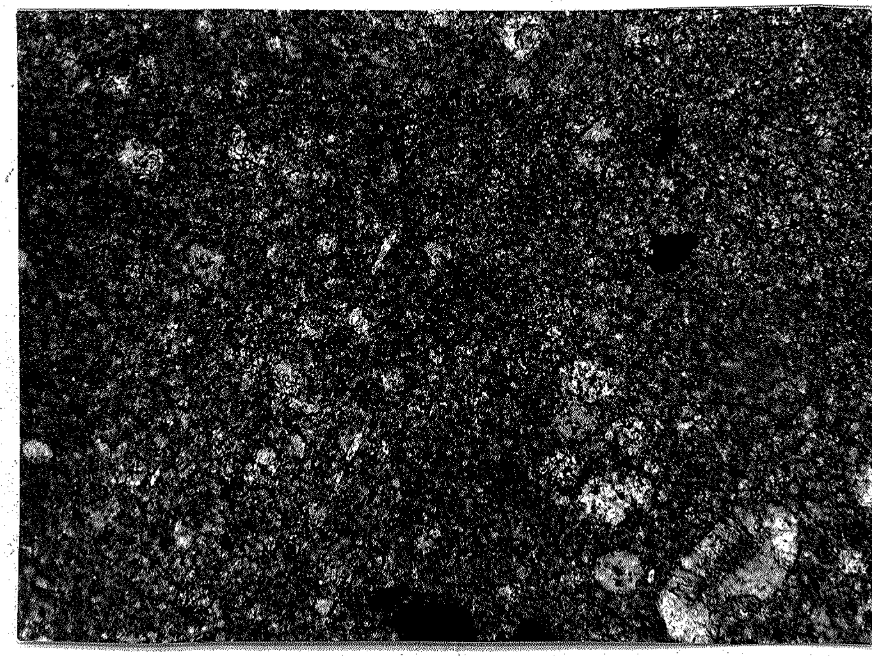
Sandstone

Only a few thin beds of sandstone are present within the Interlake Group. The lowest, marking the contact with the underlying Stonewall formation and the bed separating the Lower and Middle Interlake are described in the discussion of the Grand Rapids area in Chapter three. A third sand bed occurs at the top of the Middle Interlake and was cored in Robert Moore No. 1 (4)[1]. Several beds in the Lower Interlake contain disseminated quartz sand.

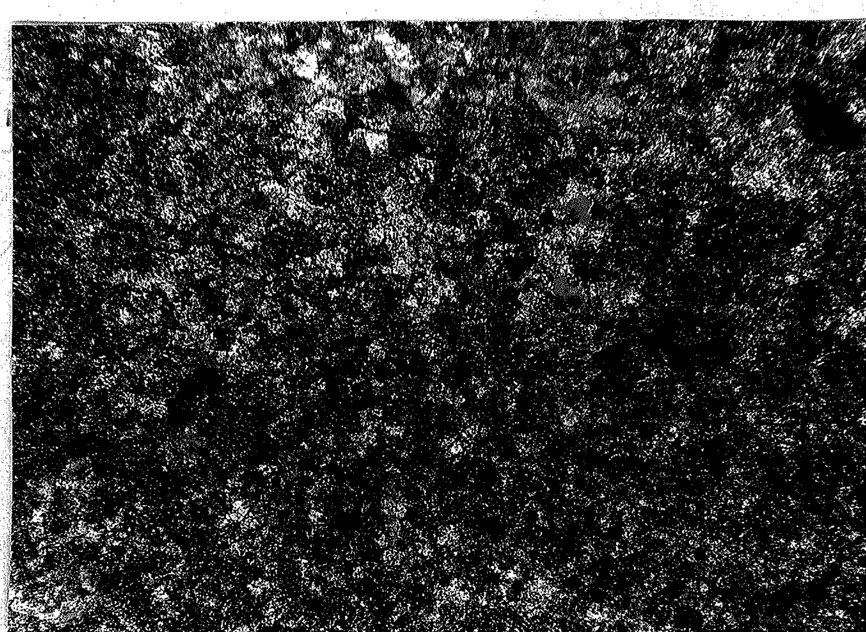
---

1. The number following the well name refers to position of the well on the index map (Figure 10 in pocket).

PLATE I

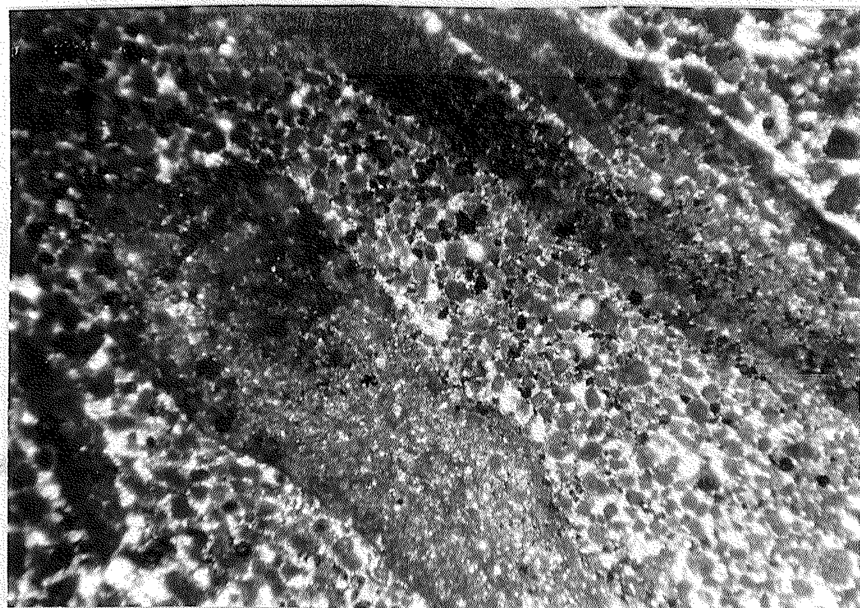


A. Cryptocrystalline anhedral dolomite with scattered patches of microcrystalline dolomite representing original grains. One skeletal grain present. (x25) Middle of Cedar Lake Formation - Anchor Point section.

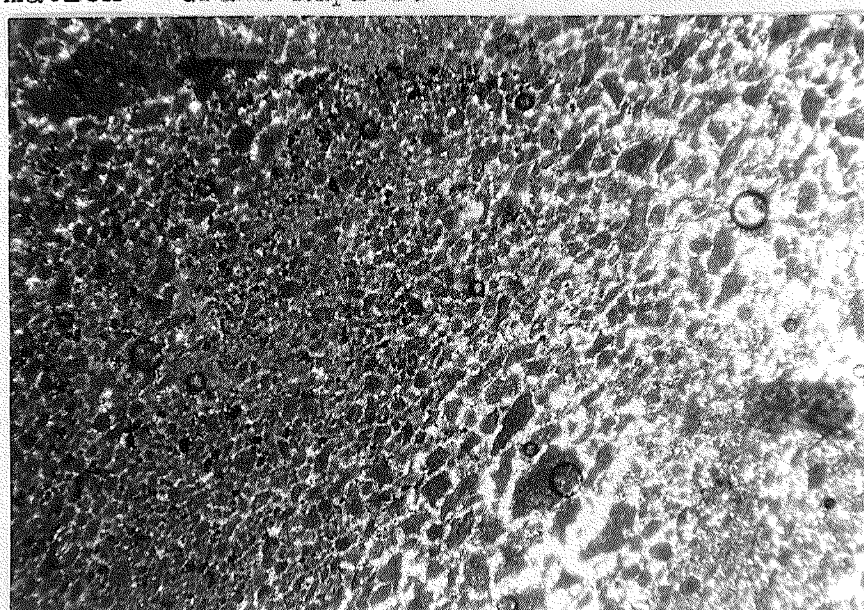


B. Gradation from microcrystalline to very fine and finely crystalline dolomite. (x31) Lower member Inwood Formation - Grand Rapids

PLATE II

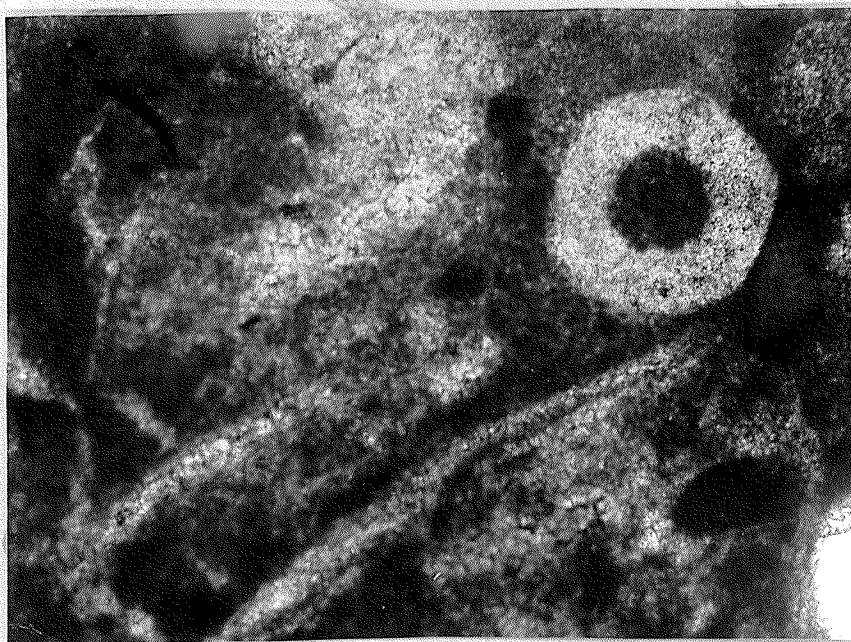


A. Spherical to subspherical shaped pellets between two intraclasts which are also pelletal but have undergone some recrystallization. (x50) Upper member, Inwood Formation - Grand Rapids.

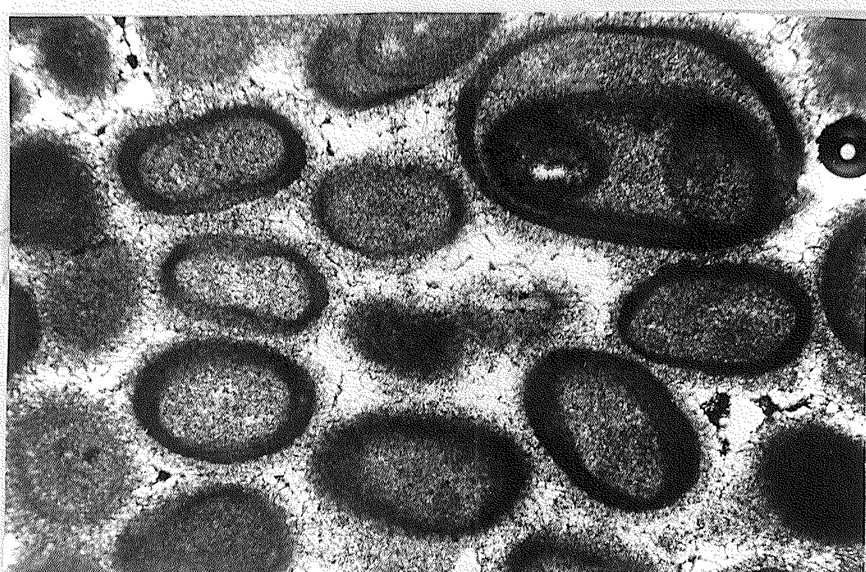


B. Spherical pellets in upper left corner grading into coarser, more irregular shaped grains, probably grapestone. (x50) Upper member, Inwood Formation - Grand Rapids.

PLATE III



A. Relict skeletal dolomite; with crinoid columnal and shell debris in a cryptocrystalline matrix. (x50) Lower part East Arm Dolomite - Grand Rapids



B. Oolitic dolomite which has undergone recrystallization. The largest oolite is a composite of several smaller oolites. (x25) Inwood Formation, Poplarfield quarry - Interlake area.

Shale

Thin shale layers occur throughout the lower part of the Interlake Group. Many of these are exposed at Grand Rapids. They may be persistent horizons, lateral equivalents of sandstone beds, or local lagoonal deposits associated with reefs or carbonate shoals. Their colour varies from light greyish green to reddish brown.

The most significant shale occurrence is in Souris Valley Warnez 5-13 (19) where 25 feet of slightly gypsiferous shale is present. This deposit is described in greater detail in chapter four.

Evaporites

Beds of gypsum and anhydrite occur sporadically throughout the Interlake Group, but they do not form any significant deposits. A six inch anhydrite bed occurs four feet above the _Virgiana_ zone in Dome Arrow River 12-10 (71). It has replaced parts of adjacent beds of dolomite resulting in highly irregular contacts. The vugs and pores at the erosion surface underlying the Ashern Formation are generally filled with pink gypsum.

A feature noted in samples from part of the Grand Rapids outcrop area is the replacement of some coarse skeletal grains by anhydrite. In addition, films of anhydrite have formed around other skeletal grains and constitute a considerable part of the matrix. These replaced grains are probably a part of the seepage refluxion process of dolomitization as described by Adams and Rhodes (1960). The presence of salt hopper impressions in parts of the outcrop section indicate at least local high salinities. In cores, selenite often occurs as secondary fillings of the vugs and fractures.

The gypsum - anhydrite deposits at Gypsumville although occurring within the outcrop belt of the Interlake Group, are of questionable age. This uncertainty is due to the lack of contact relationships with enclosing strata and is further complicated by the occurrence of Precambrian inliers within and adjacent to the deposit. Cole (1913) stated that "the gypsum deposits lie on the top of the Silurian or among the lower beds of the Devonian." Kindle (1914) placed the gypsum beds in the Silurian between the <u>Virgiana</u> and <u>Leperditia</u> zones. Baillie (1951) suggested a number of possible ages, one of which was a correlation with the Jurassic Amaranth deposits. Bannatyne (1959) summarized the geology of the Gypsumville deposit and discussed the controversy concerning the age of the deposit. He stated that although evidence is lacking for a definite age, a Silurian age is the most reasonable because of presence of anhydrite in the Silurian in several wells in the general area.

If a Silurian age is correct, there are several times within the Interlake when conditions were favourable for the deposition of evaporites. The deposit is discussed further in Chapter 6 after examining the regional sedimentation of the area.

CHAPTER THREE: STRATIGRAPHY OF THE OUTCROP AREA

Introduction

The outcrop belt of the Interlake Group in Manitoba can be separated into two areas (Figure 1). The southern or Interlake area comprises the area between Lake Winnipeg and Lake Manitoba, and the northern outcrop area is between Grand Rapids and The Pas. The two regions are separated by an extensive area of swampy ground and glacial drift.

Previously, Baillie (1951) and Stearn (1956) had described the most significant sections of both areas. Stearn has provided the more detailed subdivision of the outcrop area, establishing six formations. It will be shown later that these formations have little correspondence to the units established in the subsurface. In outcrop however, most of Stearn's formations are recognizable and can be traced over considerable distances. This is especially true in the northern area where exposure is more continuous.

New sections have been described according to Stearn (1956). However, the new information did not validate the existence of the Fisher Branch Formation or the Cross Lake Member. Consequently, it is suggested that the names be removed from the stratigraphic nomenclature for the outcrop area. Beds considered equivalent to those two units are described separately for the sake of comparison.

Southern (Interlake) Area

One of the best exposures in the southern area is at the Inwood quarry which Stearn (1956) designated as being representative of the lower member of his Inwood Formation. The upper ten feet consist of cryptocrystalline and microcrystalline dolomite, thin to medium bedded and containing abundant stromatolites. The texture of the lower fifteen feet varies, grading laterally from stromatolites into skeletal material. Organisms such as brachiopods and corals are present and presumably contributed to the skeletal debris although crinoid columnals are the only identifiable grains. Thin tabular intraclasts of cryptocrystalline dolomite occur in the proximity of several stromatolites. The lower unit contains irregular pockets and thin bands of reddish brown shale, in part flecked with light green patches. Associated with the shale is a minor amount of fine quartz sand and various sized grains of dolomite. These shales are of only local extent and are not correlatable to the non-sequential beds of the subsurface. A test pit north of the village of Broad Valley contains a similar sequence of beds and Baillie (1951) stated they can be correlated to the Inwood section.

The thickest section, 9.8 feet, of the coarsely fragmental upper Inwood Member described by Stearn (1956 p. 22) is located near the village of Sandridge. This section was not examined by the author. The oolitic bed exposed in a small quarry near Poplarfield is placed in the same unit.

The oolites range in size from one to two millimeters in diameter and are overlain by a three foot bed of microcrystalline dolomite.

The type section for the Fisher Branch Formation, the lowest formation in Stearn's subdivision, is on a low wooded ridge northwest of the village of the same name. Establishment of these beds as a separate formation was mainly on the basis of paleontology (Stearn 1956 p. 16) although he believed that it could be recognized lithologically as well. The section consists of microcrystalline to very finely crystalline dolomite containing abundant brachiopods and corals. However, due to the very poor exposure there are no features evident to distinguish this section from the beds in lower part of the Inwood quarry. The index brachiopod *Virgiana decussata* has been recovered from the base of the Interlake in the subsurface. Thus the presence of *Virgiana decussata* is the only indication that the section is in the basal beds of the Interlake. No distinctive lithologic features were recognizable at the poorly exposed type section or elsewhere in the outcrop area. The beds are considered unrecognizable as a formation.

The only other sections of significance in the southern area are close to the east shore of Lake Manitoba and located within the Cedar Lake Formation of Stearn. A test pit 1½ miles northwest of Spearhill exposes the unconformable contact between the Interlake Group and the overlying red brown shales of the Ashern Formation. Here the Cedar Lake Formation contains an organic lens composed of irregularly shaped vertical pillars firmly cemented together. The flanking beds are composed of very fine to finely crystalline dolomite with some evidence of skeletal material presumably derived from the lens. This section is described in greater detail by Baillie (1951).

The quarry at Lundar exposes 7½ feet of a reef complex. Porous vuggy dolomite grades laterally into cryptocrystalline dolomite. Patches and thin irregular beds of fine to very coarse skeletal debris occur with a close relationship to the crystalline dolomites. Numerous favositid corals, stromatoporoids and wavy bands of *Stromatactis* - like material form most of the organic framework and sediment binding agents of the reef. Pockets of reddish brown shale occur sporadically and probably represent local lagoonal conditions. Low poorly exposed outcrops near the village of Fairford show similar textures to those present in the Lundar section and probably represent a reef.

Northern (Grand Rapids - The Pas) Area

Stearn (1956), established the stratigraphy of this area from outcrop along the shores of the numerous lakes as well as on the Saskatchewan River. During 1962 and 1963, coreholes were drilled at several locations in this area. Specifically they include several deep test holes at Grand Rapids and 50 foot test holes at Easterville and Moose Lake settlements. The Grace Lake hole near The Pas was drilled through the Paleozoics by a mining firm for the purpose of testing the Precambrian basement. Construction of Manitoba Hydro's powerdam at Grand Rapids resulted in several new sections exposed at this locality. The new information is discussed in regard to Stearn's (1956) subdivisions, with correlation to the subsurface presented in the following chapter.

Beds Equivalent To The Fisher Branch Formation

An examination of the fourteen feet of the Grand Rapids section indicated by Stearn to be Fisher Branch was performed. The upper part is very fossiliferous, with complete brachiopods (including Virgiana) and solitary corals and associated with very coarse skeletal debris. The lower part is aphanitic and thick bedded in outcrop, but when examined closely, contains subrounded to round well sorted grains of cryptocrystalline dolomite. Size ranges from silt to medium grained with a lesser amount of very coarse material of apparent skeletal origin.

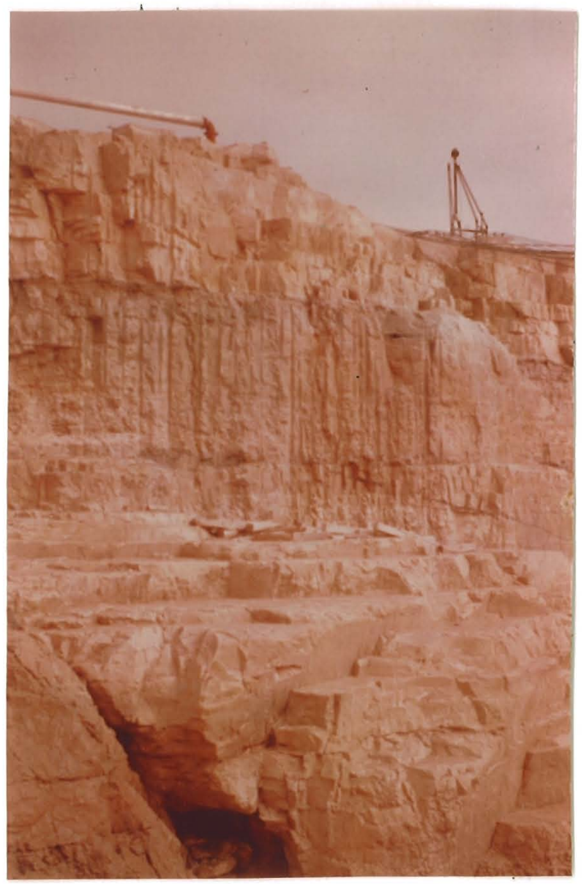
The lower contact of the "Fisher Branch" is described by Stearn (1956 p. 18) as sharply overlying the conglomeratic upper Stonewall. Only one description of the contact is provided by Stearn. This is on the south shore of Moose Lake where a thin red arenaceous shale marks the base of the Interlake Group. The same bed is present in the powerhouse excavation at Grand Rapids and consists of 18 inches of light greenish grey arenaceous dolomite and shale lying 17½ feet below the *Virgiana decussata* bed. It occurs in all drill holes of the area and its persistence has led to the use of it as a datum plane for engineering purposes. (Rettie and Patterson, 1963). In the Noranda Grace Lake (100), the same bed is two feet thick and lies fourteen feet below the *Virgiana* bed. A reddish brown and light green argillaceous silty dolomite constitutes the upper foot grading into a dolomite conglomerate with irregular pebbles up to ¾ inch in diameter set in an argillaceous matrix. The bottom two inches are shale containing medium grained dolomite sand and minor fine grained rounded quartz sand. It sharply overlies a white cryptocrystalline dolomite.

An analysis of this bed at Grand Rapids indicates the sand grains to consist of dolomite, quartz, and a small suite of heavy minerals. The dolomite grains are subrounded and concentrated mainly in the coarse and medium grained fractions. The quartz grains are of two distinct origins. The most prominent quartz grains are well rounded and occur in the coarse fraction with additional grains being fine to medium grained, angular, and in part contain biotite inclusions. The latter size fraction contains microcline and the heavy mineral suite of magnetite, garnet, and olivine. All grains are angular and the heavy minerals and microcline comprise approximately two percent of the very fine to medium grained fraction.

PLATE IV

Interlake
Group

Stonewall
Formation



Base of Interlake Group in contact with underlying Stonewall Formation. Manitoba Hydro Powerhouse excavation, Grand Rapids.

Inwood Formation

As in the Southern area, Stearn (1956) subdivided the Inwood Formation into two members for the Grand Rapids area. The geologic map accompanying his memoir shows no Inwood rocks in The Pas - Moose Lake area and Stearn gives no details as to the disappearance of this unit.

1. Lower Member

At Grand Rapids, Stearn (1956) described the lower member as consisting of 30 feet of greyish-yellow calcitic dolomite with a high argillaceous content. These are the beds designated as Unit C by Baillie (1951), and were described as containing streaks and patches of coarse silt and very fine sand with isolated round frosted quartz grains.

An examination of the same interval by the author in coreholes not far from the outcrop, revealed the member to be only slightly argillaceous, containing no silt or quartz grains, and having a general chalky appearance. It consists of cryptocrystalline and microcrystalline light buff dolomite with patches of very finely crystalline clear dolomite. Generally, the member has good intercrystalline and vuggy porosity. Perhaps part of the features described at outcrop are due to extreme weathering , poor exposure and misinterpretation.

In core, the upper two feet of this member are very light grey microcrystalline dolomite containing silt sized to fine grained cryptocrystalline grains of possible pellet origin. This in turn is overlain by a two foot bed of arenaceous dolomite which marks the upper contact of this member. The quartz sand is subrounded, medium to coarse grained and increases in abundance towards the top of the bed. A thin arenaceous band at the base of the bed is deposited on a slightly undulating surface and is associated with tabular and subrounded fragments of dolomite. This bed is the same as recorded by Baillie (1951) as marking the upper limit of his Unit C.

2. Upper Member

The upper member as described by Stearn (1956), consists of fragmental dolomite with 12 feet of beds recorded at the Grand Rapids section. Baillie (1951) placed the same beds at the base of his Unit D and described the finely fragmented dolomite as composed largely of comminuted fossil fragments.

In adjacent coreholes, equivalent beds have partings and pockets of pale green clay. Rounded grains of cryptocrystalline dolomite range from silt sized to occasionally medium grained. The larger grains are usually subangular and exhibit a mottled pattern which may represent original skeletal fragments or lithic fragments attacked by organisms. Numerous whole and disarticulate brachiopods occur with these grains.

Stearn (1956) described the upper contact of the member as gradational with the overlying Moose Lake Dolomite but established the contact as the uppermost occurrence of fragmental dolomite. Baillie (1951) also recorded this transition from fragmental dolomite into dense cryptocrystalline dolomite. This gradation may be observed in core but is ce certainly not distinctive, as fragmental beds are also present within the Moose Lake Dolomite.

Moose Lake Dolomite

Stearn (1956) proposed the name Moose Lake Dolomite for the very fine grained and dominantly stromatolitic beds overlying the Inwood Formation and underlying the Atikameg Dolomite. In outcrop at Grand Rapids, the beds attain a thickness of 23 feet and stromatolites were observed only in the upper few feet. This same interval was described by Baillie (1951) and included in his Unit D.

The dolomite consists of silt sized to fine grained cryptocrystalline dolomite grains with shapes verying from spherical to ovoid and suggestive of an original pelletal texture. Several crinoid columnals and small brachiopods in various stages of destruction are present. Conspicous stromatolitic structure is present in the upper part of the formation. A large slab broken from these beds in quarrying shows the relationship of the stromatolites (Plate VA). This type is considered to be the same as LLH-C of Logan et al. (1964), and is characteristic of intertidal mud flat environments in protected locations of re-entrant bays, and behind barrier islands and ridges. Hopper-shaped salt impressions occur within the formation.

In core from Grand Rapids, a two foot bed of dolomite breccia overlies the stromatolitic beds. The fragments are angular, occasionally subrounded and up to seven centimeters in diameter with smaller dolomite fragments contributing to the matrix. Small scattered pockets of greyish green clay are present. An "intraclast" of similar clay material occurs with skeletal and fragmental dolomite at the base of the bed. The breccia bed is overlain by strata of the Atikameg Dolomite.

Atikameg Dolomite

A massively bedded, porous, pale buff, fossiliferous unit extending throughout the northern outcrop area was named the Atikameg Dolomite by Stearn (1956). He regarded it as biostromal rather than biohermal because of the constant thickness (15 - 19 feet) throughout the area and the lack of reef builders such as corals and stromatoporoids. Baillie (1951) also described similar beds within his Unit D.

The grain size of the dolomite ranges from microcrystalline to finely crystalline and the grains are subhedral to euhedral in shape resulting in good intercrystalline porosity. Part of the dolomite consists of medium to coarse grained, subangular cryptocrystalline dolomite grains which exhibit poor sorting. Recognizable skeletal material includes small brachiopods and rare crinoid columnals. Patches of white microcrystalline dolomite occur in part. Thin wavy bands of microcrystalline dolomite interweave with the coarser crystalline and skeletal material. It probably represents the <u>Stromatactis</u>-like material described by Lowenstam (1950, 1957) as a sediment binding agent in the Niagaran reefs of Illinois.

In core, this unit is recognizable by its light buff colour and coarser grain size when compared to enclosing units. Relict grains and skeletal material as described above are interbedded with thin layers of microcrystalline dolomite, the latter probably representative of <u>Stromatactis</u>-like or similar algal material. Solitary corals are present within the unit. Numerous coarse vugs occur, some of which have been filled in by white crystalline dolomite. A sharp contact occurs with the overlying East Arm Dolomite.

East Arm Dolomite

Stearn (1956) defined the East Arm Dolomite as a fine grained stromatolitic, locally fossiliferous and oolitic dolomite exposed on the East Arm of Moose Lake with minor exposures elsewhere in the northern area. The entire formation as designated by Stearn is present in the Grand Rapids core (97) and the Moose Lake corehole (99) penetrated the upper 18 feet. In addition, the quarrying of an intake channel has resulted in the excellent exposure of the lower part of the formation at Grand Rapids.

Where examined by the author, the formation was found to contain several clastic beds in the lower part. These lower beds represent the greatest amount of terrigenous material present in the outcrops of the Interlake Group. Round, medium-coarse quartz sand occurring either as floating grains or in thin bands, is present within the basal five feet. Argillaceous material is present in part (Plate VB).

The most significant occurrence of detrital material is sixteen feet above the base of the formation. (Plate VB). A detailed examination of the bed revealed thinly interbedded shale, sandstone, siltstone and dolomite (Plate VI). Rapid changes in lithology occur, particularly in the middle sandstone layer which pinches out over the distance of a few feet. The thickness of the bed ranges from slightly less than a foot to two feet.

A sample from the main sandstone layer contains medium to fine grained, well rounded quartz grains. The pale green to greenish grey shales contain dolomite fragments, silt and some fine to medium rounded quartz grains. A few shale fragments were also noted within the sandstone layer.

The interval between the basal terrigenous-bearing beds and the sandstone bed is composed of cryptocrystalline dolomite with narrow, rare skeletal bands. A thin bed of arenaceous dolomite occurs four to six feet above the sandstone bed. Associated with the round medium grained quartz grains are angular dolomite fragments up to five centimeters

PLATE V

A. Stromatolitic development in Moose Lake Dolomite. Grand Rapids.

V

U_2

B. East Arm Dolomite containing V and U_2 non-sequential beds of the subsurface. Arch at right hand side of photograph is due to blasting operations. Intake channel, Grand Rapids.

PLATE VI

dolomite

pale green to light grey shale

dolomite

sandstone

greyish green shale

sandstone

pale green arg. dolomite

grey shale

green - buff shale grading to dolomite

dolomite

Close-up of V marker bed. Intake channel, Grand Rapids.

in diameter.

The upper part of the formation consists predominantly of very fine to medium grained, angular to subrounded, cryptocrystalline dolomite grains, suggestive of original skeletal grains or perhaps grapestone. Patches and thin bands of coarser skeletal and oolitic material are dispersed throughout this part of the formation. The upper boundary is placed at the point where the coarse skeletal material predominates.

Cedar Lake Formation

A series of thin bedded, lithographic, greyish yellow dolomites outcropping on the shores of Cedar Lake was named the Cedar Lake Formation by Stearn (1956). He recognized two distinctive units; a lower biostromal member, the Cross Lake, and a scattered reefal facies named the Chemahawin. The two members occur as lateral replacements of the main body of the Cedar Lake Formation. The reefal member was designated Unit E by Baillie (1951) with the underlying strata placed in Unit D.

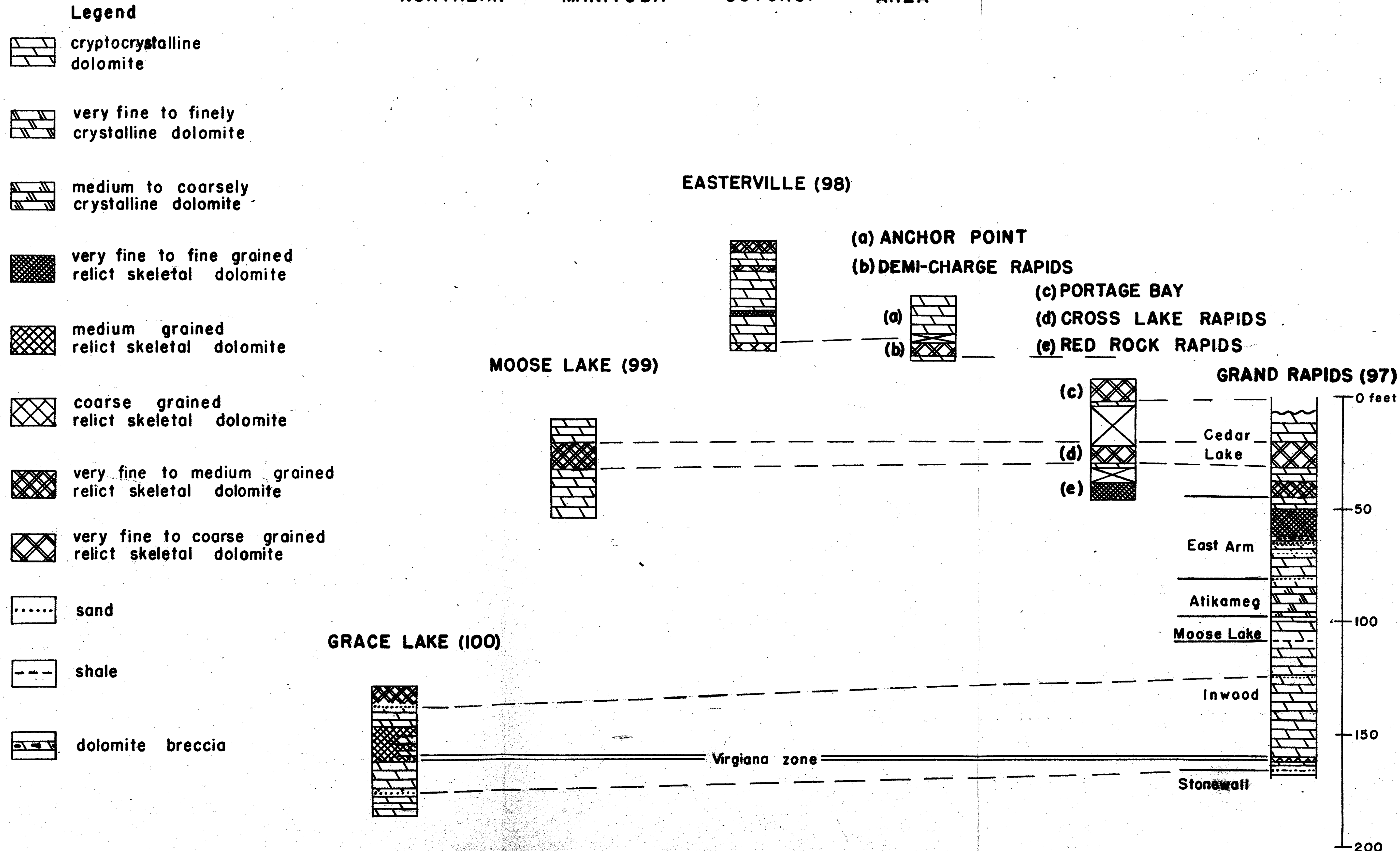
Stearn (1956 p. 37) stated that the Cross Lake Member was continuous and underlaid all of Cross Lake from Red Rock and Cross Lake Rapids, to Cedar Lake and horthward to Moose Lake. The Grand Rapids (97) and Moose Lake (99) coreholes penetrated 12 and 15 feet respectively of a skeletal dolomite overlying the East Arm Formation. This in turn was overlain by a stromatolitic, cryptocrystalline dolomite. The skeletal dolomite overlying the East Arm Dolomite crops out on the east shore of Cross Lake at Cross Lake Rapids. The skeletal dolomite on the west shore at Demi-Charge Rapids is stratigraphically higher. The two relict skeletal units are separated by cryptocrystalline dolomite present at the top of the Grand Rapids (97) and Moose Lake (99) coreholes. (see Figure 3). The Cross Lake Member as developed by Stearn (1956) appears to be only an interbedded relict skeletal and cryptocrystalline dolomite, which occurs elsewhere within the Cedar Lake Formation and thus does not appear to require a member designation as proposed by Stearn.

In the Easterville core (98), beds equivalent to those exposed at Demi-Charge Rapids are overlain by 40 feet of cryptocrystalline to microcrystalline, lithographic light grey buff dolomite with minor interbeds of relict skeletal dolomite. This closely resembles the Anchor Point section (Figure 3) and rocks exposed on the narrows of Cedar Lake. These beds are overlain by yellowish buff, very finely crystalline to medium crystalline euhedral dolomite with good vuggy and intercrystalline porosity. Parts contain coarse skeletal detritus and fossils including well preserved brachiopods and gastropods. As the top is eroded, only five feet of this bed occurs at Easterville.

The interval between Easterville and the Devonian erosional edge is represented by exposures along the shores of Cedar Lake. Stearn (1956) considered the region to be underlain by a uniform lithology of cryptocrystalline dolomite

Figure 3: STRATIGRAPHIC CROSS SECTION INTERLAKE GROUP

NORTHERN MANITOBA OUTCROP AREA



with some thin skeletal bands. The Chemahawin reefs in the upper part are equivalent to those exposed at Lundar and Fairford in the southern outcrop area. They consist of porous crystalline dolomites with stromatolites and corals and show no bedding in outcrop. The contact between the Interlake Group and the overlying Ashern Formation is not exposed in the northern area.

CHAPTER FOUR: SUBSURFACE STRATIGRAPHY

Introduction

An examination of Manitoba well data yielded the basic subdivisions established by Porter and Fuller (1959). The Lower Interlake contains additional correlatable non-sequential beds and this unit is subdivided into, 1. the Strathclair Formation and 2. the Brandon Formation with an upper member and a lower member. The contact separating the two formations is placed at Porter and Fuller's (1959) "U" horizon. The name Cedar Lake Formation is extended from the outcrop area to the Middle Interlake. The "V" horizon of Porter and Fuller (1959) marks the contact between the Cedar Lake Formation and the underlying Brandon Formation. The Upper Interlake is present only in the extreme southwest corner of Manitoba. The early Middle Devonian Ashern Formation unconformably overlies the Interlake in the subsurface except in the area south of Winnipeg and east of the Devonian erosional edge where the Interlake is directly overlain by Jurassic sediments.

Strathclair Formation

Definition

The name Strathclair Formation is proposed for a sequence of dolomites representative of reef and interreef deposits overlying the Stonewall Formation and conformably underlying the Brandon Formation. The reef complexes consist of medium to coarse crystalline dolomite, relict skeletal dolomite, and fossiliferous dolomite with minor interbeds of cryptocrystalline dolomite grading laterally to the interreef and littoral deposits of cryptocrystalline to very finely crystalline dolomite.

In Dome Arrow River 12-10 (81) all but the basal 10 feet of the formation has been cored. However, the electric logs of this well are poor and Dome Strathclair 8-34-16-21 W1 (77) is designated as the type well. Only the lower 15 feet of the formation has been cored in this well. In outcrop the Strathclair Formation includes the Fisher Branch Formation and the lower member of the Inwood Formation of Stearn (1956).

Contacts of the Strathclair Formation

The contact of the Strathclair Formation with the underlying Stonewall Formation is marked throughout the subsurface by a thin reddish brown shale or argillaceous dolomite. In Dome Strathclair 8-34 (77), 2½ feet of shale is present with two feet of argillaceous dolomite overlying it. In Red River Lower Farm (16), the contact is marked by approximately two feet of dark red, silty, argillaceous beds.

The upper contact of the Strathclair is the same as the "U" marker bed of Porter and Fuller (1959). In the Dome Pelican Lake 7-34 (13) core, this contact is represented by a foot of greyish green clay with thin interbeds of dolomite. In the area southwest of Winnipeg, the shales at the contact have a thicker development than elsewhere in the province. The additional five to ten feet is along a linear trend extending from Sweetgrass Altamont 2-35 (17) to Cego Elm Creek 5-26 (44) with possible extension to Calstan Woodlands 4-6 (72) (Figure 5). The shale rapidly thins westward and more gradually to the east. No cored intervals exist but well cuttings indicate a reddish brown color.

Lithology and Distribution

The Strathclair Formation has the greatest variance in thickness of any formation in the Interlake Group. In a distance of 15 miles, it thins from 78 feet at Western Graysville 9-22 (24) to 25 feet at B.A. Gates 16-22 (28). In general, the area southwest of Winnipeg adjacent to the eastern erosional edge has the thickest succession of sediments within the Strathclair Formation.

In Western Graysville 9-22 (24) the lower 30 feet consists of cryptocrystalline and microcrystalline anhedral dolomite overlain by 20 feet of medium to coarse grained skeletal dolomite containing recognizable crinoid columnals and shell debris. A fine grained oolite constitutes the lower 10 feet of the skeletal dolomite. The remainder of the formation consists of approximately 25 feet of subhedral microcrystalline dolomite grading to cryptocrystalline dolomite in part with minor fine grained skeletal material near the top of the formation.

Fifteen miles to the north, in Can. Sup. Haywood 7-32 (35), the oolite bed has thinned to seven feet and is intercalated in part with skeletal dolomite. It is underlain by 14 feet of microcrystalline grading to cryptocrystalline, anhedral, slightly calcareous dolomite and overlain by approximately 20 feet of anhedral cryptocrystalline dolomite. The formation thins westward accompanied by disappearance of the oolite bed.

A comparison of Can. Sup. Rusywich 6-11 (36) with Cego Treherne 13-7 (37) nine miles further west, reveals a changing from abundant, very fine to coarse grained, poorly sorted skeletal dolomite and oolitic dolomite in the thicker portions to cryptocrystalline dolomite with minor interbeds of skeletal dolomite present in the thinner portions. Northward the formation consists of interbedded skeletal and cryptocrystalline dolomite at Calstan Woodlands 4-6 (72) and cryptocrystalline dolomite with a basal bed of fine grained skeletal and fine to medium grained crystalline dolomite in Hem. Helium Taylor 16-15 (87).

A relatively isolated thick part of the Strathclair Formation is penetrated by Dome Pelican Lake 7-34 (13). In this well it consists of very fine to coarse grained, subrounded to rounded skeletal material becoming very fine to fine grained interbedded with microcrystalline euhedral dolomite near its base and grading to cryptocrystalline dolomite in the lower five feet.

A similar thick succession of sediments occurs in the Springhill area further north where Cego Springhill 13-12 (73) contains fine to medium grained skeletal dolomite but differs from the Pelican Lake area in that the grains are set in a cryptocrystalline matrix of dolomite. This has resulted in fair to poor porosity.

A more extensive distribution of medium to coarse grained material is located in the Arrow River - Foxwarren area adjacent to the Saskatchewan boundary. In Dome Arrow River 12-10 (71), the formation is 58 feet thick and was almost entirely cored. The upper ten feet and the lower 40 feet are beds of relict skeletal dolomite, separated by an eight foot bed of cryptocrystalline, stromatolitic dolomite which is slightly argillaceous in part. The skeletal dolomites consist of fine, medium and occasionally coarse grains which are subangular to rounded and poorly sorted. Recognizable skeletal material includes whole and fragmented brachiopods, crinoid columnals, favositid corals and a few stromatoporoids. The lower skeletal bed is underlain by a five inch bed of anhydrite exhibiting local replacement of the dolomite. This in turn is underlain by medium to coarse grained skeletal dolomite containing Virgiana, which grades to cryptocrystalline dolomite at the base of the formation. Northwest of this location, Imperial Madelaine 16-18 (84) contains microcrystalline and cryptocrystalline dolomites interbedded with very fine to coarse skeletal dolomites.

A broad area of generally very fine to fine grained dolomites extends north and northeastward from Brandon. Canadian Superior Hockins 3-19 (65) is situated in the middle of this belt and contains round, well sorted cryptocrystalline dolomite grains of very fine to fine grain size with occasional medium grained material. Fragments of Fardenia ellipsoides were noted in the well cuttings. Other wells in this area contain cryptocrystalline to microcrystalline dolomites with minor varying amounts of very fine grained crystalline or relict skeletal dolomite in the Strathclair Formation.

Southward of this area an east - west belt containing a thin succession of sediments roughly parallels the Assiniboine River. Cego Hilton 13-5 (29) is situated in this trend and contains microcrystalline grading to cryptocrystalline, anhedral, rarely subhedral, dolomite with a thin bed of very fine to coarse skeletal dolomite at its base.

Elsewhere in the area of study, the formation generally consists of cryptocrystalline dolomite with minor interbeds of relict skeletal dolomite.

Brandon Formation

Definition

The name Brandon Formation is proposed for a sequence of relict skeletal dolomites, local oolitic dolomite and cryptocrystalline dolomite overlying the Strathclair Formation and underlying the Cedar Lake Formation. The type well is designated as Dome Pelican Lake 7-34-4-15 W1 (13) in which the entire formation is cored. The name Brandon was chosen because of the previous use of "Pelican" and that the wells of the Brandon area show the various facies changes present in the formation. The formation is divided into an upper and lower member, separated by a correlatable marker bed designated as "U_2". This bed is not discernible in some wells and thus has resulted in the consideration of the interval as one formation rather than two separate formations.

In outcrop, the Brandon Formation is represented by the upper member of the Inwood Formation, the Moose Lake Dolomite, the Atikameg Dolomite, and the lower part of the East Arm Dolomite of Stearn (1956).

Contacts of Brandon Formation

The lower contact of the Brandon Formation is the "U" marker bed described on page 43 in connection with the Strathclair Formation. The upper contact of the formation corresponds to the extensive and prominent "V" non-sequential bed of Porter and Fuller (1959). In Dome Pelican Lake 7-34 (13), this contact is represented by six inches of reddish brown, slightly anhydritic shale overlying six inches of argillaceous, cryptocrystalline dolomite. This in turn is underlain by a two foot dolomite breccia bed. It contains poorly sorted, angular fragments ranging in size from two to six centimeters across and set in a pale green argillaceous matrix. An equivalent bed in Calstan Hartney 16-33 (20) consists of two inches of dark green shale. Cuttings from this interval in most wells are argillaceous and/or show some quartz sand or silt.

Lithology and Distribution

1. Lower Member

The lower member of the Brandon Formation contains coarse grained areas of varying dimensions in a region of generally fine grained deposits. A northward increase in thickness is accompanied by a general increase in grain size.

The western edge of one of the most extensive of the coarse grained areas was cored in Dome Pelican Lake 7-34 (13). The lower seven feet consists of fine to medium grained, subrounded relict skeletal grains associated with Stromatactis-like material and favositid corals. These beds grade upward into eleven feet of coarse grained oolite. The remaining upper five feet of the member consists of stromatolites with lenses and thin interbeds of skeletal dolomite. A similar sequence is present on the east side of this coarse grained area in Sweetgrass Altamont 2-35 (17).

A more restricted area of coarse grained dolomites is present in the vicinity of Brandon. Here the lower member contains very fine to very coarse grained, subangular to round skeletal dolomite grains. The enclosing deposits are chiefly cryptocrystalline to microcrystalline dolomites containing little relict skeletal material.

There is a general increase in grain size and thickness in a northward progression of the lower member. In this area, the lower part of the member consists of fine to coarse, subrounded to round, relict skeletal grains, with minor oolites and interbeds of cryptocrystalline dolomite. This is overlain by cryptocrystalline and microcrystalline dolomite containing fine to medium grained relict skeletal debris. The top part of the member is generally cryptocrystalline and microcrystalline dolomite although well sorted skeletal dolomite may locally occur as in Cego Springhill 13-12 (73). Quartz silt and occasional round, coarse to very coarse sand grains may be present in the upper part of the member such as in Sweetgrass Duck Mountain No. 1 (91).

The rapid changes in thickness and lithology noted in the Strathclair Formation in the area southwest of Winnipeg are not reflected in the sediments of the lower Brandon. An east-west belt of cryptocrystalline dolomite extends across this area. North of this trend another area of relict skeletal dolomite and oolite occurs in the Woodlands area. The oolite beds at the Poplarfield quarry are probably an extension of this oolite.

An interesting feature of the Lower Brandon is the distribution of the oolites. They are best developed in the southern area with the coarser grained occurrences being near or at the base of the lower member. Their distribution is coincident with the regions of thick sediment in the underlying Strathclair Formation.

2. Upper Member

The upper member of the Brandon Formation maintains a relatively uniform thickness throughout the study area. It consists of cryptocrystalline to microcrystalline dolomite with only a few occurrences of coarser crystalline dolomite or relict skeletal material.

The cored interval at Dome Pelican Lake 7-34 (13) consists of cryptocrystalline dolomite with patches of fine to occasionally medium grained relict skeletal material with some stromatolitic texture evident in part. Some of cryptocrystalline dolomite contains round silt sized grains of dolomite suggestive of a relict pelletal or grapestone texture.

The Treherne area in the southeast portion of the study area is one of the few places where relict skeletal material constitutes a considerable part of this member. The material occurs near or at the base and consists of fine to medium relict skeletal grains, increasing in abundance towards the erosional edge. Isolated relict skeletal deposits are also present in Robert Moore No. 1 (4) and Dome Brandon 16-27 (48).

Cedar Lake Formation

Definition

In the outcrop area, Stearn (1956) gave the name Cedar Lake Formation to a sequence of cryptocrystalline dolomites containing extensive biohermal deposits and mound-shaped reefs. A similar succession of deposits is present in the subsurface with the relict skeletal dolomites more prevalent than once thought. No subdivisions of the Cedar Lake could be made due to the lack of non-sequential beds. Brindle (1960) established a "W" marker approximately 80 feet above the "V" marker. The "W" marker may be detected in some wells near Saskatchewan, but cannot be traced further east in Manitoba. Since it is not correlatable in Manitoba, the "W" marker is not used in this thesis.

The Cedar Lake Formation of the subsurface has been expanded to include the upper part of the East Arm Dolomite in addition to the Cedar Lake of Stearn's (1956) outcrop stratigraphy.

Contacts of the Cedar Lake Formation

The lower contact is represented by the "V" non-sequential bed described on page 48 in connection with the Brandon Formation. The Cedar Lake is unconformably overlain by the Middle Devonian Ashern Formation except in the area south of Winnipeg and east of the Ashern erosional edge where it is overlain by Jurassic sediments. The Cedar Lake is overlain by Upper Interlake in only one well. This is in the extreme southwest corner of the province at Robert Moore No.1(4). The contact is marked by a bed of well rounded sand.

Lithology and Distribution

The lowest occurrence of extensive relict skeletal dolomite is at the base of the Cedar Lake Formation. It is most common in the southern area with a more sporadic distribution in northern wells. In Shell Swan River No. 2 (93) a possible equivalent development occurs ten feet above the "V" horizon. The basal bed was cored in Dome Greenway 16-13 (12). Fifteen feet of very fine to very coarse relict skeletal dolomite is present with some locally well sorted material. It is interbedded with stromatolites and some minor amounts of green argillaceous material occurs in the matrix. At Dome Brandon 16-7 (48), part of the relict skeletal material can be identified as shell fragments and crinoid columnals. Microcrystalline to very finely crystalline, subhedral to euhedral dolomite is present at the base of the formation in some wells though others contain cryptocrystalline anhedral dolomite.

The most prominent relict skeletal bed in the Cedar Lake occurs in the middle of the formation. No cored intervals exist but well cuttings indicate a fine to very coarse grained relict skeletal dolomite such as present in B.A. Morrisseau

8-20 (45). The bed attains a maximum thickness of 60 feet in Sweetgrass Pilot Mound 3-9 (11).

Overlying and underlying this prominent skeletal dolomite bed are cryptocrystalline, anhedral dolomites with minor interbeds of very finely crystalline dolomite and fine to medium grained relict skeletal dolomite.

In some wells coarsely crystalline dolomite occurs near or at the top of the Cedar Lake Formation. It is difficult to evaluate the continuity of this dolomite because of truncation by the overlying Middle Devonian sediments.

In Souris Valley Warnez 5-13 (19), 25 feet of red brown, slightly gypsiferous shale is present 204 feet above the base of the Cedar Lake Formation and is overlain by 35 feet of light grey microcrystalline and very finely crystalline dolomite. Andrichuk (1959) considered this interval to be Ashern. However, the overlying dolomites resemble more closely the light coloured dolomites present elsewhere in the Interlake, not the brownish dolomites of the Middle Devonian, Winnipegosis Formation.

A thinner development of the shale was noted in Western Orthez 13-36 (13) which lies 18 miles east of the Warnez well. A possible southward extension of the shale may be present in Jumping Pound Horton 8-15 (8). To the west, in Calstan Hartney 16-33 (20), a portion of equivalent beds was cored and contained a coarse dolomite conglomerate. The fragments are subrounded to subangular, up to five centimeters in diameter and set in a slightly calcitic dolomite matrix. The pebbles are of varied texture, including some with cryptocrystalline dolomite and others with relict skeletal grains and good porosity. They appear to represent the coarse carbonate clastics of a fore-reef facies. A stratigraphic explanation for these features is given in Chapter five, interpretative stratigraphy.

<u>Subsurface - Surface Correlations</u>

The strata of the outcrop area described on pages 23 to 40, except for the Fisher Branch Formation and the Cross Lake Member, follows the work of Stearn (1956). This detailed subdivision is not discernible in the subsurface partly because of the great distances between the wells and the outcrop area, the general lack of control and the absence of continous cored sections away from the outcrop belt. In the cored intervals available, some of the outcrop features can be recognized such as the presence of <u>Virgiana</u> in Dome Arrow River 12 - 10 (71) and Dome Strathclair 8-34 (77). The faunal zone in these wells occurs in a similar stratigraphic relationship as is present in outcrop. However, in the subsurface, strata can be correlated by means of non-sequential marker beds. These beds occur in outcrop and can be seen at Grand Rapids in the northern outcrop belt. Figure 4 illustrates the relationship between the outcrop section at Grand Rapids and the subsurface as represented by Dome Strathclair 8-34 (77) for the Interlake Group in Manitoba.

The boundary between the Stonewall Formation and the Interlake Group occurs at the first prominent sandy argillaceous bed lying below the Virgiana zone. In outcrop, at Grand Rapids this boundary is 17½ feet below the Virgiana zone. In the subsurface the bed marking the contact is 12 feet below the Virginia zone in Dome Arrow River 12-10 (71) and 2 feet below the same zone in Dome Strathclair 8-34 (77). Thus it appears that the deflection of the SP curve considered by the Saskatchewan Geological Society (1958) to represent the top of the Stonewall in the subsurface is correct as the beds described above correspond with the deflection.

The "U" marker is equivalent to a sandy bed within the Inwood Formation and is at 122.5 feet in the Grand Rapids core (97). The "U_2" marker correlates to a two foot argillaceous bed with floating quartz sand at the base of the East Arm Dolomite. A poorly developed argillaceous silty zone, 12 feet above the "U" marker at Grand Rapids may be correlated with a sporadic, weakly developed non-sequential marker in the lower member of the Brandon Formation.

The extensive "V" horizon has its equivalent in the sandstone developed at the 66-69 foot interval in the Grand Rapids core (97) and exposed in the intake channel for the powerdam at the same locality (Plate V B). It occurs in the lower part of the East Arm Dolomite. A sandy brecciated zone lying three feet above the "V" horizon at Grand Rapids may be correlated with an argillaceous bed lying immediately above

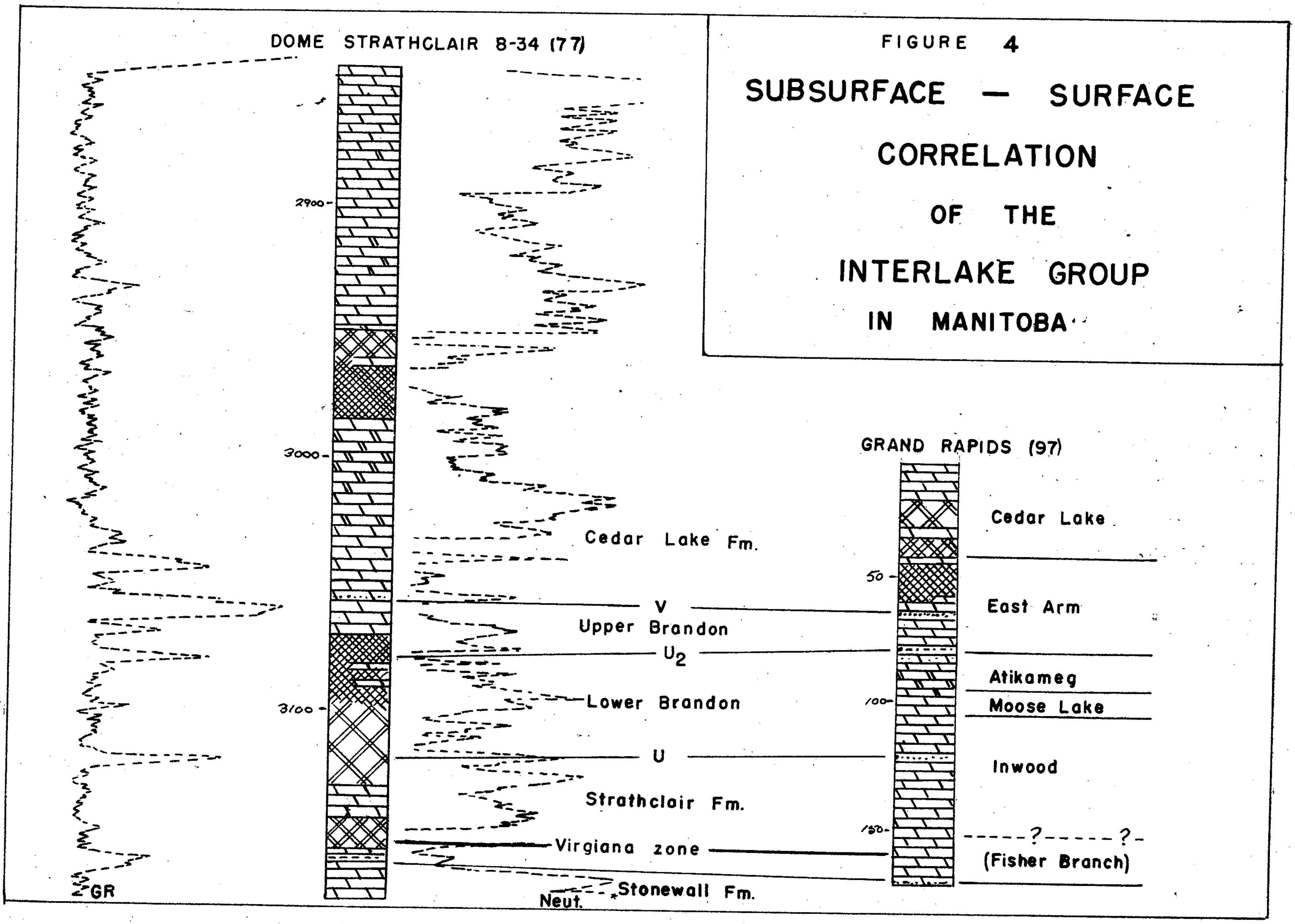


FIGURE 4

SUBSURFACE — SURFACE CORRELATION OF THE INTERLAKE GROUP IN MANITOBA the "V" horizon in many wells.

From the correlation of the subsurface units as defined by non-sequentialbeds, to the outcrop area, there appears to be little agreement with the terminology of Stearn (1956) (see Figure 4). The lowest beds of the Interlake Group which Stearn termed the Fisher Branch Formation, are represented in the lower part of the Strathclair Formation. The reefs of the lower Inwood have their equivalents in the relict skeletal dolomites of the Strathclair. The fragmental, oolitic upper Inwood Member, the overlying cryptocrystalline Moose Lake Dolomite and biohermal Atikameg are equivalent to the lower member of the Brandon Formation. The upper Brandon Member is thin in the Grand Rapids outcrop, represented by the lower 16 feet of the East Arm Dolomite. The Cedar Lake Formation has the same characteristics in outcrop as in subsurface. In the subsurface it has been expanded to include the upper part of the East Arm Formation. The Chemahawin and Cross Lake Members are not recognizable in the subsurface.

CHAPTER FIVE: INTERPRETIVE STRATIGRAPHY

General Remarks

Previous consideration of the Interlake Group in this thesis was concerned with the presentation of pertinent factual data, with little or no interpretation of the data. In the following pages, the significance of the data is considered and the depositional history of the Interlake Group is inferred from this information.

Strathclair Formation

The Strathclair Formation overlies the Stonewall Formation throughout the area of study. The contact is marked by a weak argillaceous or shale development which may have some sand associated with it. Stearn (1956) believed that the contact between the Stonewall and the basal beds of the Interlake marked a hiatus representative of Lower Silurian time. Porter and Fuller (1959) after examining a study of the regional tectonics, and Brindle (1960) after a subsurface paleontological study, both indicated there was little evidence for such a large time break. They also suggested that Stonewall sedimentation persisted into Lower Silurian time and that Interlake deposition had begun later in the Lower Silurian.

At Grand Rapids, the beds marking the contact indicate that some of the underlying Ordovician sediments and parts of the Precambrian shield were exposed at the beginning of Strathclair time. The basal bed contains rounded dolomite fragments, coarse rounded quartz sand, and angular grains derived from an igneous or metamorphic terrain, This suite of grains was probably derived from Ordovician carbonates, Winnipeg Sandstone, and Precambrian rocks exposed to the east of the area. Because of the angularity of the grains derived from the shield area, it is possible that this area was relatively close to the site of deposition. The existence of these areas was probably due to epeirogenic forces within the shield area.

In the southcentral and western portions of the study area, (Figure 11 in pocket) several localities of medium to coarse grained dolomites are located on the highs delineated by the isopach contours. Although wide well spacing hampers a detailed interpretation, it was found that there is a decrease in the amount of relict skeletal material accompanied by a general decrease in grain size as one progressed from wells penetrating the centres of the highs to neighbouring wells. This relationship is somewhat analagous to that described by Ingels (1963) who showed grain size decreased away from the core of the Thornton (Illinois) Niagaran reef. Thus it is believed that the isolated coarse grained highs of the Strathclair Formation are reefs. Compared with the broad shelf area on which the reefs existed, their height suggests that their growth was in a vertical direction.

In some areas, there is a high proportion of relict skeletal material but no corresponding high. These are interpreted as shallow water bank areas. They contain abundant organic life, but the ecology was not suitable for prolific reef growth.

Most of the area consists of cryptocrystalline to microcrystalline dolomites with minor varying amounts of very fine grained crystalline or relict skeletal dolomite. These areas represent restricted shallow water on the shelf or interreef deposits with the amount of skeletal material dependant on the proximity of the reef or the organic bank.

The area of thicker sediments in the southeast portion of the area (see Figure 5) was deposited in a small basin isolated from western part of the area by a northward extension of the Cavalier High (Ballard 1963). This high is not noticeable north of the Assiniboine River, but this may be due to lack of control in this area. A shoal area was established over this mild tectonic feature which resulted in the formation of oolites which were subsequently swept into the basin area east of the high. Organic activity followed oolite formation over the high and current action distributed debris into the basin as well.

The top of the Strathclair Formation is marked by a thin shale development which extends over the study area. An additional 5 - 10 feet of shale occurs in the local basin immediately east of the Cavalier high. From the distribution

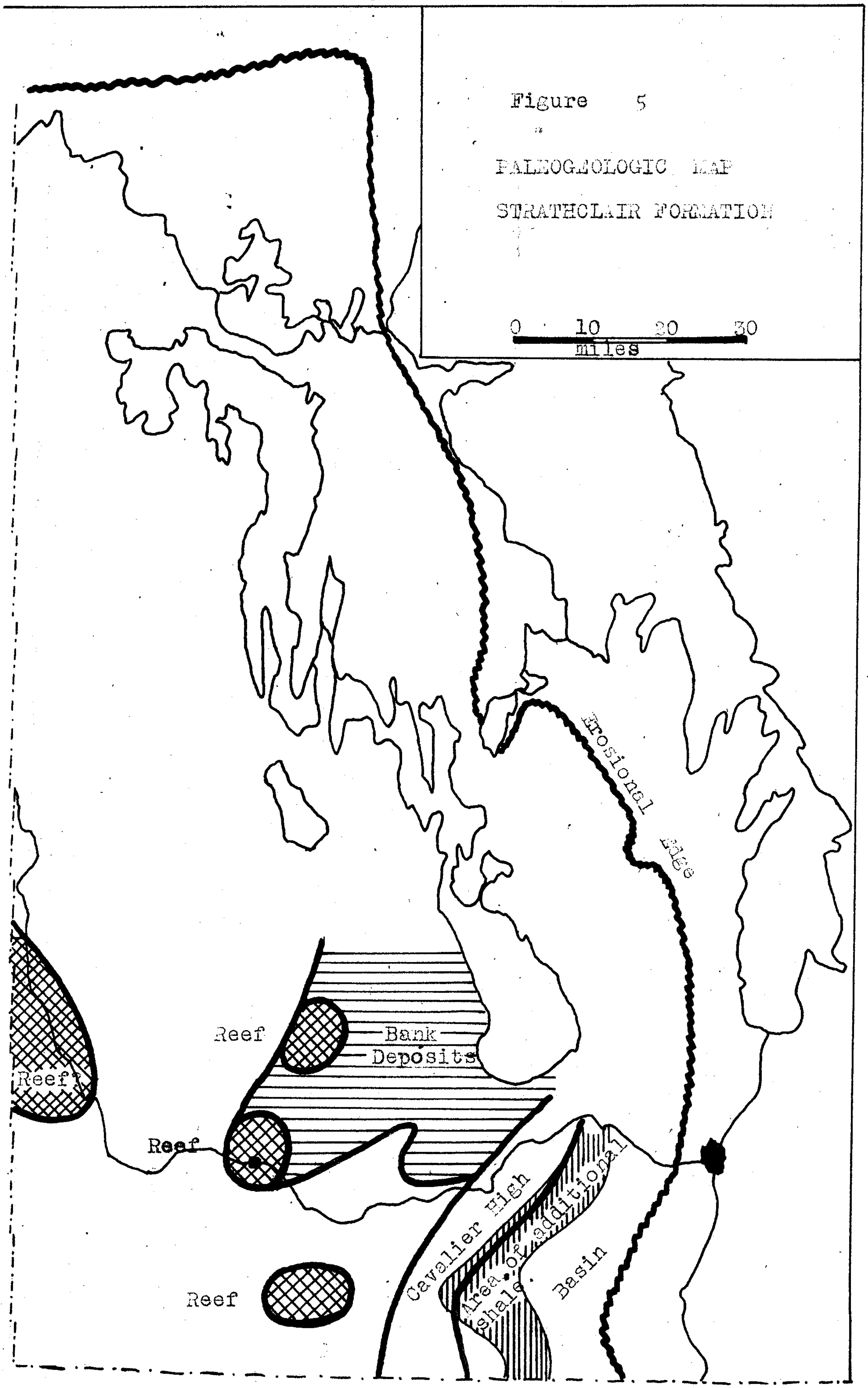


Figure 5

PALEOGEOLOGIC MAP
STRATHCLAIR FORMATION

of the shale (Figure 5) it appears to represent a broad channel on the Strathclair erosion surface. An alternate explanation is that the shales may be associated with evaporites if a local basin became restricted during uplift of the surrounding area. Due to poor samples from this interval the presence of evaporites could not be ascertained. However, if present they in addition to the shales would represent the final residue from evaporating waters.

Brandon Formation

Lower Member

There is a general absence of relict skeletal material at the base of the lower member of the Brandon Formation in the southern area. An exception is over the Strathclair reefal highs. This suggests a flooding of the surface to a relatively deep depth of water. Such a flood would not allow erosion of the Strathclair highs or reworking of other pre-existing deposits. In addition, any organism which had established itself on low areas of the Strathclair surface would not be able to keep pace with the rapidly rising sea level. Only the reefal highs in the southern area and bank areas further north (Figure 5) would be above wave base, thereby in conditions favourable for organic growth.

Organisms established themselves in the areas described in the preceding paragraph. They formed shoal areas in an otherwise fairly deep shelf sea. Conditions at many of shoals were suitable for the formation of oolites. It is believed that oolite formation occurred in a manner similar to that described by Purdy (1961) at the Bahama Banks. The warm waters were subjected to a high degree of agitation over the shoal areas resulting in oolitic accretion. Coarse oolitic deposits occur at shoals in the Pelican Lake and Brandon areas and parts of the extensive bank area present in the Strathclair Formation northwest of Winnipeg.

Conditions changed, and organisms again established themselves in the shoal areas. They were governed by slightly fluctuating sea level, consequently expanded laterally, and creating reefs of greater horizontal extent than the reefs which existed in Strathclair time. Current and wave action winnowed some fine material off the reefs and into the inter-reef areas and lows in the surface of the Strathclair Formation.

In the central and northern parts of the study area, a shallow bank existed which supported organic growth throughout most of lower Brandon time (Figure 6). Slight fluctuations in sea level resulted in transgression and regression of the strand line across this area. This activity created thick widespread skeletal deposits which are finer grained in the southern part of the area (Figure 12 in pocket). On the shallowest parts of the shelf and in the littoral zone LLH-C type stromatoporoids, intraclastic dolomite, and cryptocrystalline dolomite are present. These features may be seen in

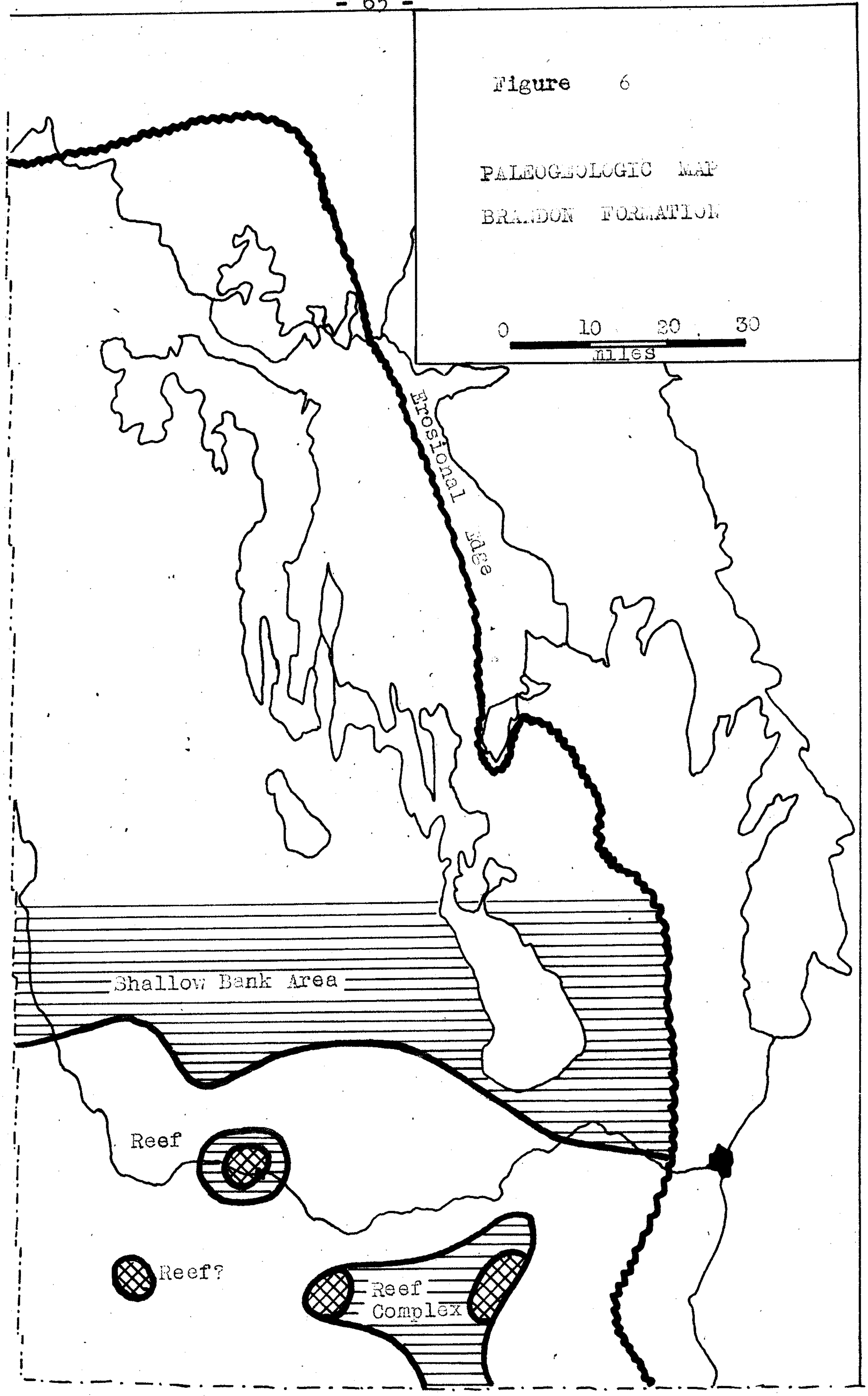


Figure 6
PALEOGEOLOGIC MAP
BRANDON FORMATION
0 10 20 30
miles
Erosional Edge
Shallow Bank Area
Reef
Reef?
Reef
Complex

lower Brandon equivalent beds at Grand Rapids.

Upper Member

The upper Brandon seas were not so extensive as those of the lower Brandon and a good deal shallower. There is little evidence of prolific organic activity as is present in the underlying units. The most prominent occurrence of skeletal material is in the Treherne - Woodlands area, approximately 40 miles west of Winnipeg. The member is of uniform thickness (Figure 13 in pocket) throughout the area of study.

The restricted extent of the sea left considerable areas of land exposed and as a result the upper member contains an unusually high amount of terrigenous material especially in the northern part of the study area.

The "V" marker, which is the boundary between the Cedar Lake and Brandon Formations, has a shale development throughout the area. Coarser terrigenous sediment occurs as small lenses in the interval and probably represent local stream conditions.

Cedar Lake Formation

The Cedar Lake Formation is characterized by extensive deposits of relict skeletal dolomite and by beds of cryptocrystalline and microcrystalline dolomite. The great lateral development is the result of transgression and regression over a broad shelf area creating blanket carbonates (Krumbein and Sloss, 1963 p. 567). In time the sea became too shallow for abundant organic growth. Facies developed in this case would be those favouring these conditions; growth of LLH-C type stromatoporoids, pellet formation or perhaps direct precipitation of carbonates.

The seas were widespread, and covered the areas which had supplied the terrigenous material to the upper Brandon member. A poorly developed shale and sandy horizon, five to ten feet above the base of the Cedar Lake indicates that parts of the surrounding land mass was not completely inundated until later. Later conditions became favourable for local organic growth, and patch reefs such as those present in outcrop, probably developed (Figure 7). They were in part destroyed by the advancing and retreating sea. However, portions of these reefs survived such action and these are probably represented in outcrop sections at Lundar, Fairford and Chemahawin.

Not all reefs had their characteristics destroyed by the fluctuating sea level. In the extreme southwest part of the area, it appears that a large atoll-type reef grew in waters that were probably deeper (Figure 7). This interpretation is based mainly on data from two wells, Souris Valley Warnez 5-13 (19) and Calstan Hartney 16-33 (20). The 25 feet of shale near the top of the Cedar Lake in Souris Valley Warnez 5-13 (19), represents a large restrictive lagoon which extended as far east as Western Orthez 13-36 (13). The origin of the shale is in doubt. It is possible that muds

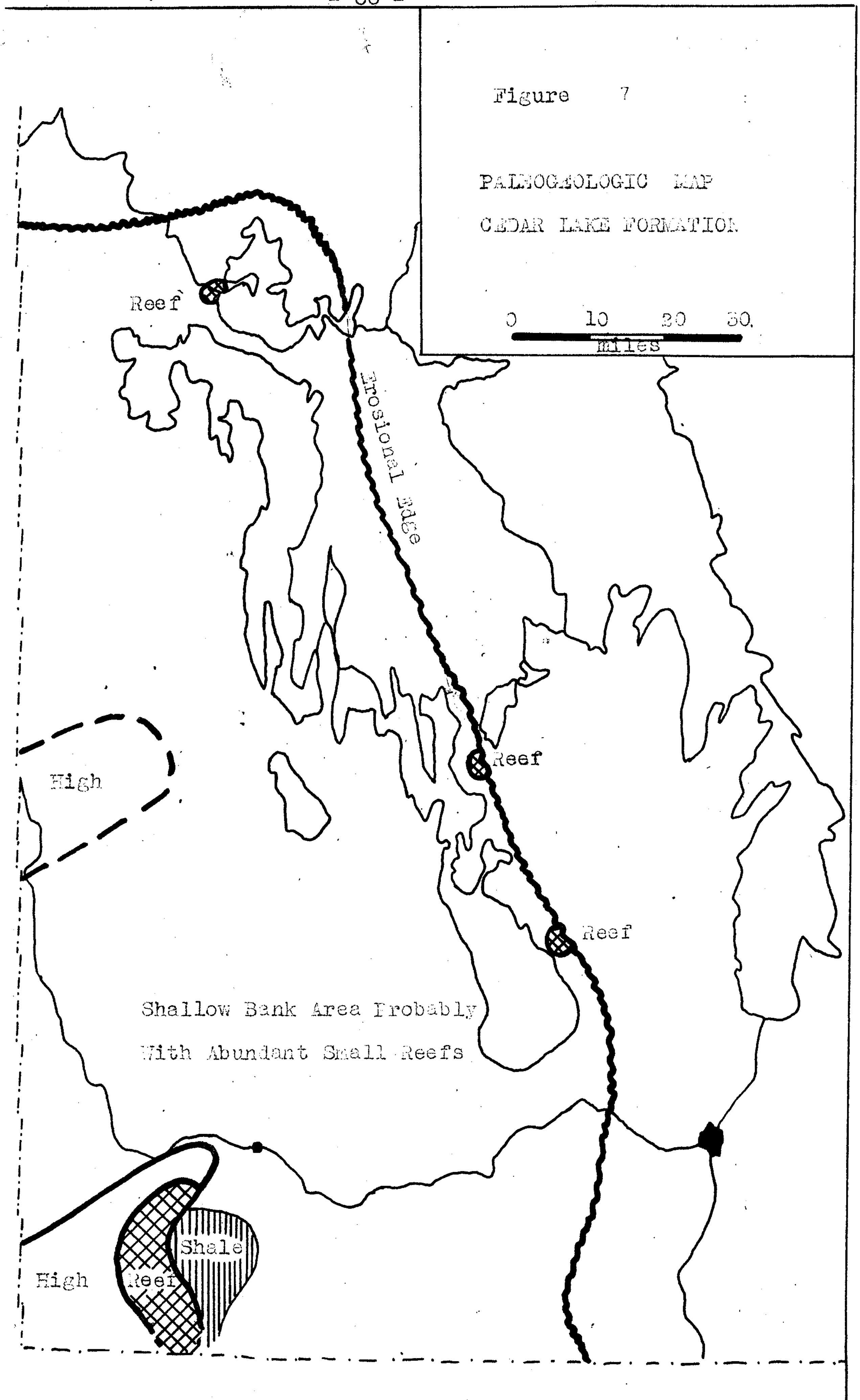


Figure 7
PALEOGEOLOGIC MAP
CEDAR LAKE FORMATION
0 10 20 30
miles
Reef
Erosional Edge
Reef
Reef
High
Shallow Bank Area Probably
With Abundant Small Reefs
Shale
High
Reef

were derived from local areas on the bank which had become subject to erosion and carried in suspension by turbulent bank waters.

As mentioned previously a dolomite conglomerate is present in equivalent beds in Calstan Hartney 16-33 (20), and it probably represents deposition in a fore-reef environment. Thus a prominent reef is postulated lying between the fore-reef of dolomite conglomerate and the red brown shales of a lagoon. It is believed that the reef must have been a prominent feature in order to isolate the 25 feet of shale. However, whether or not the reef was an atoll cannot be ascertained because of the lack of data. It appears that an atoll would be the most favourable explanation due to the oval distribution of the lagoonal shales (Figure 7). Other Paleozoic strata show anomalous thickening or thinning in the Hartney area, (see McCabe, 1958 for Mississippian, and McKennitt, 1961, p. 29, for Devonian). These features and the thick Cedar Lake section in the Hartney area (Figure 14) and the possible reef trend may be related to a single feature such as basement faulting.

Regional Sedimentation

The area under discussion in this thesis forms part of the northeast segment of the Williston Basin. Although this study is limited to a specific area, it is possible that features seen in the various formations of the Interlake Group in Manitoba are present elsewhere on the basin margin.

A regional description of Interlake sediments was given by Fuller and Porter (1962). The isopach of the total Lower Interlake (Porter and Fuller 1959 p. 162-163) shows several irregularities in Manitoba. The general east - west trend of the isopachs of individual formations suggests a basin centre south of Manitoba during Lower Interlake time.

In North Dakota, Carlson and Eastwood (1962) indicated that conditions of deposition in the Lower Interlake Interval (Strathclair and Brandon Formations of this thesis) were more saline than normal, citing as evidence the occurrence of three thin beds of anhydrite in the central basin area. The uppermost bed is the only one of which the stratigraphic position is mentioned and corresponds to the "V" horizon. The anhydrite is not part of the normal depositional pattern, but probably represents the final stages in uplift of the area. The anhydrite was precipitated from the final waters concentrated in the centre of the basin. The position of the other two anhydrite beds is not given, but a similar pattern of non-sequential relationships might exist for the "U" and "U_2" marker beds. Carlson and Eastwood (1962) described the Nesson Anticline as a growing structure in the Middle and Upper Interlake times. Thus the presence of active tectonic highs such as the Cavalier High within the Williston Basin is normal rather than an exception.

A uniform dip towards the centre of the presentday Williston Basin is interpreted from structure contour maps (Figures 15 and 16 in pocket). Several minor variations are present in the pattern but cannot be fully evaluated because of the wide well spacing.

The existence of outliers on the present Precambrian shield, and the occurrence of Niagaran strata in the Hudson Bay region indicate that the seas in parts of the Interlake time extended northward and covered a considerable area. During periods of emergence it appears that most of the terrigenous sediment was derived from the Precambrian area or underlying Paleozoic rocks. The high degree of rounding exhibited by most quartz grains suggests that the grains are at least second generation and derived from sources given below. Chernoff (1961) showed a good comparison to the sand of the Winnipeg Formation. Other possible sources of rounded quartz sand are the extensive area of late Precambrian quartzite (Athabaska, Churchill and Sioux). Porter and Fuller (1959 p. 177) stated that scouring influxes from the exposed Precambrian Shield area, resulted in the terrigenous sediments within the Interlake. It is believed that if the source area had been continuously exposed, the proportion of terrigenous clastics would be much higher than the amount which does occur. This is further evidence that seas covered these source areas for most of Interlake time.

Porter and Fuller (1959 p. 177) also described reef builders flourishing in the eastern shallows with the colonies attaining no more than a few feet in height. This contrasts with the idea presented in this thesis of isolated reef highs of the Strathclair Formation or the possible large atoll-like reefs in the Cedar Lake Formation.

Summary of Geologic Events

At the beginning of Strathclair time, seas advanced over the uniform Stonewall surface. The lower part of the Strathclair was uniformly deposited over a wide area under conditions favourable for organic growth as indicated by the distribution of Virgiana. The establishment of organic banks from the skeletal debris was accompanied by a change of conditions which made reef growth quite active. Consequently reefs became the dominant feature in the Strathclair sea. They have considerable vertical dimension, which was controlled by either a slight uniform subsidence of the area or a slowly rising sea level. Shoal areas also existed over the northern part of the Cavalier High. The function of this high besides creating a shoal area, separated a basin to the east from the main area to the west. At the close of Strathclair time, the area was subjected to a broad gentle uplift and the seas receded. This emergence is marked by shale development in the study area.

At the beginning of Brandon time, an inundation by the sea covered the Strathclair topography. In the south the reefal highs were the only features to project into the zone of wave agitation and existed as shoal areas in early Brandon time. Northward, the seas became shallower, enabling organic growth to construct a broad bank area. The Cavalier high was no longer a tectonic feature, although a shoal area was established over part of it.

The isolated shoal areas in the south and parts of the bank area became favourable sites for the formation of oolites. Oolite formation in the shoal areas was then followed by organic growth. However, this activity, governed by a slightly fluctuating sea level resulted in reefs of greater lateral extent. Current and wave action winnowed some fine material off the reefs into the interreef areas and lows on the Strathclair surface. The same fluctuations in the sea level resulted in transgression and regression over the shallow bank area. This resulted in thick widespread skeletal deposits.

The upper Brandon sea was shallow and of restricted extent. It failed to flood much of the adjacent land mass and as a result considerable terrigenous material was introduced into the sea. The sea slowly retreated leaving a one to three foot bed of sand and shale as a deposit over a wide area.

Much of the area in Cedar Lake time existed as a broad shelf, on which small patch reefs established themselves. Transgression and regression of the sea at certain times within the Cedar Lake, destroyed and redistributed the reefs establishing extensive blanket deposits of relict skeletal material. At other times the water depth was too shallow for prolific organic growth, and pelletal, grapestone and micrograined carbonate sediments were deposited.

A diagrammatic picture of sedimentation within the Interlake is given in Figures 8 and 9.

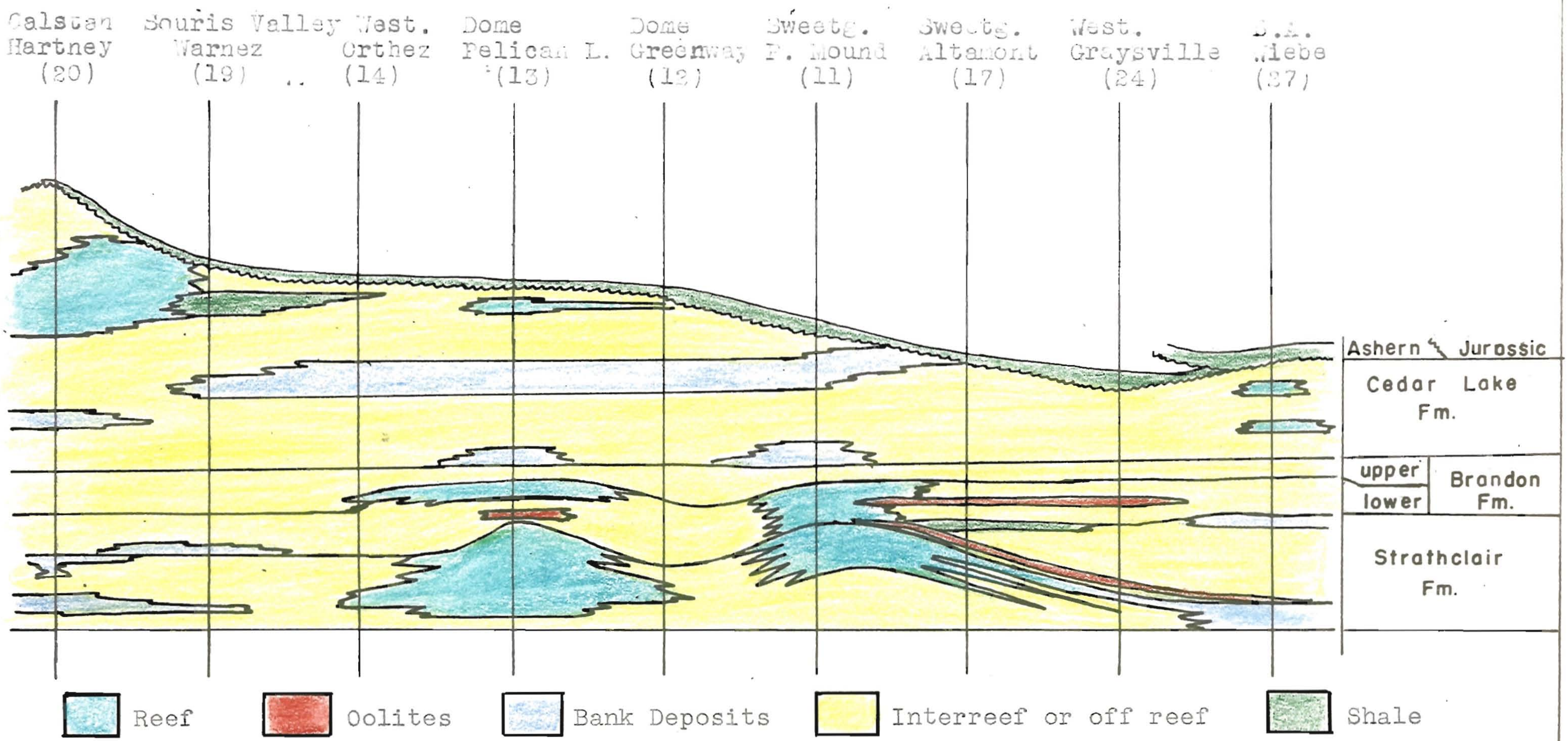


Figure 8:- Diagrammatic west - east stratigraphic cross section of the Interlake Group.

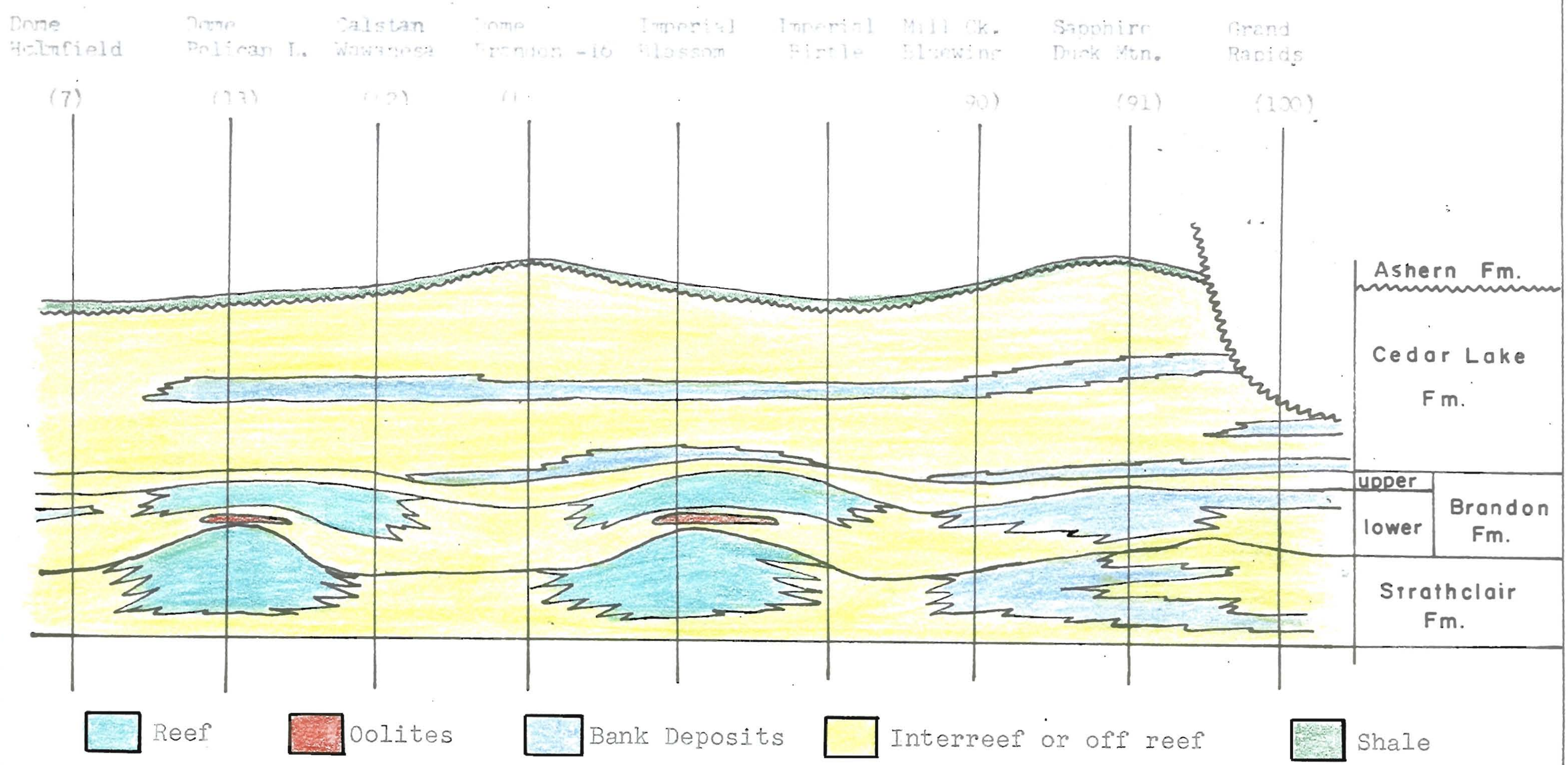


Figure 9:- Diagrammatic south - north stratigraphic cross section of the Interlake Group.

CHAPTER SIX: ECONOMIC POSSIBILITIES

Petroleum and Natural Gas

Most of the coarse grained deposits are accompanied by good intercrystalline and vuggy porosity. This porosity is best developed in the isolated reefal highs of the Strathclair Formation, the oolitic and relict skeletal deposits of the Brandon Formation and the extensive relict skeletal dolomites and reefs of the Cedar Lake Formation. In addition, the thin sand beds are usually accompanied by some porosity.

The best trap occurs at the pre-Middle Devonian unconformity. The overlying Ashern Formation provides an impermeable seal and in some instances filling of the pores by clay and anhydrite has occurred in Interlake rocks immediately below the unconformity. Lesser traps could be present beneath the thin shales represented by the non-sequential beds. Traps formed by the change from porous medium and coarse grained dolomites into cryptocrystalline dolomites could occur. Stout (1964) indicated that cryptocrystalline dolomite with 17 per cent porosity but having a low permeability may form a cap rock with five - ten percent leakage through the cap.

Source rocks are lacking in the area, with the Interlake consisting of light coloured dolomites with no apparent dark bituminous carbonates present. Shale sequences such as are present in the Cedar Lake Formation in Souris

Valley Warnez 5-13 (19) could have been a possible source. However, it is impossible to tell whether or not organic material was associated with the red brown shales of the Warnez well. The lack of ideal source material within the Interlake should not be a deterrent in exploration as oil is produced from similar light colored carbonates elsewhere in the Williston Basin.

Known shows of oil and gas are listed by the Mines Branch, Province of Manitoba (1962). These are 180 feet of "gassy" mud recovered from the lower part of the Cedar Lake Formation in Imperial Madelaine 16-18 (84); slight oil stain in cuttings from the middle Cedar Lake Formation in Calstan Wawanesa 3-1 (42) and in the Hartney area where drillstem test from the upper Cedar Lake yielded black sulphury water. In addition, Andrichuk (1959 p. 2397) reported slight oil staining from the same horizon in Calstan Hartney 16-33 (20). This occurs in the dolomite conglomerate, considered to represent the fore-reef beds of a prominent reef lying between Hartney and the lagoonal shales in Souris Valley Warnez 5-13 (19). It is possible that more significant accumulations of oil lie in this reef.

Nearest oil production from the Interlake Group occurs in North Dakota in the Beaverlodge and Antelope pools on the Nesson anticline. This region is approximately 90 miles southwest of the southwest corner of the province of Manitoba. The pools occur in the Upper Interlake which is absent from the thesis area except in the extreme southwest corner of the province. Production does occur from the lower and middle portions of the Interlake in eastern Montana and is associated with Lower Paleozoic structure below the pre-Middle Devonian unconformity.

The existence of tectonic highs present in the lower Paleozoics has been established throughout the Williston Basin. The Nesson anticline near the centre of the basin is the most prominent. Ballard (1963) has described several in eastern North Dakota. In Manitoba, the only definite tectonic high noted was a northward extension of the Cavalier High, although possibilities include highs in the Cedar Lake Formation in the Hartney and Duck Mountain areas. Well control is not sufficient in western and northern Manitoba to exclude the existence of these and other highs.

Analagous situations to those present in Montana could exist in Manitoba. The excellent porosity, in conjunction with structure and a good trap at the pre-Devonian unconformity may have resulted in oil accumulation.

Gypsum

Mineable deposits of gypsum occur at the village of Gypsumville, which lies in the general trend of the Interlake outcrop belt. As mentioned previously the age of this deposit is in doubt. A Silurian age seems to be as reasonable as the others which have been postulated. If a Silurian age is correct, then there were three separate times within the Interlake Group when evaporitic deposits such as that at Gypsumville had the greatest likelihood of forming.

1. In Strathclair time, with a northward extension of the Cavalier high creating a basin on its eastern flank, similar to that developed in the southeast part of the study area. Local evaporitic conditions did exist in the Strathclair, as Dome Arrow River 12-10 (71) contains a thin bed of anhydrite near the base of the formation.

2. Evaporites could have been deposited in the restricted upper Brandon seas.

3. Evaporites could have been deposited behind an extensive reefal area in Cedar Lake time.

Additional gypsum deposits may be hidden beneath the extensive glacial drift cover occurring north and south of Gypsumville.

CHAPTER SEVEN: SUMMARY AND CONCLUSION

Summary

To provide a basis for description and reconstruction of a sedimentary pattern, the dolomites were classified as either having a crystalline or relict texture. Grain size of the dolomite has a direct relationship to the original limestone grain size. Relict textures were examined in detail in the outcrop sections with an attempt at recognition of similar textures in well cuttings. The most readily identifiable is relict skeletal material, although recognition of individual grains is difficult. Relict pellet, grapestone and intraclastic textures are rarely discernible in well cuttings and are usually represented by cryptocrystalline dolomite.

Most of the formations established by Stearn (1956) in the outcrop area can be recognized. The following exceptions are presented. The Fisher Branch Formation is undistinguishable from the lower Inwood, and the Cross Lake biostromal member is not as extensive as originally described but consists of two beds of relict skeletal dolomite separated by a thick bed of cryptocrystalline dolomite. This sequence is similar to dolomites elsewhere in the Cedar Lake Formation and is not confined to the lower part. Both units are considered to be unrecognizable and therefore not valid as stratigraphic units.

The Interlake Group of the subsurface is subdivided on a basis similar to that proposed by Porter and Fuller (1959) with a further subdivision of the Lower Interlake. This resulted in the Strathclair Formation and an overlying Brandon Formation, the latter having an upper and lower member. The outcrop name Cedar Lake Formation is applied to equivalent beds in the subsurface which comprise the Middle Interlake. The non-sequential beds marking the lower contact of the Interlake, the Strathclair - Brandon contact ("U" horizon), the upper - lower Brandon contact ("U_2" horizon), and the Brandon - Cedar Lake contact ("V" horizon) are all exposed at Grand Rapids; The formations as established by Stearn (1956) for the outcrop area do not correspond to those established for the subsurface.

The Strathclair Formation consists of isolated reef complexes, with associated interreef and shallow bank deposits. An extension of the Cavalier high into southeast Manitoba isolated a basin on the eastern flank of the high. Oolitic accretion and organic activity occurred over this high.

The lower Brandon Member contains oolitic and skeletal dolomite. The reefal highs of the Strathclair existed as shoal areas in lower Brandon seas and on which extensive oolite formation and organic activity took place. Northward, a broad shallow shelf existed and the high wave energy resulted in thick deposits of relict skeletal material. The upper Brandon Member consists predominantly of cryptocrystalline dolomite with terrigenous material indicative of a restricted shallow sea with exposure of adjacent land masses.

The sediments of the Cedar Lake Formation consist of interbedded relict skeletal and cryptocrystalline dolomites representing transgressive and regressive seas over a long period of time. Reefs were restricted to horizontal development in the shallow waters, although in deeper water in the southwest part of the province it is possible that large atoll-like reefs occurred.

Conclusions

The regional sedimentation history as inferred from the Manitoba area is somewhat different when compared to earlier descriptions. The lower Interlake as defined by Andrichuk (1959) was an extremely shallow water shelf area with numerous patch reefs unable to develop into thick bioherms because of slow subsidence. This coarser grained upper unit was believed to represent an original coarse grained limestone. Porter and Fuller (1959) pictured reef builders flourishing in the eastern shallows of the Williston Basin, but stated that the colonies grew no more than a few feet in height. Carlson and Eastwood (1962) stated that the Lower and Middle Interlake sediments were deposited in a shallow sea slightly more saline than normal marine waters because of the presence of anhydrite and evaporitic dolomite in the centre of the basin.

The ideas of sedimentation presented in this thesis generally suggest deeper shelf waters in the southern area, with decreasing water depth northward and very shallow waters over the area presently occupied by the Precambrian Shield. The deeper water in the south is necessary to account for the prominent vertical reef growth in the Strathclair Formation, the presence of shoals over these reefs in lower Brandon and possible atoll-like reefs in the Cedar Lake.

Petroleum possibilities appear to be in conjunction with tectonic highs in highly porous zones and trapped at the pre-Devonian unconformity.

BIBLIOGRAPHY

ADAMS, J.R., and RHODES, M.L., 1960: Dolomitization by Seepage Refluxtion; Am. Assoc. Petroleum Geologists Bull., Vol. 44, pp. 1912-1920.

ANDRICHUK, J.M., 1959: Ordovician and Silurian Stratigraphy in Southwestern Manitoba, Canada; Am. Assoc. Petroleum Geologists Bull., Vol. 43, pp. 2333-2398.

BAILLIE, A.D., 1951: Silurian Geology of the Interlake Area; Manitoba Dept. Mines and Nat. Res., Mines Branch Pub. 50-1.

BALLARD, F.V., 1963: Structural and Stratigraphic Relationships in the Paleozoic Rocks of Eastern North Dakota; N. Dak. Geol. Survey Bull. 40.

BANNATYNE, B.B., 1959: Gypsum-Anhydrite Deposits of Manitoba; Manitoba Dept. Mines and Nat. Res., Mines Branch, Publ. 58-2.

BRINDLE, J.E., 1960: The Faunas of the Lower Paleozoic Carbonate Rocks in the Subsurface of Saskatchewan; Sask. Dept. of Min. Res., Report No. 52.

CARLSON, C.G., and EASTWOOD, W.P., 1962: Upper Ordovician and Silurian Rocks of North Dakota; N. Dak. Geol. Survey Bull. 38.

CHERNOFF, C.N., 1959: Lithology of the Interlake Group in Saskatchewan; unpublished M.Sc. thesis, Univ. of Saskatchewan.

CLOUD, P.E., 1962: Environment of Calcium Carbonate Deposition West of Andros Island, Bahamas; U.S. Geological Survey Prof, Paper 350.

COLE, L.H., 1913: Gypsum in Canada; Mines Branch, Canada, Rept. No. 245.

DRUMMOND, J.M., 1963: Carbonates and Grade Size; Canadian Petrol. Geol. Bull., Vol. 11, pp. 33-53.

FAIRBRIDGE, R.W., 1957: The Dolomite Problem; in Regional Aspects of Carbonate Deposition; Soc. Econ. Paleon. and Mineral, Spec. Pub. 5, pp. 125-178

FOLK, R.L., 1959: Practical Petrographic Classification of Limestones; Am. Assoc. Petroleum Geologists Bull., V. 43, pp. I-38.

__________ 1962: Spectral Subdivision of Limestone Types; in Classification of Carbonate Rocks, pp. 62-84.

FULLER, J.G.C.M., and PORTER, J.W., 1962: Cambrian, Ordovician and Silurian Formations of the Northern Great Plains and Their Regional Connections; Jour. Alberta Soc. Petrol. Geol., V. 10, pp. 435-485.

ILLING, L.V., 1954: Bahaman Calcareous Sands; Am. Assoc. Petrol. Geologists Bull., Vol. 38, pp. 1-95.

INGELS, J.J.C., 1963: Geometry, Paleontology, and Petrography of the Thorton Reef Complex, Silurian of Northeast Illinois; Am. Assoc. Petrol. Geologists, V. 47, pp. 405-440.

KERR, L.B., 1959: The Stratigraphy of Manitoba with Reference to Oiland Natural Gas Possibilities; Man. Dept. Mines and Nat. Res., Mines Br. Pub. 49-1.

KINDLE, E.M., 1914: The Silurian and Devonian Section of Western Manitoba; Geol. Surv., Canada, Sum. Rept. 1912, pp. 247-261.

__________ 1915: Notes on the Geology and Paleontology of the Lower Saskatchewan River Valley; Geol. Surv., Canada, Mus. Bull. No. 21.

KRUMBEIN, W.C., and SLOSS, L.L., 1963: Stratigraphy and Sedimentation, 2nd edition; W.H. Freeman and Co. San Francisco, Calif.

LEIGHTON, M.W., and PENDEXTER, C., 1962: Carbonate Rock Types; in Classification of Carbonate Rocks, Am. Assoc. Petrol. Geologists, Memoir 1; pp. 33-61.

LOGAN, B.W., and REZAK, R., and GINSBURG, R.N., 1964: Classification and Environmental Significances of Algal Stromatolites; Journ. of Geology, V. 72 pp. 68-83

LOWENSTAM, H.A., 1950: Niagaran Reefs of the Great Lakes Area; Jour. Geology, V. 58, pp. 430-487.

__________ 1957: Niagaran Reefs in the Great Area; in Treatise on Marine Ecology and Paleoecology, Vol. 2, Paleoecology: Geol. Soc. America, Mem. 67, pp 215-248.

McCABE, H.R., 1959: Mississippian Stratigraphy of Manitoba; Manitoba Dept. Mines and Nat. Res., Mines Br., Publ. 58-1.

McKENNITT, D.B., 1961: The Middle Devonian Elk Point Group in Manitoba; unpublished M.Sc, thesis, University of Manitoba.

MINES BRANCH, PROVINCE OF MANITOBA, 1962: Lower Paleozoic Drill Stem Tests and Oil and Gas Shows - Bakken to Precambrian.

PLUMLEY, W.J., et al., 1962: Energy Index for Limestone Interpretation and Classification; in Classification of Carbonate Rocks, Am. Assoc. Petrol. Geologists, Memoir No. 1.

PORTER, J.W., and FULLER, J.G.C.M., 1959: Lower Paleozoic Rocks of Northern Williston Basin and Adjacent Areas; Am. Assoc. Petrol. Geologists, Bull., V.43 pp. 124-189.

PURDY, E.G., 1961: Bahamian Oolite Shoals; in Geometry of Sandstone Bodies, Am. Assoc. of Petrol. Geologists.

__________ 1963a: Recent Calcium Carbonate Facies of the Great Bahama Bank, Part 1: Petrography and Reaction Groups; Jour. Geology, V. 71, pp. 334-355.

__________ 1963b: Recent Calcium Carbonate Facies of the Great Bahama Bank, Part 2: Sedimentary Facies; Jour. Geology, V. 71, pp. 472-497.

RETTIE, J.R., and PATTERSON, F.W., 1963: Some Foundation Considerations at the Grand Rapids Hydro-Electric Project; The Engineering Jour., V.46, No. 12, pp. 32-39.

SASKATCHEWAN GEOLOGICAL SOCIETY, 1958: Report of the Lower Paleozoic Names and Correlations Committee.

STEARN, C.W., 1953: Ordovician-Silurian Boundary in Manitoba; Bull. Geol. Soc. Amer., V.64, pp. 1477-1478.

__________ 1956: Stratigraphy and Paleontology of the Interlake Group and Stonewall Formation of Southern Manitoba; Geol. Survey, Canada, Mem. 281.

STOUT, J.L., 1964: Pore Geometry as Related to Carbonate Stratigraphic Traps; Am. Assoc. Petrol. Geologists Bull., V. 48, pp. 329-337.

THOMAS, G.E., 1962: Grouping of Carbonate Rocks into Textural and Porosity Units for Mapping Purposes; in Classification of Carbonate Rocks, Am. Assoc. Petrol. Geologists, Memoir No. 1, pp. 193-223.

TYRRELL, J.B., 1892: Report on Northwestern Manitoba; Geol. Surv., Canada, Ann. Rept. 1890-91, pt. E, pp. 1-235.

WHITEAVES, J.F., 1906: Fossils of the Silurian Rocks of Keewatin, Manitoba, the Northeastern Shore of Lake Winnipegosis, and the Lower Saskatchewan River; Geol. Surv., Canada, Paleozoic Fossils, V. 3, pt. IV, pp. 243-298.

APPENDIX I

WELL DATA

1. Well locations are given according to legal subdivision, section, township, and range. All wells are west of the Principal Meridian with the exception of two wells which are indicated.

2. Well numbers correspond to location numbers on the index map (Figure 10, in pocket).

3. Measurements represent depth below Kelly Bushing in feet. Exceptions occur in wells number 97 to 100 where depths were measured from ground elevation.

4. Legend

---	formation not present
?	top of formation uncertain
	total depth of well insufficient to penetrate formation.
Jr.	overlain by Jurassic rather than Ashern.
#	ground elevation.

Well No.	Well Name	Location				K.B. Elevation	Ashern	Interlake Group				Stonewall
		Lsd.	Sec.	Twp.	Range WPM			Cedar Lake Top	Upper Brandon Top	Lower Brandon Top	Strathclair Top	
1	Cego Cretna	1	28	1	2	830	Jr.	---	---	---	---	290
2	B.A. Union Arbuckle	13	24	1	12	1536	2320	2354	2458	2476	2506	2541
3	GNCC Coulter	16	16	1	27	1497	5473	5510	5784	5804	5837	5892
4	Robert Moore#1	5	20	1	27	1490	5520	5555	5837	5855?	5890	5947
5	Comm. Manitou #2	8	26	2	9	1270	1520	1530	?	?	?	?
6	Nipiron Purves	16	11	2	10	1577	2040	2060	2141	2162	2193	2238
7	Dome Holmfield	13	5	2	15	1561	2999	3006	3177	3198	3230	3266
8	Jumping Pound Horton	8	15	2	20	1913	4180	4202	4380	4405	4428	4466
9	Calstan Whitewater	15	36	3	22	1638	4063	4080				
10	Green Wakely Roland	1	28	4	4	860	Jr.	---	---	---	555?	?
11	Sweetgrass Pilot Mound	3	9	4	11	1546	2070	2102	2199	2217	2250	2310

Well No.	Well Name	Location				K.B. Elevation	Ashern	Interlake Group				Stonewall
		Lsd.	Sec.	Twp.	Range WPM			Cedar Lake Top	Upper Brandon Top	Lower Brandon Top	Strathclair Top	
12	Dome Greenway	16	33	4	13	1427	2253	2258	2410	2429	2462	2502
13	Dome Pelican L.	7	34	4	15	1499	2257	2598	2749	2769	2792	2856
14	Western Orthez	13	36	4	19	1628	3415	3475	3607	3625	3653	3693
15	Red River Lowe Farm #2	2	1	5	1	795	Started within Stony Mountain					
16	Red River Hepner	3	1	5	2	791	Jr.	---	---	---	1927	250?
17	Sweetgrass Altamont	2	35	5	8	1449	1457	1480	1560	1585	1606	1676
18	Bueno Baldur	1	27	5	14	1408	2321	2364	2504	2524	2541	2575
19	Souris Valley Warnez	5	13	5	22	1635	3916	3957	4140	4159	4182	4224
20	Calstan Hartney	16	33	5	24	1426	3772	3795	4110	4126	4170	4213
21	L&M Hartney	1	29	5	24	1425	4065	4095	4380	4405	4428	4475
22	Amerada Lauder	9	35	5	25	1425	4118	4142	4411	4428	4461	4495

Well No.	Well Name	Location				K.B. Elevation	Ashern	Interlake Group				Stonewall
		Lsd.	Sec.	Twp.	Range WPM			Cedar Lake Top	Upper Brandon Top	Lower Brandon Top	Strathclair Top	
23	Sun.C. Hole #1		20	6	1	787	Jr.	---	---	---	75	?
24	Western Braysville	9	22	6	6	951	685?	698	753	772	794	872
25	Baysel Bruxelles	1	27	6	11	1682	2094	2100	2262	2279	2311	2345
26	Dome St. Alphonse	13	16	6	12	1331	1945	1958	2103	2123	2148	2182
27	B.A. Wiebe	7	35	7	4	826	Jr.	282	389	409	432	481
28	B.A. Gates	16	22	7	10	1415	1647	1658	1800	1821	1847	1872
29	Cego Hilton	13	5	7	15	1258	2330	2350	2512	2530	2561	2587
30	Calstan Findlay	9	26	7	25	1421	3905	3950				
31	Calstan Linklater	9	21	7	28	1618	4784	4840				
32	Sun C. Hole #2	ne	12	8	1 East of PM	784			started within Stony Mountain			
33	Sun Carman	4	6	8	3	814	Jr.	250	345	376	400	444
34	Sun Carman	16	12	8	4	818	Jr.	?	?	?	370	414

Well No.	Well Name	Location				K.B. Elevation	Ashern	Interlake Group				Stonewall
		Lsd.	Sec.	Twp.	Range WPM			Cedar Lake Top	Upper Brandon Top	Lower Brandon Top	Strathclair Top	
35	Can. Superior Haywood	7	32	8	5	914	508	540	660	682	693	734
36	Can. Superior Rusywich	6	11	8	7	1006	802	836	915	935	958	1015
37	Cego Treherne	13	7	8	9	1205	1355	1380	1505	1524	1558	1585
38	GNCC Spruce Woods	16	21	8	12	1145	1620	1644	1774	1795	1821	1853
39	Cego Glenboro	8	36	8	14	1047	1689	1698	1882	1902	1926	1958
40	Dillman Spruce Woods	7	35	8	15	1220	2020	2030	2225	2244	2275	2308
41	Can. Superior Rounthwaite	10	17	8	17	1278	2503	2523	2702	2722	2752	2786
42	Calstan Wawanesa	3	1	8	18	1364	2674	2695	2900	2919	2952	2981
43	Calstan Ewart	4	14	88	28	1611	4573	4625				
44	Cego Elm Creek	5	26	9	5	836	382	414	492	507	526	574
45	B.A. Morisseau	8	20	9	6	977	628	644	798	815	833	875

Well No.	Well Name	Location: Lsd.	Sec.	Twp.	Range WPM	K.B. Elevation	Ashern	Interlake Group: Cedar Lake Top	Upper Brandon Top	Lower Brandon Top	Strathclair Top	Stonewall
46	N.B.C. Holland	13	10	9	11	1187	1479	1488	1640	1652	1680	1728
47	Dome Brandon	3	5	9	19	1374	2810	2825	3051	3067	3090	3138
48	Dome Brandon	16	27	9	19	1329	2607	2619	2825	2843	2867	2920
49	Sun C.Hole #6	nw	14	10	2	793	Jr?	38	?	?	?	186
50	B.A. Lavenham	5	3	10	10	1182	1250	1255	1410	1445	1470	1526
51	Dillman Spruce Woods	11	9	10	16	1238	2105	2118	2316	2342	2364	2402
52	Coutts Brandon	14	16	10	19	1319	2570	2604	2790	2807	2832	2890
	Union Griswold	13	4	10	22	1387	3124	3154	3369	3388	3418	3458
53	Calstan Daly	15	18	10	27	1614	4178	4220	4438	4462	4497	4556
54	Sun C. Hole #10	nw	15	11	1 East of PM	795	Jr.	---	---	---	---	20
55	Sun C. Hole #9	nw	1	11	1	791	Jr.	---	---	---	45	60
56	Sun C. Hole #8	ne	4	11	1	791	Jr.	48?	?	?	?	105
57	Cego Gregg	5	31	11	13	1303	1720	1731	1898	1915	1941	1988
58	B.A. Mitchell	7	26	11	17	1311	2137	2154	2310	2335	2384	2432

Well No.	Well Name	Location				K.B. Elevation	Ashern	Interlake Group				Stonewall
		Lsd.	Sec.	Twp.	Range WPM			Cedar Lake Top	Upper Brandon Top	Lower Brandon Top	Strathclair Top	
59	Dome Harding	4	27	11	22	1381	2920	2935	3171	3195	3231	3261
60	Calstan Imperial	2	20	11	24	1503	3416	3465	3647	3666	3712	3752
61	Calstan Elkhorn	7	8	11	29	1783	4555	4610				
62	Portage la Prairie #1	3	9	12	7	850	500	510	?	?	?	?
63	Imp. Blossom	3	17	12	24	1350	3355	3386	3580	3600	3631	3678
64	Cego Westbourne	16	20	13	9	853	634	640	809	839	870	896
65	Cdn. Superior Hockins	3	19	13	15	1285	1790	1818	2000	2016	2046	2082
66	Wilson Woodland	16	36	14	3	895	---	130	?	?	?	286
67	Baum & Feil Bonnie Doon	7	11	14	5	830	---	182	348	365	384	437
68	Calstan Langfd. Neepawa	5	29	14	14	1142	1432	1495	1599	1622	1670	1728
69	Dome Minnedosa	16	26	14	18	1824	2461	2479	2676	2694	2730	2770
70	B.A. Union Brazell	2	7	14	20	1824	2890	2930	3106	3123	3158	3194

Well No.	Well Name	Location				K.B. Elevation	Ashern	Interlake Group				Stonewall
		Lsd.	Sec.	Twp.	Range WPM			Cedar Lake Top	Upper Brandon Top	Lower Brandon Top	Strathclair Top	
71	Dome Arrow R.	12	10	14	25	1643	3286	3302	3520	3545	3572	3630
72	Calstan Woodlands	4	6	15	2	888	---	154	177	205	230	278
73	Cego Springhill	13	12	15	16	1371	1732	1777	1935	1955	1983	2043
74	Gridoil Minnedosa	2	21	15	18	1941	2560	2567	2775	2801	2838	2870
75	Homestead Birdtail	10	8	15	27	1535	3408	3472				
76	Cego Plumas	12	13	16	13	966	971	978	1177	1205	1244	1286
77	Dome Strathclair	8	34	16	21	1991	2823	2844	3055	3077	3118	3157
78	Dome Naco St. Lazare	12	34	16	29	1576	3500	3540	3725?	?	?	3638
79	B.A. Birnie	16	11	17	15	1218	1340	1356	1580	1604	1646	1681
80	Shell Newdale	12	23	17	20	2060	2688	2707	2894	2915	2961	3003
81	Cdn. Superior Strathclair	6	23	17	23	1862	2840	2885	3055	3077	3118	3157
82	Imp. Birtle	1	27	17	26	1791	3180	3235	3280	3408	3454	3498

Well No.	Well Name	Location				K.B. Elevation	Ashern	Interlake Group				Stonewall
		Lsd.	Sec.	Twp.	Range WPM			Cedar Lake Top	Upper Brandon Top	Lower Brandon Top	Strathclair Top	
83	Anglo Birdtail	4	30	18	26	1809	3150	3190				
84	Imp. Madelaine	16	18	18	29	1597	3317	3354	3540	3572	3630	3675
85	Imp. Foxwarren	16	32	19	27	1821	3120	3165	3308	3333	3378	3429
86	Hemisphere Helium Lundar	14	17	20	5	835	?	?	246	270	310	350
87	Hemisphere Helium Taylor	16	15	20	6	830	?	112	292	312	336	386
	Riddle Russell	4	19	21	27	1877	3040	3074	3228	3253	3301	3346
88	Dauphin #1	se¼	14	24	20	1100	?	1260	?	?	?	?
89	Imperial Bluewing Lake	13	4	24	27	1880	2762	2815				
90	Mill Ck. Oil E. Bluewing L.	1	11	24	26	1823	2494	2507	2715	2750	2778	2822
91	Sapphire Duck Mtn. #2	2	2	31	25	2262	2387	2410	2648	2669	2712	2750
92	Sweetgrass Duck Mtn. #3	16	35	34	26	1834	1788	1808	2022	2044	2094	2133

Well No.	Well Name	Location				K.B. Elev-ation	Ash-ern	Interlake Group				Stone-wall
		Lsd.	Sec.	Twp.	Range WPM			Cedar Lake Top	Upper Brandon Top	Lower Brandon Top	Strath-clair Top	
93	Shell Swan R #2	13	3	35	29	1369	1570	1592	1786	1806	1859	1904
94	Shell Swan R #1	9	1	37	28	1186	1220	1235	1380	1415?	1458?	1515
95	Mafeking #2	4	23	43	26	1150	660?	680				
96	Mafeking #1		14	44	25	841	300	325	436?	?	515?	565?
97	Grand Rapids	12	20	47	14	846#	---	8	66	84	122	174
98	Easterville	1	6	48	17	865#	---	½ total depth 50 ft.				
99	Moose Lake	sw	35	54	20	est.850#	---	6 total depth 50 ft.				
100	Noranda Grace L.	3	9	56	25	est.875#	---	---	---	95	104	152

The following wells are in Saskatchewan. They were used to provide additional control.

Well Name	Lsd.	Sec.	Twp.	Range WPM	K.B. Elevation	Ashern	Cedar Lake Top	Upper Brandon Top	Lower Brandon Top	Strathclair Top	Stonewall
Socony Carievale	16	4	3	32	1690	6615	6668 (top of Upper Interlake)				
							6755	7092	7112	7153	7193
Imperial Lightning Creek	16	7	6	32	1949	6188	6247	6596	6618	6663	6704
Riddle St. Marthe	1	4	17	30	1580	3640	3676	3856	3880	3904	3964
Riddle Rocanville	16	32	15	31	1755	4130	4164	4320	4350	4392	4462
Riddle Marchwell	1	16	20	30	1647	3261	3285	3448	3468	3507	3576

APPENDIX II

DESCRIPTIONS OF SELECTED LITHOLOGIC SECTIONS

Grade scale after Leighton and Pendexter (1962)

-- .004 mm	cryptocrystalline
.004 - .06 mm.	microcrystalline and silt
.06 - .12 mm.	very fine grained very finely crystalline
.12 - .25 mm.	fine grained finely crystalline
.25 - .50 mm.	medium grained medium crystalline
.50 - 1.0 mm.	coarse grained coarsely crystalline
1.0 - 2.0 mm.	Very coarse grained very coarsely crystalline
2.0	Breccias and conglomerates

Well No. 13 — Dome Pelican Lake

7 - 34 - 4 - 15 W1 — K.B. 1499

Ashern Formation

2581 - 2598 Shale; light reddish brown, with dolomite; white to light pink, cryptocrystalline, anhedral.

Interlake Group

2598 Cedar Lake Formation

2598 - 2620 Dolomite; very light grey, cryptocrystalline to microcrystalline in part, anhedral.

2620 - 2650 Dolomite; very light grey, relict skeletal, very fine to coarse grained, subrounded, fair sorting with finer grained material at base; with dolomite; microcrystalline, anhedral, trace vuggy porosity.

2650 - 2670 Dolomite; light grey, relict skeletal, very fine to fine grained, subrounded, fair intergranular porosity.

2670 - 2690 Dolomite; light grey, microcrystalline to very finely crystalline, euhedral, excellent intercrystalline porosity.

2690 - 2700 Dolomite; light grey, cryptocrystalline to microcrystalline, anhedral to subhedral.

2700 - 2710 Dolomite; light grey, relict skeletal, very fine to coarse grained, irregular to rounded, fair to good sorting, contains some brachiopod fragments and oolites, fair intergranular porosity.

2710 - 2733 Dolomite; light grey, microcrystalline grading to cryptocrystalline, anhedral.

2733 - 2743 Dolomite; light grey, very fine to finely crystalline, euhedral, good intercrystalline porosity.

2743 - 2749 (core) Dolomite; very light grey, cryptocrystalline anhedral, with fine grained, rounded cryptocrystalline grains in part, becomes nodular with thin shale partings near base.

2749 Upper Member Brandon Formation

2749 - 2749½ (core) Shale; reddish brown, silty in part, possibly anhydritic.

2749½ - 2750 (Core) Dolomite; light grey and light pink, cryptocrystalline, anhedral, possible relict pelletal texture.

2750 - 2752 (core) Dolomite conglomerate; light grey and pale green, fragments two inches thick grading to sand size, angular, poorly sorted, with light red and light green argillaceous matrix.

2752 - 2759 (core) Dolomite; light grey, relict skeletal, patches of fine to occassionally medium relict skeletal grains in a cryptocrystalline matrix, some stromatolitic structure, fair vuggy porosity.

2759 - 2769 (core) Dolomite; very light grey, cryptocrystalline, possible relict pelletal texture.

2769 Lower Member Brandon Formation

2769 - 2773 (core) Dolomite; light grey, stromatolitic with minor zones of medium grained skeletal material.

2773 - 2784 (core) Dolomite; light grey, oolitic, coarse grained, round, well sorted, becomes fine grained with skeletal material near base, good intergranular porosity.

2784 - 2787 (core) Dolomite; light grey, relict skeletal, fine to medium grained, subangular, to subrounded, fair sorting, some small brachiopods and oolites, good intergranular porosity.

2787 - 2792 (core) Dolomite; light grey to grey buff, relict skeletal, fine to medium grained, brachiopods, favositid corals; interbedded with stromatoporoids.

2792 - 2793 (core) Dolomite; light grey, cryptocrystalline interbedded with greyish green clay bands, scattered grains of subrounded quartz sand.

2793 Strathclair Formation

2793 - 2795 (core) Dolomite; light grey, cryptocrystalline, anhedral, chalky appearance, fair intercrystalline porosity.

2795 - 2830 Dolomite; light grey to light grey buff, relict skeletal, very fine to coarse grained, subrounded to rounded, good sorting, very good intergranular porosity.

2830 - 2850 Dolomite; light grey, relict skeletal, very fine to fine grained, round, well sorted, chalky appearance; with minor dolomite; microcrystalline, euhedral; good intergranular porosity.

2850 - 2856 Dolomite; light greyish purple, cryptocrystalline, anhedral, argillaceous.

2856 Stonewall Formation

2856 - 2890 Dolomite; light grey, cryptocrystalline to microcrystalline, slightly argillaceous, with silt and fine round quartz sand at base.

Well No. 17 SWEETGRASS ALTAMONT

2 - 35 - 5 - 8 W1 K.B. 1449

Overlain by Ashern Formation

Interlake Group

1480 Cedar Lake Formation

1480 - 1490 Dolomite; light grey, to very light pink, relict skeletal, fine to coarse, subangular, poorly sorted, consists of braciopod valves and crinoid columnals; with dolomite; microcrystalline, anhedral.

1490 - 1510 Dolomite; light grey, cryptocrystalline, anhedral.

1510 - 1530 Dolomite; light grey, cryptocrystalline, anhedral, slightly calcareous, fair vuggy porosity; minor very finely crystalline, euhedral dolomite at base.

1530 - 1540 Dolomite; light grey, microcrystalline to cryptocrystalline, fair vuggy porosity.

1540 - 1550 Dolomite; light grey, as above; and dolomite; light grey, relict skeletal, very fine to medium, poor intergranular porosity.

1550 - 1560 Dolomite; light grey, microcrystalline to cryptocrystalline, anhedral.

1560 Upper Member, Brandon Formation

1560 - 1585 Dolomite; light grey, microcrystalline to cryptocrystalline, anhedral.

1590 - 1606	Dolomite; light grey buff, relict skeletal, very fine to medium, subrounded, with some cryptocrystalline, anhedral dolomite, fair intergranular porosity.

1606 Strathclair Formation

1606 - 1630	Dolomite; light grey to grey buff, relict skeletal, very fine to medium, subrounded, well sorted, possible fine grained oolite in 1610-1620, good intergranular porosity.
1630 - 1640	Dolomite; light grey, relict skeletal, very fine grained, rounded, good intergranular porosity.
1640 - 1650	Dolomite; light grey buff, cryptocrystalline minor microcrystalline, anhedral.
1650 - 1660	No sample.
1660 - 1676	Dolomite; light grey buff, as above.

1676 Stonewall Formation

1676 - 1680	Dolomite; light grey, with light pink, cryptocrystalline, anhedral, minor relict skeletal.

Well No. 16 Souris Valley Warnez

5 - 13 - 5 - 22 W1 K.B. 1635

Ashern Formation

3950 - 3957	Dolomite; reddish brown, very fine to finely crystalline, subhedral to euhedral, argillaceous.

Interlake Group

3957 Cedar Lake Formation

3957 - 3970	Dolomite; light grey to very light purple, very fine to finely crystalline, anhedral.
3970 - 3980	Dolomite; light grey, microcrystalline to very finely crystalline, anhedral to subhedral.
3980 - 3990	Dolomite; light grey, relict skeletal, very fine to coarse grained with cryptocrystalline matrix, irregular to subrounded, poorly sorted, slightly argillaceous.

3990 - 4020	Shale, reddish brown to maroon, some small blebs of white gypsum.
4020 - 4030	Dolomite; light grey buff, cryptocrystalline, anhedral, translucent appearance.
4030 - 4040	Dolomite; light grey buff, cryptocrystalline, anhedral, slightly calcareous.
4040 - 4070	Dolomite; light medium grey; very fine to finely crystalline, subhedral to euhedral, fair intercrystalline porosity.
4070 - 4080	Dolomite; light grey, microcrystalline to very finely crystalline, anhedral to subhedral, poor intercrystalline porosity.
4080 - 4090	No sample
4090 - 4100	Dolomite; light buff; relict skeletal, very fine to medium grained, round; and dolomite; cryptocrystalline, anhedral.
4100 - 4120	Dolomite; cryptocrystalline to microcrystalline, anhedral to subhedral.
4120 - 4140	Dolomite; light buff, relict skeletal, very fine to medium grained, subrounded to rounded, and dolomite, cryptocrystalline, anhedral, poor intergranular porosity.
4140	Upper Member Brandon Formation
4140 - 4150	Dolomite; light grey; cryptocrystalline, anhedral.
4150 - 4159	Dolomite; light grey, cryptocrystalline to microcrystalline, anhedral.
4159	Lower Member Brandon Formation
4159 - 4182	Dolomite; light grey, microcrystalline to cryptocrystalline, anhedral.
4182	Strathclair Formation
4182 - 4190	Dolomite; light grey, cryptocrystalline to microcrystalline, anhedral and dolomite; relict skeletal, very fine to medium grained, subrounded.
4190 - 4210	Dolomite; light grey, microcrystalline to cryptocrystalline, anhedral.

4210 - 4224 Dolomite; light medium grey, cryptocrystalline anhedral, and dolomite; relict skeletal, very fine to medium grained, subrounded.

4224 Stonewall Formation

4224 - 4230 Dolomite; light grey to white, cryptocrystalline, anhedral with minor pelletal texture.

Well No. 20 Calstan Hartney

16 - 33 - 5 - 24 W1 K.B. 1426

Ashern Formation

3775 - 3780 (core) Dolomite; medium grey, cryptocrystalline, anhedral, argillaceous.

3780 - 3795 (core) Dolomite; light brown grey, cryptocrystalline, interbedded with thin medium grey argillaceous bands.

Interlake Group

3795 Cedar Lake Formation

3795 - 3802 (core) Dolomite; light grey, cryptocrystalline to microcrystalline, anhedral.

3802 - 3840 Dolomite; light grey, cryptocrystalline to microcrystalline in part, anhedral.

3840 - 3855 No samples

3855 - 3863 (core) Dolomite; very light grey, cryptocrystalline, anhedral with thinly interbedded stromatoporoids and finely relict skeletal material at 3859 feet.

3863 - 3869 (core) Dolomite conglomerate; medium grey fragments in white matrix, fragments range from .2 to 4 centimeters, subrounded, poorly sorted, scattered intergranular porosity in part.

3869 - 3876 (core) Dolomite; very light grey, cryptocrystalline, with abundant fine cryptocrystalline grains, well sorted, scattered intercrystalline porosity.

3876 - 3880	No samples
3880 - 3900	Dolomite; light grey to medium grey, microcrystalline to finely crystalline, subhedral to euhedral, with minor medium to very coarse grained relict skeletal dolomite at base, fair intercrystalline porosity.
3900 - 3910	Dolomite; light grey, cryptocrystalline to very finely crystalline, anhedral to subhedral, fair intercrystalline porosity.
3910 - 3920	Very poor samples.
3920 - 3930	Dolomite; light grey, microcrystalline to very finely crystalline, subhedral to euhedral, fair intercrystalline porosity.
3930 - 3945	Dolomite; light grey, very finely crystalline, subhedral to euhedral, and dolomite; relict skeletal, very fine to medium grained, subrounded to round, good sorting.
3945 - 3968	(core) Dolomite conglomerate; light to medium fragments in a white matrix, fragments up to 5 centimeters in diameter, subangular to subrounded, texture of fragments varies.
3968 - 4000	Dolomite; light grey, microcrystalline to very finely crystalline, subhedral to euhedral, fair to good porosity.
4000 - 4010	Dolomite; light grey cryptocrystalline to microcrystalline, subhedral, fair intercrystalline porosity.
4010 - 4030	Dolomite; light grey, microcrystalline to very finely crystalline, rarely finely crystalline, anhedral to subhedral, fair intercrystalline porosity.
4030 - 4080	Dolomite; light grey, cryptocrystalline to microcrystalline, anhedral to euhedral, fair to good intercrystalline porosity.
4080 - 4095	Dolomite; light grey to light grey buff, microcrystalline to very finely crystalline, subhedral, and dolomite; relict skeletal, very fine to fine grained, round, well sorted.
4095 - 4110	(core) Dolomite; very light grey, cryptocrystalline anhedral, interbedded with dolomite conglomerate; fragments up to 3 cm. in diameter, in

diameter, in argillaceous matrix, good stromatoporoid structure in part; two inches dark green shale at base.

4110 Upper Member Brandon Formation

4110 - 4116 (core) Dolomite; light grey, cryptocrystalline, to microcrystalline, anhedral, slight banding in part.

4116 - 4126 Dolomite; very light grey, cryptocrystalline to microcrystalline, anhedral.

4126 Lower Member Brandon Formation

4126 - 4140 Dolomite; light grey, microcrystalline to cryptocrystalline to very fine and finely crystalline in part, subhedral to euhedral, fair intercrystalline porosity.

4140 - 4170 Dolomite; very light grey, cryptocrystalline to microcrystalline, anhedral to subhedral with dolomite; relict skeletal, subrounded to round at base, fair to good porosity.

4170 Strathclair Formation

4170 - 4190 Dolomite; light grey, cryptocrystalline, anhedral with dolomite; relict skeletal, very fine to medium, some brachipod shells.

4190 - 4213 Dolomite; light grey, relict skeletal, very fine to medium grained, good sorting, minor cryptocrystalline dolomite, excellent intergranular porosity.

4213 Stonewall Formation

4213 - 4220 Dolomite; light grey, cryptocrystalline, anhedral.

Well No. 27 B. A. WIEBE

7 - 35 - 7 - 4 W1 K.B. 826

Jurassic

280 - 282 Shale, reddish brown.

Interlake Group

282 Cedar Lake Formation

282 - 335 Dolomite; light grey, cryptocrystalline to microcrystalline, with abundant shale cavings in upper part.

335 - 345 Dolomite; light grey buff, relict skeletal, very fine to medium, subrounded, subrounded; and dolomite; microcrystalline to very finely crystalline, subhedral.

345 - 365 Dolomite; very light grey to white, cryptocrystalline, slightly calcareous.

365 - 375 Dolomite; light grey, cryptocrystalline to microcrystalline, anhedral, fair vuggy porosity.

375 - 389 Dolomite; very light grey, very finely crystalline to microcrystalline, subhedral, minor relict skeletal fragments in part, corals, ostracods, trace intercrystalline porosity.

389 Upper Member Brandon Formation

389 - 395 Dolomite; very light grey, microcrystalline with minor very finely crystalline, subhedral to anhedral, slightly calcareous.

395 - 405 Dolomite; very light grey, microcrystalline, subhedral to anhedral.

405 - 409 Dolomite; very light grey, cryptocrystalline, anhedral, calcareous.

409 Lower Member Brandon Formation

409 - 415 Dolomite; as above.

415 - 432 Dolomite; very light grey, microcrystalline to cryptocrystalline in part, anhedral to subhedral, calcareous.

432 Strathclair Formation

432 - 455 Dolomite; very light grey, microcrystalline with very fine to finely crystalline in part, "ghosts" of relict skeletal grains, argillaceous at top of unit.

455 - 465 Dolomite; very light grey, cryptocrystalline, anhedral.

465 - 475 Dolomite; very light grey, relict skeletal, very fine to medium grained, subrounded to rounded; with relict oolite, fine grained, round, good intergranular porosity.

481 Stonewall Formation

481 - 485 Dolomite; light grey, cryptocrystalline, anhedral.

Well No. 71 Dome Arrow River

12 - 10 - 14 - 25 W1 K.B. 1643

Overlain by Ashern Formation

Interlake Group

3302 Cedar Lake Formation

3302 - 3310 Dolomite; light medium grey, microcrystalline, anhedral.

3310 - 3340 Dolomite; light grey, relict skeletal, very fine to medium grained, round poor to fair sorting, with minor dolomite; cryptocrystalline, anhedral.

3340 - 3350 Dolomite; light grey, relict skeletal, very fine grained with dolomite; cryptocrystalline, anhedral.

3350 - 3380 Dolomite; light grey to light reddish brown, cryptocrystalline to microcrystalline, anhedral to subhedral.

3380 - 3400 Dolomite; light grey microcrystalline to very finely crystalline subhedral to euhedral, good intercrystalline porosity.

3400 - 3440 Dolomite; light grey microcrystalline to cryptocrystalline, subhedral, fair to good intercrystalline porosity.

3440 - 3450 Dolomite; light grey, cryptocrystalline to very finely crystalline, subhedral, good intercrystalline porosity.

3450 - 3460 Dolomite; light grey, very fine to finely crystalline, euhedral, very good intercrystalline porosity.

3460 - 3470 Dolomite; light grey, relict skeletal, very fine to finely grained, subrounded good intergranular porosity.

3470 - 3480 Dolomite; light grey, cryptocrystalline, anhedral.

3480 - 3510 Dolomite; light grey, microcrystalline to cryptocrystalline, anhedral, with dolomite; relict skeletal, very fine to coarse grained, subrounded, fair sorting; minor medium to coarse grained quartz sand, silt and shale at base.

3510 - 3520 Dolomite; light grey, microcrystalline, anhedral to subhedral.

3520 Upper Member Brandon Formation

3520 - 3545 Dolomite; light grey, microcrystalline to very finely crystalline, subhedral to euhedral, fair intercrystalline porosity.

3545 Lower Member Brandon Formation

3545 - 3560 Dolomite; light grey, microcrystalline, anhedral to subhedral, with dolomite; relict skeletal, very fine to fine grained, round, fair intergranular porosity.

3560 - 3570 Dolomite; light grey, microcrystalline to cryptocrystalline, subhedral to anhedral, with quartz silt at base.

3570 - 3572 (core) Dolomite; very light grey, cryptocrystalline, anhedral, possibly pelletal.

3572 Strathclair Formation

3572 - 3581½ (core) Dolomite; very light grey, relict skeletal, medium to very coarse grained, rounded, oolitic, becomes poorly sorted below 3575, good intergraular porosity.

3581½ - 3583½ (core) Dolomite; very light grey, cryptocrystalline, stromatolitic, minor patches relict skeletal dolomite.

3583½ - 3585 (core) Dolomite; medium grey, cryptocrystalline, anhedral, thinly laminated.

3585 - 3589½ (core) Dolomite; very light grey, cryptocrystalline, with very fine to medium grained cryptocrystalline lumps in part.

3589½ - 3602 (core) Dolomite; very light grey, relict skeletal, fine to medium grained, subangular to round, poor to fair sorting, with coarse shell fragments in part.

3602 - 3614 (core) Dolomite; light grey buff, relict skeletal, coarse to very coarse, subangular, grading to fine to medium grained, subrounded; Favositid corals, brachiopods, good stromatopotoids, throughout, minot patches of anhydrite, fair porosity.

3614 - 3614½ (core) Anhydrite, irregular contact with adjacent dolomite.

3614½- 3620 (core) Dolomite; light grey, relict skeletal, medium to coarse grained, crinoid columnals, Virginia at 3618½, good intergranular porosity.

3620 - 3630 Dolomite; light grey, microcrystalline to cryptocrystalline, anhedral, with relict skeletal; medium to very coarse grained, round fair intergranular porosity.

3630 Stonewall Formation

3630 - 3640 Dolomite; light grey microcrystalline to cryptocrystalline, anhedral.

Well No. 73 CEGO Springhill

13 - 12 - 15 - 16 Wl K.B. 1371

Ashern Formation

1770 - 1777 Dolomite; reddish brown, cryptocrystalline, anhedral with shale; reddish brown.

Interlake Group

1777 Cedar Lake Formation

1777 - 1800 Dolomite; light grey, to light reddish brown in upper part, cryptocrystalline to microcrystalline, anhedral to subhedral, fair intercrystalline porosity.

1800 - 1810 Dolomite; light medium grey, relict skeletal, fine to very coarse grained, round, good sorting, with dolomite; cryptocrystalline to microcrystalline, anhedral, poor intercrystalline porosity.

1810 - 1820 Dolomite; light grey to light purplish grey, microcrystalline to cryptocrystalline, anhedral, fair intercrystalline porosity.

1820 - 1850	Dolomite; light grey; microcrystalline to very finely crystalline, anhedral to subhedral, fair intercrystalline porosity.
1850 - 1860	No samples
1860 - 1880	Dolomite; light grey, microcrystalline, anhedral and dolomite, relict skeletal; fine to very coarse grained, round.
1880 - 1910	Dolomite; light grey, microcrystalline to cryptocrystalline, anhedral.
1910 - 1920	No samples
1920 - 1930	Dolomite; light grey, relict skeletal, very fine to medium grained, with minor cryptocrystalline dolomite, poor intergranular porosity.
1930 - 1935	No samples
1935	Upper Member Brandon Formation
1935 - 1955	Dolomite light grey, microcrystalline to cryptocrystalline, anhedral, good intercrystalline porosity.
1955	Lower Member Brandon Formation
1955 - 1960	Dolomite; light grey, relict skeletal, very fine to fine grained, round.
1960 - 1970	Dolomite; very light grey, microcrystalline to cryptocrystalline, anhedral, poor intercrystalline porosity.
1970 - 1983	Dolomite; light grey buff, relict skeletal, very fine to medium grained, subrounded, fair sorting, with dolomite; cryptocrystalline, anhedral, fair intergranular porosity.
1983	Strathclair Formation
1983 - 2043	Dolomite; light grey to light grey buff, relict skeletal, very fine to coarse, subrounded to round, fair to good sorting, with dolomite; cryptocrystalline in matrix in part, poor to fair intergranular porosity.
2043	Stonewall Formation

2043 - 2050 Dolomite; light grey to very light pink, relict skeletal, very fine to medium grained, subangular to round, fair intergranular porosity.

Well No. 77 Dome Strathclair

8 - 34 - 16 - 21 W1 K.B. 1921

Overlain by Ashern Formation

Interlake Group

2844 Cedar Lake Formation

2844 - 2850 Dolomite; reddish brown, microcrystalline, euhedral, argillaceous.

2850 - 2863 Dolomite; light grey; microcrystalline to cryptocrystalline, anhedral to subhedral.

2863 - 2880 (core) Dolomite; very light grey, cryptocrystalline, possible skeletal in part, stromatoporoids in part.

2880 - 2887 (core) Dolomite; light grey, relict skeletal, fine to medium grained, subrounded, with patches of cryptocrystalline dolomite, good fine vuggy porosity.

2887 - 2895 (core) Dolomite; very light grey, cryptocrystalline to microcrystalline, anhedral, possible relict skeletal in part.

2895 - 2909 (core) Dolomite; very light grey, microcrystalline to cryptocrystalline, with patches fine to medium grained relict skeletal, good vuggy porosity.

2909 - 2912 (core) Dolomite; very light grey, cryptocrystalline to microcrystalline, anhedral.

2912 - 2950 Dolomite; light grey, microcrystalline to very finely crystalline, anhedral to euhedral, subrounded to rounded.

2950 - 3010 Dolomite; light grey, relict skeletal, very fine to medium grained, subrounded to rounded, fair to good sorting, with dolomite; microcrystalline, subhedral, fair to good intergranular porosity.

3010 - 3030 Dolomite; light grey, cryptocrystalline to finely crystalline, anhedral to euhedral, fair intercrystalline porosity.

3030 - 3055 Dolomite; light grey to light grey pink, cryptocrystalline to microcrystalline, Trace quartz silt at base.

3055 Upper Member Brandon Formation

3055 - 3077 Dolomite; light grey, cryptocrystalline to microcrystalline, anhedral.

3077 Lower Member Brandon Formation

3077 - 3110 Dolomite; light grey, relict skeletal, very fine to fine grained, rarely medium grained, subrounded to round, good sorting, with dolomite; cryptocrystalline, as matrix, poor intergranular porosity.

3110 - 3118 Dolomite; light grey relict skeletal, very fine to fine grained, subrounded to round, minor cryptocrystalline dolomite, fair intergranular porosity.

3118 Strathclair Formation

3118 - 3130 Very poor samples

3130 - 3140 Dolomite; light grey, cryptocrystalline, anhedral, with dolomite; relict skeletal, very fine to fine grained, round.

3140 - 3150 (core) Dolomite; light grey, relict skeletal, very fine to medium, subrounded, fair to good sorting, some vugs filled with anhydrite.

3150 - 3151 (core) Dolomite; very light grey, cryptocrystalline, anhedral.

3151 - 3153 (core) Dolomite; very light grey, relict skeletal as 3140 - 3150, with favositid corals, Virginia at 3153.

3153 - 3155 (core) Dolomite; very light greyish green, cryptocrystalline, argillaceous.

3155 - 3157 (core) Shale; reddish brown, thinly laminated, gypsiferous.

3157 Stonewall Formation

3157 - 3160 Dolomite; light grey to purplish grey, crypto-crystalline to very finely crystalline, anhedral.

Well No. 97 Grand Rapids (hole No. 362)

12 - 20 - 47 - 14 W1 G. Elev. 846

Cored throughout.

0 -	7.8	Overburden
	7.8	Cedar Lake Formation
7.8-	17.0	Dolomite; light grey buff, microcrystalline to cryptocrystalline, one millimeter solution pits 15.3 - 16.8.
17.0-	20.4	Dolomite; as above, shows prominent stromatoporoidal structure.
20.4-	32.0	Dolomite; buff, relict skeletal, very fine to coarse grained, poorly sorted, consists shell debris, some small whole brachiopods; very thin green shale partings in upper part.
32.0-	37.0	Dolomite; light grey buff, microcrystalline.
37.0-	46.0	Dolomite; light grey buff, relict skeletal, with interbeds of cryptocrystalline dolomite; skeletal material difficult to identify some crinoid columnals and whole brachiopods, stromatolites 37-39 feet.
46.0-	51.2	Dolomite; light grey buff, microcrystalline to cryptocrystalline, with thin interbeds of relict skeletal material; fine to medium grained, poorly sorted; slightly argillaceous.
51.2-	63.7	Dolomite; very light buff, relict skeletal, "pseudobreccia" in part, minor interbeds of microcrystalline dolomite; slightly argillaceous, more friable below 54.5.
63.7-	64.2	Dolomite; light grey buff, arenaceous, with abundant fragments of dolomite; very fine to coarse grained, subrounded to rounded and quartz sand; very fine to very coarse, round, minor silt, mainly concentrated in two 1½ inch bands.

64.2 -	66.2	Dolomite; light to medium grey, microcrystalline, with light green shale bands.
66.2 -	69.0	Sandstone; light grey to pale green, sand is quartzose, medium to coarse grained, round, with minor green shale interbeds, dolomitic and argillaceous in part.
	69.0	Upper Member Brandon Formation
69.0 -	78.0	Dolomite; light grey buff; microcrystalline to cryptocrystalline, minor interbeds of relict skeletal and intraclastic dolomite, shale partings, slightly more argillaceous at base.
78.0 -	80.0	Dolomite; light grey, microcrystalline, argillaceous.
80.0 -	81.2	Dolomite; light grey, microcrystalline, with greenish grey shale partings, and disseminated medium to very coarse rounded quartz sand.
81.2 -	85.0	Dolomite; light grey, microcrystalline, one to two inch greyish green shale beds, trace medium to coarse grained rounded quartz sand.
	85.0	Lower Member Brandon Formation
85.0 -	96.8	Dolomite; very light buff, very fine to medium crystalline, interbedded relict skeletal dolomite and cryptocrystalline dolomite, numerous coarse vugs, some scattered corals.
96.8 -	97.4	Dolomite breccia; light buff, large angular fragments up to e inches in diameter.
97.4 -	98.8	Dolomite; light grey, intraclastic, fragments are tabular, subrounded, with thin shale fragments in a matrix of very fine grained relict skeletal material.
98.8 -	106.0	Dolomite; very light buff to grey buff; cryptocrystalline, some stromatoporoids at 100 feet.
106.0 -	110.8	Dolomite; light grey to light brown buff, thin wavy strands of Stromatactis-like material in a light grey argillaceous dolomite, minor greenish grey shale partings in part.
110.8 -	122.5	Dolomite; light grey buff, microcrystalline to cryptocrystalline, pale green shale partings.

122.5 - 124.5 Dolomite; light grey to grey buff, arenaceous, sand is quartzose, medium to coarse grained, subrounded, minor silt, occurs as floating grains in upper part, and in lower part is interbedded with thin bands of cryptocrystalline dolomite.

124.5 Strathclair Formation

124.5 - 164.2 Dolomite; very light grey to white, microcrystalline, chalky below upper few feet, slightly calcareous, abundant thin interbeds of relict skeletal material, with *Virgiana decussata* at 163.2 - 163.7, good intercrystalline porosity.

(hole no. 403)

164.2 - 166.4 Dolomite; very light grey buff, cryptocrystalline.

166.4 - 167.7 Dolomite; very light grey to light grey, cryptocrystalline, argillaceous.

167.7 - 172.0 Dolomite; light grey, relict skeletal, chalky near base, calcareous.

172.0 - 173.5 Dolomite; very light grey, finely crystalline, minor relict skeletal material, slightly calcareous.

173.5 - 175.5 Shale; greyish green, dolomitic, arenaceous, sand is quartzose, medium to coarse grained, subrounded to rounded, scattered dolomite fragments.

175.5 Stonewall Formation

175.5 - 178.0 Dolomite; very light to medium grey, relict skeletal, vuggy, mottled appearance.

178.0 - 179.8 Dolomite; light grey, microcrystalline.

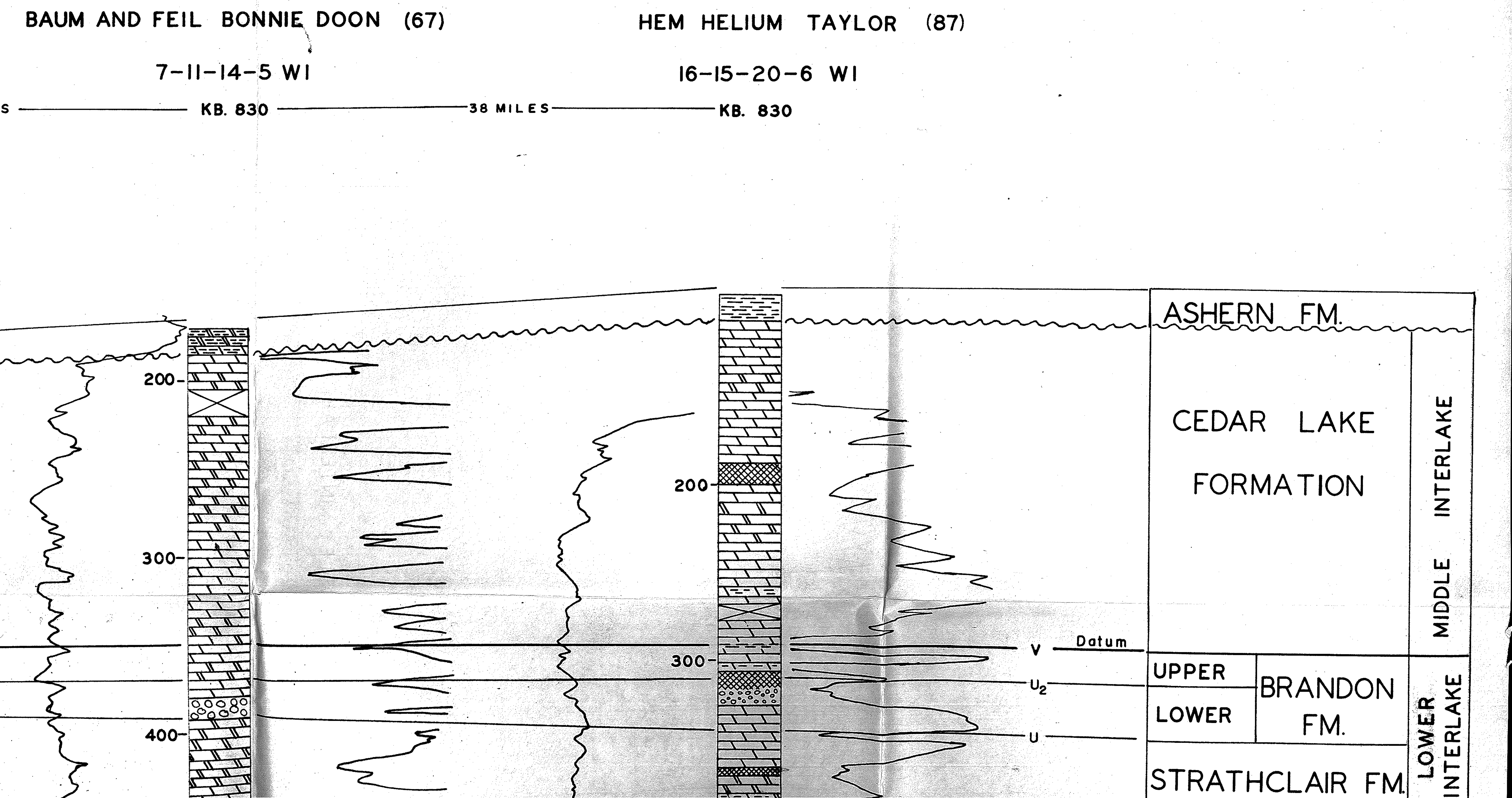
179.8 - 183.6 Dolomite; white to light grey buff, nodular appearance with poor core recovery, chalky, vuggy, calcareous.

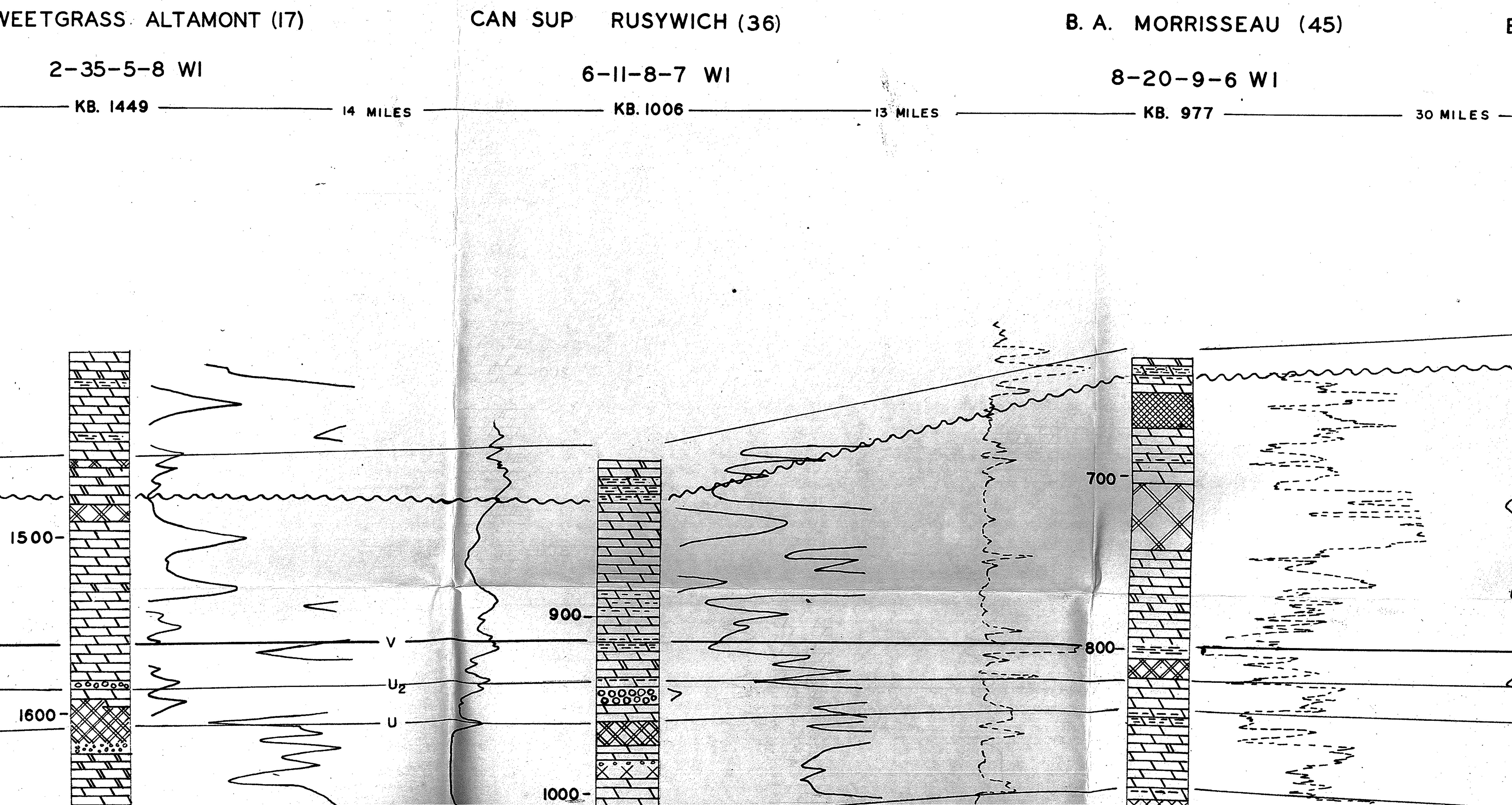
Well No. 100 Noranda Mines Grace Lake

3 - 9 - 56 - 25 W1 Est. G. Elev. 875

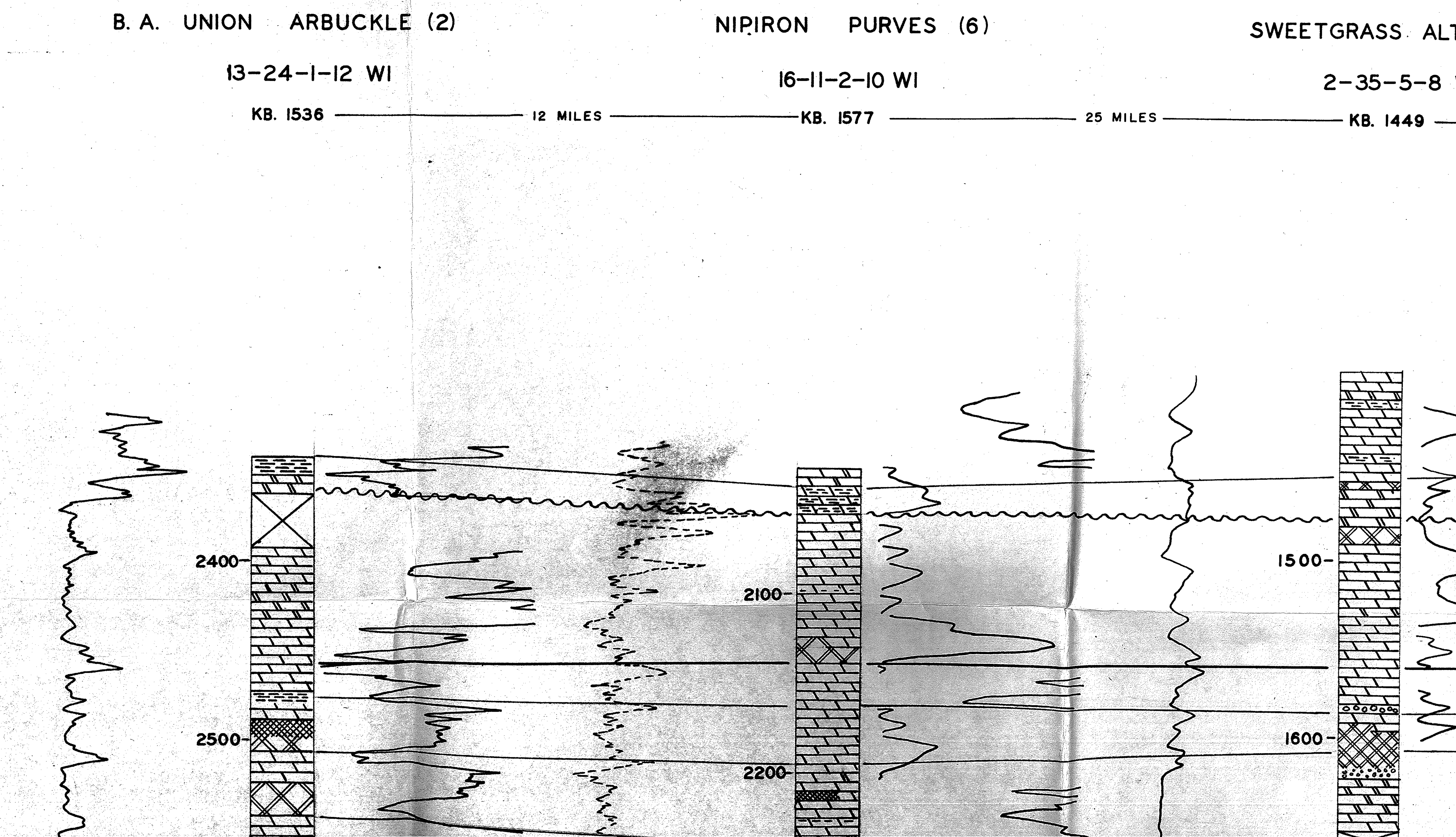
Cored throughout

0.0 - 95.0	Overburden
95.0	Lower Member Brandon Formation
95.0 - 104.0	Dolomite; very light grey, relict skeletal, medium to very coarse, some cryptocrystalline dolomite.
104.0 - 105.0	Shale; light green, arenaceous, sand is quartzose, medium grained well rounded, occurs at base of unit and grades into underlying dolomite.
105.0	Strathclair Formation
105.0 - 106.5	Dolomite; light grey, relict skeletal, medium grained, arenaceous, sand is quartzose, medium grained round, occurs in pockets in relict skeletal material.
106.5 - 114.0	Dolomite; very light grey, intraclastic, with fragments $\frac{1}{2}$ to $\frac{3}{4}$ inches long and one-eighth inch thick, also possible pelletal texture.
114.0 - 119.0	Dolomite; very light grey, cryptocrystalline.
119.0 - 136.0	Dolomite; very light grey, relict skeletal, fine to medium grained, fossiliferous, with _Virginia_ 135 - 136, numerous coarse vugs, some of which are filled with light green shale.
136.0 - 139.5	Dolomite; medium grey, cryptocrystalline, argillaceous, slightly banded in part.
139.5 - 150.0	Dolomite; very light grey, cryptocrystalline with some fine to medium grained relict skeletal below 144, some brachiopods and scattered corals.
150.0 - 152.0	Dolomite; pale reddish brown to pale green, upper one foot is argillaceous, grades into dolomite conglomerate with fragments up to $\frac{3}{4}$ inch in diameter in a matrix of reddish and green clay.
152	Stonewall Formation
152.0 - 162.0	Dolomite; very light grey, cryptocrystalline with relict skeletal material below 158 feet, includes brachipod debris and crinoid columnals.

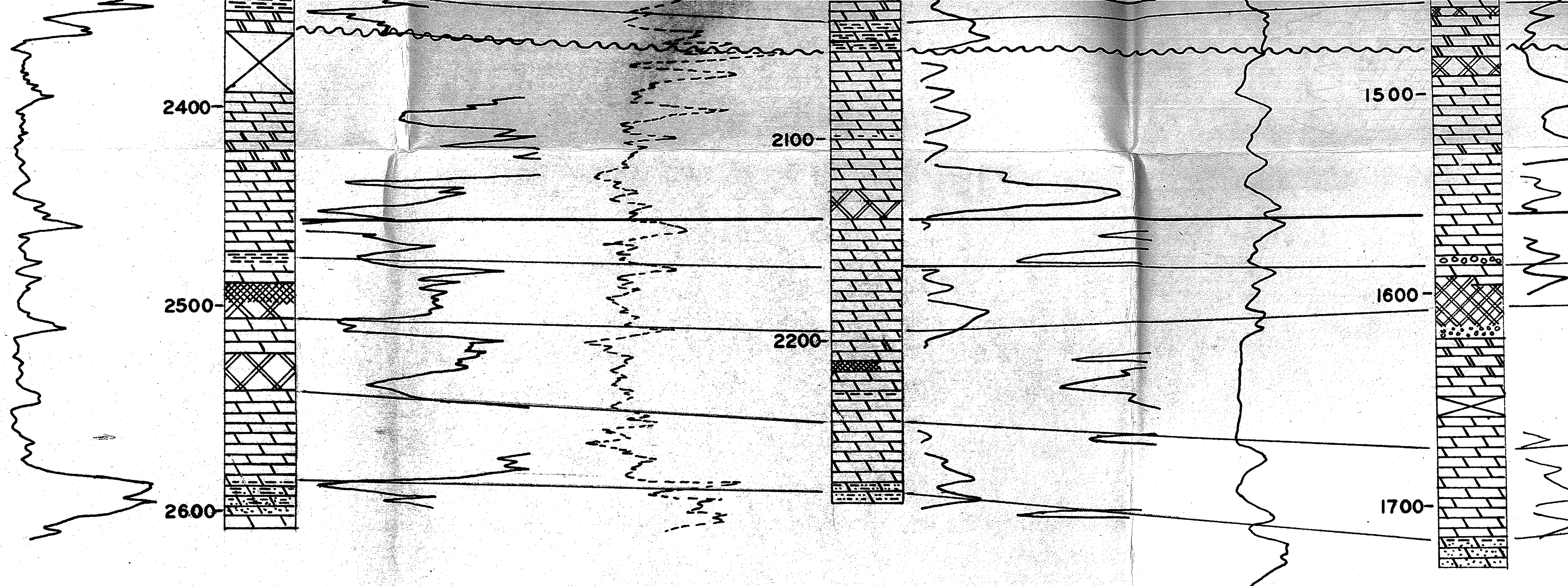

BAUM AND FEIL BONNIE DOON (67)
7-11-14-5 WI
KB. 830
38 MILES
HEM HELIUM TAYLOR (87)
16-15-20-6 WI
KB. 830
200
300
400
200
300
V
Datum
U_2
U
ASHERN FM.
CEDAR LAKE FORMATION
MIDDLE INTERLAKE
UPPER
LOWER
BRANDON FM.
LOWER INTERLAKE
STRATHCLAIR FM.



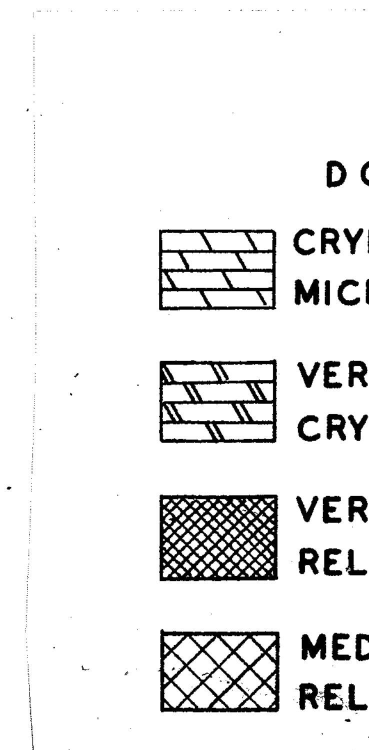
WEETGRASS ALTAMONT (17)
2-35-5-8 WI
KB. 1449
14 MILES
CAN SUP RUSYWICH (36)
6-11-8-7 WI
KB. 1006
13 MILES
B. A. MORRISSEAU (45)
8-20-9-6 WI
KB. 977
30 MILES
1500
1600
V
U2
U
900
1000
700
800

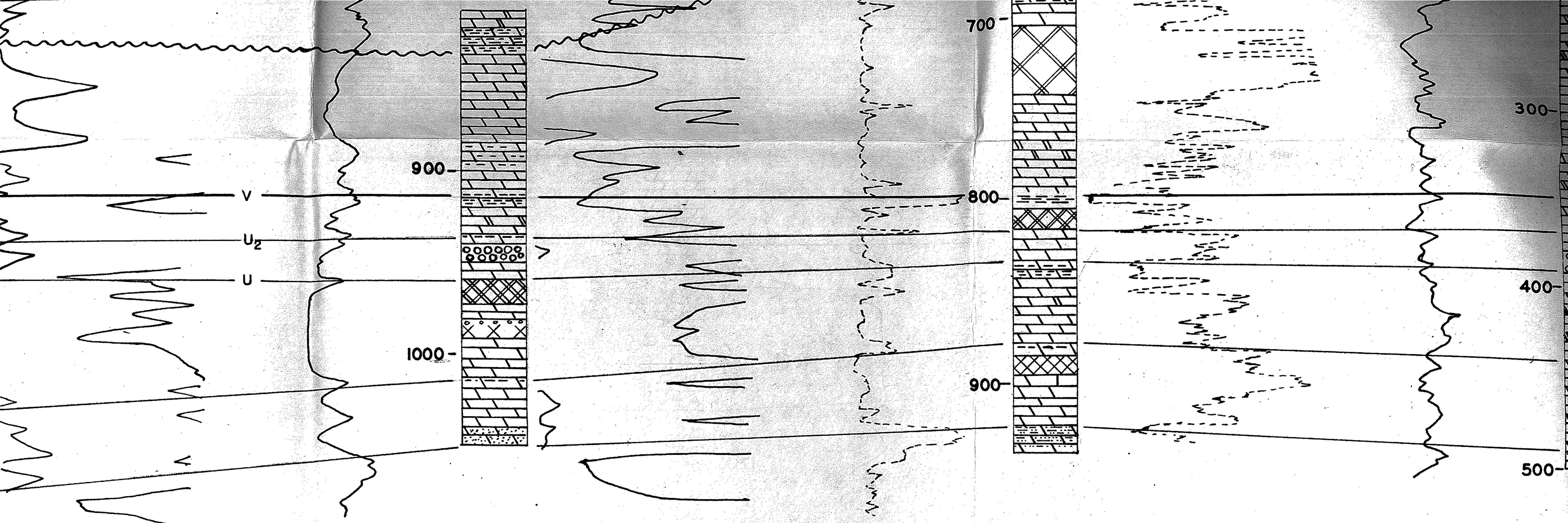


B. A. UNION ARBUCKLE (2)
13-24-1-12 WI
KB. 1536
12 MILES
NIPIRON PURVES (6)
16-11-2-10 WI
KB. 1577
25 MILES
SWEETGRASS ALT
2-35-5-8
KB. 1449
2400
2500
2100
2200
1500
1600



2400
2500
2600
2100
2200
1500
1600
1700





STRATIGRAPHIC CROSS SECTION D - D′

LEGEND

DOLOMITE

CRYPTOCRYSTALLINE TO MICROCRYSTALLINE

VERY FINE TO FINELY CRYSTALLINE

VERY FINE TO FINE GRAINED RELICT SKELETAL

MEDIUM GRAINED RELICT SKELETAL

COARSE TO VERY COARSE GRAINED RELICT SKELETAL

VERY FINE TO COARSE GRAINED RELICT SKELETAL

VERY FINE TO MEDIUM GRAINED RELICT SKELETAL

RELICT OOLITIC

ARGILLACEOUS

ARENACEOUS

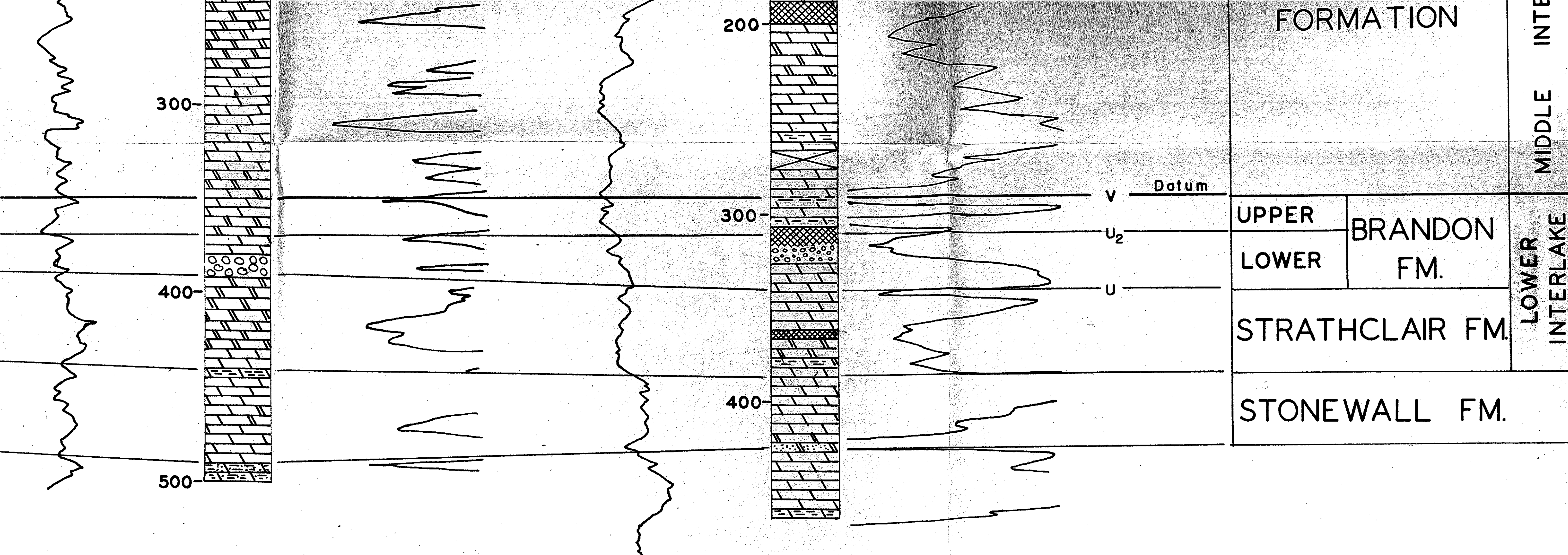
STROMATOLITIC

DOLOMITE CONGLOMERATE

SHALE

SAND

NO SAMPLES



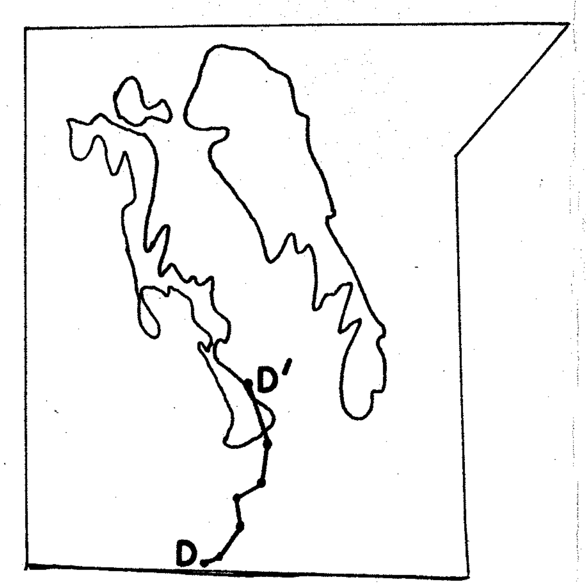
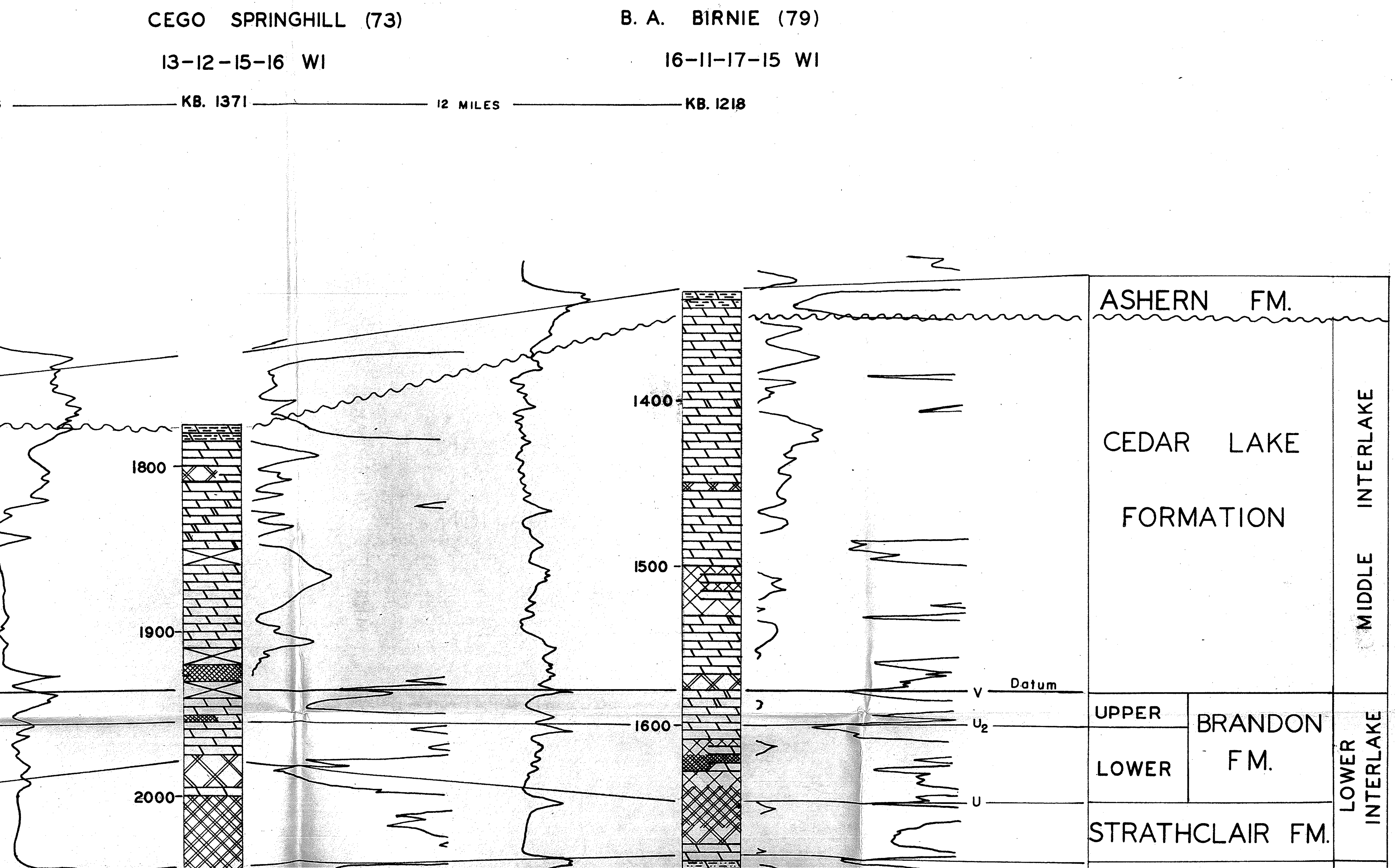


FIGURE 20

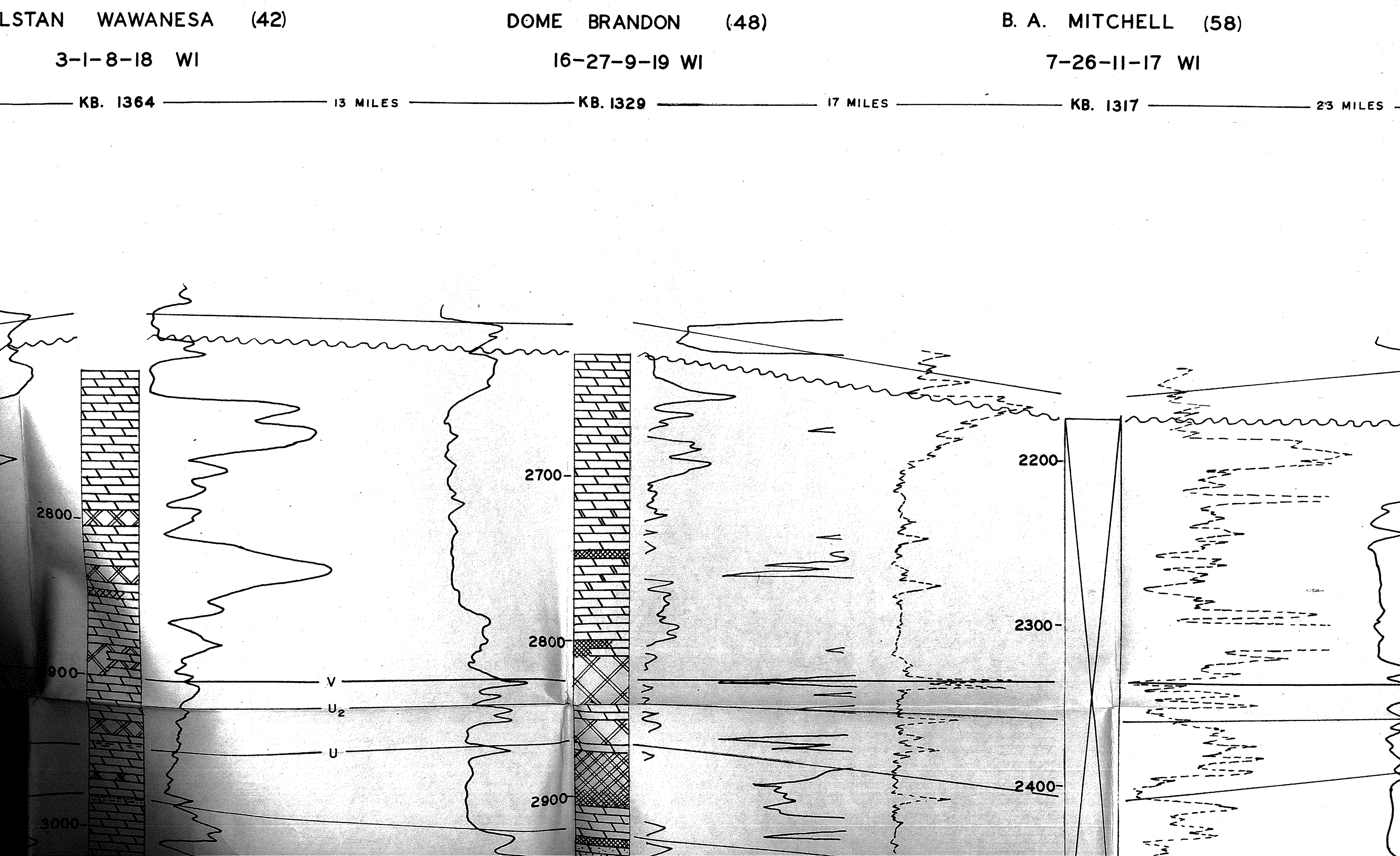
THE INTERLAKE GROUP IN MANITOBA

MARCH 1964

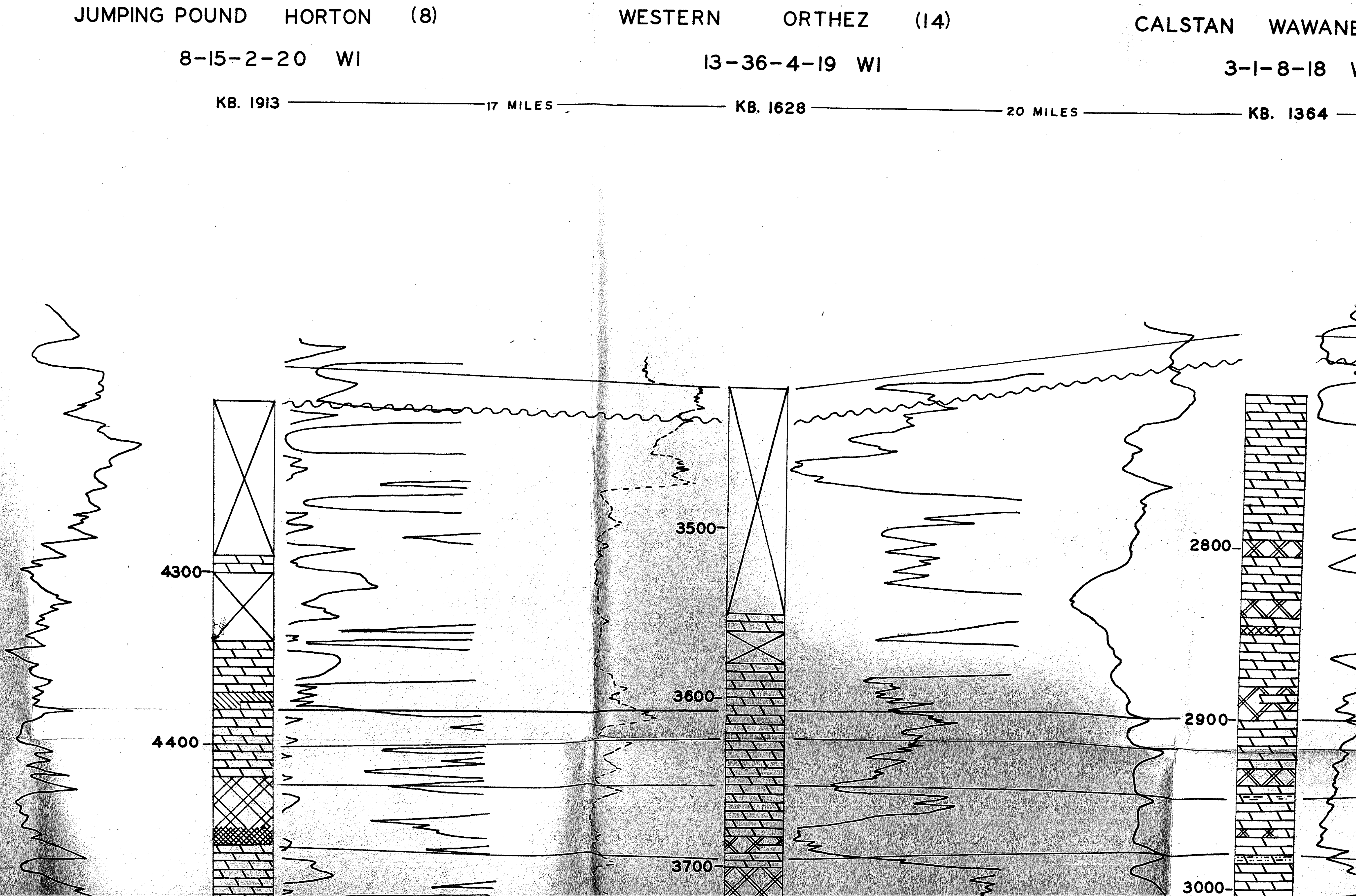
K. R. KING

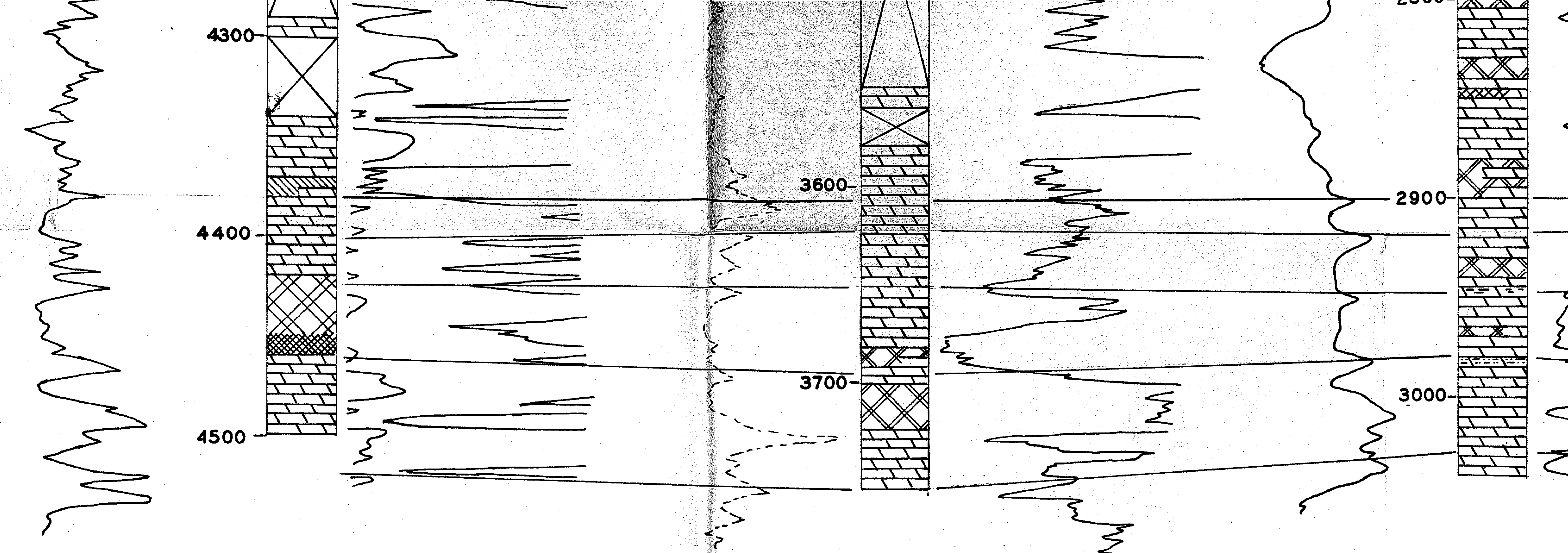


CEGO SPRINGHILL (73)
13-12-15-16 WI
KB. 1371
12 MILES
B. A. BIRNIE (79)
16-11-17-15 WI
KB. 1218
1800
1900
2000
1400
1500
1600
V
Datum
U2
U
ASHERN FM.
CEDAR LAKE FORMATION
MIDDLE INTERLAKE
UPPER
LOWER
BRANDON FM.
LOWER INTERLAKE
STRATHCLAIR FM.



LSTAN WAWANESA (42)
3-1-8-18 WI
KB. 1364
13 MILES
DOME BRANDON (48)
16-27-9-19 WI
KB. 1329
17 MILES
B. A. MITCHELL (58)
7-26-11-17 WI
KB. 1317
23 MILES
2800
2900
3000
V
U_2
U
2700
2800
2900
2200
2300
2400


JUMPING POUND HORTON (8)
8-15-2-20 W1
KB. 1913
17 MILES
WESTERN ORTHEZ (14)
13-36-4-19 W1
KB. 1628
20 MILES
CALSTAN WAWANE
3-1-8-18
KB. 1364
4300
4400
3500
3600
3700
2800
2900
3000



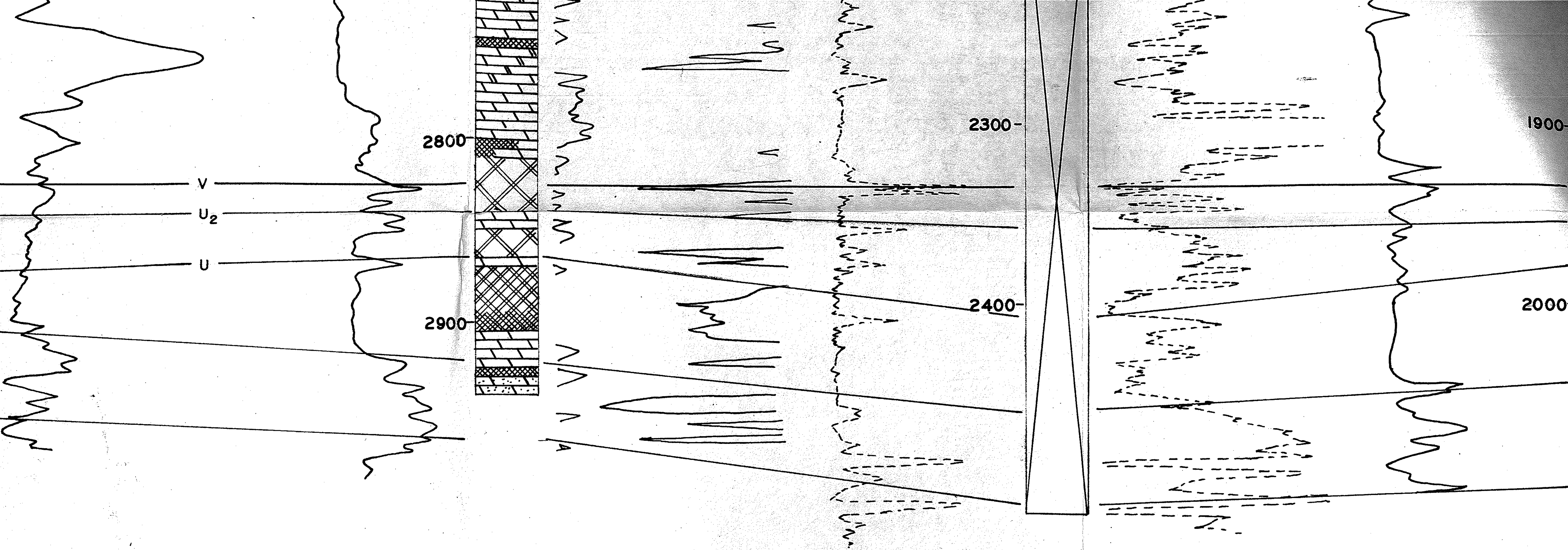
DOLOMITE

CRYPTOCRYSTALLIN
MICROCRYSTALLINE

VERY FINE TO F
CRYSTALLINE

VERY FINE TO FIN
RELICT SKELETAL

MEDIUM GRAINED
RELICT SKELETAL



STRATIGRAPHIC CROSS SECTION C – C′

LEGEND

LINE TO
NE

FINELY

INE GRAINED
AL

D
TAL

COARSE TO VERY COARSE GRAINED RELICT SKELETAL

VERY FINE TO COARSE GRAINED RELICT SKELETAL

VERY FINE TO MEDIUM GRAINED RELICT SKELETAL

RELICT OOLITIC

ARGILLACEOUS

ARENACEOUS

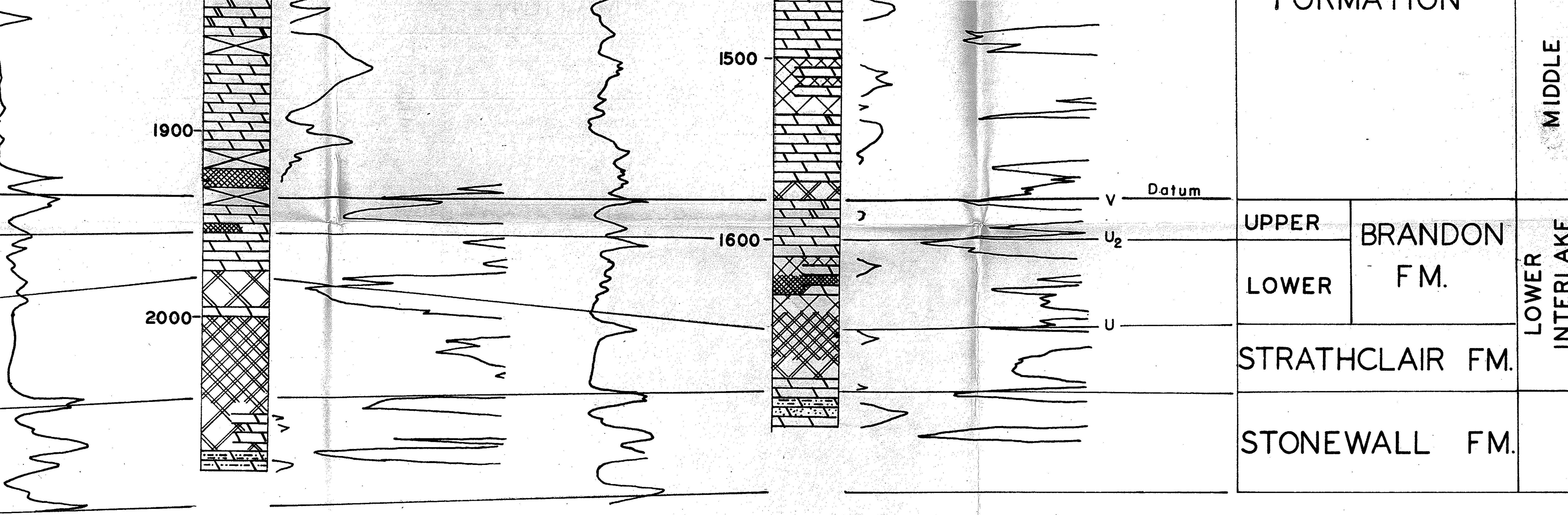
STROMATOLITIC

DOLOMITE CONGLOMERATE

SHALE

SAND

NO SAMPLES



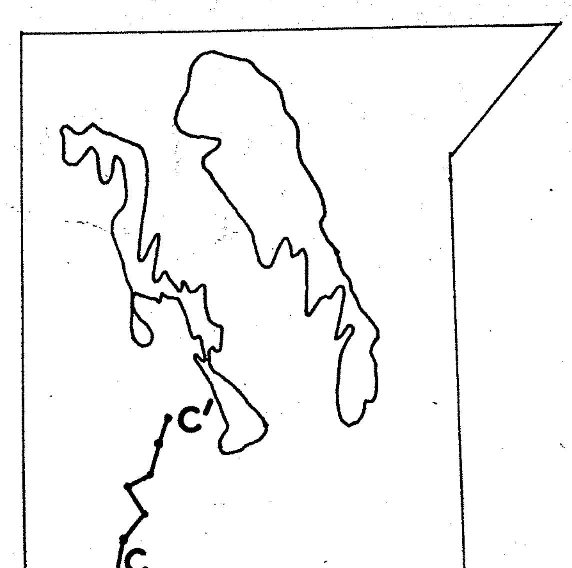
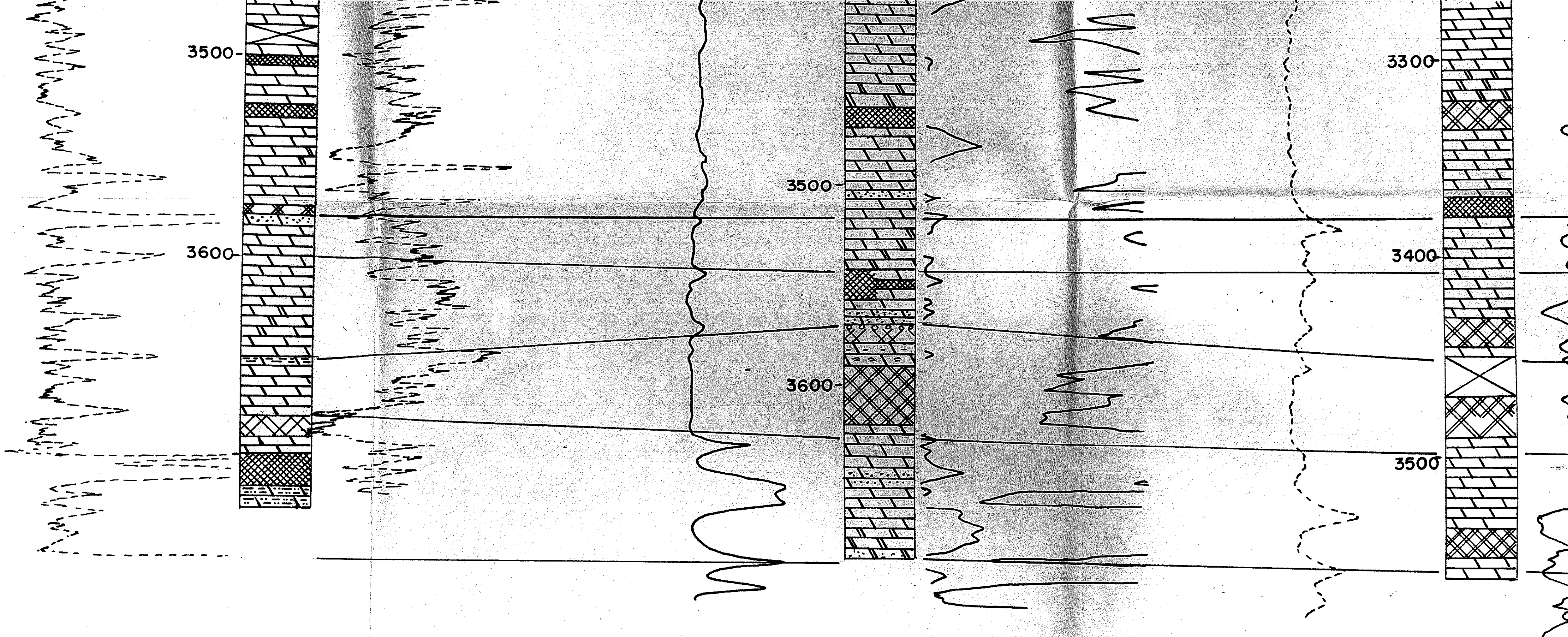


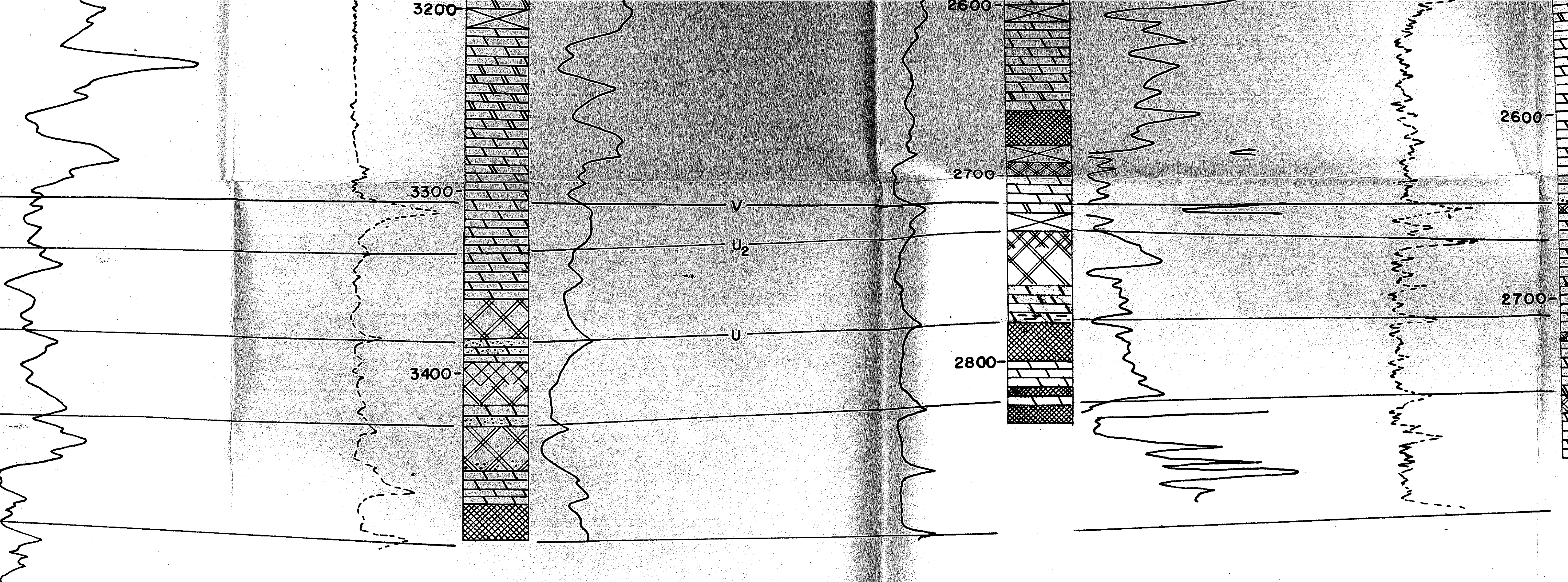
FIGURE 19

THE INTERLAKE GROUP IN MANITOBA

MARCH 1964

K. R. KING


3500-
3600-
3500-
3600-
3300-
3400-
3500

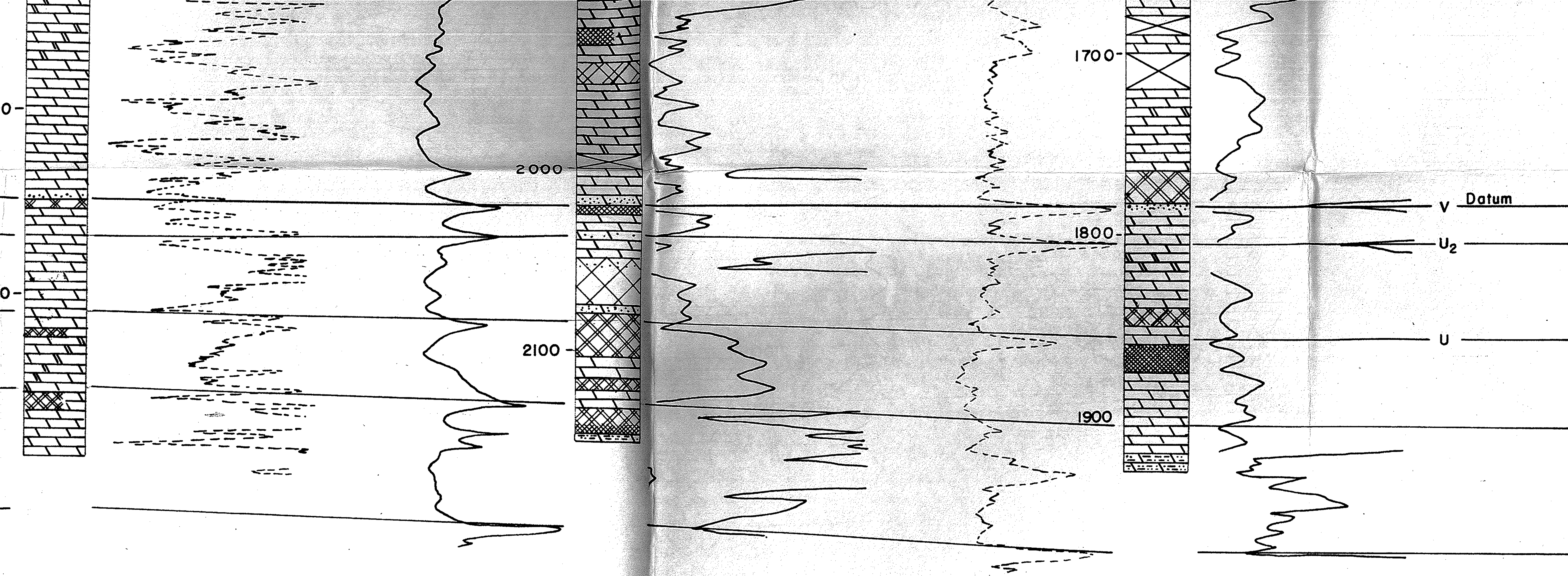


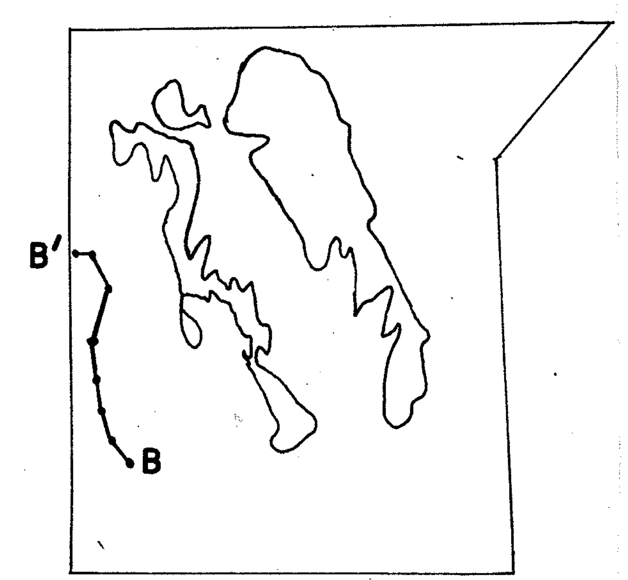
STRATIGRAPHIC CROSS SECTION B-B′

LEGEND

DOLOMITE

- CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
- VERY FINE TO FINELY CRYSTALLINE
- VERY FINE TO FINE GRAINED RELICT SKELETAL
- MEDIUM GRAINED RELICT SKELETAL
- COARSE TO VERY COARSE GRAINED RELICT SKELETAL
- VERY FINE TO COARSE GRAINED RELICT SKELETAL
- VERY FINE TO MEDIUM GRAINED RELICT SKELETAL
- RELICT OOLITIC
- ARGILLACEOUS
- ARENACEOUS
- STROMATOLITIC
- DOLOMITE CONGLOMERATE
- SHALE
- SAND
- NO SAMPLES



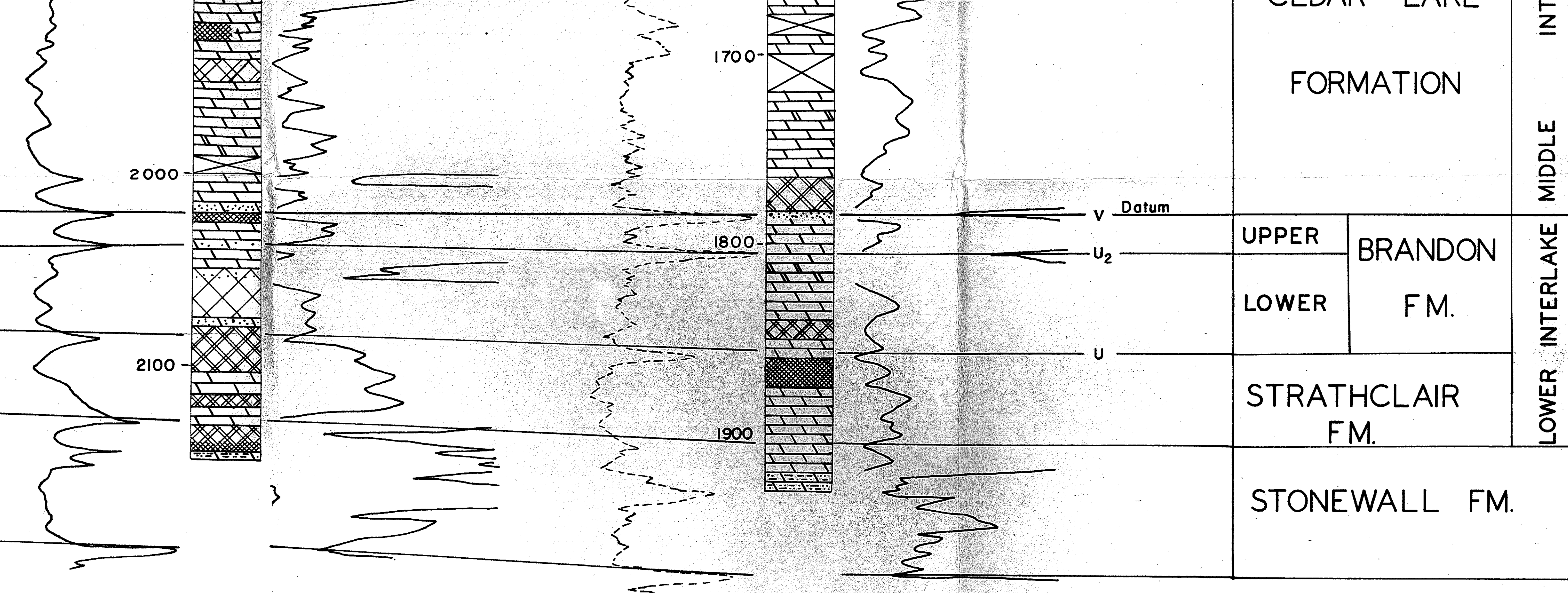


F

THE INT

IN

MARCH 1964



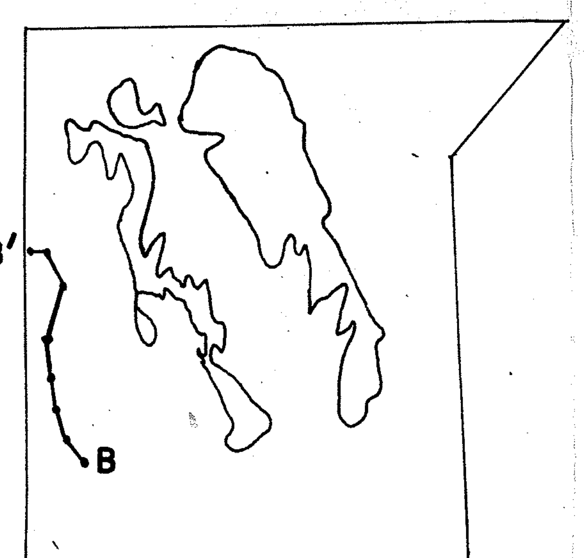
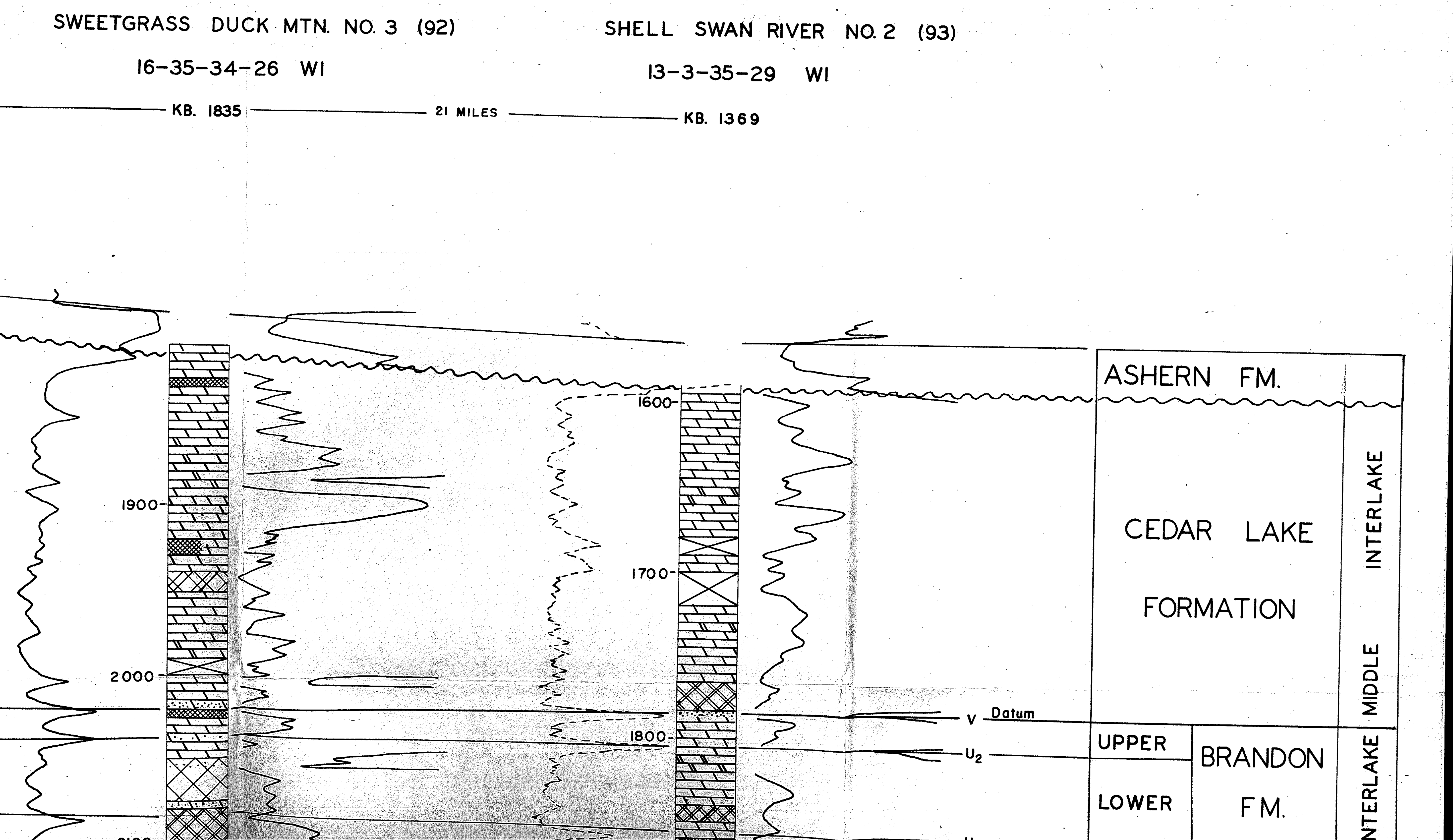


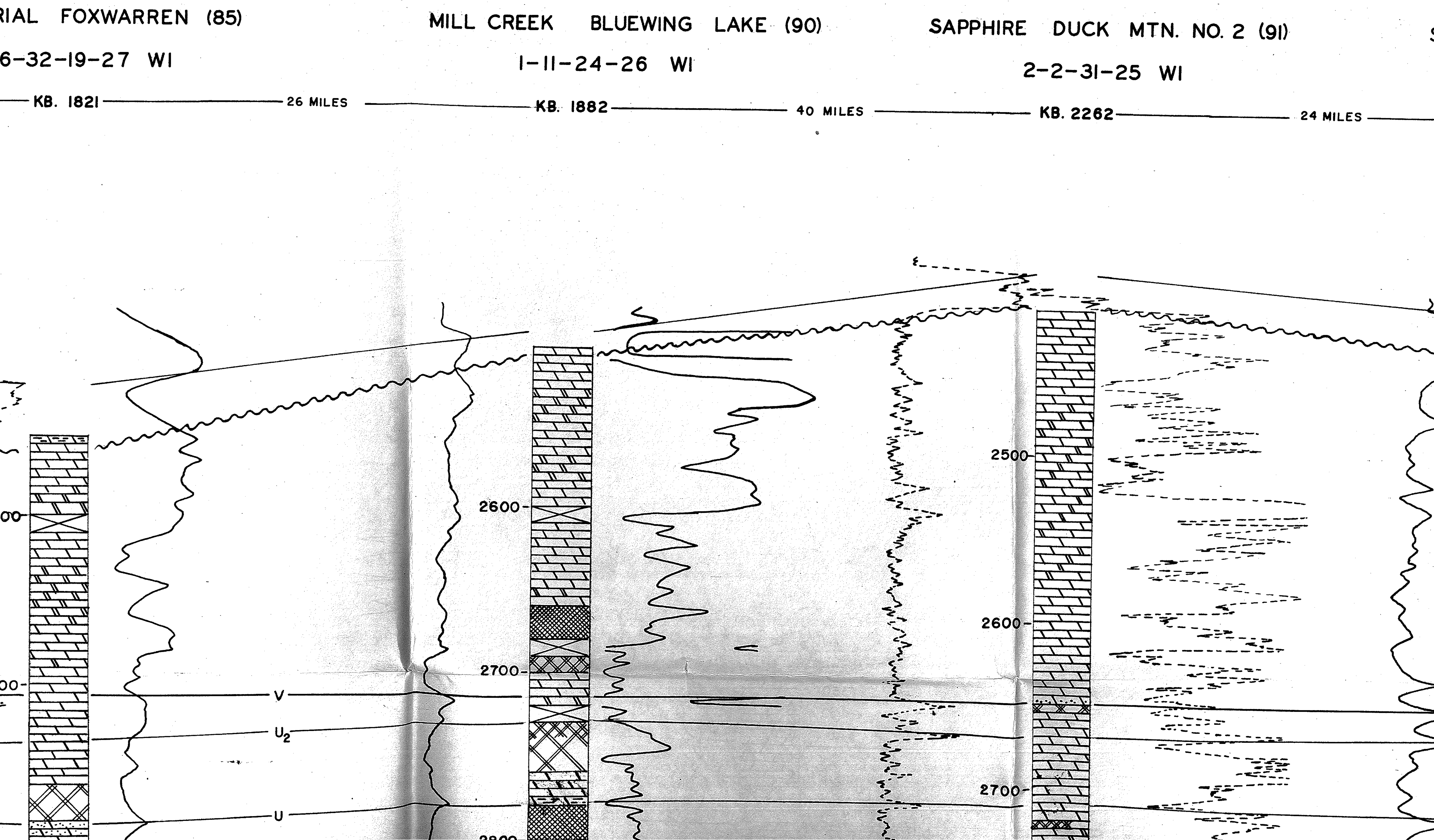
FIGURE 18

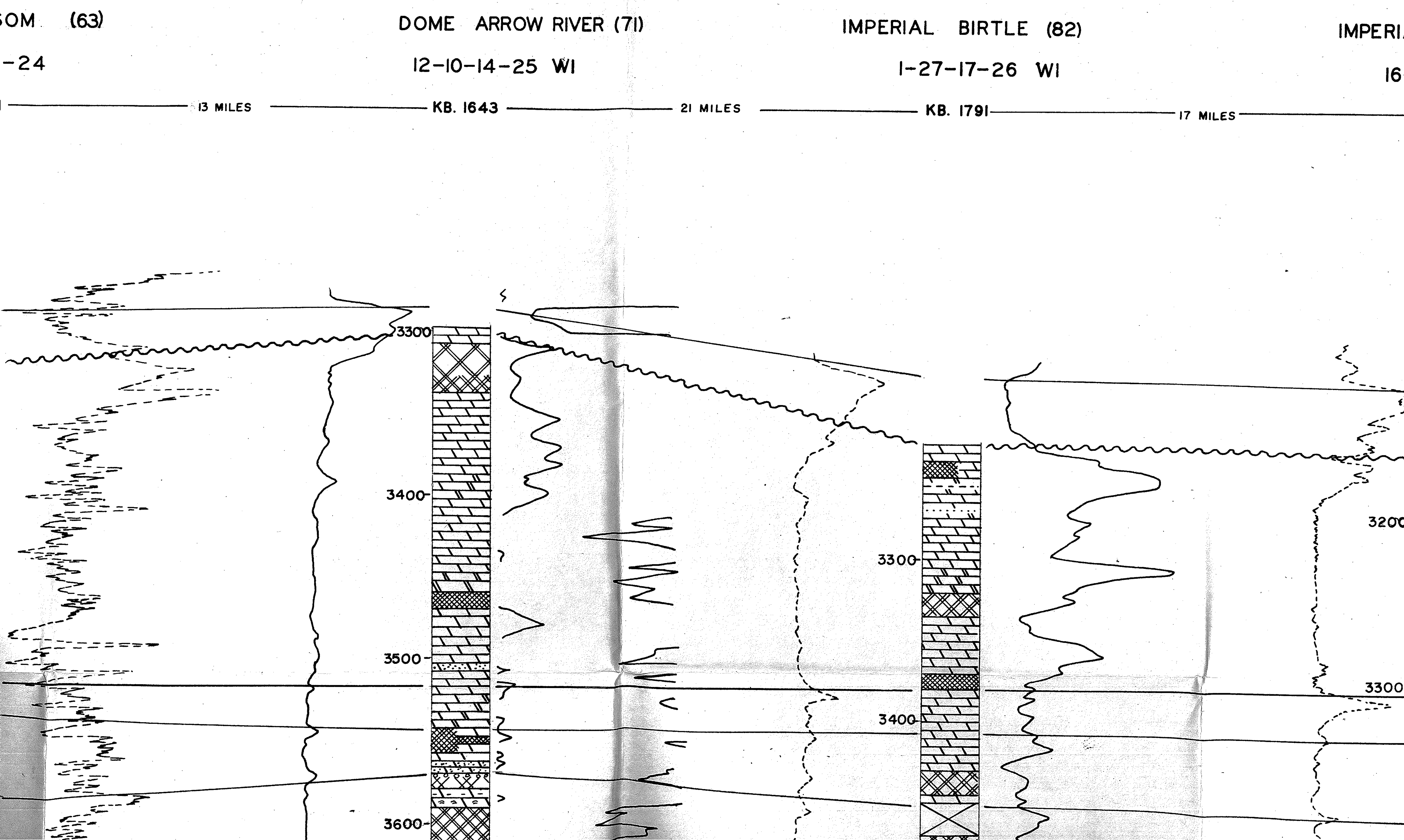
THE INTERLAKE GROUP
IN MANITOBA

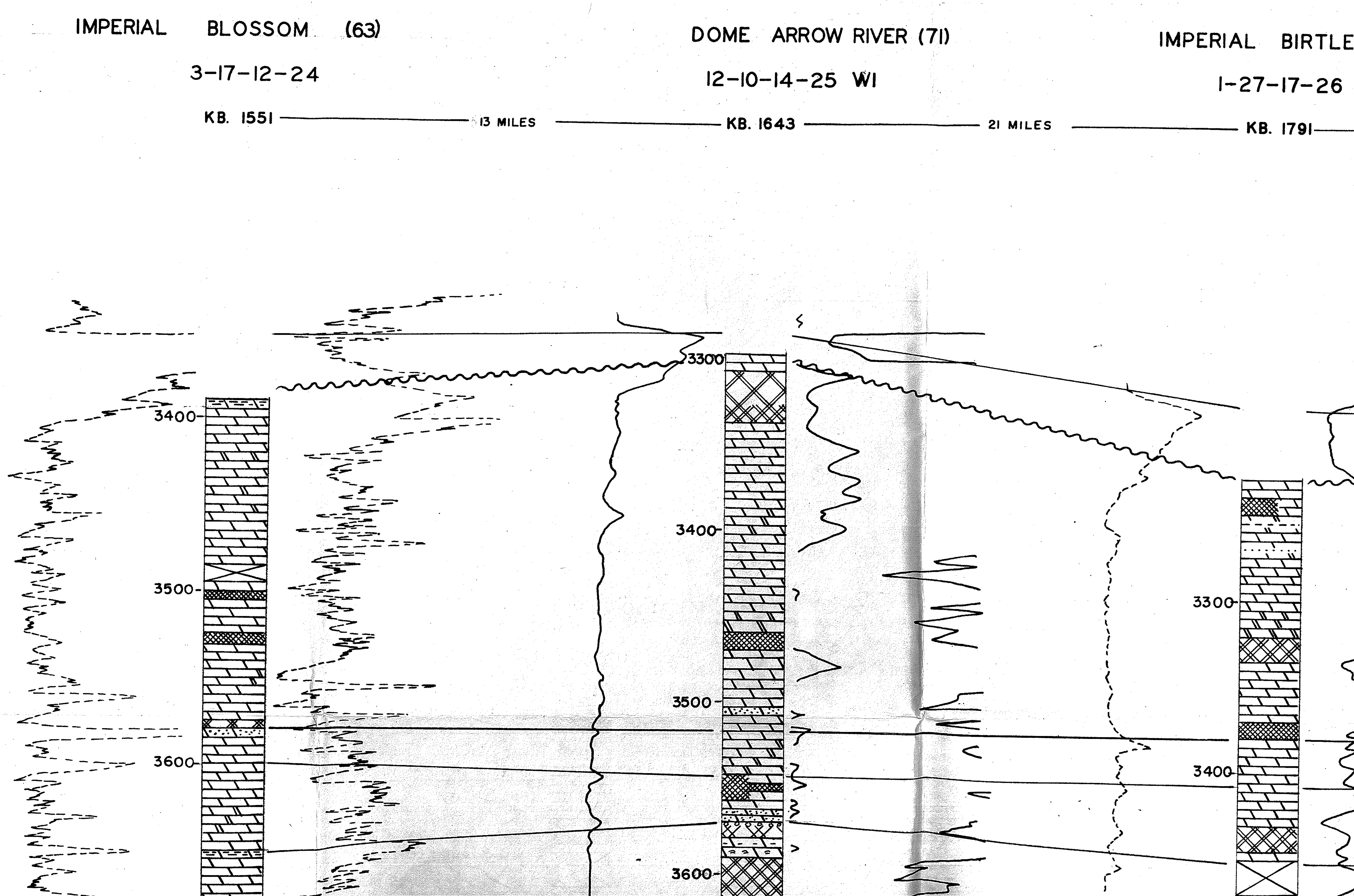
MARCH 1964

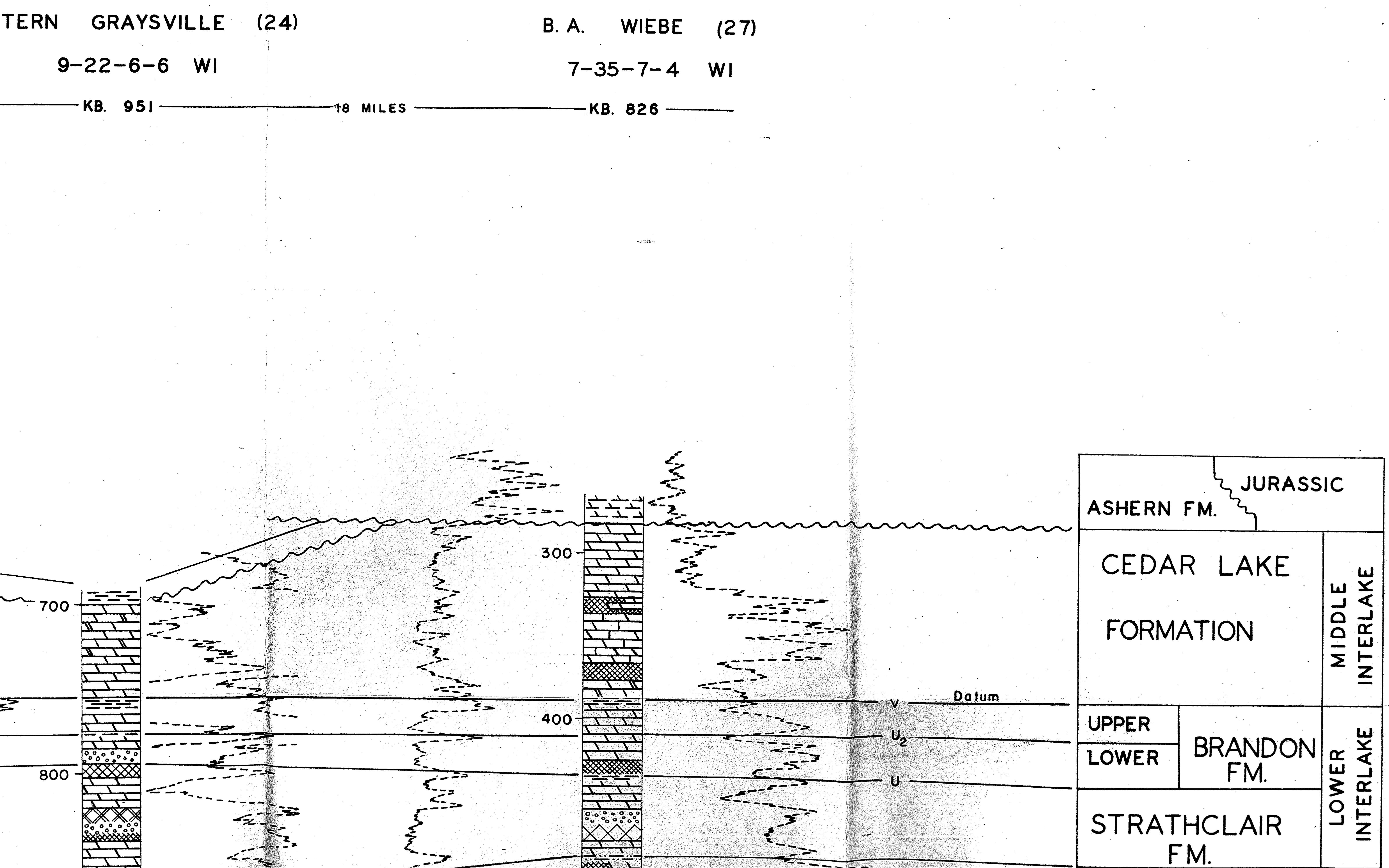
K.R. KING


SWEETGRASS DUCK MTN. NO. 3 (92)
16-35-34-26 WI
SHELL SWAN RIVER NO. 2 (93)
13-3-35-29 WI
KB. 1835
21 MILES
KB. 1369
1900
2000
1600
1700
1800
V
Datum
U_2
ASHERN FM.
CEDAR LAKE
FORMATION
INTERLAKE
MIDDLE
UPPER
LOWER
BRANDON
FM.
INTERLAKE

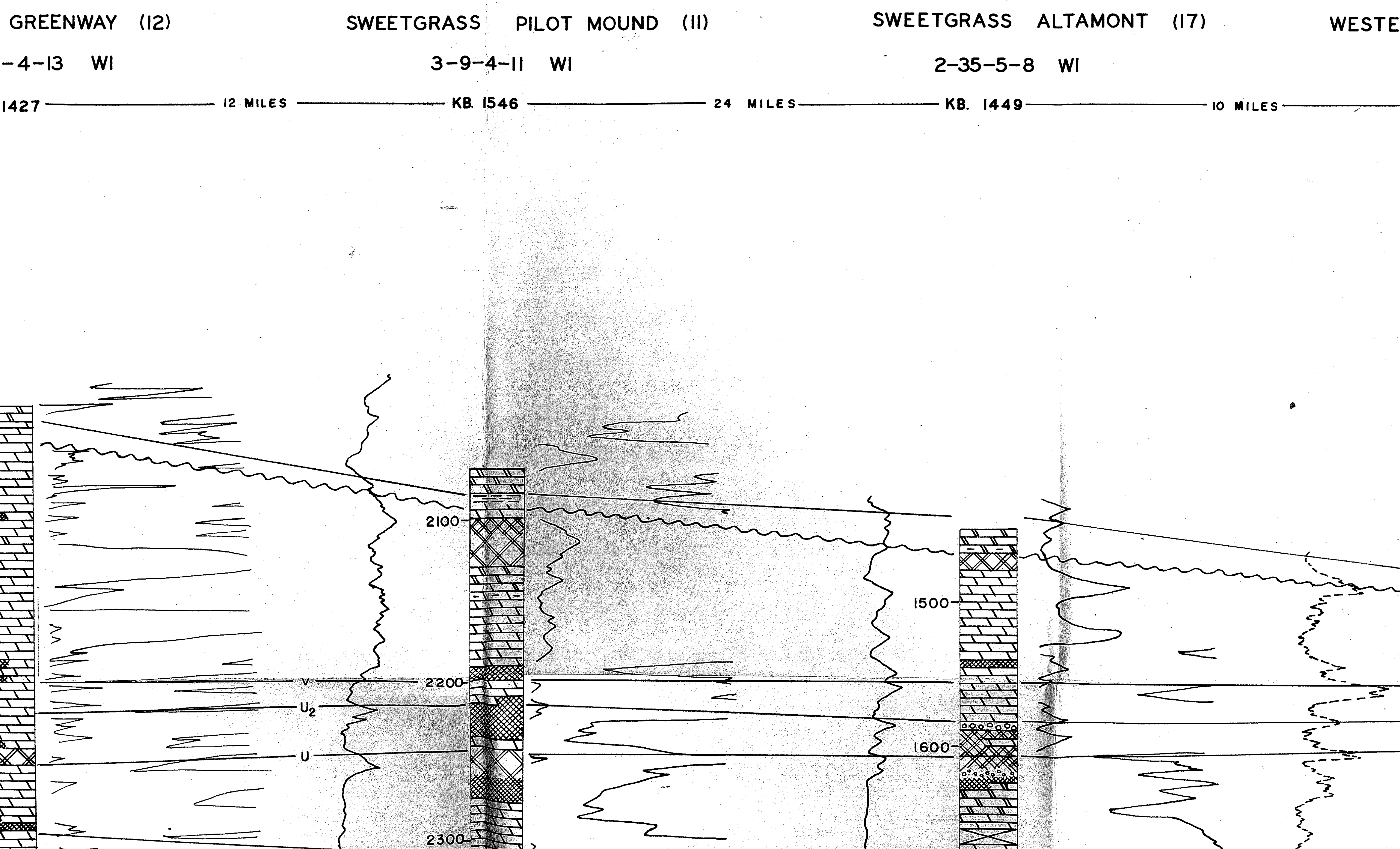

RIAL FOXWARREN (85)
6-32-19-27 WI
KB. 1821
26 MILES
MILL CREEK BLUEWING LAKE (90)
1-11-24-26 WI
KB. 1882
40 MILES
SAPPHIRE DUCK MTN. NO. 2 (91)
2-2-31-25 WI
KB. 2262
24 MILES
00
00
2600
2700
2500
2600
2700
V
U2
U

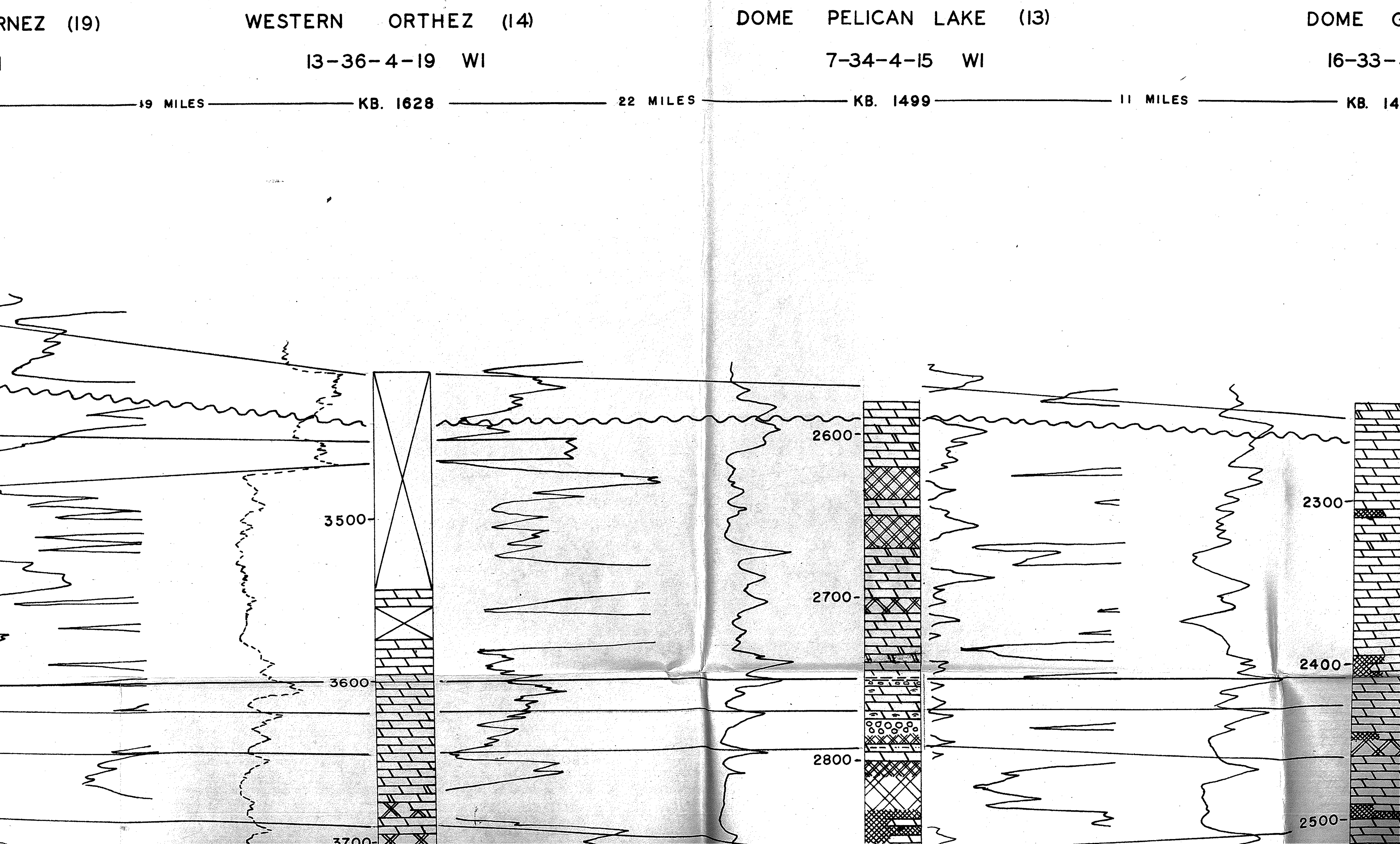

SOM (63)
-24
13 MILES
DOME ARROW RIVER (71)
12-10-14-25 WI
KB. 1643
21 MILES
IMPERIAL BIRTLE (82)
1-27-17-26 WI
KB. 1791
17 MILES
IMPERI
16
3300
3400
3500
3600
3300
3400
3200
3300

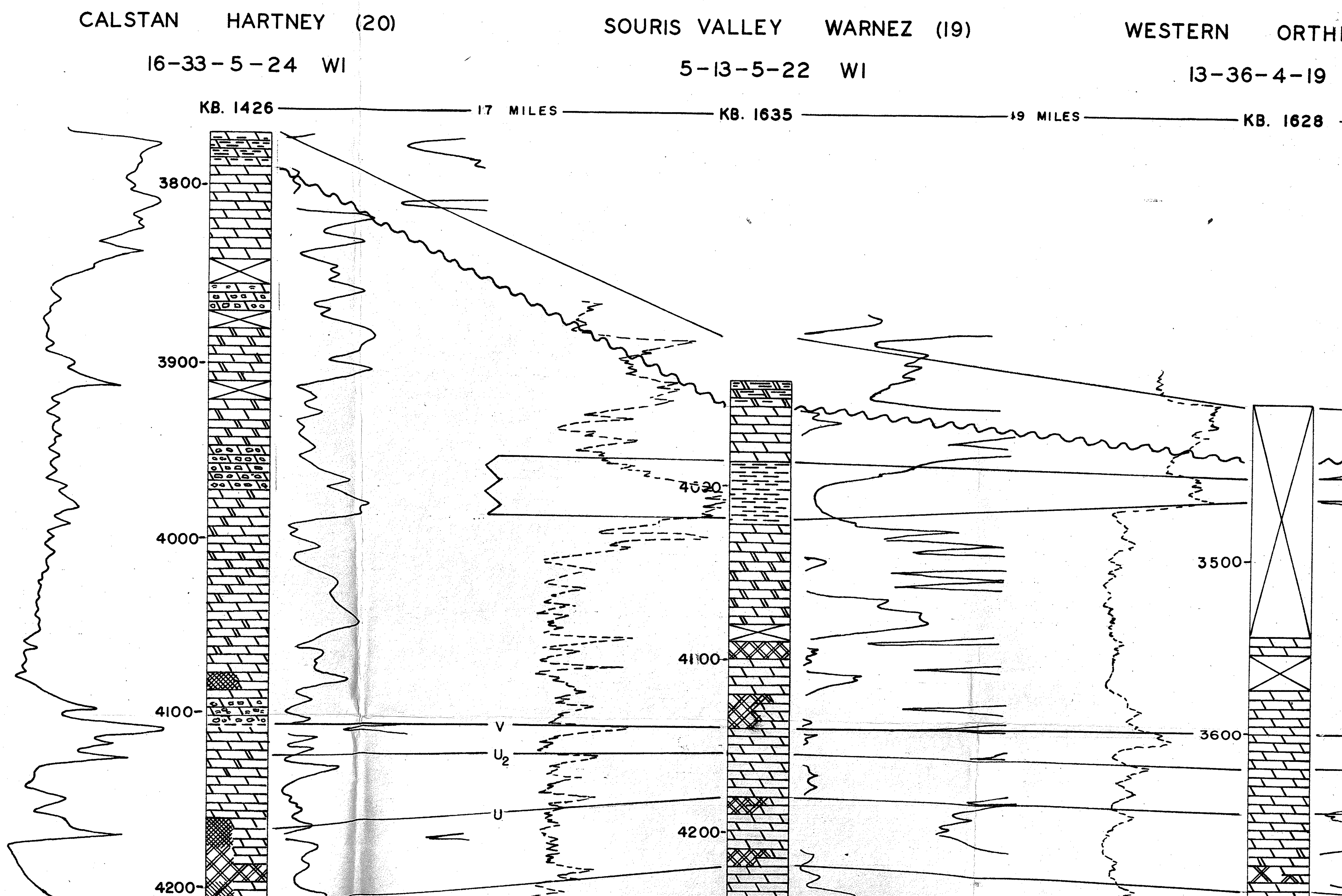

IMPERIAL BLOSSOM (63)
3-17-12-24
KB. 1551
13 MILES
DOME ARROW RIVER (71)
12-10-14-25 WI
KB. 1643
21 MILES
IMPERIAL BIRTLE
1-27-17-26
KB. 1791
3400
3500
3600
3300
3400
3500
3600
3300
3400

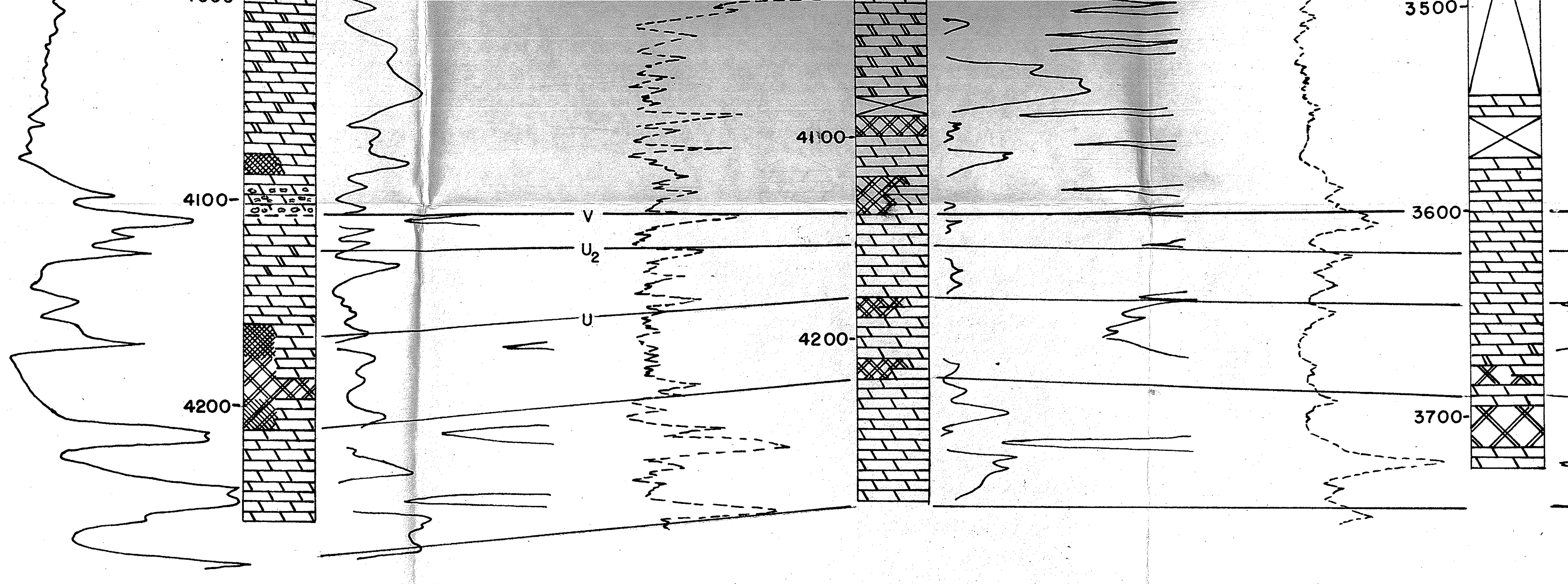


TERN GRAYSVILLE (24)
9-22-6-6 WI
KB. 951
18 MILES
B. A. WIEBE (27)
7-35-7-4 WI
KB. 826
700
800
300
400
V
Datum
U_2
U
ASHERN FM.
JURASSIC
CEDAR LAKE
FORMATION
MIDDLE INTERLAKE
UPPER
LOWER
BRANDON FM.
STRATHCLAIR FM.
LOWER INTERLAKE

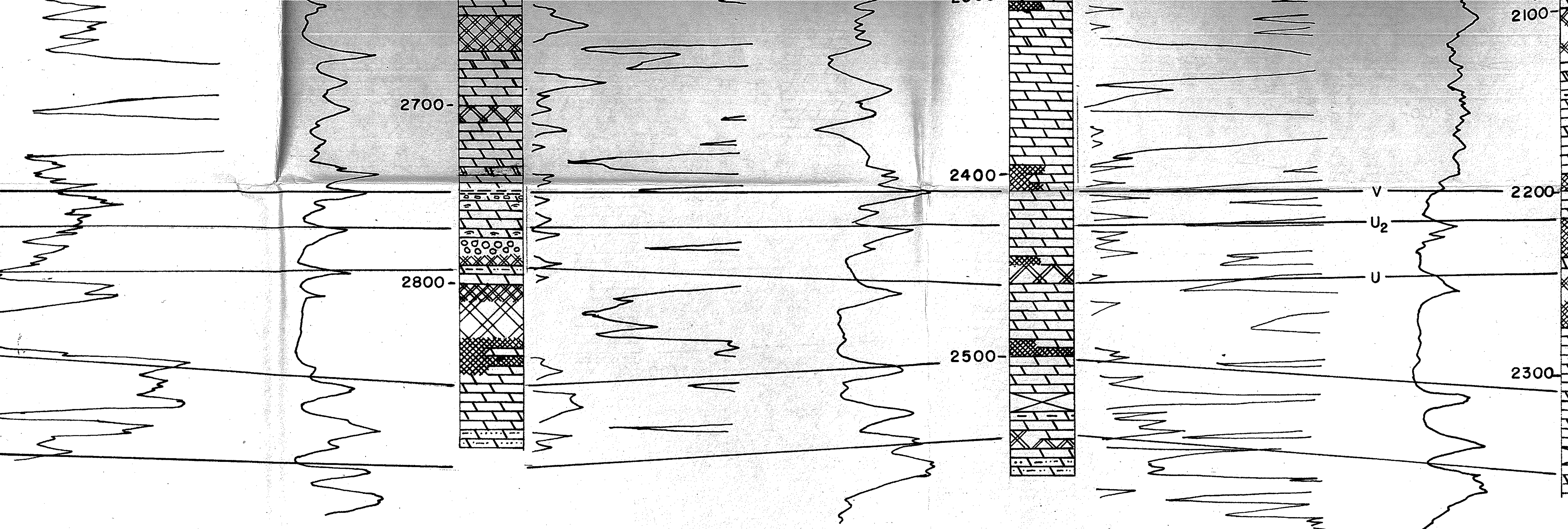

GREENWAY (12)
-4-13 WI
1427
12 MILES
SWEETGRASS PILOT MOUND (11)
3-9-4-11 WI
KB. 1546
24 MILES
SWEETGRASS ALTAMONT (17)
2-35-5-8 WI
KB. 1449
10 MILES
WESTE
2100
2200
2300
V
U_2
U
1500
1600


WESTERN ORTHEZ (14)
13-36-4-19 WI
19 MILES
KB. 1628
22 MILES
DOME PELICAN LAKE (13)
7-34-4-15 WI
KB. 1499
11 MILES
DOME
3500
3600
3700
2600
2700
2800
2300
2400
2500


CALSTAN HARTNEY (20)
16-33-5-24 WI
KB. 1426
17 MILES
SOURIS VALLEY WARNEZ (19)
5-13-5-22 WI
KB. 1635
19 MILES
WESTERN ORTH
13-36-4-19
KB. 1628
3800
3900
4000
4100
4200
V
U_2
U
4020
4100
4200
3500
3600



4100
4200
V
U_2
U
4100
4200
3500
3600
3700

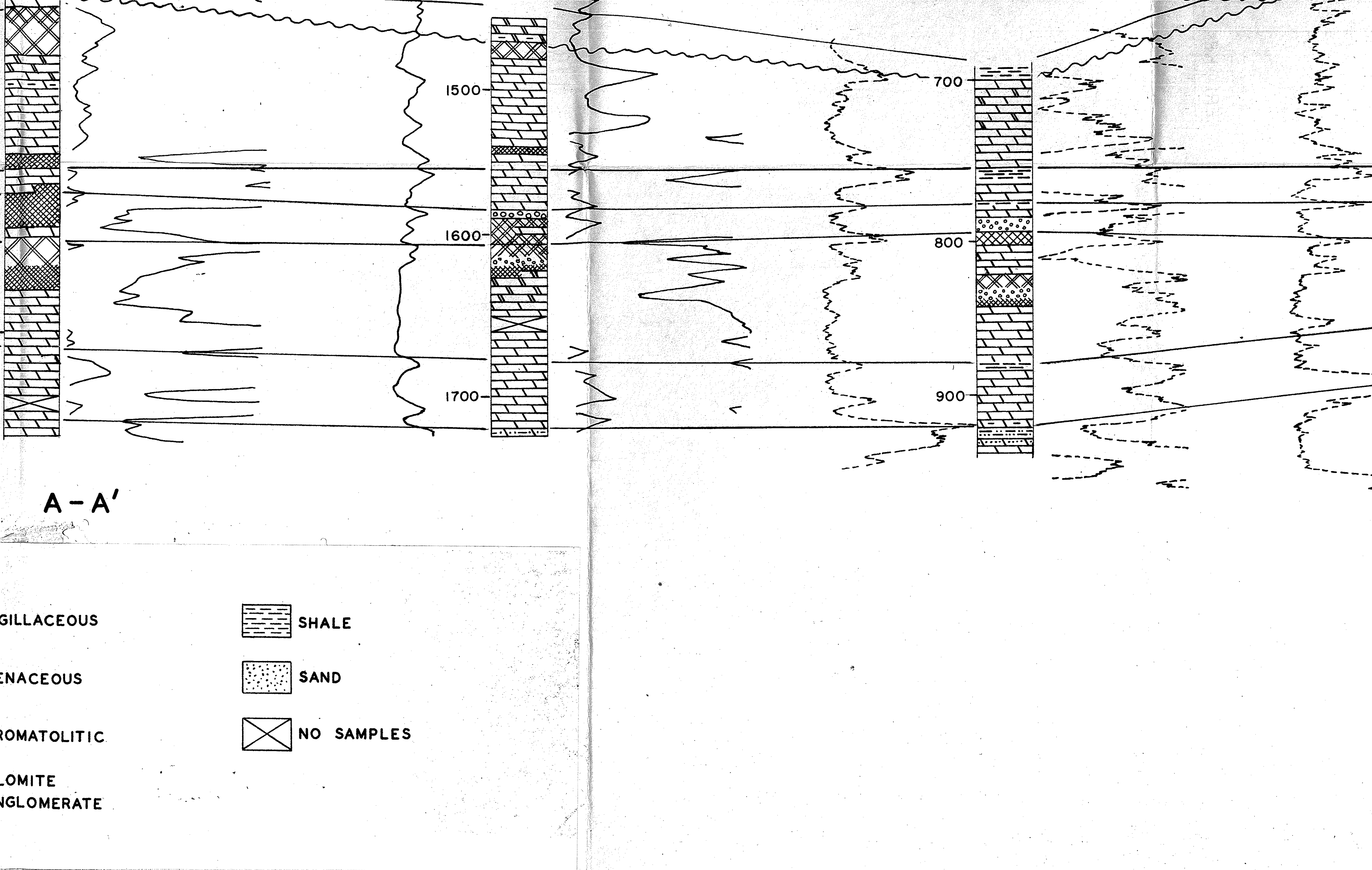


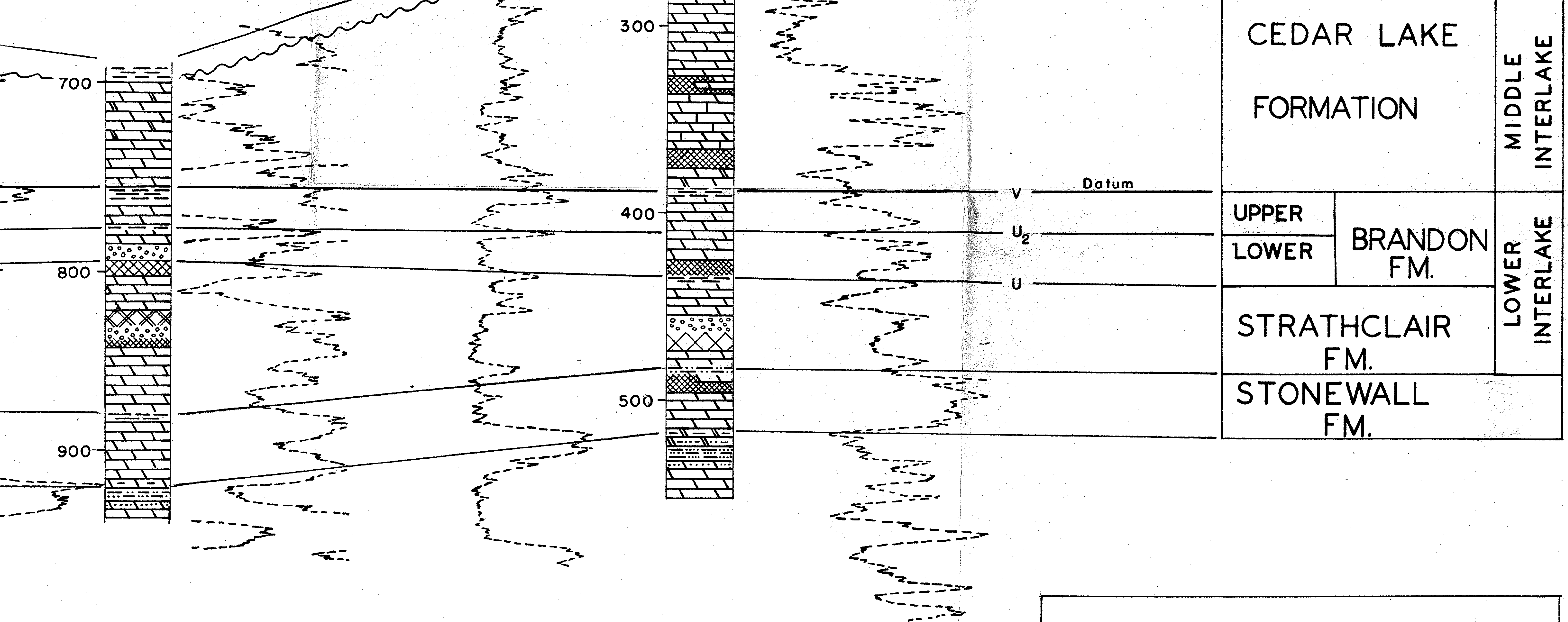
STRATIGRAPHIC CROSS SECTION

LEGEND

DOLOMITE

- CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
- VERY FINE TO FINELY CRYSTALLINE
- VERY FINE TO FINE GRAINED RELICT SKELETAL
- MEDIUM GRAINED RELICT SKELETAL
- COARSE TO VERY COARSE GRAINED RELICT SKELETAL
- VERY FINE TO COARSE GRAINED RELICT SKELETAL
- VERY FINE TO MEDIUM GRAINED RELICT SKELETAL
- RELICT OOLITIC
- ARG
- ARE
- STR
- DOL CON


1500
1600
1700
700
800
900
A - A'
GILLACEOUS
ENACEOUS
ROMATOLITIC
LOMITE
NGLOMERATE
SHALE
SAND
NO SAMPLES



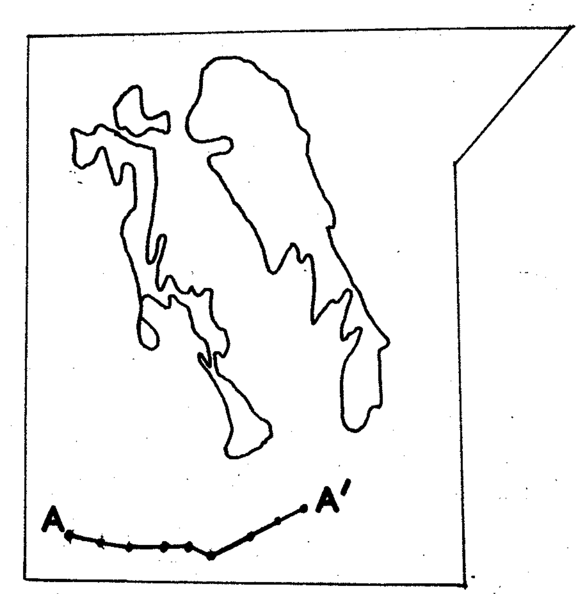
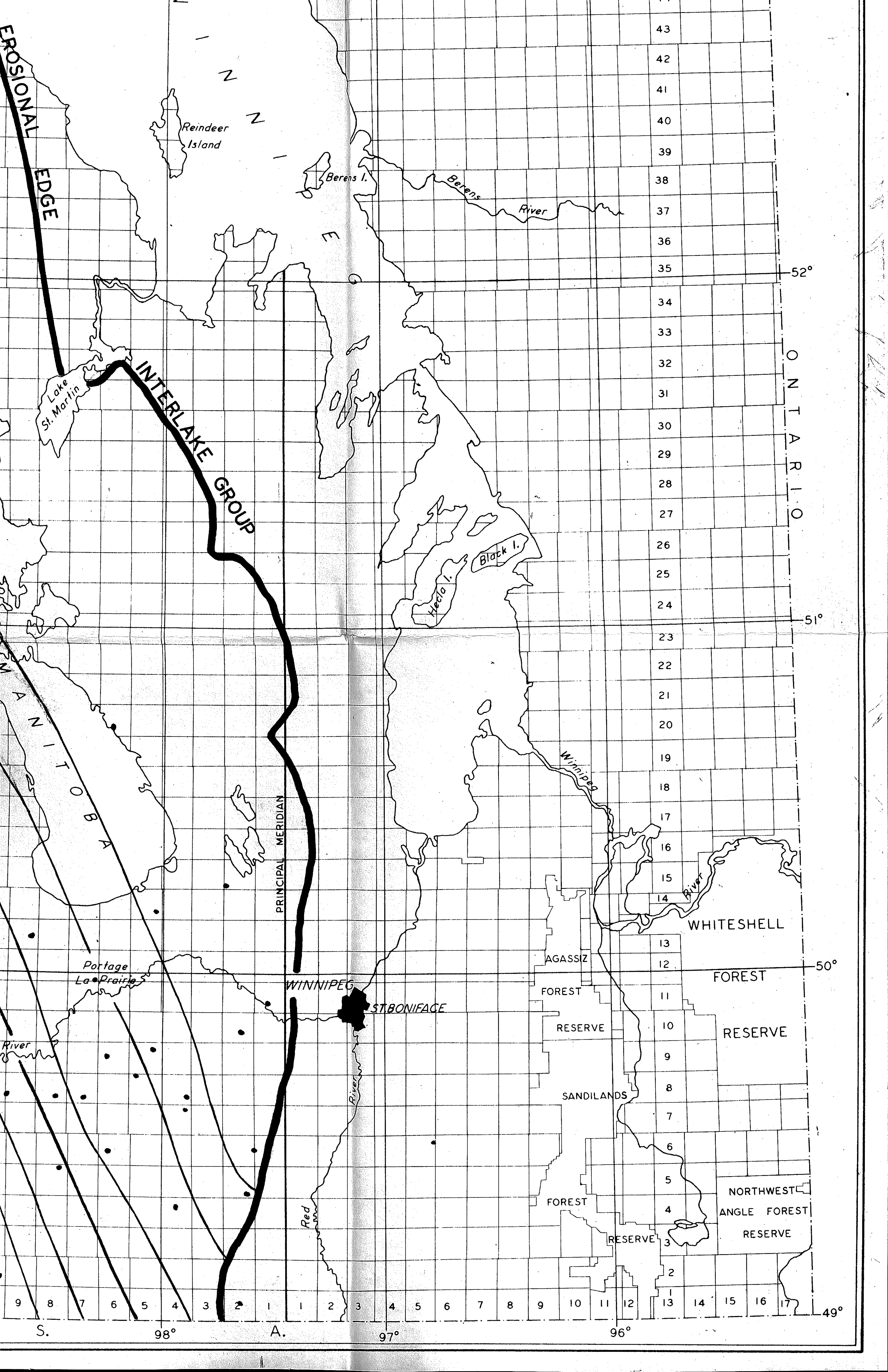


FIGURE 17

THE INTERLAKE GROUP IN MANITOBA

MARCH 1964

K. R. KING



EROSIONAL EDGE
INTERLAKE GROUP
Reindeer Island
Berens I.
Berens River
Lake St. Martin
Hecla I.
Black I.
MANITOBA
Winnipeg
River
Portage La Prairie
River
WINNIPEG
ST. BONIFACE
Red River
PRINCIPAL MERIDIAN
ONTARIO
WHITESHELL FOREST RESERVE
AGASSIZ FOREST RESERVE
SANDILANDS FOREST RESERVE
NORTHWEST ANGLE FOREST RESERVE
52°
51°
50°
49°
98°
97°
96°
S.
A.

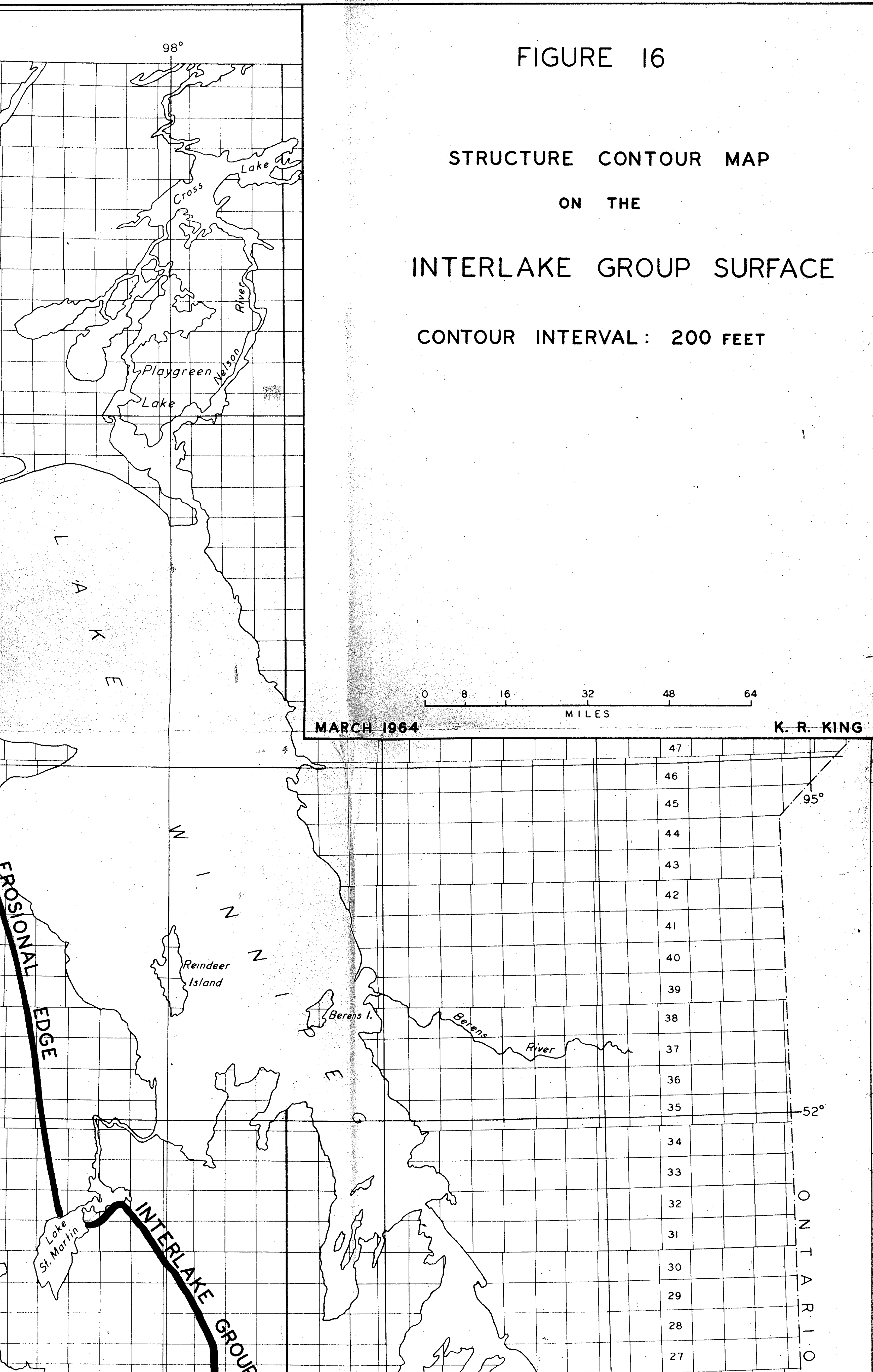


FIGURE 16

STRUCTURE CONTOUR MAP

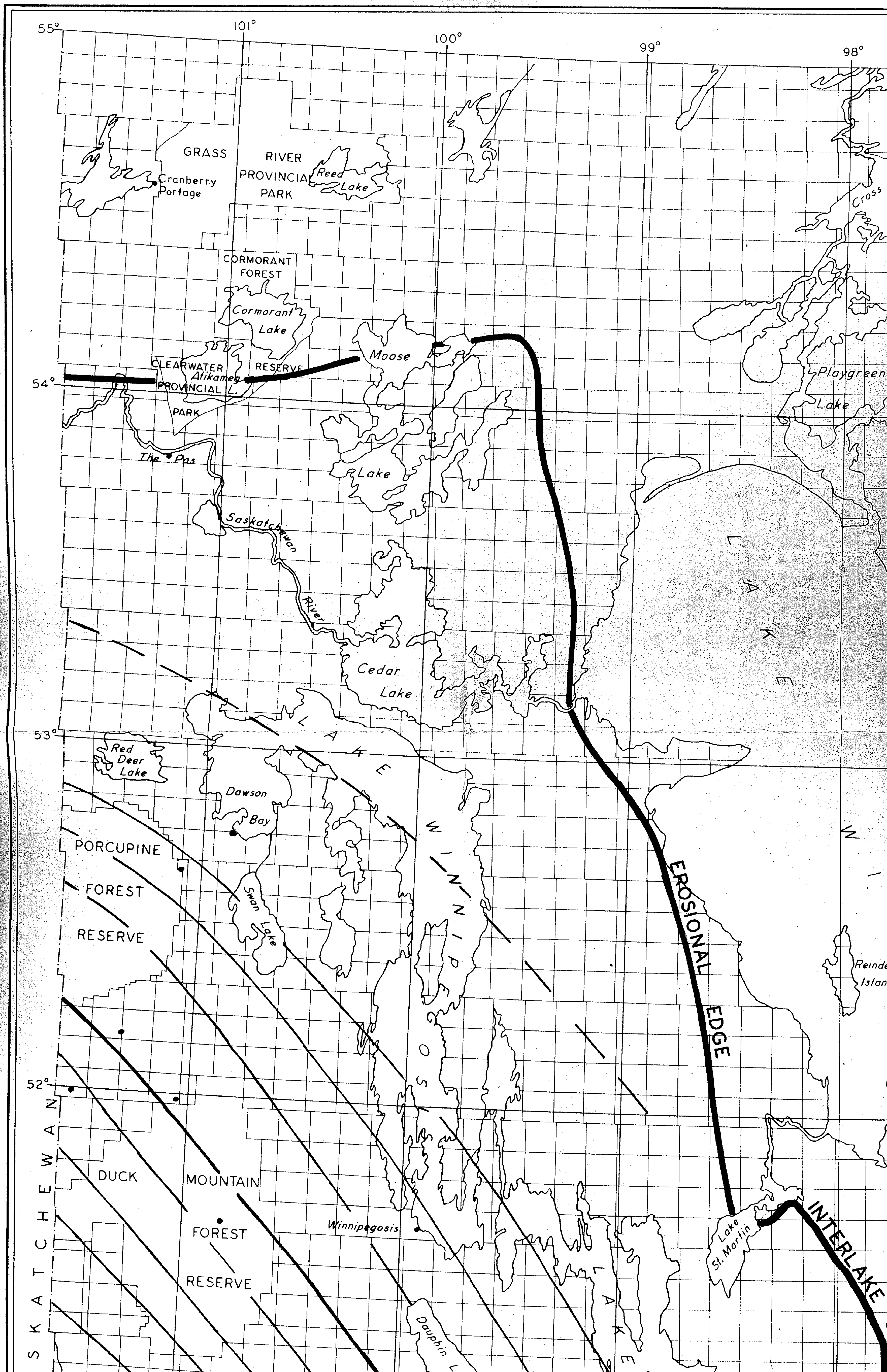
ON THE

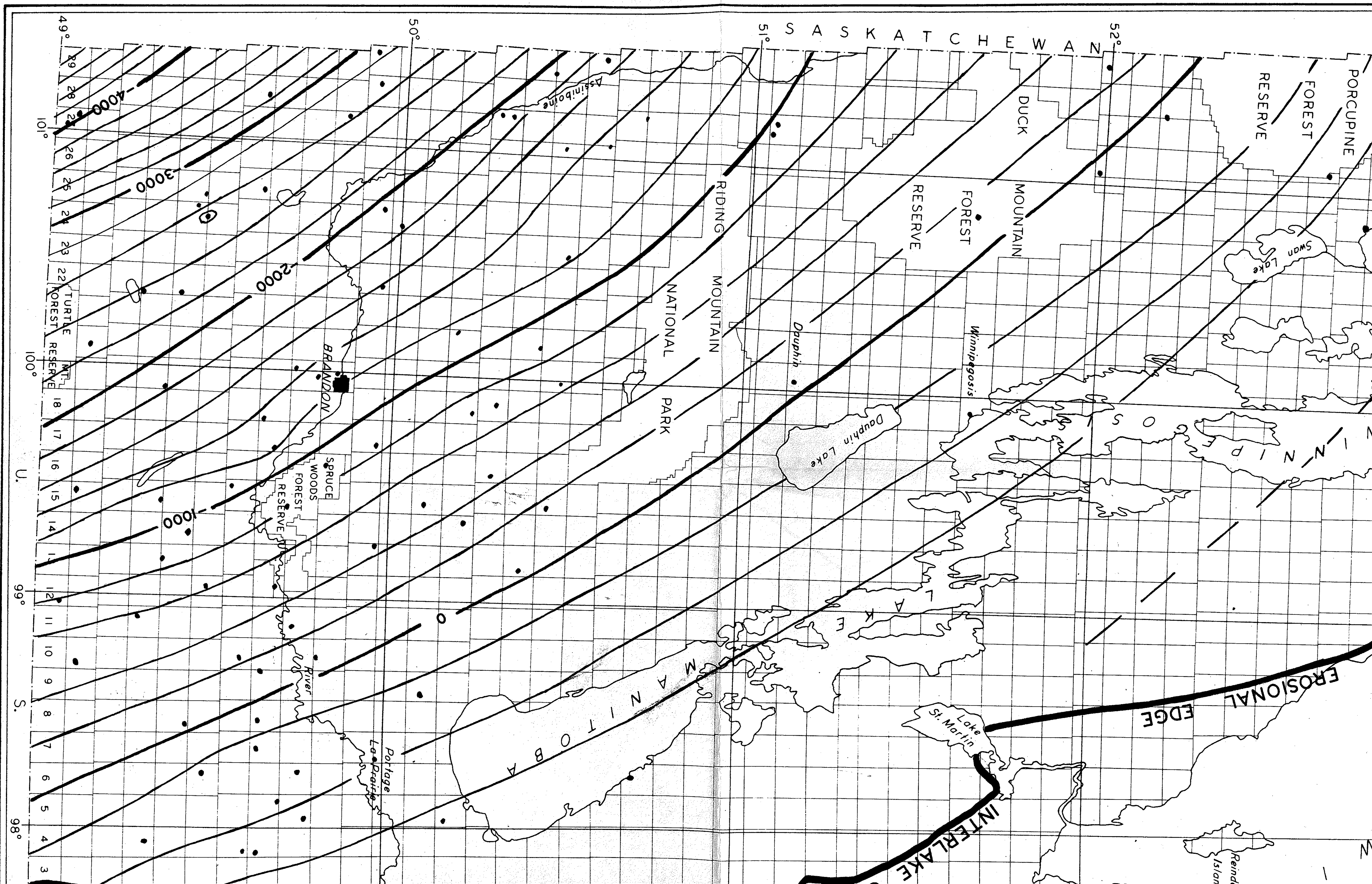
INTERLAKE GROUP SURFACE

CONTOUR INTERVAL: 200 FEET

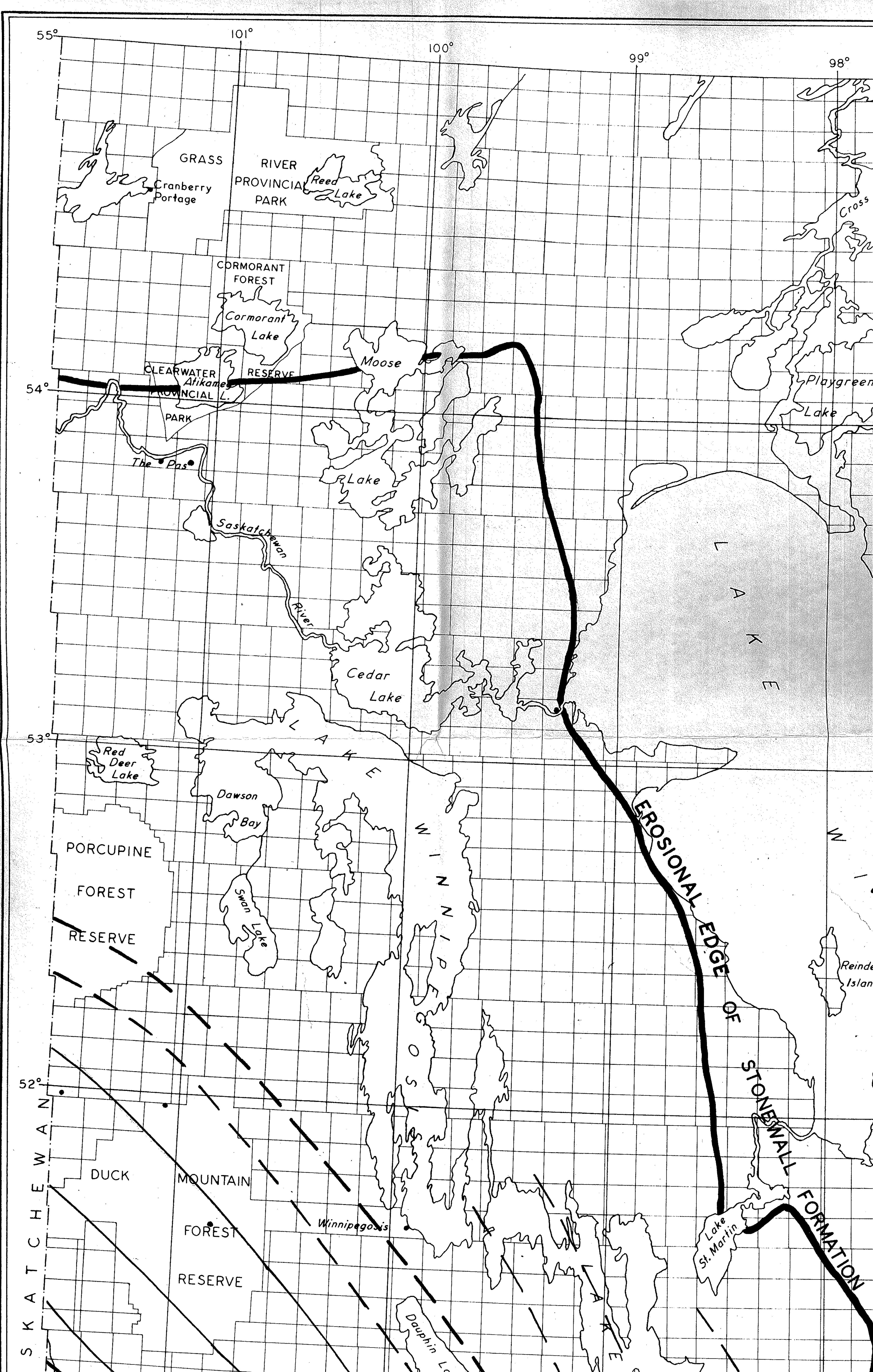
MARCH 1964

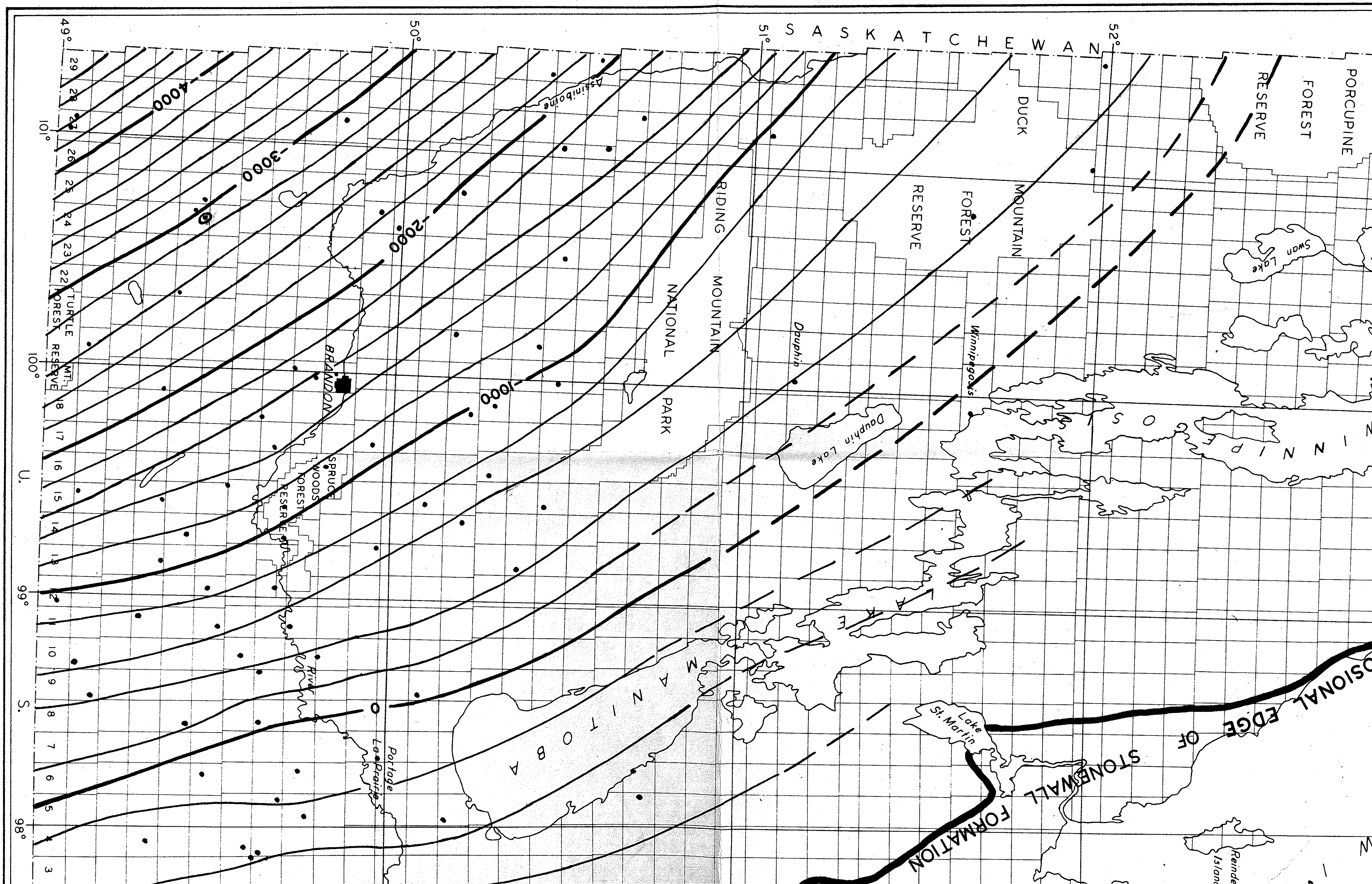
K. R. KING


55°
101°
100°
99°
98°
54°
53°
52°
GRASS RIVER PROVINCIAL PARK
Reed Lake
Cranberry Portage
CORMORANT FOREST RESERVE
Cormorant Lake
CLEARWATER PROVINCIAL PARK
Atikameg L.
Moose Lake
The Pas
Saskatchewan River
Cross
Playgreen Lake
LAKE
Cedar Lake
LAKE WINNIPEGOSIS
Red Deer Lake
Dawson Bay
Swan Lake
PORCUPINE FOREST RESERVE
EROSIONAL EDGE
Reindeer Island
DUCK MOUNTAIN FOREST RESERVE
Winnipegosis
Lake St. Martin
INTERLAKE
Dauphin L.
SASKATCHEWAN

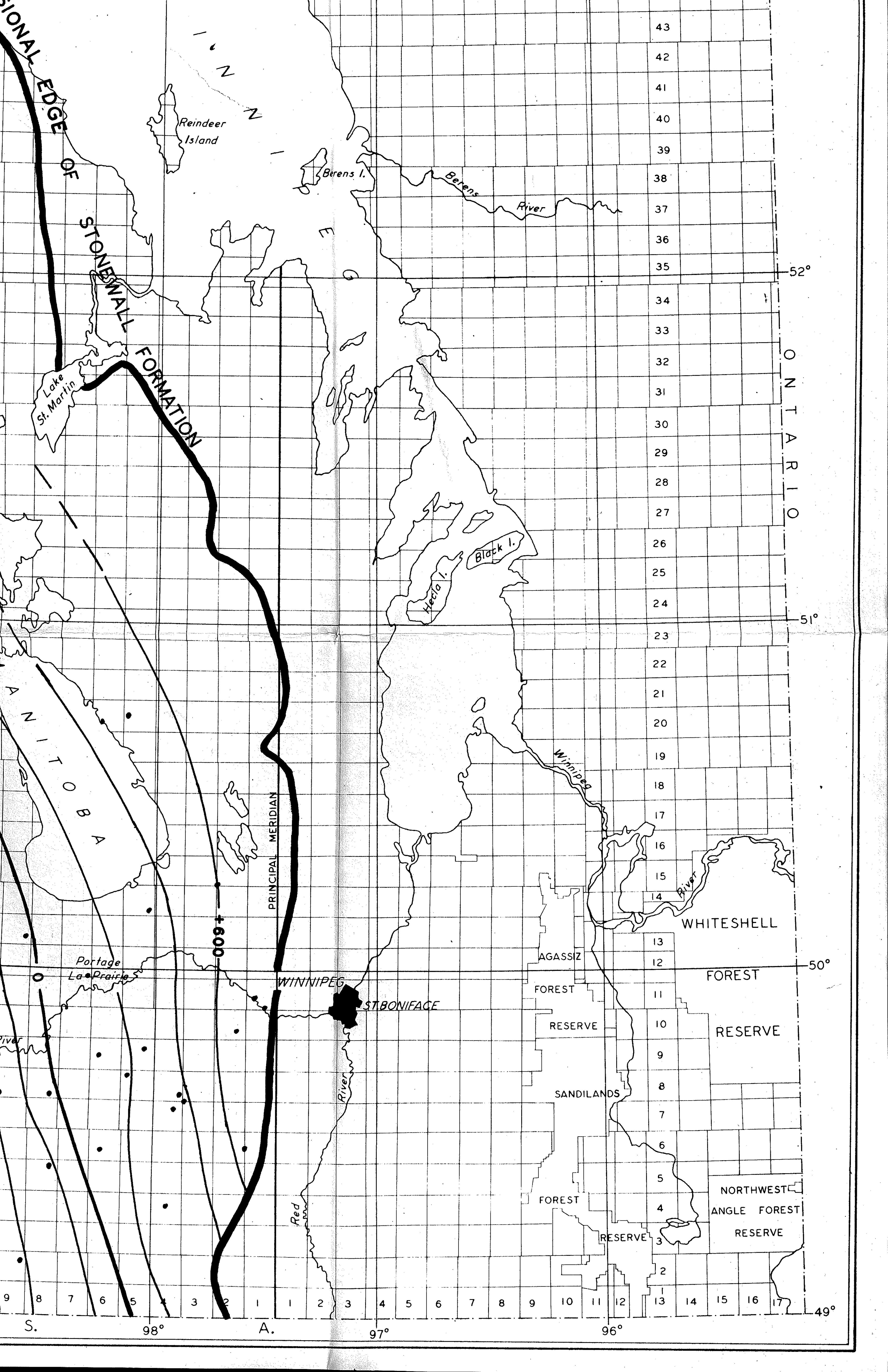


SASKATCHEWAN
U. S.
49°
50°
51°
52°
101°
100°
99°
98°
-4000
-3000
-2000
-1000
0
Assiniboine
BRANDON
TURTLE MT. FOREST RESERVE
SPRUCE WOODS FOREST RESERVE
RIDING MOUNTAIN NATIONAL PARK
DUCK MOUNTAIN FOREST RESERVE
PORCUPINE FOREST RESERVE
Dauphin
Dauphin Lake
Winnipegosis
Swan Lake
LAKE WINNIPEGOSIS
LAKE MANITOBA
Lake St. Martin
River
Portage La Prairie
EROSIONAL EDGE
INTERLAKE


55°
101°
100°
99°
98°
54°
53°
52°
GRASS RIVER PROVINCIAL PARK
Cranberry Portage
Reed Lake
CORMORANT FOREST RESERVE
Cormorant Lake
CLEARWATER PROVINCIAL PARK
Atikameg L.
Moose Lake
The Pas
Saskatchewan River
Cedar Lake
Cross
Playgreen Lake
LAKE WINNIPEG
Red Deer Lake
Dawson Bay
LAKE WINNIPEGOSIS
Swan Lake
PORCUPINE FOREST RESERVE
DUCK MOUNTAIN FOREST RESERVE
Winnipegosis
Dauphin L
Lake St. Martin
Reindeer Island
EROSIONAL EDGE OF STONEWALL FORMATION
SASKATCHEWAN



SASKATCHEWAN
49°
50°
51°
52°
101°
100°
99°
98°
-4000
-3000
-2000
-1000
0
Assiniboine
DUCK
PORCUPINE FOREST RESERVE
RIDING MOUNTAIN FOREST RESERVE
RIDING MOUNTAIN NATIONAL PARK
TURTLE MT. FOREST RESERVE
BRANDON
SPRUCE WOODS FOREST RESERVE
River
Portage La Prairie
Dauphin
Dauphin Lake
Winnipegosis
Swan Lake
MANITOBA
LAKE
WINNIPEGOSIS
Lake St. Martin
STONEWALL FORMATION
EROSIONAL EDGE OF
U. S.



SIONAL EDGE OF STONEWALL FORMATION
Reindeer Island
Berens I.
Berens River
Lake St. Martin
Black I.
Hecla I.
Winnipeg
River
WHITESHELL FOREST RESERVE
AGASSIZ FOREST RESERVE
SANDILANDS FOREST RESERVE
NORTHWEST ANGLE FOREST RESERVE
PRINCIPAL MERIDIAN
+600
0
Portage La Prairie
WINNIPEG
ST BONIFACE
Red River
River
ONTARIO
52°
51°
50°
49°
98°
97°
96°
S.
A.

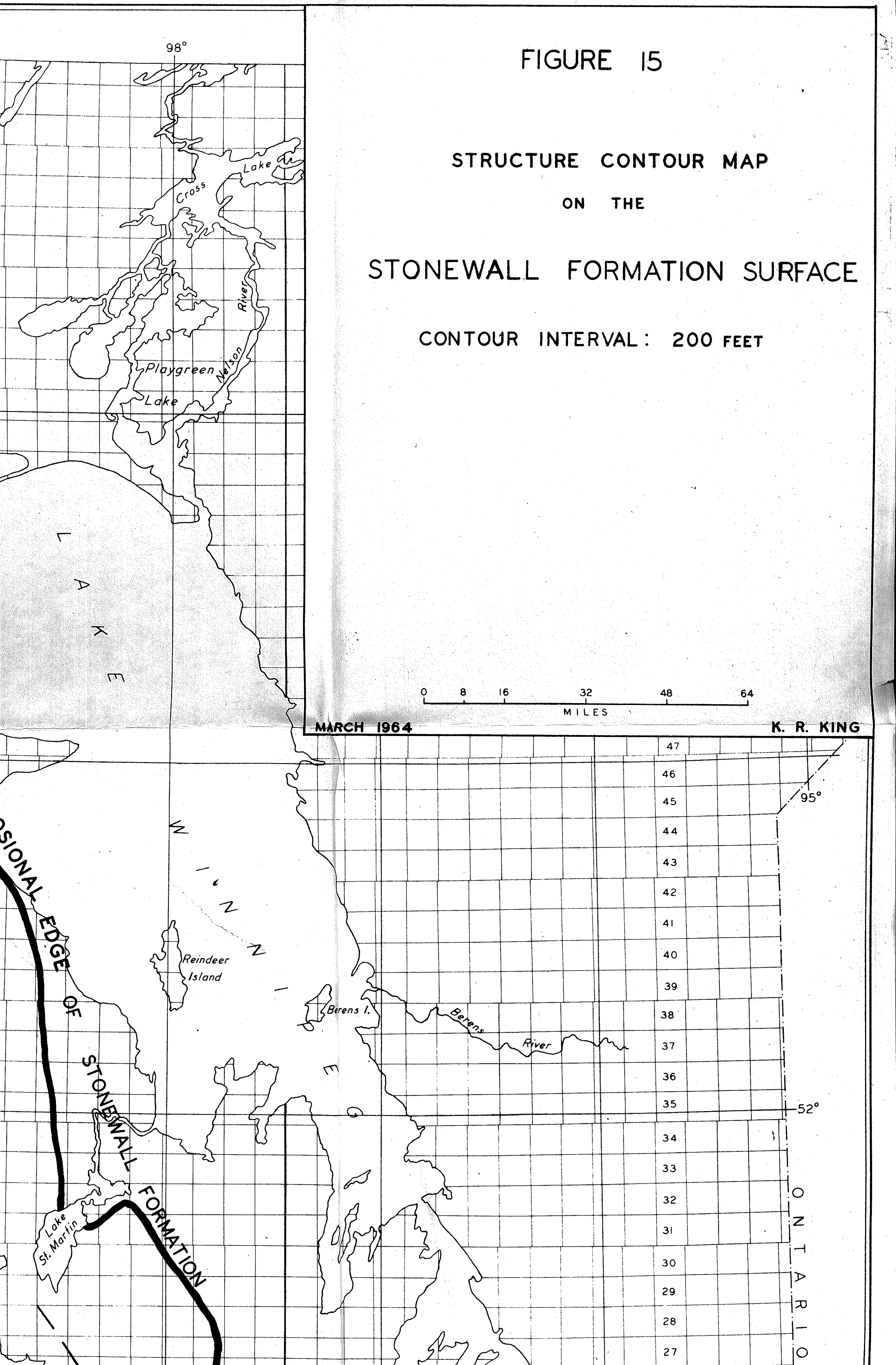
FIGURE 15

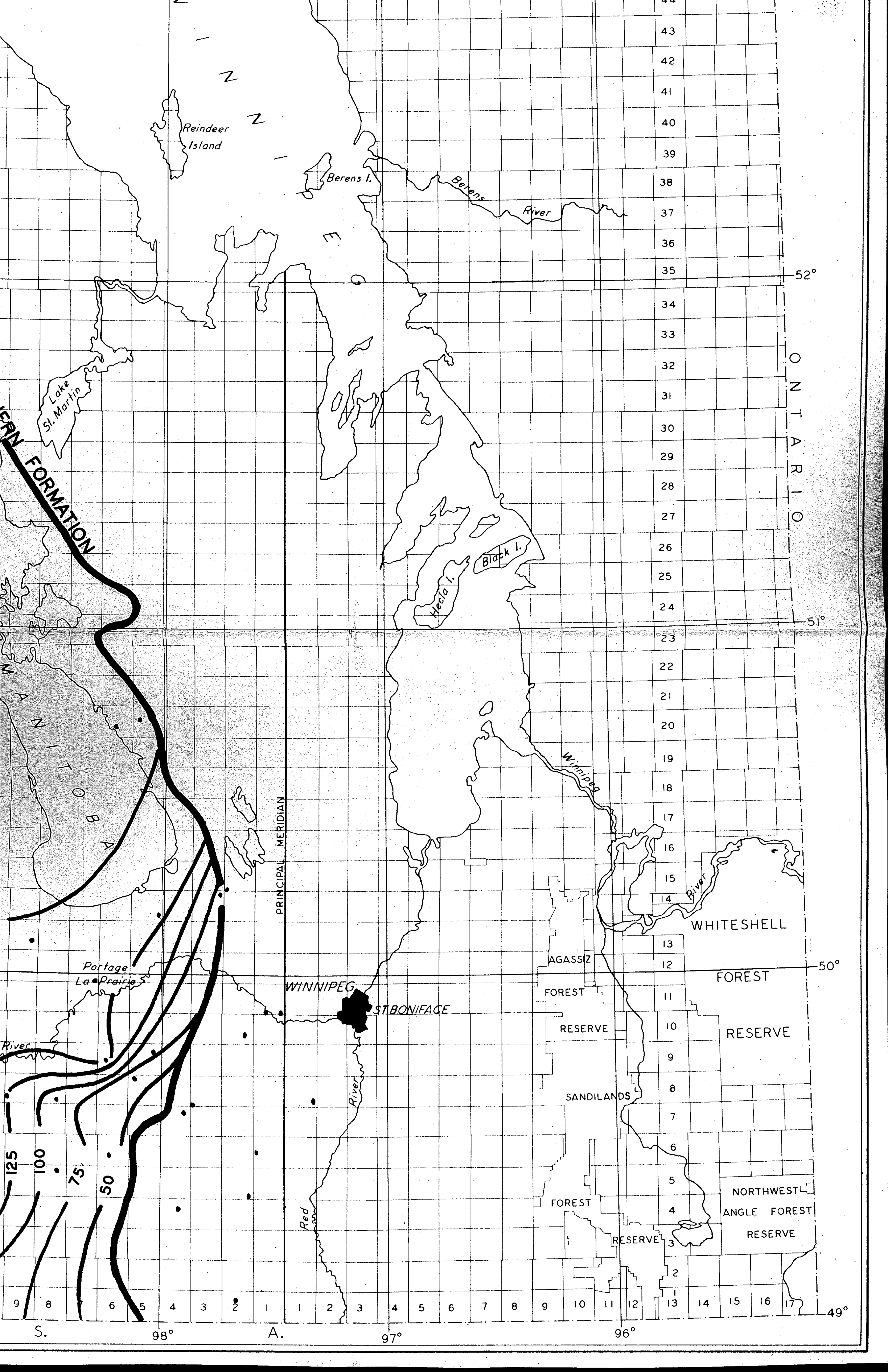
STRUCTURE CONTOUR MAP ON THE STONEWALL FORMATION SURFACE

CONTOUR INTERVAL: 200 FEET

MARCH 1964

K. R. KING




Reindeer Island
Berens I.
Berens River
Lake St. Martin
FORMATION
MANITOBA
Hecla I.
Black I.
Winnipeg River
PRINCIPAL MERIDIAN
Portage La Prairie
WINNIPEG
ST. BONIFACE
Red River
River
WHITESHELL FOREST RESERVE
AGASSIZ FOREST RESERVE
SANDILANDS FOREST RESERVE
NORTHWEST ANGLE FOREST RESERVE
ONTARIO
125
100
75
50
52°
51°
50°
49°
98°
97°
96°
S.
A.

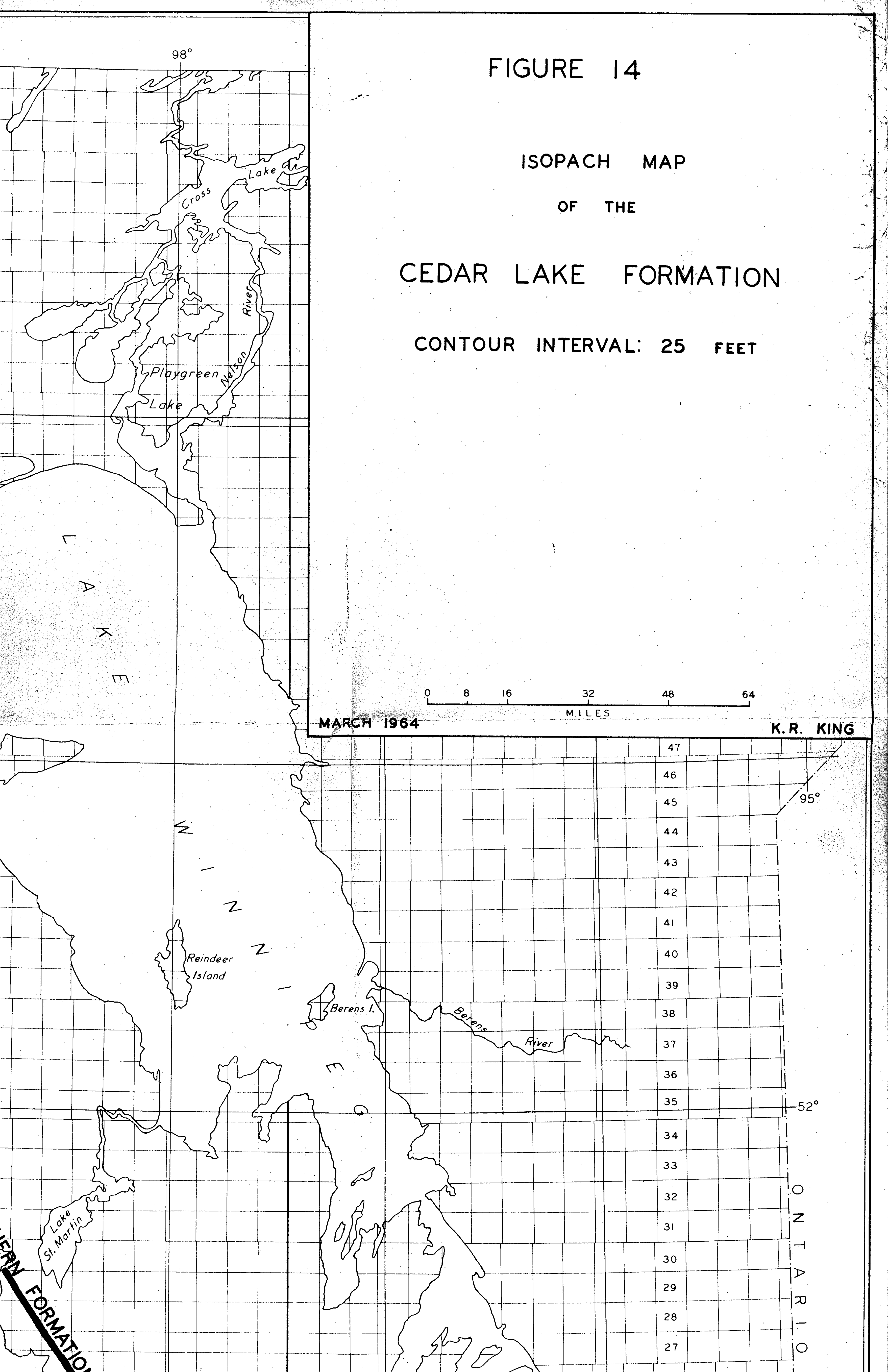


FIGURE 14

ISOPACH MAP

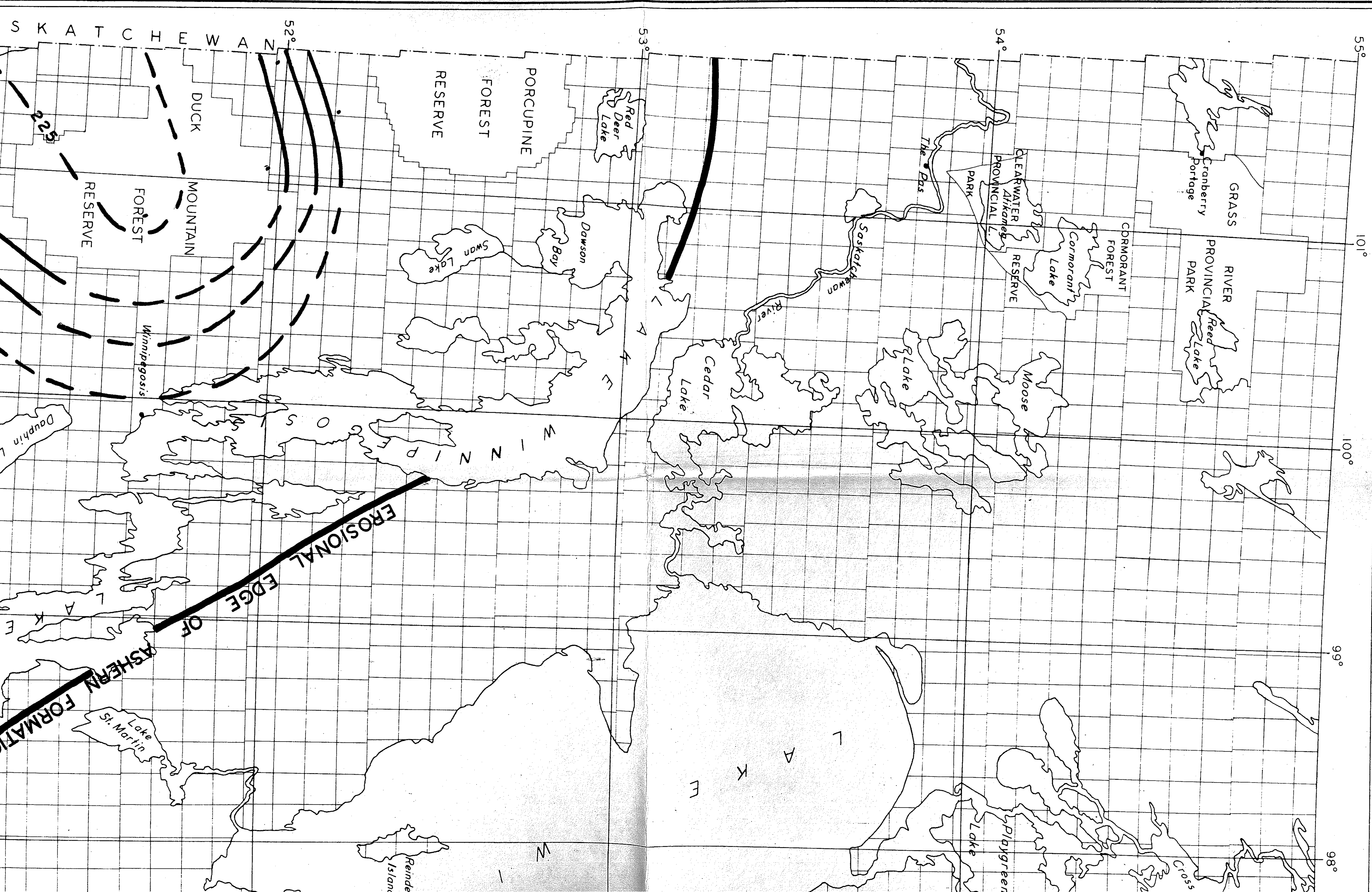
OF THE

CEDAR LAKE FORMATION

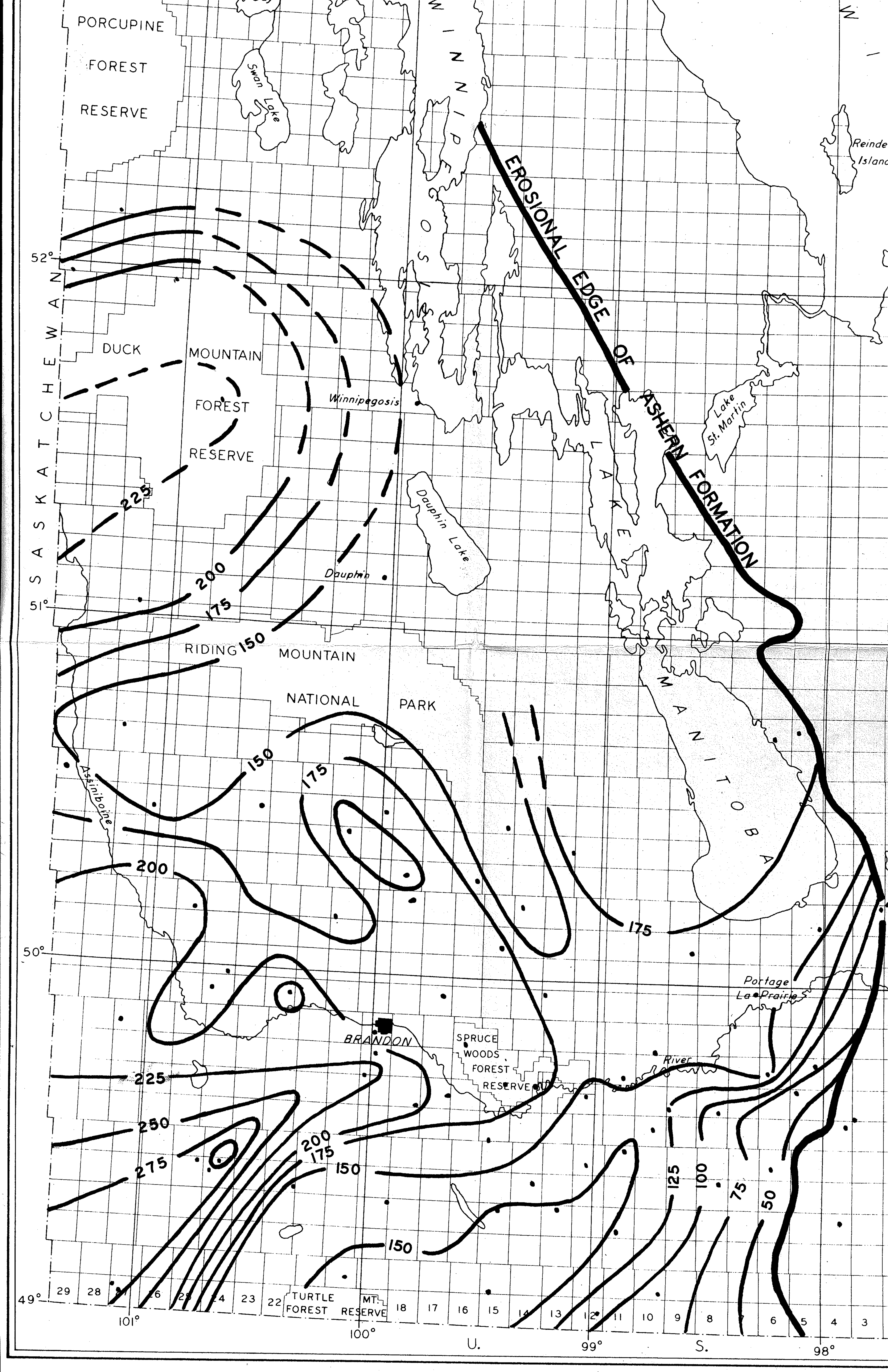
CONTOUR INTERVAL: 25 FEET

MARCH 1964

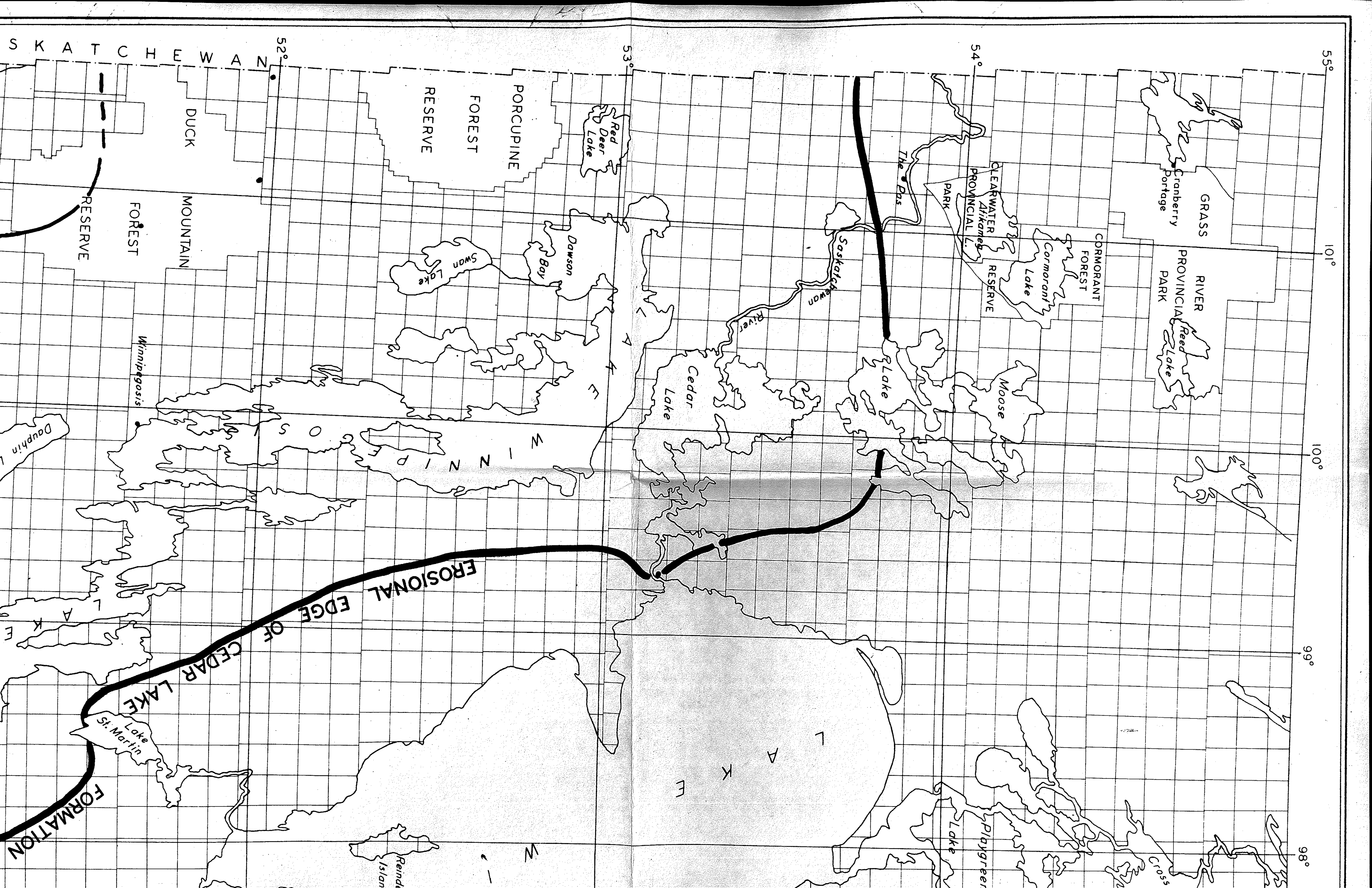
K.R. KING



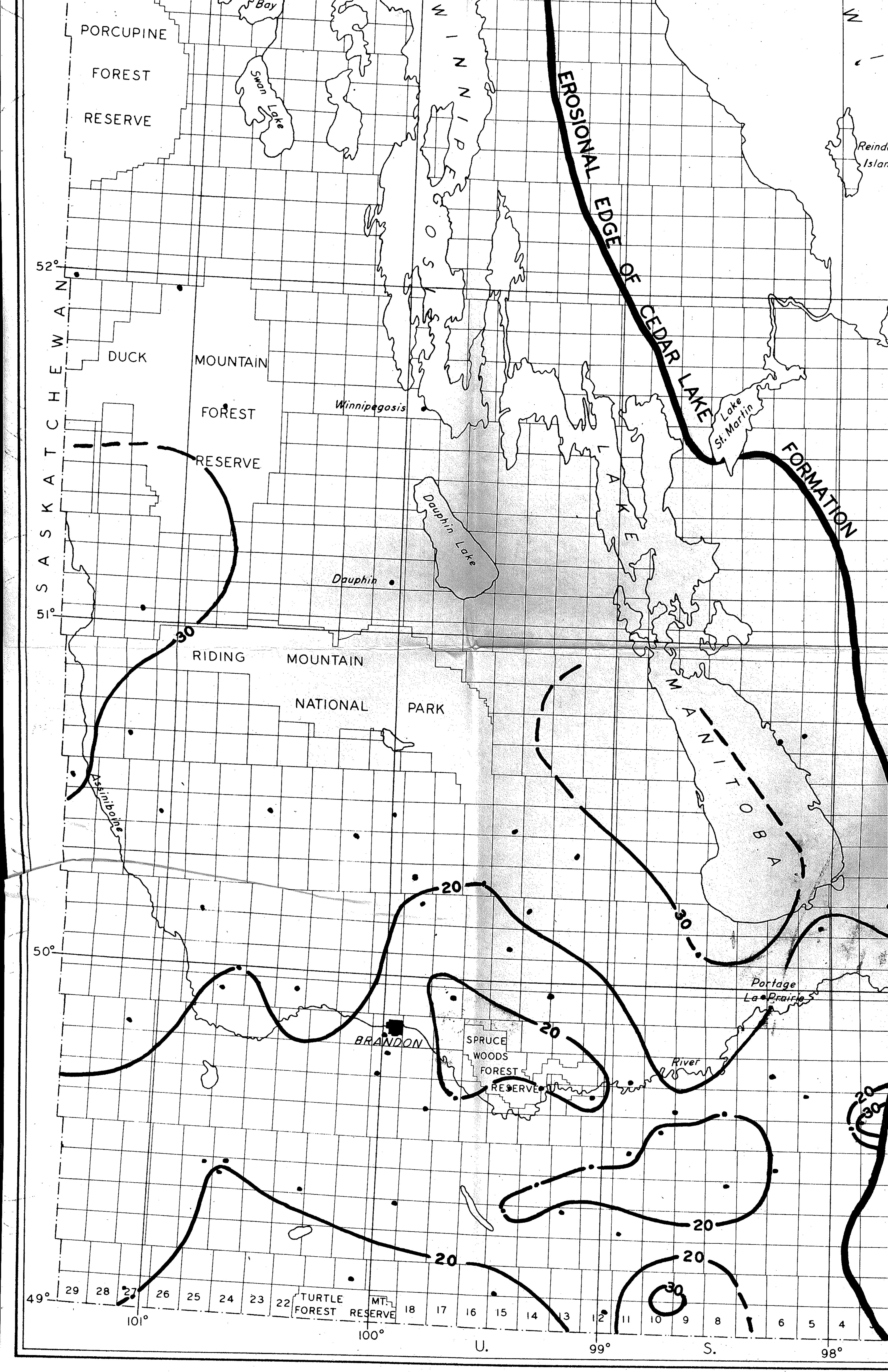
SASKATCHEWAN
52°
53°
54°
55°
101°
100°
99°
98°
225
DUCK MOUNTAIN FOREST RESERVE
PORCUPINE FOREST RESERVE
Red Deer Lake
Swan Lake
Dawson Bay
Winnipegosis
LAKE WINNIPEGOSIS
Dauphin L
The Pas
Saskatchewan River
CLEARWATER PROVINCIAL PARK
Atikameg L.
RESERVE
CORMORANT FOREST
Cormorant Lake
Cranberry Portage
GRASS RIVER PROVINCIAL PARK
Red Lake
Cedar Lake
Lake
Moose
EROSIONAL EDGE OF ASHERN FORMATI
LAKE
Lake St. Martin
LAKE WI
Reinde Island
Lake
Playgreen
Cross



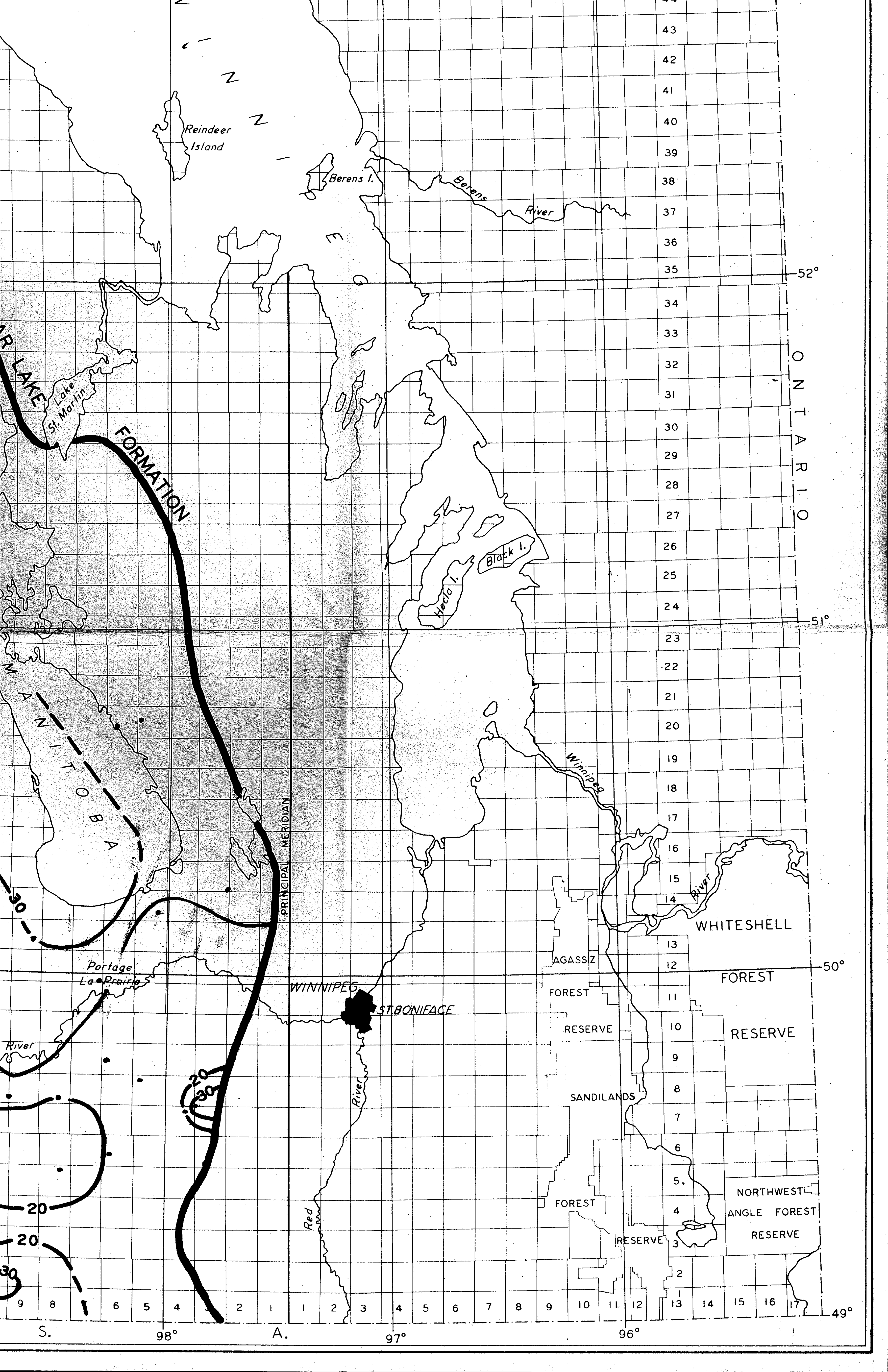
PORCUPINE FOREST RESERVE
Swan Lake
WINNIPEGOSIS
EROSIONAL EDGE OF ASHERN FORMATION
Reindeer Island
DUCK MOUNTAIN FOREST RESERVE
Winnipegosis
Lake St. Martin
LAKE MANITOBA
Dauphin Lake
Dauphin
SASKATCHEWAN
RIDING MOUNTAIN NATIONAL PARK
Assiniboine
Portage La Prairie
BRANDON
SPRUCE WOODS FOREST RESERVE
River
TURTLE MT. FOREST RESERVE
U. S.
52°
51°
50°
49°
101°
100°
99°
98°
225
200
175
150
250
275
125
100
75
50
29
28
27
26
25
24
23
22
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3



SASKATCHEWAN
52°
53°
54°
55°
101°
100°
99°
98°
DUCK MOUNTAIN FOREST RESERVE
PORCUPINE FOREST RESERVE
Red Deer Lake
Swan Lake
Dawson Bay
The Pas
CLEARWATER PROVINCIAL PARK
Atikameg L.
CORMORANT FOREST RESERVE
Cormorant Lake
GRASS RIVER PROVINCIAL PARK
Cranberry Portage
Reed Lake
Saskatchewan River
Cedar Lake
Lake
Moose
Winnipegosis
LAKE WINNIPEGOSIS
Dauphin L
EROSIONAL EDGE OF CEDAR LAKE FORMATION
Lake St. Martin
LAKE
Lake Playgreen
Cross



PORCUPINE FOREST RESERVE
Swan Lake
W I N N I P E G O S I S
EROSIONAL EDGE OF CEDAR LAKE FORMATION
52°
S A S K A T C H E W A N
DUCK MOUNTAIN FOREST RESERVE
Winnipegosis
Lake St. Martin
Dauphin Lake
Dauphin
LAKE
51°
30
RIDING MOUNTAIN NATIONAL PARK
M A N I T O B A
Assiniboine
20
30
50°
Portage La Prairie
20
BRANDON
SPRUCE WOODS FOREST RESERVE
River
20
30
20
20
20
30
49°
29 28 27 26 25 24 23 22 TURTLE MT. FOREST RESERVE 18 17 16 15 14 13 12 11 10 9 8 6 5 4
101°
100°
U.
99°
S.
98°



Reindeer Island
Berens I.
Berens River
Lake St. Martin
FORMATION
AR LAKE
MANITOBA
Black I.
Hecla I.
Winnipeg
River
WHITESHELL
FOREST
RESERVE
ONTARIO
52°
51°
50°
49°
PRINCIPAL MERIDIAN
Portage La Prairie
WINNIPEG
ST. BONIFACE
Red River
AGASSIZ FOREST RESERVE
SANDILANDS FOREST RESERVE
NORTHWEST ANGLE FOREST RESERVE
98°
97°
96°
S.
A.
30
20

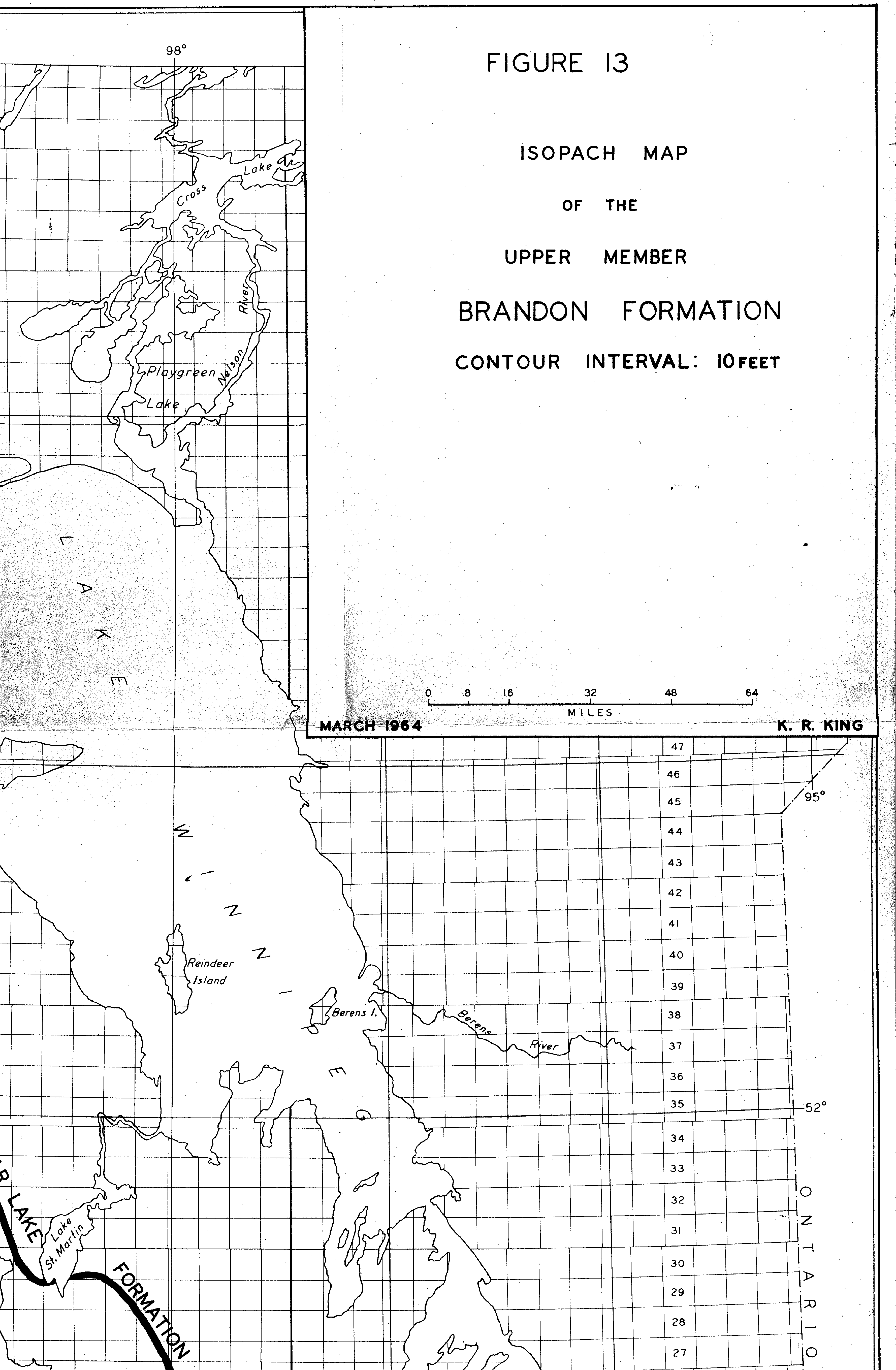


FIGURE 13

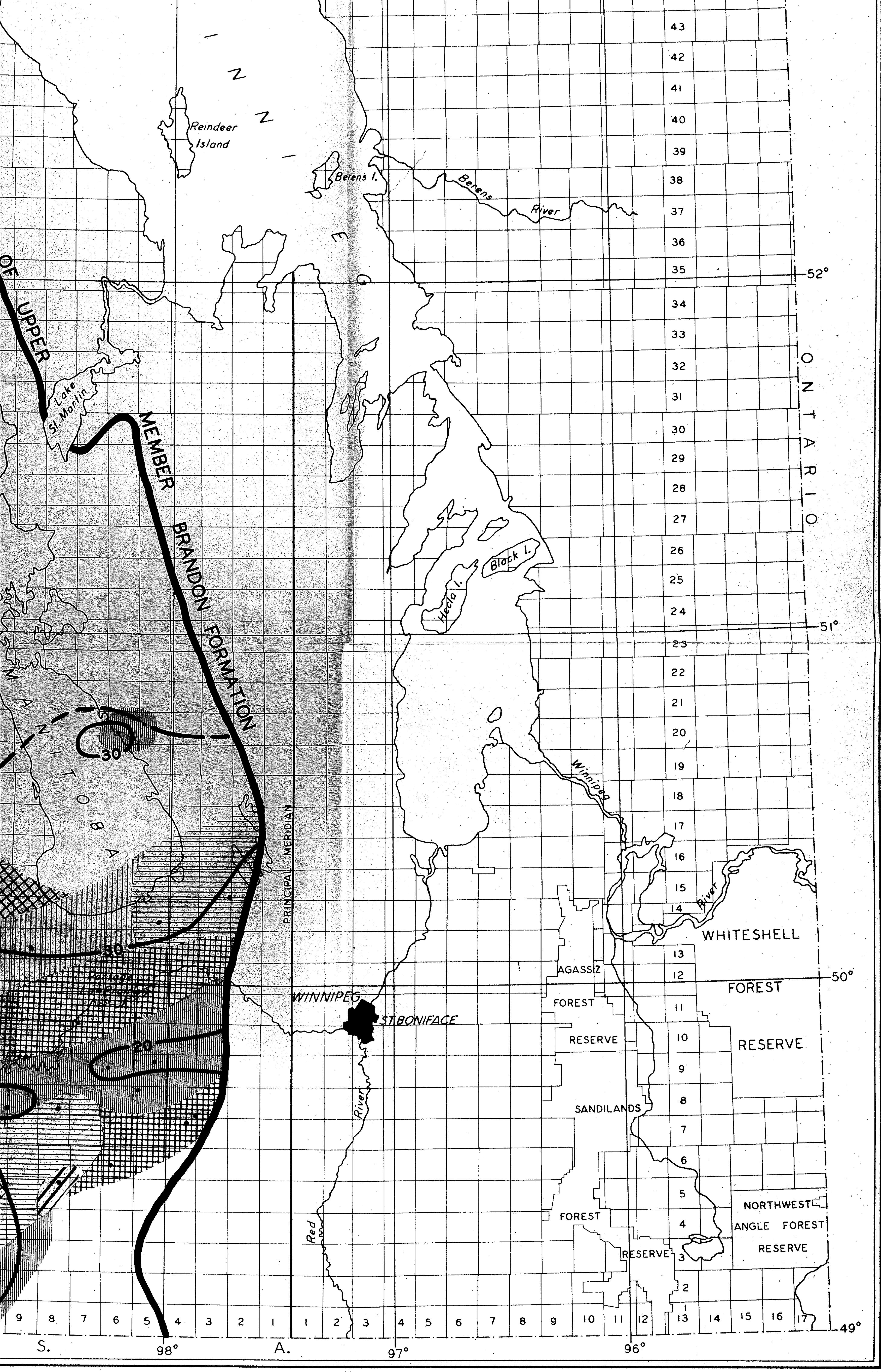
ISOPACH MAP

OF THE

UPPER MEMBER

BRANDON FORMATION

CONTOUR INTERVAL: 10 FEET



Reindeer Island
Berens I.
Berens River
OF UPPER MEMBER BRANDON FORMATION
Lake St. Martin
Black I.
Hecla I.
MANITOBA
30
20
Portage la Prairie
PRINCIPAL MERIDIAN
WINNIPEG
ST. BONIFACE
Red River
Winnipeg River
WHITESHELL FOREST RESERVE
AGASSIZ FOREST RESERVE
SANDILANDS FOREST RESERVE
NORTHWEST ANGLE FOREST RESERVE
ONTARIO
52°
51°
50°
49°
98°
97°
96°
S.
A.

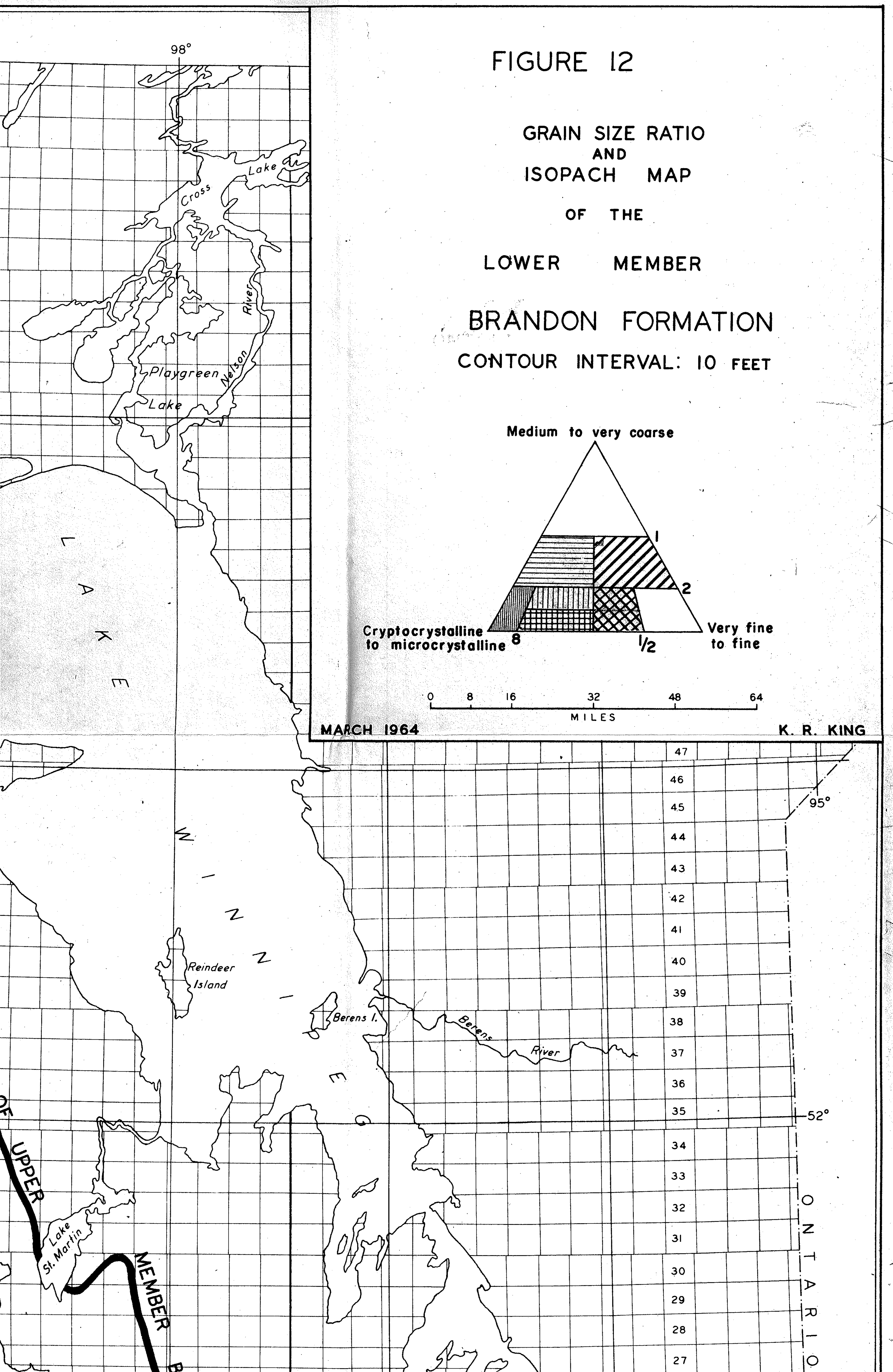
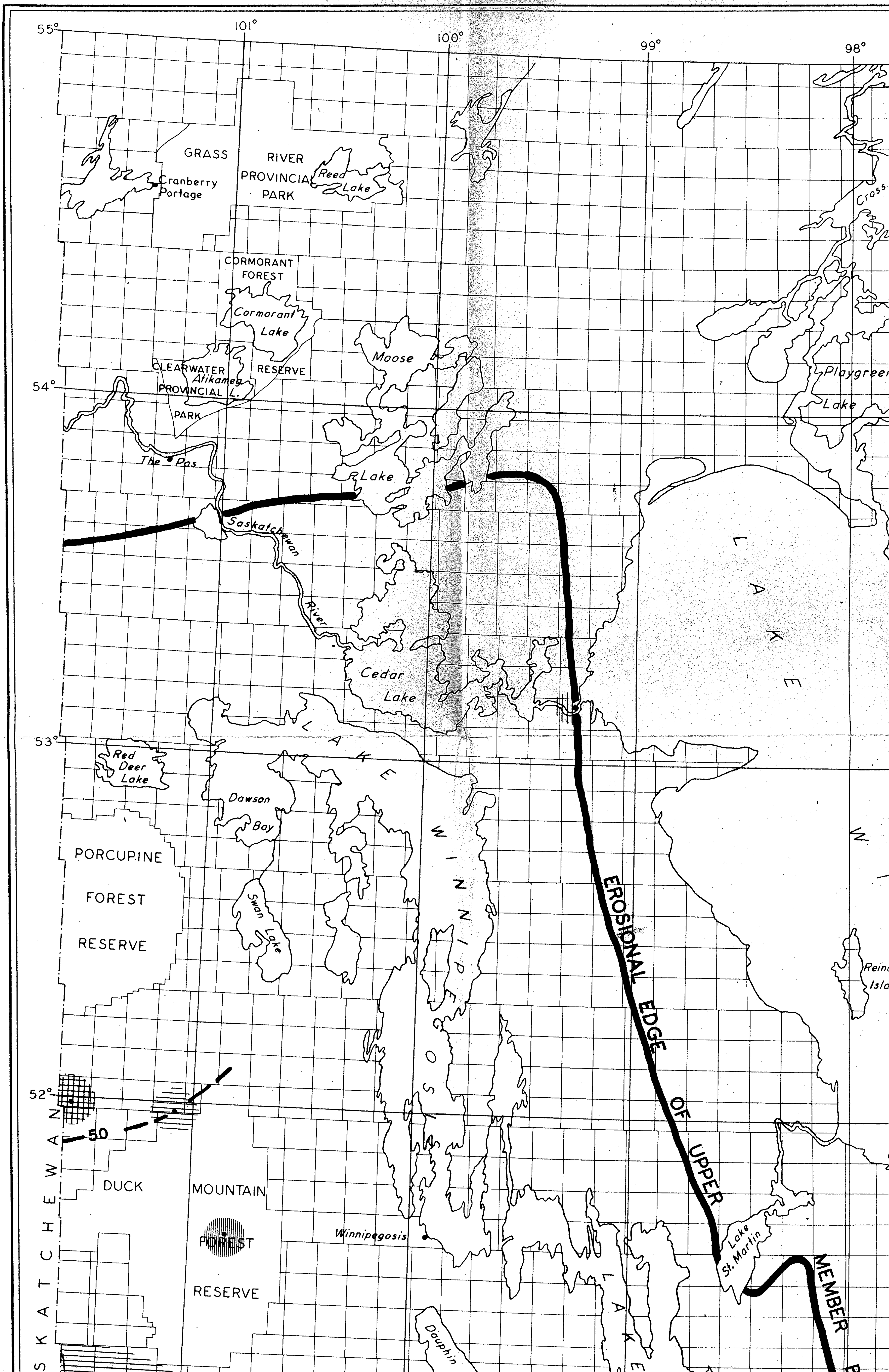
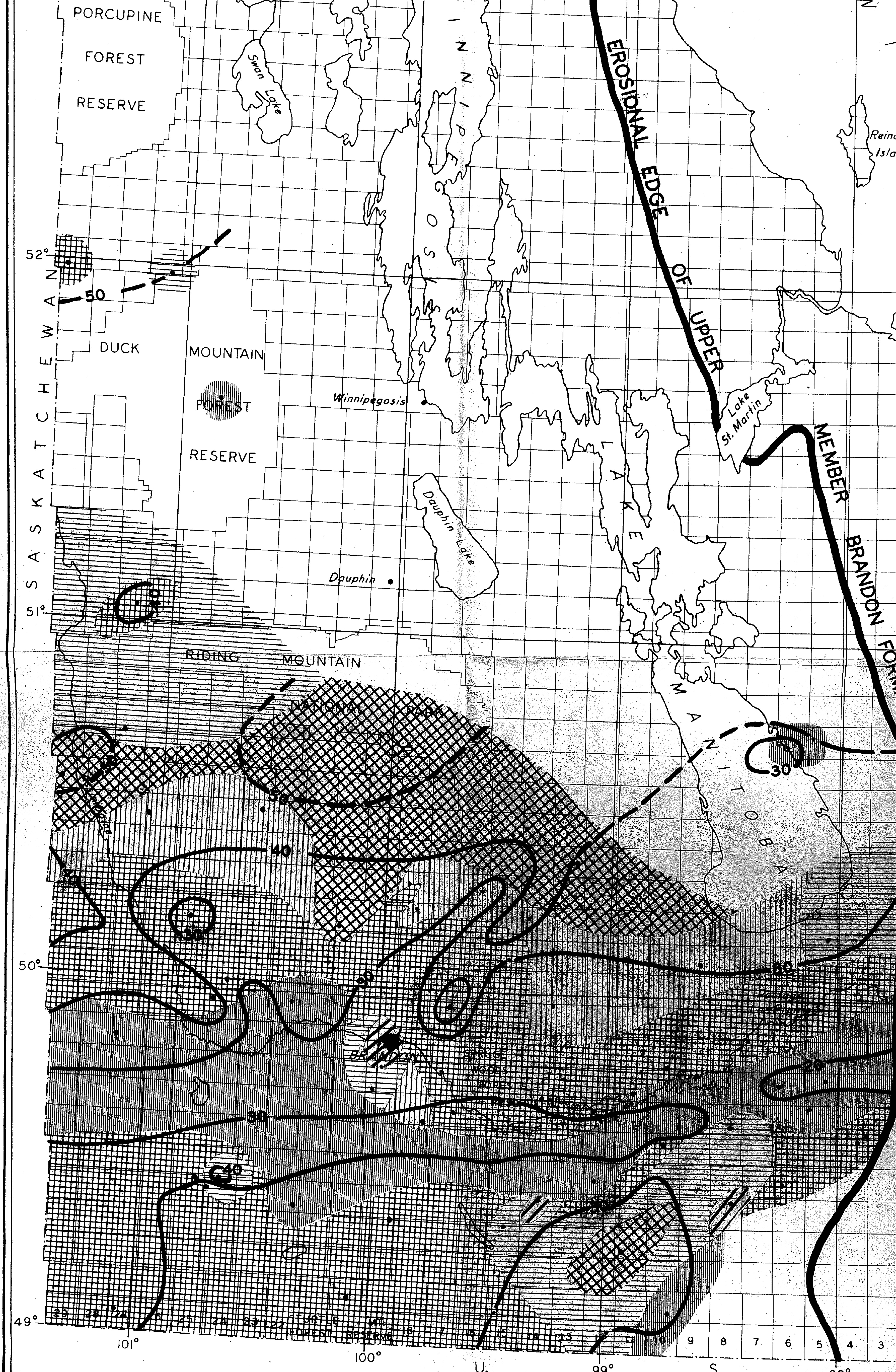


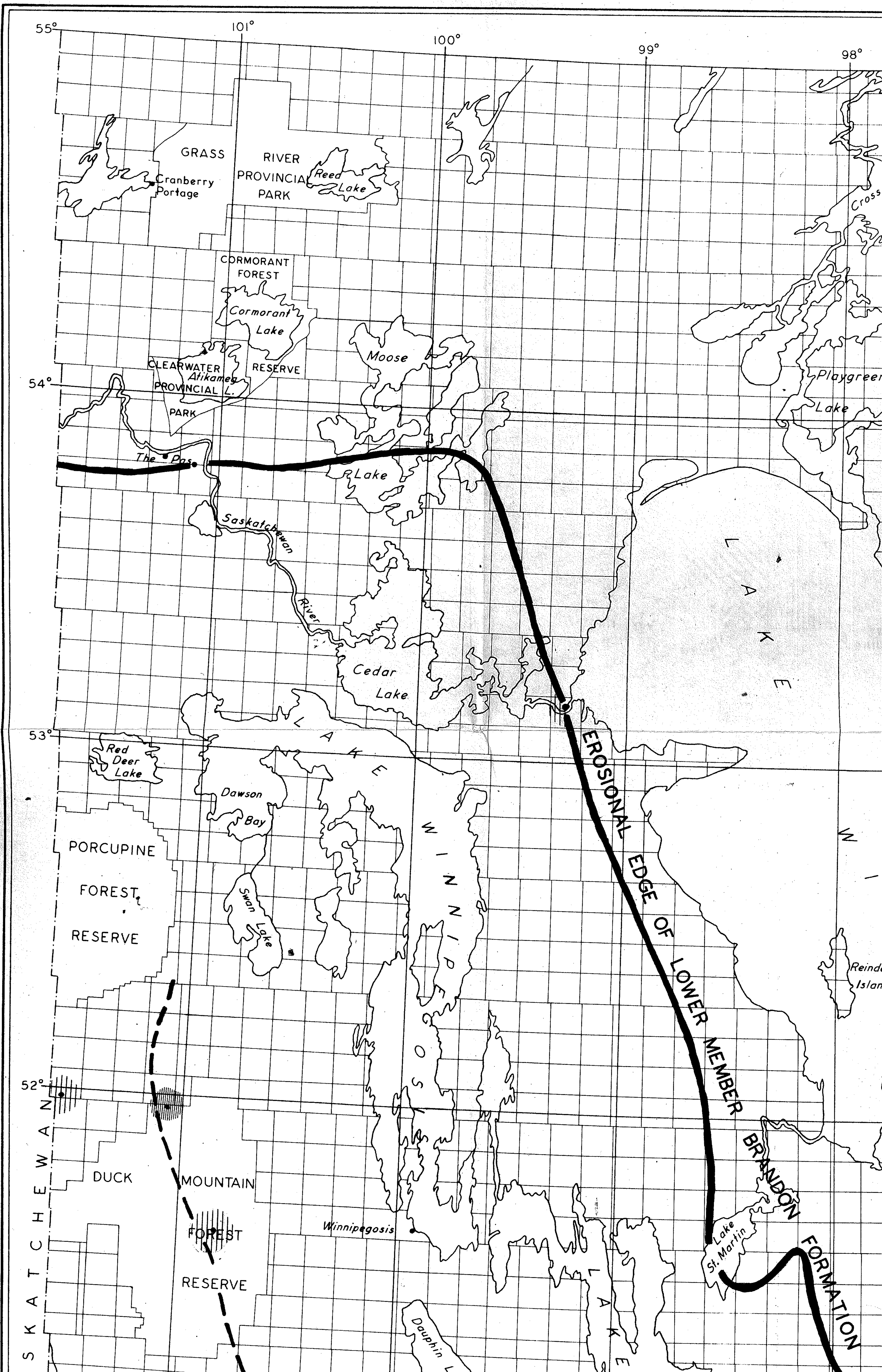
FIGURE 12
GRAIN SIZE RATIO
AND
ISOPACH MAP
OF THE
LOWER MEMBER
BRANDON FORMATION
CONTOUR INTERVAL: 10 FEET
Medium to very coarse
Cryptocrystalline
to microcrystalline
Very fine
to fine
1
2
8
1/2
0
8
16
32
48
64
MILES
MARCH 1964
K. R. KING
98°
95°
52°
ONTARIO
Cross
Lake
Nelson
River
Playgreen
Lake
LAKE
WINNIPEG
Reindeer
Island
Berens I.
Berens
River
Lake
St. Martin
OF
UPPER
MEMBER
47
46
45
44
43
42
41
40
39
38
37
36
35
34
33
32
31
30
29
28
27



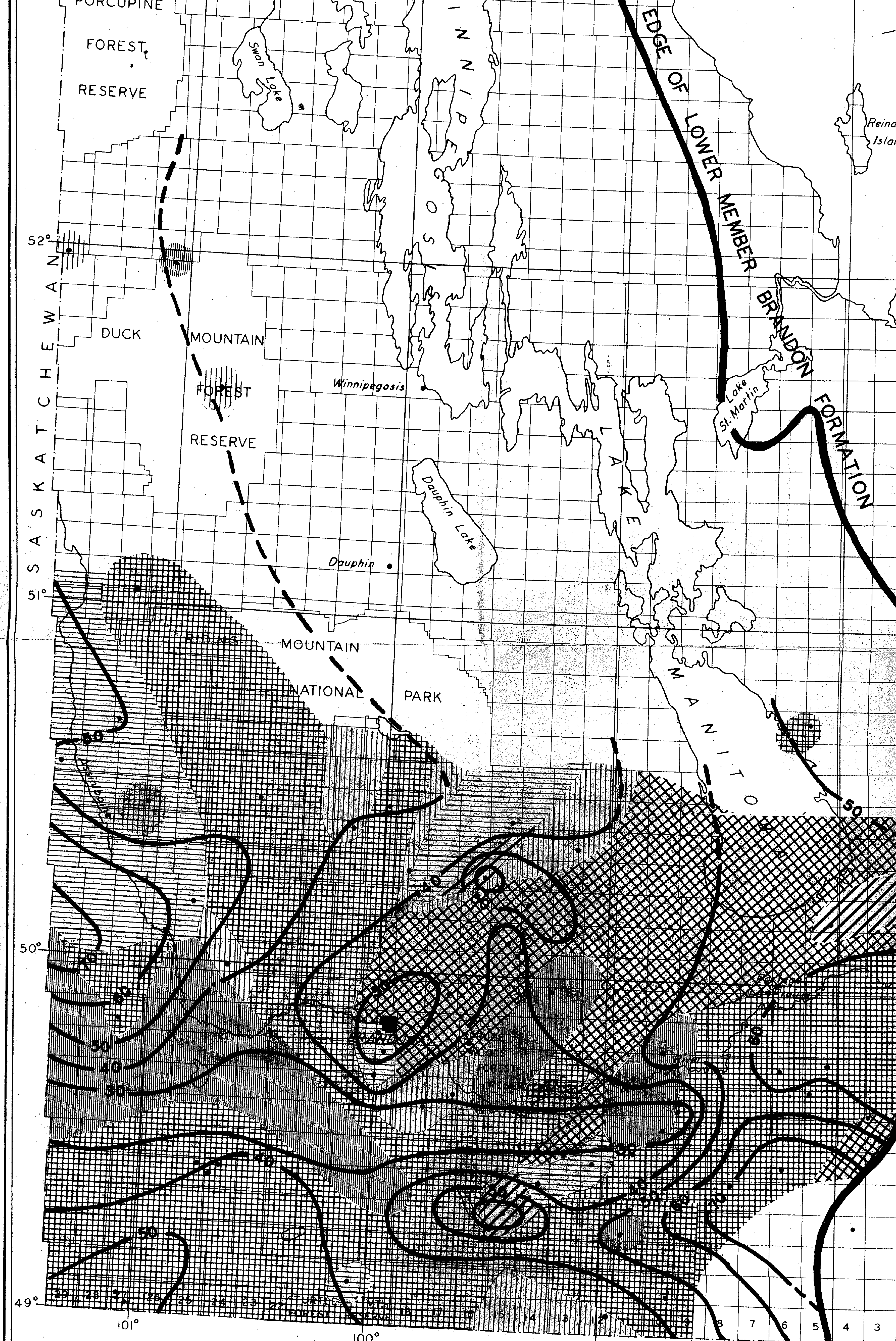
55°
101°
100°
99°
98°
54°
53°
52°
GRASS RIVER PROVINCIAL PARK
Reed Lake
Cranberry Portage
CORMORANT FOREST RESERVE
Cormorant Lake
CLEARWATER PROVINCIAL PARK
Atikameg L.
The Pas
Moose Lake
Saskatchewan River
Cedar Lake
Playgreen Lake
Cross
LAKE WINNIPEG
Red Deer Lake
Dawson Bay
Swan Lake
LAKE WINNIPEGOSIS
PORCUPINE FOREST RESERVE
DUCK MOUNTAIN FOREST RESERVE
Winnipegosis
Dauphin
50
SKATCHEWAN
EROSIONAL EDGE OF UPPER MEMBER
Lake St. Martin



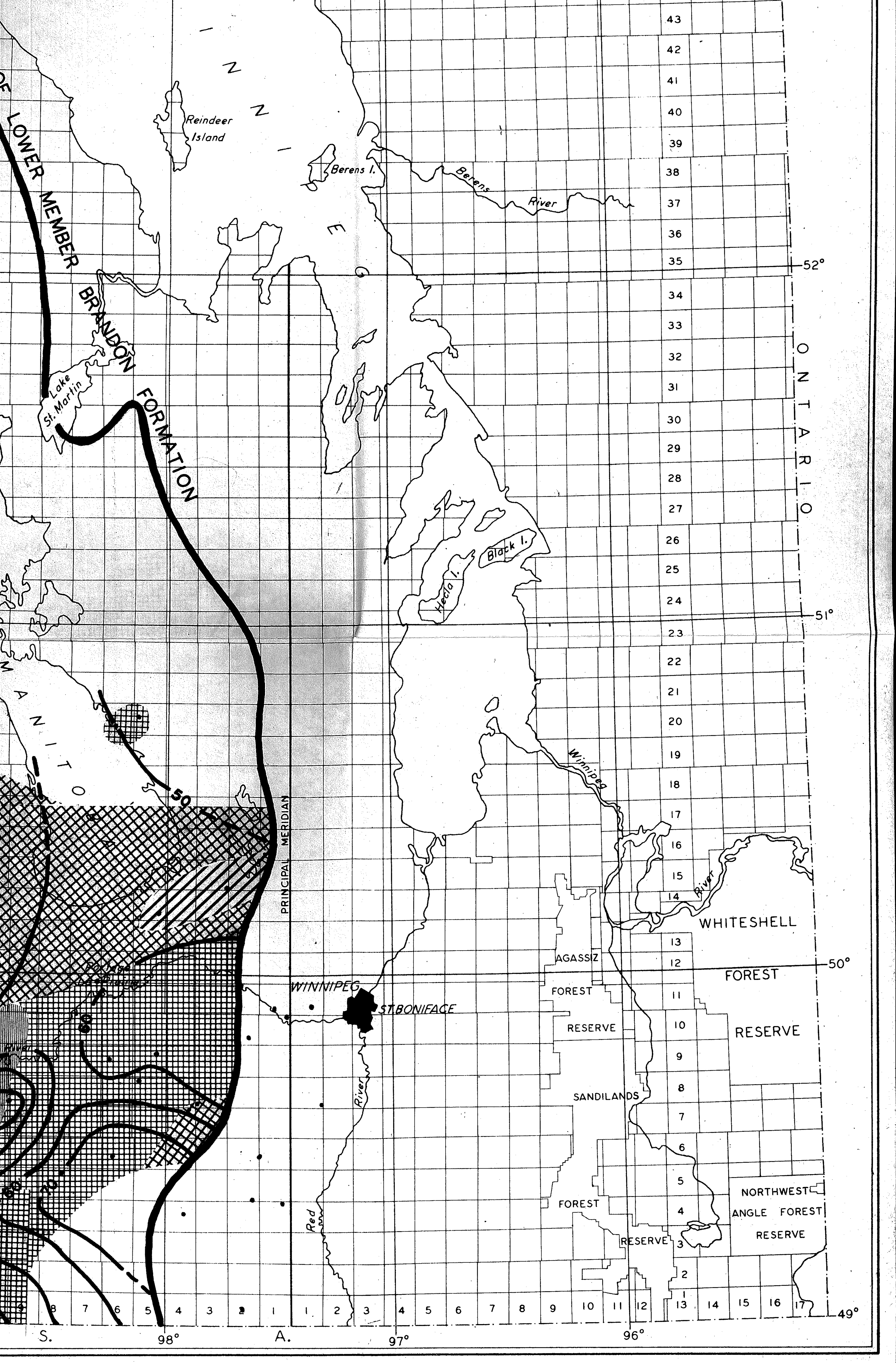
PORCUPINE
FOREST
RESERVE
Swan Lake
EROSIONAL EDGE OF UPPER
MEMBER
BRANDON FORM
Lake St. Martin
Winnipegosis
Dauphin Lake
Dauphin
DUCK
MOUNTAIN
FOREST
RESERVE
SASKATCHEWAN
RIDING MOUNTAIN
NATIONAL PARK
LAKE
MANITOBA
BRANDON
SPRUCE
WOODS
FOREST
RESERVE
TURTLE
MT.
FOREST RESERVE
52°
51°
50°
49°
101°
100°
99°
98°
U. S.
50
40
30
20



55°
101°
100°
99°
98°
54°
53°
52°
GRASS RIVER PROVINCIAL PARK
Cranberry Portage
Reed Lake
CORMORANT FOREST RESERVE
Cormorant Lake
CLEARWATER PROVINCIAL PARK
Atikameg L.
Moose Lake
The Pas
Saskatchewan River
Cedar Lake
Cross
Playgreen Lake
LAKE WINNIPEG
Red Deer Lake
Dawson Bay
LAKE WINNIPEGOSIS
PORCUPINE FOREST RESERVE
Swan Lake
Reindeer Island
DUCK MOUNTAIN FOREST RESERVE
Winnipegosis
Lake St. Martin
Dauphin L
EROSIONAL EDGE OF LOWER MEMBER BRANDON FORMATION
SASKATCHEWAN



PORCUPINE
FOREST
RESERVE
Swan Lake
DUCK
MOUNTAIN
FOREST
RESERVE
RIDING
MOUNTAIN
NATIONAL
PARK
SASKATCHEWAN
Winnipegosis
Dauphin
Dauphin Lake
LAKE
MANITOBA
Lake St. Martin
EDGE OF LOWER MEMBER BRANDON FORMATION
Reindeer Island
Assiniboine
52°
51°
50°
49°
101°
100°
99°
98°
U.
S.
50
40
30
60
70
TURTLE MT. FOREST RESERVE



LOWER MEMBER
BRANDON FORMATION
Reindeer Island
Berens I.
Berens River
Lake St. Martin
Black I.
Hecla I.
Winnipeg River
PRINCIPAL MERIDIAN
ONTARIO
WINNIPEG
ST.BONIFACE
Red River
WHITESHELL FOREST RESERVE
AGASSIZ FOREST RESERVE
SANDILANDS FOREST RESERVE
NORTHWEST ANGLE FOREST RESERVE
52°
51°
50°
49°
98°
97°
96°
50
60
70
80

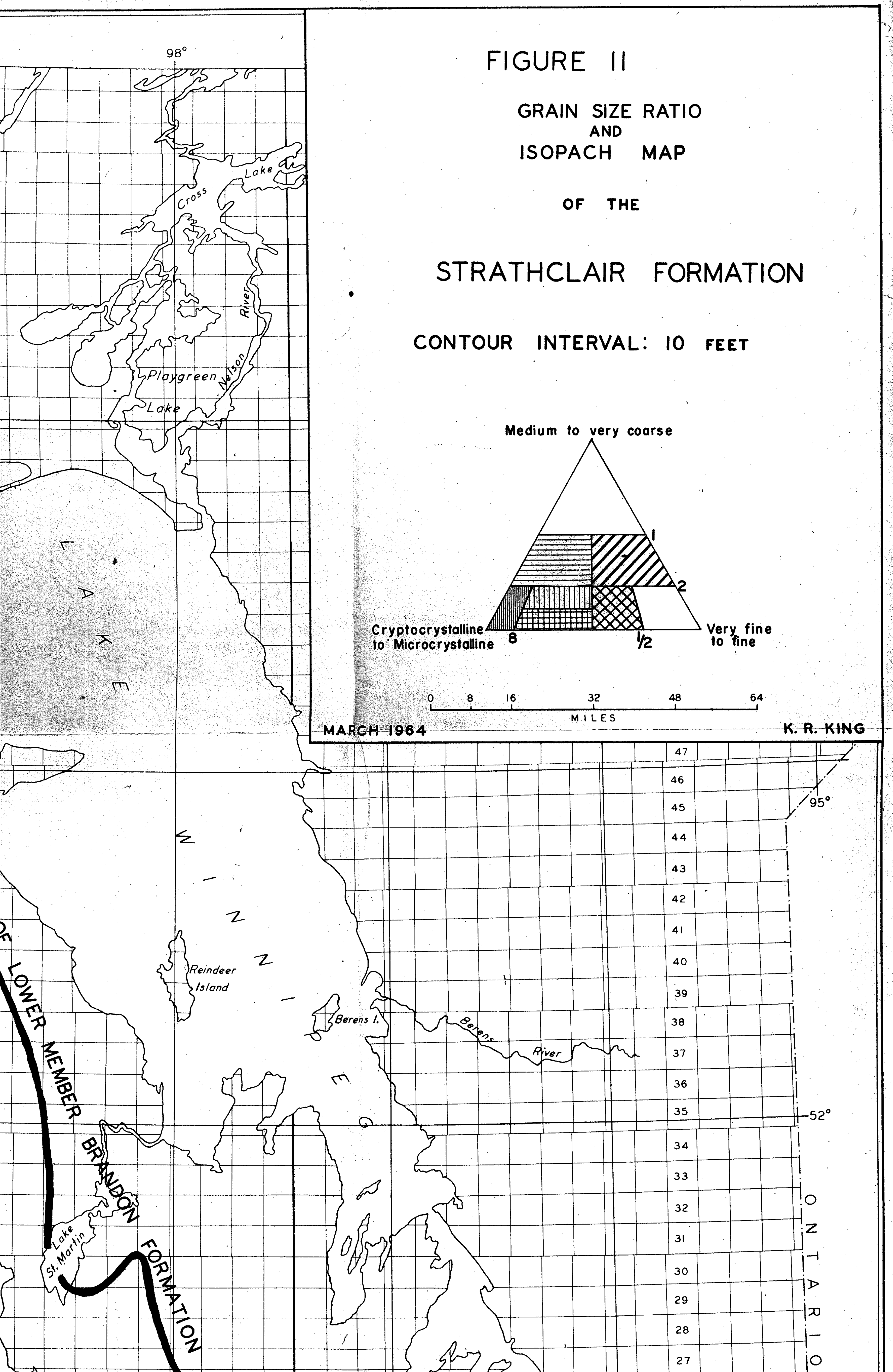
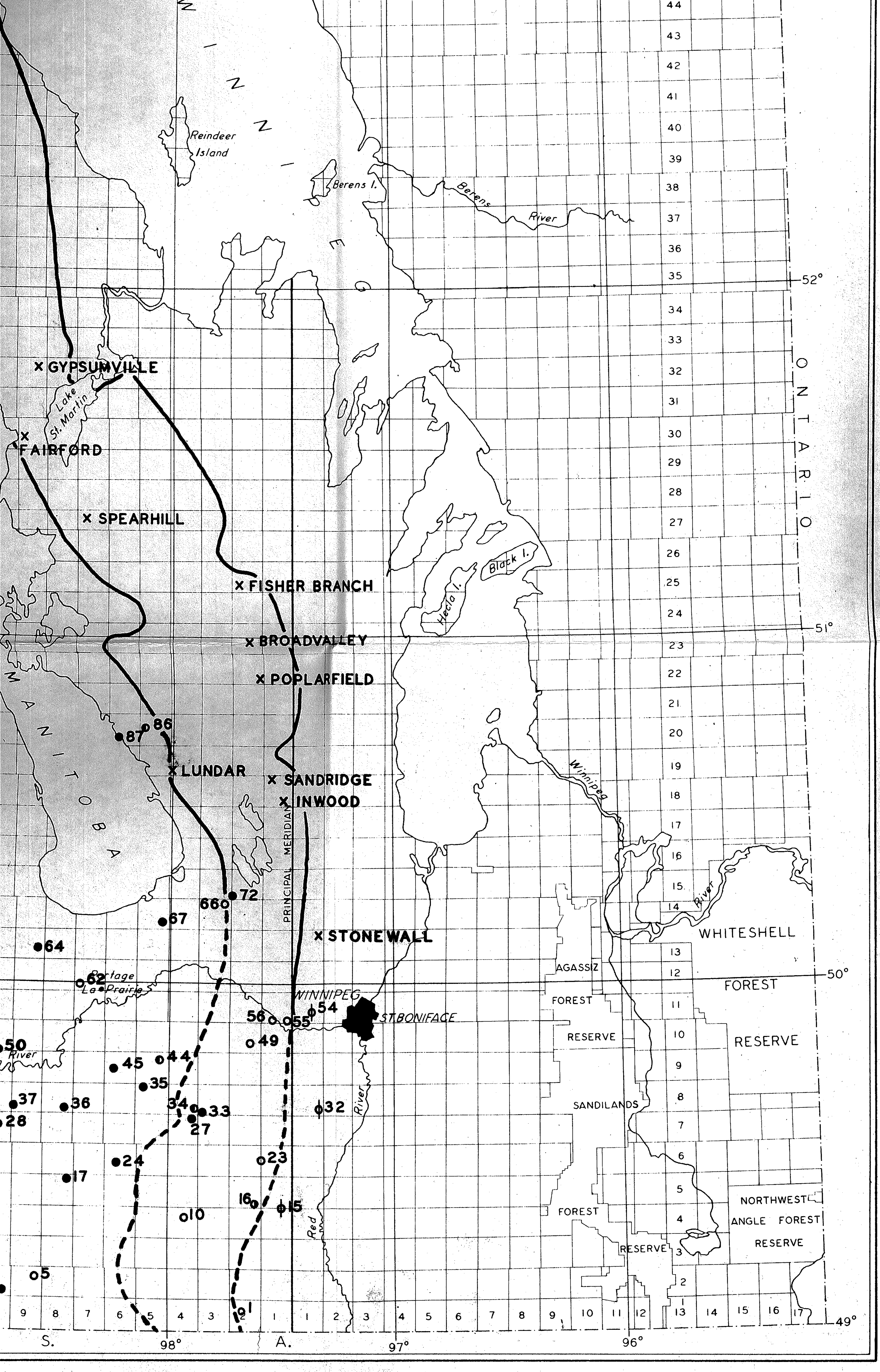


FIGURE II
GRAIN SIZE RATIO
AND
ISOPACH MAP
OF THE
STRATHCLAIR FORMATION
CONTOUR INTERVAL: 10 FEET
Medium to very coarse
Cryptocrystalline to Microcrystalline
Very fine to fine
1
2
8
1/2
0
8
16
32
48
64
MILES
MARCH 1964
K. R. KING
98°
95°
52°
ONTARIO
Cross Lake
Nelson River
Playgreen Lake
LAKE WINNIPEG
Reindeer Island
Berens I.
Berens River
Lake St. Martin
OF LOWER MEMBER BRANDON FORMATION
47
46
45
44
43
42
41
40
39
38
37
36
35
34
33
32
31
30
29
28
27



Reindeer Island
Berens I.
Berens River
GYPSUMVILLE
Lake St. Martin
FAIRFORD
SPEARHILL
FISHER BRANCH
BROADVALLEY
POPLARFIELD
LUNDAR
SANDRIDGE
INWOOD
STONEWALL
Black I.
Hecla I.
Winnipeg
M A N I T O B A
ONTARIO
PRINCIPAL MERIDIAN
Portage La Prairie
WINNIPEG
ST. BONIFACE
River
Red River
River
AGASSIZ FOREST RESERVE
WHITESHELL FOREST RESERVE
SANDILANDS FOREST RESERVE
NORTHWEST ANGLE FOREST RESERVE
52°
51°
50°
49°
98°
97°
96°
S.
A.
87
86
72
66
67
64
62
56
55
54
50
49
45
44
37
36
35
34
33
32
28
27
24
23
17
16
15
10
5
1

FIGURE 10

INDEX MAP

SHOWING LOCATION OF CONTROL POINTS
AND
TYPES OF CONTROL

WELLS

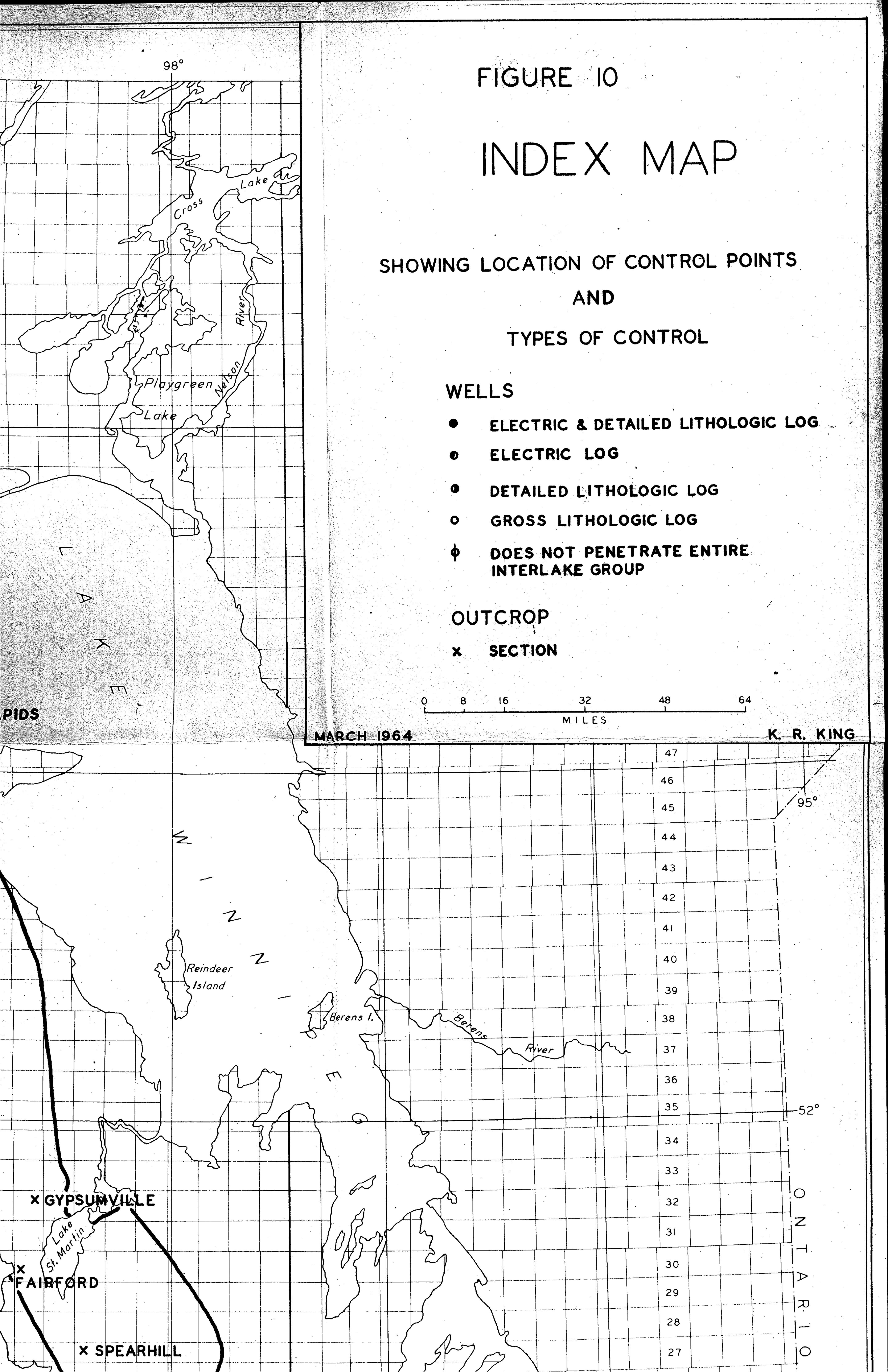
- ● ELECTRIC & DETAILED LITHOLOGIC LOG
- ◐ ELECTRIC LOG
- ◑ DETAILED LITHOLOGIC LOG
- ○ GROSS LITHOLOGIC LOG
- ϕ DOES NOT PENETRATE ENTIRE INTERLAKE GROUP

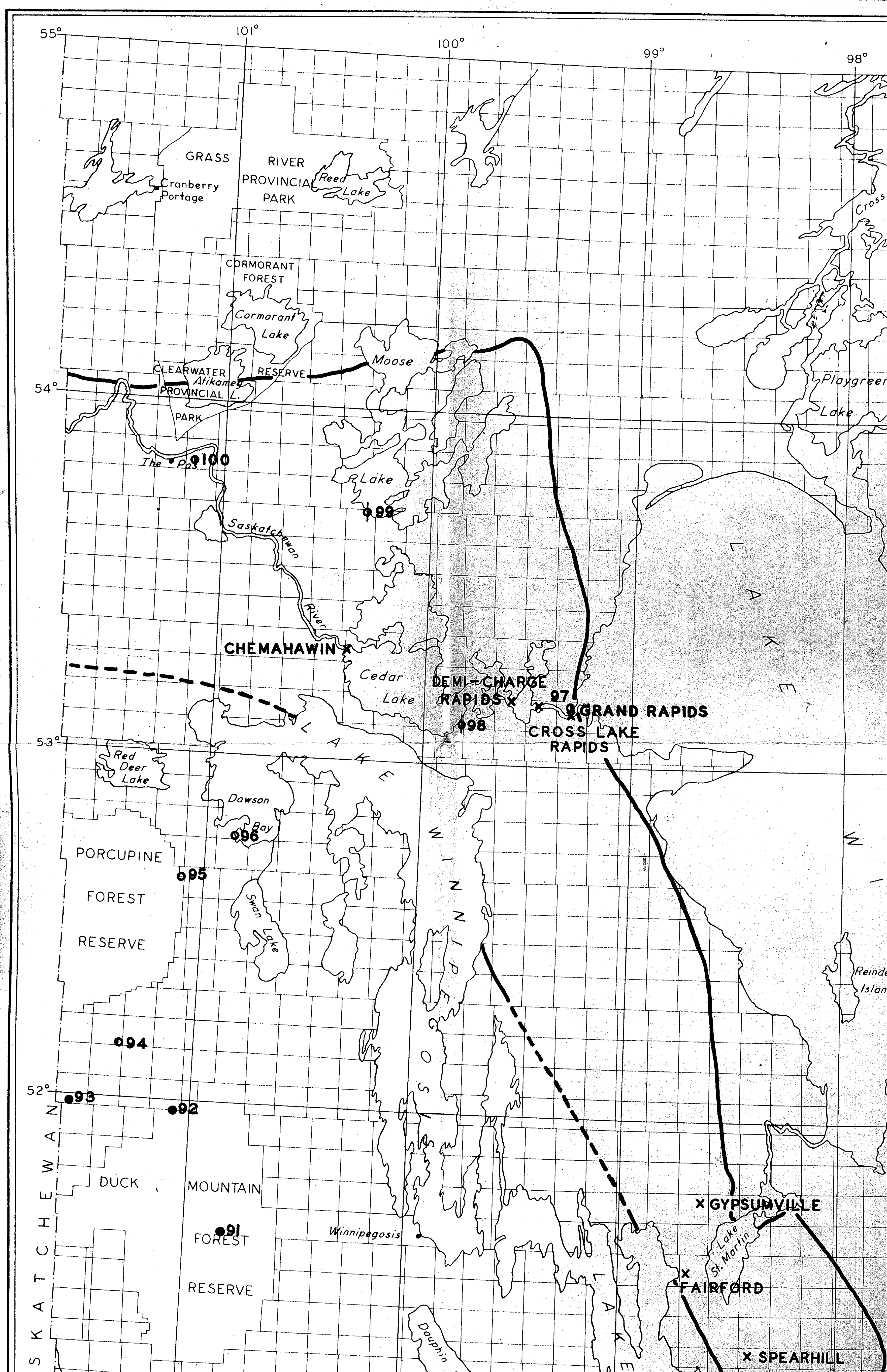
OUTCROP

- × SECTION

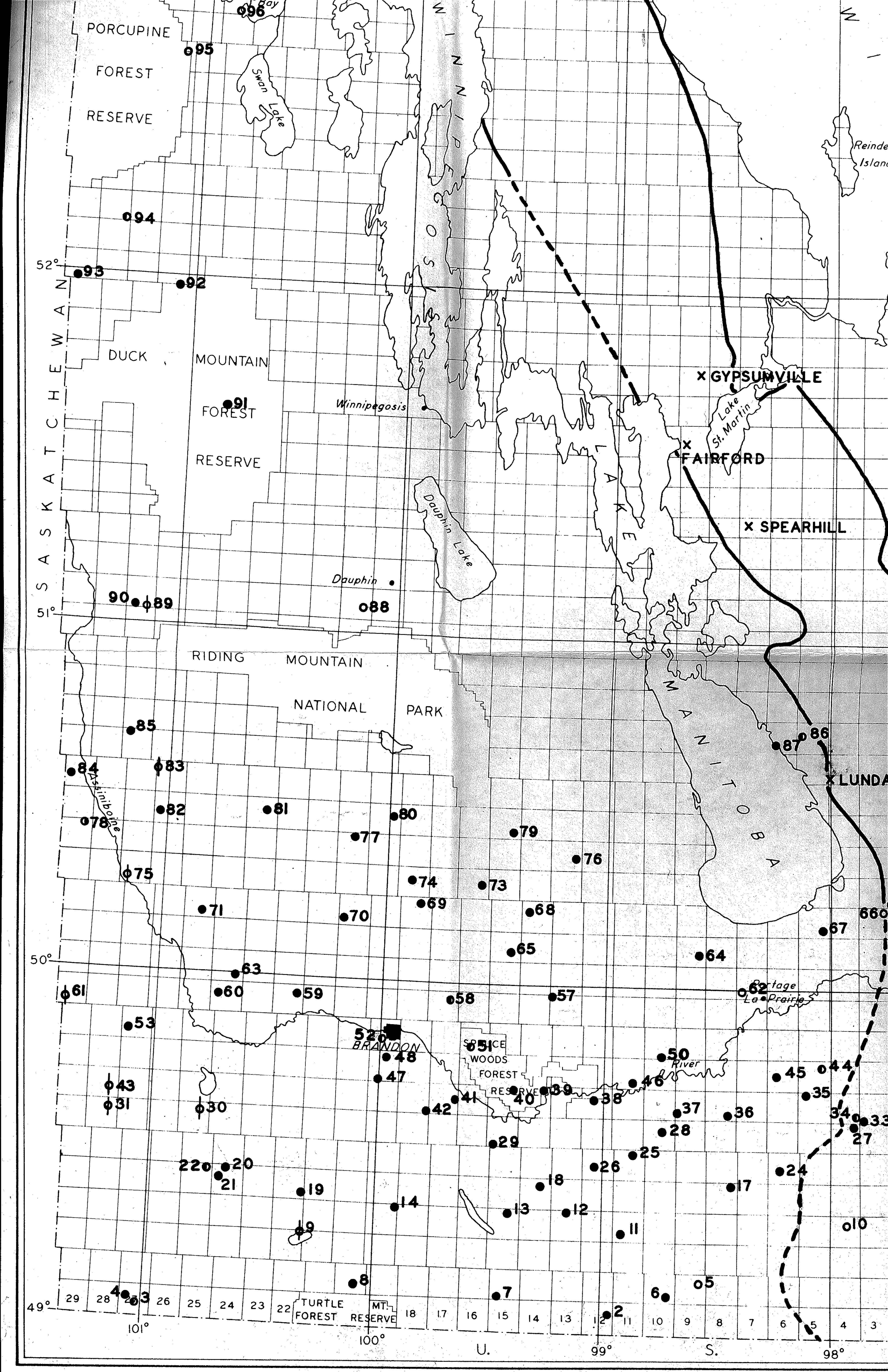
0 8 16 32 48 64
MILES

MARCH 1964 K. R. KING





55°
101°
100°
99°
98°
54°
53°
52°
GRASS
RIVER
PROVINCIAL
PARK
Reed Lake
Cranberry Portage
CORMORANT FOREST
Cormorant Lake
CLEARWATER PROVINCIAL PARK
RESERVE
Atikameg L.
Moose Lake
The Pas
100
Saskatchewan River
99
CHEMAHAWIN
Cedar Lake
DEMI-CHARGE RAPIDS
97
GRAND RAPIDS
CROSS LAKE RAPIDS
98
Cross
Playgreen Lake
LAKE
Red Deer Lake
Dawson Bay
96
95
PORCUPINE FOREST RESERVE
Swan Lake
LAKE WINNIPEGOSIS
Reindeer Island
94
93
92
DUCK MOUNTAIN FOREST RESERVE
91
Winnipegosis
GYPSUMVILLE
Lake St. Martin
FAIRFORD
SPEARHILL
Dauphin
LAKE
SASKATCHEWAN



PORCUPINE
FOREST
RESERVE
Swan Lake
WINNIPEGOSIS
Reindeer Island
52°
SASKATCHEWAN
DUCK
MOUNTAIN
FOREST
RESERVE
Winnipegosis
X GYPSUMVILLE
Lake St. Martin
X FAIRFORD
LAKE
Dauphin Lake
X SPEARHILL
Dauphin
51°
RIDING
MOUNTAIN
NATIONAL
PARK
MANITOBA
X LUNDA
Assiniboine
50°
Portage La Prairie
BRANDON
SPRUCE
WOODS
FOREST
RESERVE
River
TURTLE
MT.
FOREST
RESERVE
49°
101°
100°
99°
98°
U.
S.
29
28
27
26
25
24
23
22
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
3
4
5
6
7
8
9
10
11
12
13
14
17
18
19
20
21
22
24
25
26
27
28
29
30
31
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
50
51
52
53
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96