THE RAPITAN GROUP, MACKENZIE MOUNTAINS, N.W.T.

THE RAPITAN GROUP, SOUTHEASTERN MACKENZIE MOUNTAINS, NORTHWEST TERRITORIES.

by

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CHAPTER I

INTRODUCTION

The Rapitan Group crops out in an arcuate 250 mile long belt extending from a few miles north of the South Nahanni River, District of Mackenzie (lat. 62° 15' N, long. 126° 15' W) to the Bonnet Plume River area, Yukon (approx. lat. 65° 15' N, long. 133° 30' W, see Fig. 1). The existence of rocks of this Group in the Mackenzie Mountains has been known for many years (Keele, 1906 ; Camsell, 1906) but it was not until the discovery of the Snake River iron deposit by Crest Exploration in 1962 that attention was focused on them. The term Rapitan was introduced at that time by Green and Godwin (1963) of the Geological Survey of Canada for rocks of this Group in the vicinity of Rapitan Creek, Yukon.

The Rapitan Group was studied during the 1965 field season as part of Operation Selwyn, an investigation by the Geological Survey of Canada under the direction of Dr. H. Gabrielse of the geology of the northern Cordillera. This work essentially completed Wrigley Lake (95M), Glacier Lake (95L) and Flat River (95E) map-areas, included in 1963 during Operation Nahanni, and began the mapping of adjacent map-areas to the west (Fig. 1).

More than 15,000 feet of stratigraphic section were measured, sampled and described by the author at three localities in Wrigley Lake and Sekwi Mountain map-areas. Rapitan rocks were also observed at several localities during traversing in conjunction with mapping.

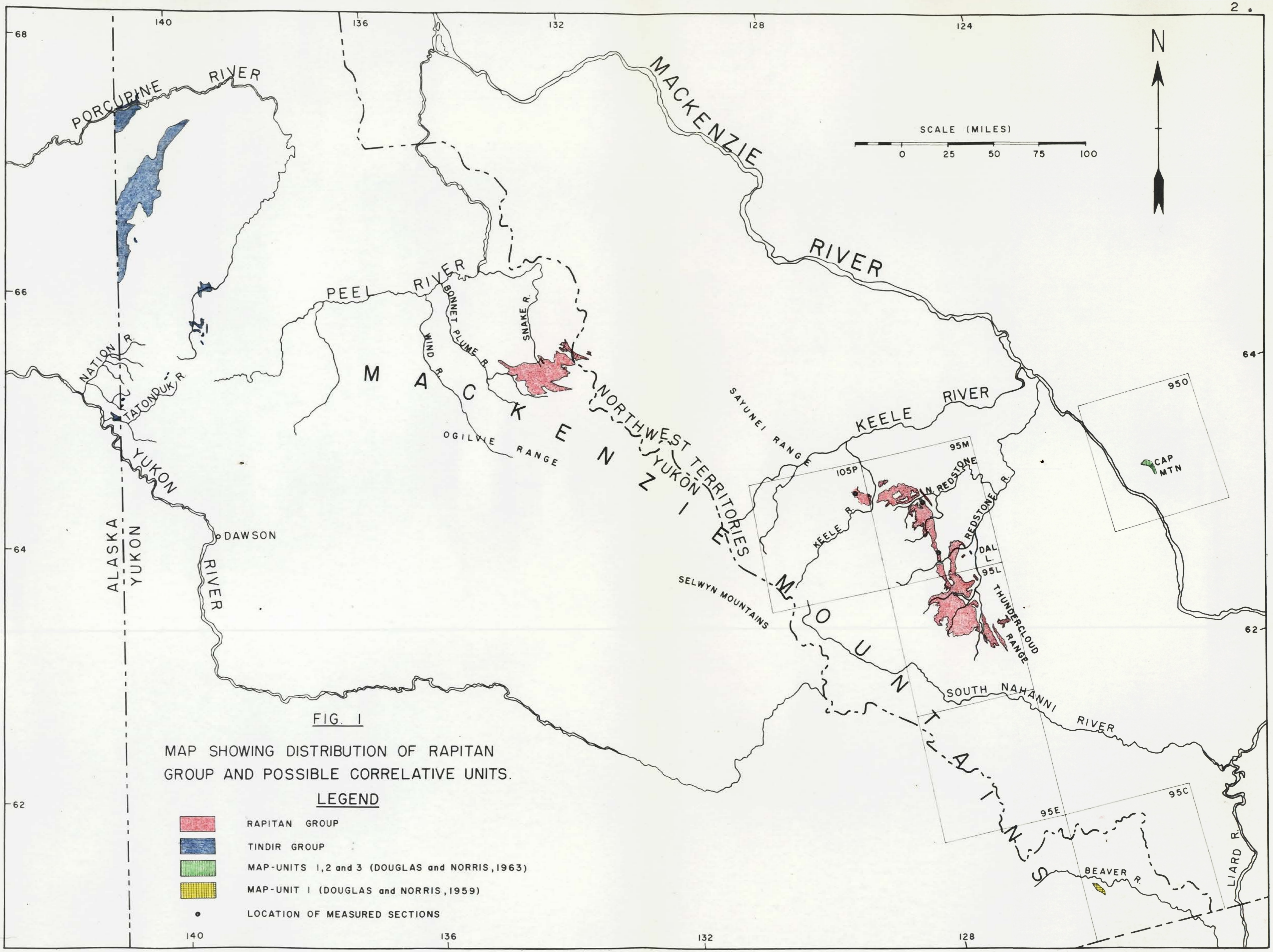

FIG. 1

MAP SHOWING DISTRIBUTION OF RAPITAN GROUP AND POSSIBLE CORRELATIVE UNITS.

LEGEND

- RAPITAN GROUP
- TINDIR GROUP
- MAP-UNITS 1, 2 and 3 (DOUGLAS and NORRIS, 1963)
- MAP-UNIT 1 (DOUGLAS and NORRIS, 1959)
- LOCATION OF MEASURED SECTIONS

This thesis includes a summary of the stratigraphy of the Rapitan in these map-areas and the Snake River area, petrographic examination and minor spectrochemical analyses of the Rapitan Group in the Southeastern Mackenzie Mountains, and a correlation with possibly equivalent units in the Yukon and southwestern District of Mackenzie. Relatively little data have been published on these rocks. An attempt is made, with the limited data available, to determine the provenance and the environment of deposition of the Rapitan Group.

ACKNOWLEDGEMENTS

The writer is extremely indebted to Dr. H. Gabrielse of the Geological Survey of Canada, who not only suggested the problem, but made time and helicopter support available during Operation Selwyn in the summer of 1965. The Geological Survey of Canada paid for shipment of rock specimens and additional samples with thin sections were made available by Dr. Gabrielse.

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GENERAL GEOLOGY

The geology of Glacier Lake and Wrigley Lake map-areas has been outlined and briefly described by Gabrielse, Roddick and Blusson (1965).

Proterozoic rocks can be divided into at least fourteen units of formational rank. These consist of thick sequences of bright colored limestones and dolostones, multicolored shales and slates, quartzites, grits, conglomerates and iron formation and trend north to north westerly throughout the Backbone Ranges. Lower Paleozoic quartzites, sandstones, siltstones and carbonates are exposed north and south of the South Nahanni River in the southern part of Glacier Lake map-area. Gabrielse et al., (1965, P.3) observed that "significant facies changes take place in Cambrian and Proterozoic strata in the Ragged Range and ...... make correlation difficult. Middle to Late Paleozoic formations, mainly carbonates and shales are well defined and show remarkable lateral persistance throughout the northern and eastern parts of the map-areas". Near Grizzly Bear Lake, in the northwestern corner of Glacier Lake map-area, a facies change occurs in the Ordovician and Silurian where carbonates change southwest and south to shales and dark, fine-grained clastics. Granitic rocks of Cretaceous (?) age outcrop in the southwest corner of Glacier Lake map-area, southwest of the South Nahanni River.

Regional unconformities occur in the Proterozoic units, at the base of the Middle Cambrian and Upper Ordovician sequences.

The main structural elements within the Glacier Lake and Wrigley Lake map-areas trend northerly to northwesterly. The most widespread structures in the map areas are moderately steep linked folds, broken by generally west dipping thrust faults. Toward the eastern margins of these map-areas, thrusts generally dip easterly (Gabrielse et al., 1965).

Extensive areas of low dipping or almost flat lying strata, including the Rapitan Group, occupy north central Glacier Lake and part of western Wrigley Lake map-area. A prominent westerly dipping thrust fault marks the northeast and eastern boundary of these areas. Gabrielse et al., (1965, P.26) stated that "western and southern part of Glacier Lake map-area are dominated by gently to moderately plunging folds and associated thrust faults. Some of the major structures appear to be linked en échelon. Many folds involving argillaceous strata are tightly compressed and local overturning of beds to the northeast or east is not uncommon."

In the Snake River area, Yukon, Green and Godwin (1963, P.16) noted "the main structures of the area are open, northwest trending folds with gentle dips. Superimposed on these are west and northwest trending thrust faults. Locally, steep dips are associated with both folds and faults."

In the vicinity of the Bonnet Plume River, between about 132° 00' and 134° 30' W longitude and 65° 00' and 65° 25' N latitude, the stratigraphic and structural relationships suggest that the dominant north-south or northwest-southeast trending folds and faults were superimposed on earlier east-west folds and faults (Officers of Operation Porcupine, Geol. Survey, Canada, 1966, written communication).

AGE AND CORRELATION

The Rapitan is considered as being the basal group of Windermere System, Late Proterozoic age (Gabrielse, 1966, personal communication). It is separated from underlying Early Proterozoic or Beltian rocks by an apparently widespread angular unconformity in the southwestern Northwest Territories and Yukon at the base of the Rapitan Group. This unconformity also appears to be prominent throughout much of the northern and southern Cordillera. (Mulligan, 1957; Reesor, 1957; Gabrielse, 1963)

The lowermost Rapitan is correlated with map unit 1 of Douglas and Norris (1959) (see Fig.2). This unit is exposed south of the Beaver River in La Biche map-area and consists of massive to thinly bedded, platy green and greenish gray argillites, siliceous in part. They appear slightly red when observed from the air. An apparent unconformity separates this unit from overlying possibly Paleozoic conglomerates. Unit thickness is unknown, as the base is not exposed.

Northward, in Wrigley map-area near Cap Mountain, Douglas and Norris (1963) describe three map units (1 to 3) that are unconformably overlain by the Lone Land Formation. Map-unit 1 consists of 1700 feet of interbedded dolostone, hematitic sandstone, siltstone and shale. It is underlain by the Cap fault. Map-unit 2 is dusky-red shale, hard, thin bedded, with thin interbeds of red, ferruginous siltstone and sandstone. It is 1,585 feet thick. Map-unit 3 is dusky red to dark olive-green platy shale, thinly bedded siltstone and gray, green or dark brown sandstone and quartzite. This unit is approximately 1,510 feet thick. On the basis of lithology and stratigraphic position the author believes these three units to be correlative with the Rapitan Group.

Along the Alaska-Yukon border, in the Tatonduk-Nation district, and northward between the Porcupine and Yukon Rivers some rocks of the Tindir Group are almost identical with the Rapitan. (Cairnes, 1914; Mertie, 1932; Brabb and Churkin, 1964).

Mertie (1932, P.375) described a sequence of red beds (Unit C) which are, in the author's opinion, correlative with the iron-bearing Lower Rapitan unit. The total thickness of this unit is between 2,200 and 2,600 feet. Brown-red argillites, red shales, conglomerates, and jasper with hematite are the predominant lithologic types present. Volcanics, mainly lavas and tuffs are present and are indistinguishable in hand specimen from the average red beds. The base of the unit is a red coarse pebble and cobble conglomerate containing pebbles and cobbles of dolostone, greenstone and minor chert. The matrix is hematitic and argillaceous.

Total thickness of the Tindir, is about 13,000 feet, (Mertie, 1932). The Tindir Group is overlain by Middle Cambrian rocks in the Tatonduk Nation district and Mertie concluded that a marked stratigraphic hiatus exists between the Middle Cambrian rocks and the Tindir. Brabb and Churkin (1964, 1965) have inferred a possible Lower Cambrian age for the upper part of the Tindir Group.

Fig. 2 Correlation chart of Late Precambrian units, eastern Alaska and southeastern Mackenzie Mountains, Northwest Territories.

	CHARLEY RIVER QUADRANGLE, EAST CENTRAL ALASKA. Brabb and Churkin, (1964)	FLAT RIVER, GLACIER LAKE, WRIGLEY LAKE, DISTRICT OF MACKENZIE, YUKON. Gabrielse, Roddick, Blusson (1965)			DAHADINNI AND WRIGLEY MAP-AREAS, NORTHWEST TERRITORIES. Douglas and Norris, (1963)			FORT LIARD AND LA BICHE MAP-AREAS, NORTHWEST TERRITORIES AND YUKON. Douglas and Norris, (1959)		
	Lithology	Map Unit	Lithology	Thickness (feet)	Map Unit	Lithology	Thickness (feet)	Map Unit	Lithology	Thickness (feet)
CAMBRIAN AND/OR PRECAMBRIAN		I4	Carbonate, shaly, brown, dark gray, orange weathering	0-I,000						
CAMBRIAN AND/OR PRECAMBRIAN		I3	Quartzite, sandstone, white, pink, purple, red; limestone and dolomite, crypto-grained, mottled, mauve, pink; shale; minor conglomerate	7,000+						
PRECAMBRIAN	Tindir Group —— May be Lower Cambrian in part.	I2	Phyllite, slate, quartzite, siltstone, argillite, agglomerate, conglomerate, volcanic rocks, schist	I0,000						
PRECAMBRIAN		II	Shale and slate, dark weathering, red and green weathering; quartzite; calcarenite; quartz pebble conglomerate; siltstone; minor limestone; phyllite	I0,000						
PRECAMBRIAN	Limestone, dark gray, laminated, interbeds of greenish gray shale, siltstone, sandstone; minor sandy limestone, dolomite, chert-carbonate gritstone	I0	Carbonate, platy, sandy, orange weathering	I,000						
PRECAMBRIAN		9	Shale, siltstone, dark gray, recessive	3,I85						
PRECAMBRIAN	Sandstone, light gray; shale, minor gritstone, conglomerate, weathers pale orange	8	Sandstone, dolomitic, orange weathering; dolomite, sandy; mafic flow	2,500	4	Sandstone, white to ferruginous brown; conglomerate; shale, gray; mudstone purplish red and green	970			
PRECAMBRIAN	Basalt, green-gray, basaltic tuff; shale, grayish red, siliceous; minor green-gray shale, jasper, greenstone-dolomite conglomerate, hematitic doloarenite, vitric tuff replaced by hematite and carbonate	7	RAPITAN GROUP	4,500 +	3	Shale, dusky-red and olive-green, hard; siltstone and sandstone, hematitic, fine grained	I,5I0	I	Green argillite	?
PRECAMBRIAN		6	Limestone, fetid, dark gray; slate; limestone conglomerate	675						
PRECAMBRIAN		5	Siltstone, pink, slaty; gabbro	I,500	2	Shale, dusky-red and green, hard; siltstone	I,585			
PRECAMBRIAN	Dolomite, gray, massive, weathers orange; contains chert, dolomite breccia, dolomite-chert gritstone, gray shale.	4	Dolomite, gray, buff, orange, sandy; minor siltstone, slate, conglomerate	4,350	I	Sandstone, fine grained, green; dolomite, cryptocrystalline, green and brown; shale, dusky red and green	I,700			
PRECAMBRIAN	Shale, gray-black, carbonaceous; minor quartzite, limestone, oolitic limestone, dolomite, dolomite conglomerate	3	Limestone, well bedded, gray, stromatolitic; dolomite, minor slate, diorite, mafic volcanic rocks.	I,468-2,400						
PRECAMBRIAN		2	Quartzite, white, pink, purple; minor slate and dolomite	4,300						
PRECAMBRIAN	Dolomite and doloarenite; interbeds of gray-black shale, quartzite.	I	Shale, olive-green; slate, quartzite; minor dolomite	I,600						

Note: Map-units do not necessarily imply relative stratigraphic position.

Rocks of the Tindir Group are also found on the Alaska-Yukon border, in the Keele Range and near the Porcupine River (Norris, Price, Mountjoy, 1963). These strata are believed to be, in part, correlative with the Rapitan Group.

Rocks described by Trettin (1966), in the M'Clintock Inlet Region, northeastern Ellesmere Island may be related to the lowermost Rapitan. Thin bedded pure and argillaceous dolomite, black shale, and ribbon chert are associated with minor amounts of limestone, siltstone, sandstone, conglomerate and red cherty iron formation. Trettin (1966, P.8) stated "it resembles the ore from the Snake River, Y.T.". The iron formation is associated with sediments in part and also with volcanic rocks, mainly flows with some tuffs and breccias. According to Trettin these rocks are thought to be Precambrian and Lower Cambrian and are unconformably overlain by Middle Ordovician strata.

STRATIGRAPHY

General Statement

The complete stratigraphic succession in the Mackenzie Mountains in Glacier Lake and Wrigley Lake map-areas is described by Gabrielse et al.,(1965). Only a brief description of the immediately underlying and overlying units is presented here (Fig.2).

In the southeast part of Glacier Lake map-area the base of the Rapitan Group is not exposed or it is underlain unconformably by buff and grey dolomite with minor buff and orange weathering siltstone, conglomerate and slate (unit 4 of Gabrielse et al.,1965). Locally, near Little Dal Lake, platy siltstone, and dark gray fetid limestone, black slate and limestone conglomerate (units 5 and 6) unconformably underlie the Rapitan. North of the Redstone River much of unit 4 has been removed by erosion and the Rapitan rests on unit 3, well bedded, stromatolitic limestone and gray dolostone, cherty in part (see Plate 1). East of the Keele River this unit includes a mafic sill or flow.

Much of the area west of the Keele River remains unmapped, however, the same units appear to underlie the Rapitan with marked angular unconformity just west of the Keele River. Additional information will be forthcoming with a preliminary publication of Sekwi Mountain map-area by S.L. Blusson of the Geological Survey of Canada.

In the Thundercloud Range, the Rapitan Group is overlain unconformably by the Ordovician or Silurian Whittaker Formation, consisting of dark gray dolostones and light gray limestones (see Plate 2). Northward, in the Backbone Ranges, orange weathering, dolomitic sandstone, and sandy dolostone of late Precambrian age (unit 8 of Gabrielse _et al_., 1965) overlie the Rapitan with apparent unconformity. This unit is persistent northward throughout the Backbone Ranges. In the Sayunei Range, in Sekwi Mountain map-area, black, recessive "chippy" shales, probably Precambrian in age overlie the Rapitan, apparently conformably.

In the Snake River area, Green and Godwin (1963) state that "the Rapitan rests with slight angular discordance on a sequence of buff orange and gray weathering shale and a carbonate ...... the Rapitan

Plate 1 : Lower and Middle Rapitan unconformably overlying gray limestone and dolostone (map-unit 3 of Gabrielse <u>et al</u>., 1965), 12 miles south of North Redstone River, Backbone Range.

Plate 2 : Lower Rapitan maroon mudstones and iron formation, thin Middle Rapitan, unconformably overlain by Ordovician or Silurian Whittaker Formation, (light gray) Thundercloud Range.

Group is overlain with angular unconformity by a thick sequence of massive grey-weathering carbonate ...... probably of Cambrian age".

Rapitan Group

Three complete and well-exposed sections of the Rapitan Group were measured. Included were partial sections of the underlying and overlying units. Sections were located in the Mackenzie Mountains, north of the Redstone River (63° 14' N, 127° 05' W), south of North Redstone River (63° 34' N, 127° 02' W) and west of the Keele River in the Sayunei Range, Sekwi Mountain map-area (63° 45' N, 128° 15' W). Additional sections were obtained from reports by Green and Godwin (1963), and F. Condon (1964) (see Fig.3).

Gabrielse *et al*., (1965) divided the Rapitan into two units. However, in the light of recent field work the Rapitan group can be divided into three units, each of formational rank. The units will be referred to as the Lower Rapitan, Middle Rapitan, and Upper Rapitan. The base of the Rapitan is a markedly angular unconformity, truncating as much as 4,000 feet of underlying beds. The unconformity is best seen near the Redstone River or west of the Keele River (Plate 3, Fig.1). The top of the Rapitan appears conformable with the overlying units in the Sayunei Range, yet it is distinctly unconformable north of the Redstone River (Plate 3, Fig.2).

Two additional unconformities (?) separate the Rapitan into three units (Plate 3, Fig.3). The lower is approximately 1,000 feet thick in the Thundercloud Range (Condon, 1964). North of the Redstone River, the Lower Rapitan is 230 feet thick but it increases in thickness to 1,335 feet south of the North Redstone River, and 525 feet west of the Keele River. Locally, especially west of Dal Lake, it is missing completely. In the Snake River area it thickens considerably to approximately 2,790 feet although Green and Godwin (1963, P.16) may have included 750 feet of Middle Rapitan in this unit.

The Middle Rapitan thickens northwestwardly. Only a thin 50-foot wedge is present in the eastern Thundercloud Range (Plate 2). This increases to 1,215 feet north of the Redstone River, to 1,555 feet south of the North Redstone River and 2,705 feet west of the Keele River. The same unit is 2,600 feet thick in the Bonnet Plume area (Ziegler, 1959) and roughly 3,000 feet thick in the Snake River area (Ziegler, 1959 ; Martin, 1959).

The Upper Rapitan is absent in the Thundercloud Range. It is 3,845 feet thick north of the Redstone River, 1,870 feet thick south of the North Redstone River and 2,710 feet thick west of the Keele River. Thicknesses in the Snake River Area are not known and the Upper Rapitan may be missing completely.

Fig. 1 Marked angular unconformity at the base of the Rapitan Group, 10 miles west of the Keele River, Sayunei Range.

Fig. 2 Sandstone and dolostone (unit 8 of Gabrielse et al., 1965) unconformably overlying Upper Rapitan, south of North Redstone River. Note the very slight angular discordance.

Fig. 3 Unconformable contact between the Lower and Middle Rapitan about 10 miles west of the Keele River, Sayunei Range. Note hammer in centre of photo.

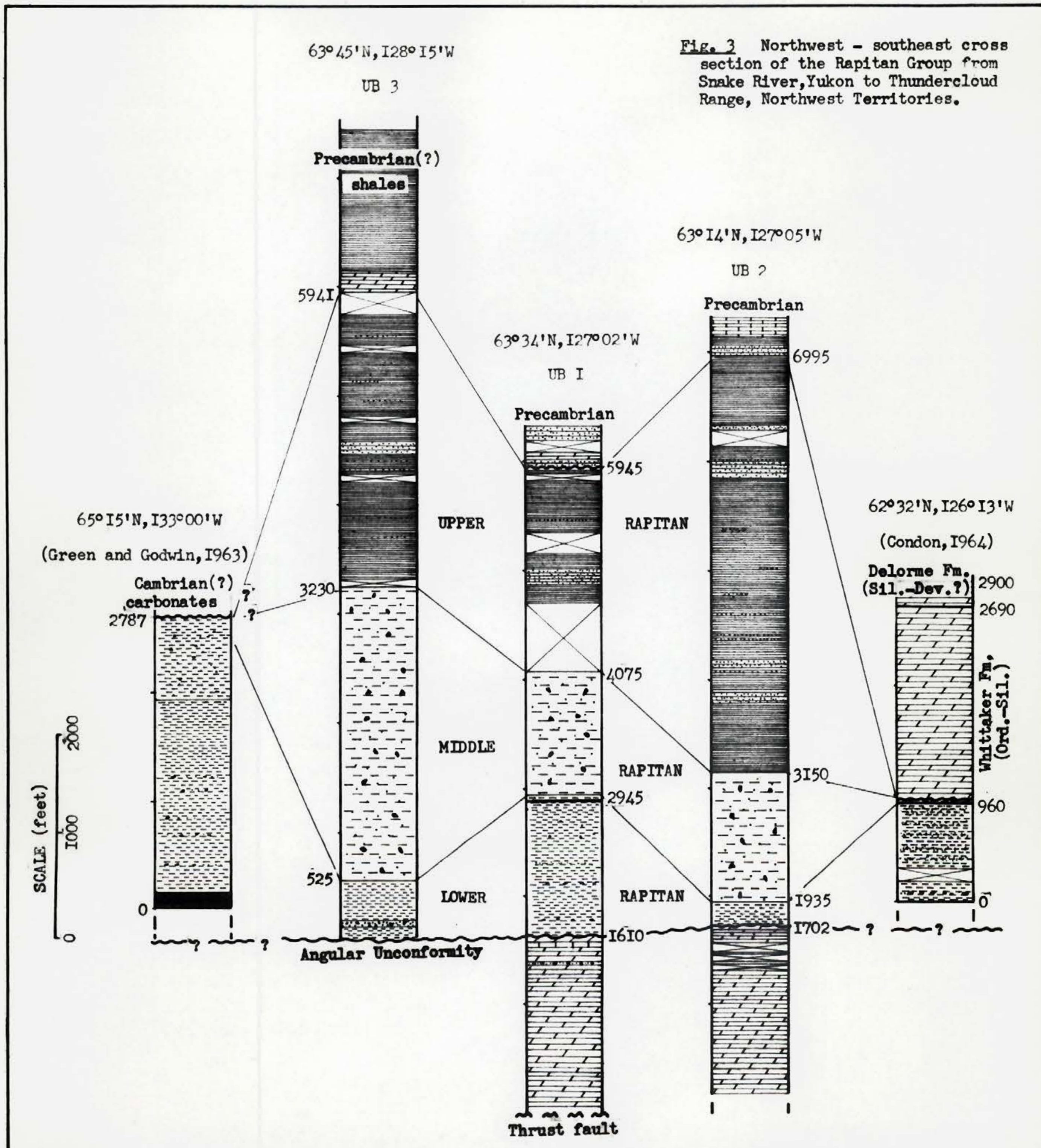


Fig. 3 Northwest - southeast cross section of the Rapitan Group from Snake River, Yukon to Thundercloud Range, Northwest Territories.

CHAPTER II

GROSS LITHOLOGIC DESCRIPTION

Lower Rapitan

About 70 percent of the Lower Rapitan is reddish brown or maroon mudstone, commonly weathering dark maroon. Mudstone ranges from predominantly clay mudstone to very slightly silty mudstone. Thin 1 to 3 inch fissile and platy beds are predominant but massive bedding up to several feet thick does occur. Laminations occur on a microscopic and megascopic scale. Mudstone is very slightly calcareous in places, appearing finely crystalline and recessive and weathering grayish to grayish brown. Very thin sand size and fine conglomeratic lenses and interbeds are common.

Conglomerate makes up about 25 to 30 percent of the Lower Rapitan. Clasts in decreasing order of abundance are: green mudstone, laminated and non-laminated (some volcanics in part?), light gray dolostone, brown sandstone, maroon mudstone, gray chert, light gray limestone and very minor gneiss(?). Clasts range in size from one-sixteenth of an inch to one foot but generally average 3/4 to 2 inches. Sorting is very poor and clasts are subangular to subrounded. In some beds they are covered by a green chlorite(?) coating. Matrix is maroon mudstone or slightly calcareous silty green mudstone. Conglomerate beds weather dark maroon or greenish maroon and are either very thin, averaging 1/4 to 2 inches or westward near the Keele River are up to 5 feet thick. Lower contacts of the thinner beds tend to be sharp but often wavy whereas upper ones are sometimes gradational. Often solitary cobbles or boulders occur in fine to medium sand size beds and laminated mudstone sequences (see Plate 4, Fig.1).

Jasper and Hematite occur only south of the North Redstone River (Section UB-1) and represent only about 2 percent of the total section. Condon (1964) has described similar iron formation from the Thundercloud Range. Jasper is cryptograined, bright red or purplish red, occurring in thin 1/4 to 2 inch interbeds or lenses. Hematite is gun metal gray in thin "streaks" or fine interbeds. Banded hematite and jasper are predominant although in places hematite contains 1/8 to 1/4 inch rounded and oval "eyes" or nodules of orange and red jasper. Jasper weathers red to red-brown, is generally well jointed and breaks into angular, sharp fragments.

Sedimentary Structures

Mudcracks

Mudcracks were observed only in close association with jasper and iron beds, south of the North Redstone River. Polygons were 3 to 4 inches wide, separated by 1/8 to 1/4 inch cracks, which were infilled with maroon mudstone.

Ripple Marks

Ripple marks would appear to be common but were observed only in talus, from the thinner bedded, platy mudstone. Most ripple marks were "microripples" in that their amplitude was 1/8 to 1/4 inches and their wave length about 1/2 inch. Crests were rounded and appear asymmetrical in cross section.

Graded Bedding

Graded bedding is common in thin conglomeratic or sandy sequences. Lower contacts are sharp and may be wavy or undulating but grade upward into mudstone. Sand size beds are not visibly graded although at times these have a distinct lower contact and a less distinct upper contact. Often the uppermost 1/2 inch of these beds show grading.

Deformational Structures

Where conglomeratic thin interbeds show undulating or wavy lower contacts with underlying mudstones, laminations in the mudstone beneath the coarser conglomerate clasts are often bent beneath the clasts. Pebbles, cobbles and boulders, scattered throughout the laminated mudstone sequence also have laminations bent beneath the clasts as well as arching over them (see Plate 4, Fig.1). Laminations also show recumbent folds, indicating penecontemporaneous lateral slumping or flowage of thin portions of the mudstone.

"Varve-like" Laminations

Regular, alternating, 1/4 inch wide varve-like laminations occur between conglomerate beds. Up to 1 1/2 feet of these have been observed. Often such sequences contain widely dispersed isolated pebbles or cobbles.

Middle Rapitan

The Middle Rapitan is almost entirely a massive blue-gray to gray, locally greenish gray, pebbly mudstone. It is devoid of easily apparent bedding or structure, yet, from a distance it appears vaguely bedded. South of the North Redstone River about twenty feet of light brownish gray, calcareous, very fine grained sandstone is interbedded with the pebbly mudstone. It is not present in the other measured sections.

The ratio of clasts to matrix varies from 5 to 30 percent of the rock, generally averaging about 15 to 20 percent. The majority of the clasts, in decreasing order of abundance, are light and dark gray dolostone, greenstone, gray limestone, quartzite, gray and black chert, mudstone, igneous and metamorphic rock fragments and stromatolitic limestone. Fig. 4 shows the variation in clast composition for the section south of the North Redstone River. One hundred clasts over 1/4 inch in diameter were examined over each one hundred foot interval. Clasts range in size from 1/16 inch to 2 feet (see Plate 4, Fig.3) but generally average about 1 to 1 1/2 inches. Large pebbles, cobbles and boulders are locally absent. Sorting is extremely poor. Most clasts are subrounded to rounded but few, especially the larger ones, are well rounded. Completely angular fragments are uncommon. Faceted and striated pebbles are rare, generally the carbonate pebbles showing striae. A few carbonate pebbles also show flat iron shapes.

The matrix is a very fine-grained, dolomitic mudstone. Fine sand size quartz grains are generally present and often abundant. Small pyrite cubes, generally less than 1/16 inch in size, are speckled throughout the matrix in minor amounts.

The Middle Rapitan weathers greenish gray and light and dark brown to dark reddish brown. Near the Redstone River it is difficult to distinguish from the Lower Rapitan. Northwestward, near the Keele River,

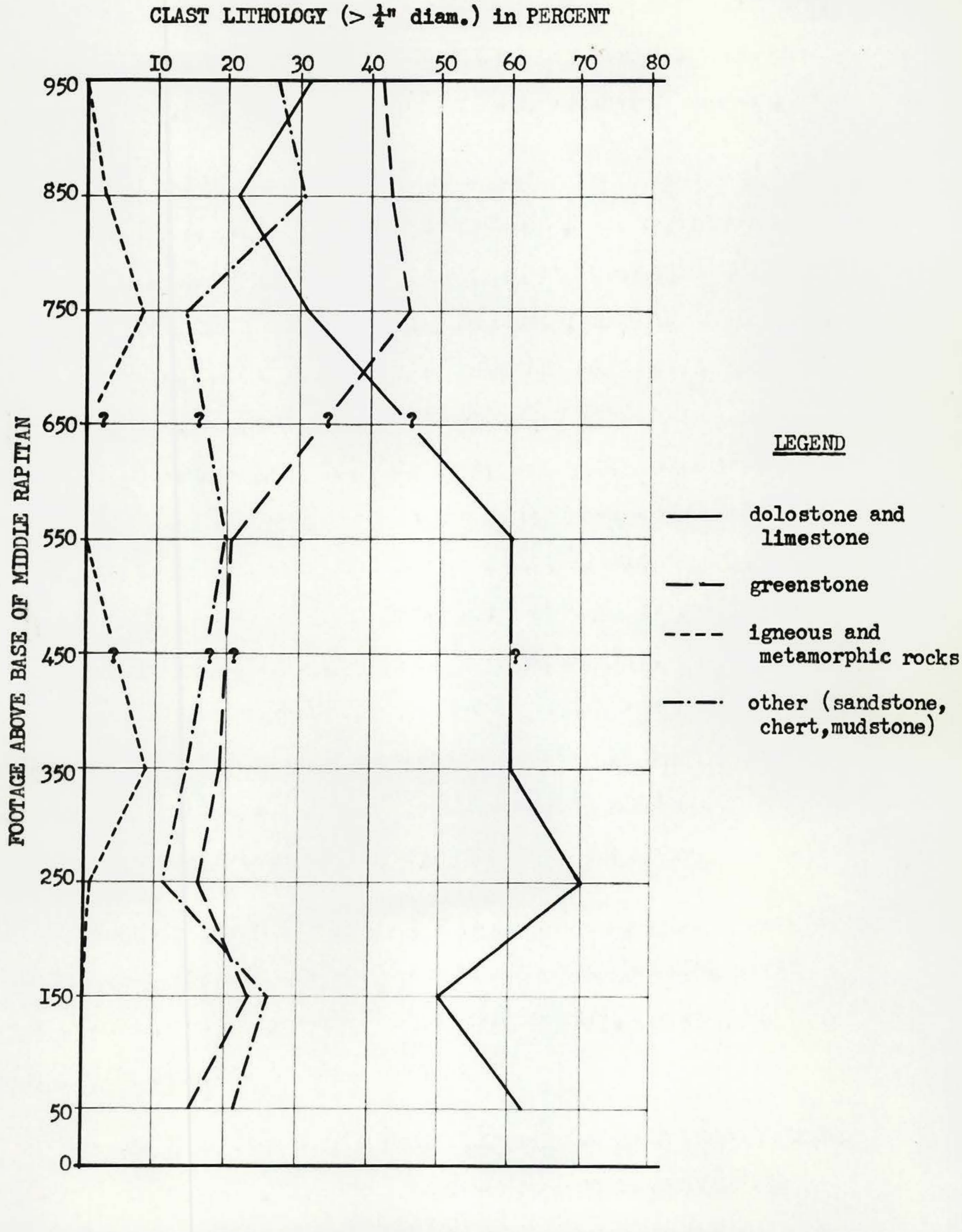


Fig. 4. Variation in clast composition of Middle Rapitan, south of the North Redstone River.

it weathers a distinct orange-brown. Weathered fragments are flat and platy (see Plate 4, Fig.2). Outcrops are generally recessive, partially grass covered or covered with talus.

Upper Rapitan

From 65 to 75 percent of the Upper Rapitan is blue-black, green-gray or black shale. Shales range from clay shale to very fine silt shale and are finely laminated in places. Bedding is 1/8 to 3 inches and fragments are generally fissile, phyllitic and platy. Very thin 1/8 to 1/4 inch fine calcareous silt lenses are common near the top of the Upper Rapitan. Shales weather dark gray to greenish gray and are recessive. Beds or lenses of sandstone, form about 20 to 30 percent of the Upper Rapitan. Nearly all the sandstone is very fine to fine-grained, light green-gray to gray. In hand specimen, quartz grains predominate with some feldspar. Bedding is 1/2 inch to 1 foot, with bedding surfaces often micaceous. Lenses are from 1 to 15 feet long and up to 2 feet thick. Sandstone weathers green-gray and is resistant.

Limestone and minor dolostone make up less than 5 percent of the Upper Rapitan but only in the section north of the South Redstone River. Limestone is gray to dark gray, very fine grained crystalline. Algal structures are present in a few thin beds. These are typically rounded and laminated and form a small percentage of the limestone. Weathering colors are gray and orange-gray.

Dolostone is gray, fine to medium crystalline with 2 to 3 percent small vugs throughout. Weathering is green-gray to gray.

Sedimentary Structures

Ripple Marks

Ripple marks are abundant throughout the Upper Rapitan. Large scale ripples, with amplitudes of 2 to 3 inches and wave lengths up to 1 1/2 feet were seen near the base of the Upper Rapitan (see Plate 5, Fig.1). Crests are asymmetrical. Smaller scale ripples with amplitudes of 1/2 to 1 inch and wave lengths ranging from 2 to 4 inches are abundant throughout the sequence.

Cross Bedding

Cross bedding occurs in the fine-grained sandstones and is generally of a small scale nature, with thicknesses of cross bedded units being 1/2 to 5 inches. Most possess truncated topset and bottomset beds, with straight, linear forset beds of the tabular type. Laminations dip consistently in one direction (current-ripple type). No great variety in cross bed shape was observed in the Upper Rapitan.

Convolute Laminations

Convolute laminations are common throughout the very fine-grained sandstones in the Upper Rapitan. They are best observed on weathered surfaces, where slight changes in relief make them visible. In cross section these range from gentle crumpling of laminations to highly contorted patterns. The deformed zone usually includes the whole thickness of the sandstone bed and generally occurs in beds 2 to 4 inches thick. These convolute laminations are probably not due to slumping but are assumed to form when slight differential forces act on a weak hydroplastic deposit during its accumulation process. Overlying shales are not deformed nor do convolute laminae extend into them. Underlying shales are slightly depressed, giving support to the idea that differential loading resulted in the formation of convolute laminations.

Slump Structures

Large scale slump structures, involving narrow recumbent folds are restricted to the shales. Generally only a few beds are slumped and these occur in a sequence of undeformed beds. Most translational movements were small, and the largest slumped bed involved only about three feet of section. Thin folded beds are continuous throughout these slumps, though slightly attenuated (Plate 5, Fig.2 and 3).

Load Casts

Load casts are common and are present at sand-shale interfaces. They appear as small rounded irregular 1/8 to 1/2 inch bulges or swellings, generally showing little or no alignment. Some however tend to be slightly elongate or "squamiform", showing fan-like lobes. Distinct evidences of current orientation are not visible. They are attributed to yielding of the soft hydroplastic shale due to the weight of the superimposed sand beds.

PLATE 4

<u>Fig. 1</u> Large dolostone boulder in Lower Rapitan hematite, jasper, and maroon mudstone beds. Note that laminations bend beneath and arch over the boulder.

<u>Fig. 2</u> Middle Rapitan conglomeratic mudstone showing numerous cobbles, poor sorting and general massive nature.

<u>Fig. 3</u> Large well-rounded boulder in Middle Rapitan conglomeratic mudstone. Note the vague bedding and typical recessive outcrop.

Fig. 1 Large scale ripple marks in Upper Rapitan shales. Brown beds are sandstone.

Fig. 2 Large recumbent fold in Upper Rapitan shales. Note the undeformed underlying beds.

Fig. 3 Small slump structure (?) in Upper Rapitan shales (Geol. Survey, Canada, photo).

CHAPTER III

PETROGRAPHY

A petrographic examination of the Rapitan Group included a study of both polished hand specimens and thin sections. Detailed information regarding composition and textures was obtained primarily from thin sections.

Microscopic Examination

Over 50 samples were thin sectioned for microscopic examination and additional thin sections were obtained from the Geological Survey of Canada. The samples chosen from the three measured sections were taken as being representative of the total lithology. Hand specimens were previously oriented in the field so that way up was always indicated. All thin sections were cut perpendicular to bedding. Thin sections from conglomerate beds were usually cut so as to show the nature of the matrix and the smaller clasts.

Point Counting

Point counts were made on all sandstones in order to determine their mineralogical composition. A Swift point counter was used and 500 points per thin section were found to give accurate results. Only thin sections with an average grain size of over .12 to .15 mm. were point counted as sandstones with average grain size less than this were extremely difficult to count. Their composition, visually estimated, is similar to that found by point counting. All grains below .01 mm. in size were generally unidentifiable and were grouped with the matrix.

Textural Maturity

Qualitative determinations of the textural maturity of clastic sediments provide a descriptive scale that indicates the relative efficiency of the environment of winnowing, sorting, and abrading the detritus furnished to it, although some of this textural character would be imparted prior to reaching the site of deposition.

Qualitative measurements of roundness were not determined but grains were grouped according to a modified version of Power's (1953) comparison chart for visual estimation of roundness. Verbal roundness classes used are:

angular	(.1 -.25)
subangular	(.25 -.35)
subrounded	(.35 -.45)
rounded	(.45 -.65)
well rounded	(> .65)

Folk (1951) suggested four stages of textural maturity, as follows:

1) Immature stage. Sand grains poorly sorted, angular with more than 5 percent terrigenous clay matrix.

2) Submature stage. Sand grains poorly sorted, not well rounded but less than 5 percent clay matrix.

3) Mature stage. Sand grains well sorted, still not well rounded with little or no clay matrix.

4) Supermature stage. Sand grains well sorted, well rounded with no clay matrix.

LOWER RAPITAN

Mudstone

Mudstone is the predominant lithology in the Lower Rapitan, generally occurring in thick, massive beds. In thin section, mudstones are hematitic and clayey or silty being composed of angular silt sized grains of quartz, feldspar, mica(?), and sericite in varying amounts in a finer matrix. The clay fraction is a mixture of clay minerals and red hematite pigment giving the rock its red or maroon color. A green coloration, probably due to reduction of the hematite pigment, is present in a few beds.

Thin laminations and banding are very common and are caused both by textural changes in the mudstone and by color banding. Most laminations are due to textural changes from almost pure clayey hematitic mud to fine silty mud. Very fine scale scour channels, bent and depressed laminations are common. Silty and at times fine sandy layers exhibit graded bedding, with tops of the fine graded beds being truncated by the next silty or sandy lamination. (Plate 6, Fig.1)

Conglomerate

Conglomerate beds and lenses, varying from one inch to 30 feet thick are interbedded with the mudstone. They consist of scattered sand size to cobble and boulder clasts in a silty and sandy maroon mudstone matrix. The dominant clast lithologies are limestone, some with stromatolites, green mudstone or shale, chert, sandstone, siltstone, red mudstone silty in part, volcanic rock fragments and igneous rock fragments (Plate 6, Fig.2). The clasts in some beds are identical in lithology to that of the dolostone, cherty dolostones and limestones beneath the pre-Rapitan unconformity. In thin section many of the clasts are red, almost isotropic mudstone with abundant silt grains (Plate 6, Fig.3). Other clasts often project into these, showing that they were partially plastic when deposited (Plate 7, Fig.1). A few carbonate clasts also appear to have been somewhat plastic. Clasts are angular, subangular with few subrounded and sorting with respect to size and composition is poor.

West of the Keele River, a 10 foot thick conglomerate bed contains unusual limestone clasts enveloped in thin chlorite coatings. Other siltstone, green shale, and chert clasts as well as sand sized quartz and feldspar grains do not possess such coatings. The green chlorite crystals grow inward into the limestone and often a second layer of nearly euhedral, unaltered plagioclase crystals of albite composition are found projecting into the limestone (see Plate 7, Fig. 2 and 3). The chlorite coatings and the ingrowing albite crystals are diagenetic forming contemporaneously as partial dissolution of the limestone took place. It is possible that this bed may represent a diatreme breccia with clasts, averaging about 30 percent of the total lithology, floating in a green argillaceous matrix. Upper and lower contacts of this bed are distinct and although it appears in a normal conglomerate sequence, it is difficult to explain why the chlorite coatings should be restricted to one bed.

The percentage of volcanic fragments appears to increase slightly where hematite beds are present in the section. East of Little Dal Lake, a fine pebble conglomerate contains up to 10 percent volcanic clasts. These clasts are highly altered with sericitized plagioclase lathes in a dark isotropic matrix. Some clasts are chloritized and the conglomerate matrix has also partially or wholly chloritized.

Where the conglomerate is thick bedded, the ratio of clasts to matrix is high, generally varying from 20 to 1 to 10 to 1. In thin conglomerate beds or lenses the proportion of matrix increases and the ratio of clasts to matrix varies from 8 to 1 to 2 to 1. These thinner beds often show poor vertical grading from coarse to fine.

The matrix of the conglomerate is a silty or sandy mudstone, containing silt and fine sand size quartz, orthoclase, chert, minor plagioclase and igneous and volcanic rock fragments. These are subangular to rounded. Many are well rounded, in complete contrast to the angular and subangular larger clasts and some possess dark red hematitic coatings. These grains were probably rolled back and forth in shallow water before being deposited with the conglomerate. Calcite cement is present in the matrix, but in minor amounts and because of patchy distribution is of secondary origin.

Sandstone

Because of the unusual variation in composition of the grains it is difficult to classify these sandstones according to the well-known classifications. As shown in thin section, the Lower Rapitan sandstones contain from 26 to 61 percent detrital grains, 9 to 47 percent argillaceous matrix and 5 to 39 percent calcite cement, probably of secondary origin. The Lower Rapitan sandstones could be termed as lithic or slightly lithic sandstones (Pettijohn, 1957) (Plate 8, Fig.1). Sand size shale or mudstone clasts, of intrabasinal origin, are common and often abundant. Detrital grains are subangular to subrounded, with rounded grains often being present also. Some lithic clasts were probably in a semi-plastic state and thus, are better rounded. Sorting is poor and the sandstones are immature.

Constituent Minerals

Quartz

Detrital quartz varies from 7 to 31 percent. Grains range in size from .01 to .4 mm., generally averaging about .16 mm. Most grains are angular to subrounded, very few are rounded.

Several types of detrital quartz grains are present in the sandstones. In decreasing order of abundance these are:

1) single grains with straight extinction
2) single grains with abundant inclusions, bubbles
3) single grains with undulose extinction
4) single grains with rutile(?) needles
5) composite grains, stretched

Grain boundaries are generally sharp, with some subhedral and slightly embayed grains. Smaller grains tend to have irregular and sometimes corroded or serrated edges. Thin reddish coatings cover a large number of grains (Plate 8, Fig.2). Angular or subrounded grains are not coated or are partially coated. These coating are in part argillaceous and in part hematitic.

Very minor authigenic quartz is present as overgrowths on a few grains, but this rarely exceeds 1 or 2 percent of the total quartz.

Feldspar

Orthoclase is the dominant feldspar, varying from 6 to 13 percent. Grains range in size from .08 to .3 mm., averaging .15 mm. Most grains are subrounded, with very few rounded, but show a much greater roundness than quartz with well rounded individual grains being found. Orthoclase is unaltered, either clear or with some isotropic inclusions or as almost completely sericitized grains, which are difficult to distinguish from the altered matrix. Boundaries are sharp except when grains are altered. Most grains possess argillaceous hematitic coatings.

Plagioclase is present in small amounts generally less than 4 percent. Grains are very small, averaging less than .1 mm. and are interstitial. Most appear to be partially altered but can be recognized by their albite or Carlsbad-albite twinning.

Rock Fragments

Shale or mudstone rock fragments vary from 5 to 25 percent. These are almost completely sericitized and are identified by the aligned nature of the sericite flakes. They range in size from .04 to .5 mm. or more. Most are subrounded and few possess argillaceous iron oxide coatings. Many of the fragments are similar to rocks in the other parts of the section and are probably of local origin.

Reddish hematitic(?) argillaceous grains, similar in nature to the iron oxide coatings are present in amounts varying from 5 to 13 percent. These are either rounded or well rounded or occur as rather elongate semi-plastic "rip-up" clasts, probably derived from mudstone units either directly below or very nearby.

Volcanic fragments are rare (Plate 8, Fig.3), less than 2 to 3 percent and generally average from .2 to .5 mm. in size. They are almost completely altered, with thin elongate plagioclase lathes in a dark isotropic or reddish brown matrix. Original composition cannot be determined.

Igneous rock fragments are also uncommon, very altered and composition cannot be determined. They are mainly recognized on the basis of sericitized feldspar and quartz association. Fragments tend to be small, less than .4 mm. Several grains with interlocking orthoclase and plagioclase are assumed to be of igneous origin.

Minor Constituents

Chert grains and composite dark reddish brown to isotropic clasts containing quartz or orthoclase grains are present in minor amounts. The composite grains appear to have been derived from immediately underlying mudstone beds.

Matrix

Matrix varies from 38 to 74 percent with grains either "floating" in matrix or rather loosely packed. Matrix is gray to reddish brown (hematitic)(?) and argillaceous. Much has been partially altered to sericite and chlorite.

Calcite cement partially replaces the matrix and is present in amounts from 5 to 29 percent. The calcite occurs as irregular patchy areas and somewhat clear areas. In some samples with high carbonate content the rock has a relatively gray appearance, with argillaceous matrix being subordinate.

MIDDLE RAPITAN

The most characteristic feature of the Middle Rapitan rocks is the complete lack of sorting and vague stratification, the abundance and variety of the rock fragments and the fine-grained matrix. The Middle Rapitan rocks can be designated under the general term of conglomeratic or pebbly mudstones. Genetic terms such as tilloid or tillite should be avoided.

For ease of petrographic description these rocks have been divided into two fractions:

1) coarse fraction (>2 mm.)
2) matrix (<2 mm.)

Coarse Fraction

The coarse fraction is best seen in hand specimen. This fraction consists primarily of rock fragments and a few detrital mineral grains that are larger than 2 mm. This fraction constitutes from 10 to 30 percent of the rock but varies both laterally and vertically. Clast composition, sorting and size range have been described under gross lithology.

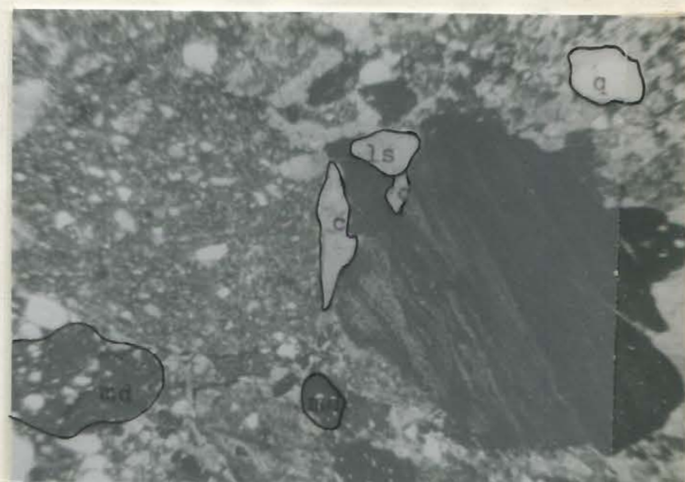
Matrix

Thin section study of the matrix shows that the rock is a hetero-

Fig. 1 Thin silty layer in mudstone. Note upward grading and truncation by another silty layer. X 20 Low. Rapitan Section UB 3, 100 feet above base of section.

Fig. 2 Mudstone(md), shale(sh), limestone(ls) and chalcedony(ch) clasts in a mud matrix. Note angular fragments and poor sorting. The large chalcedony clast is partially replaced by calcite (c).
X 20 Low. Rapitan, Section UB 2, 1,755 feet above base of section.

Fig. 3 Isotropic dark red, rounded silty mudstone(md) clasts, quartz(q) grains and limestone(ls) clasts in a fine grained argillaceous matrix. Minor secondary calcite(c) cement.
X 20 Low. Rapitan. Geol. Survey of Canada thin section.



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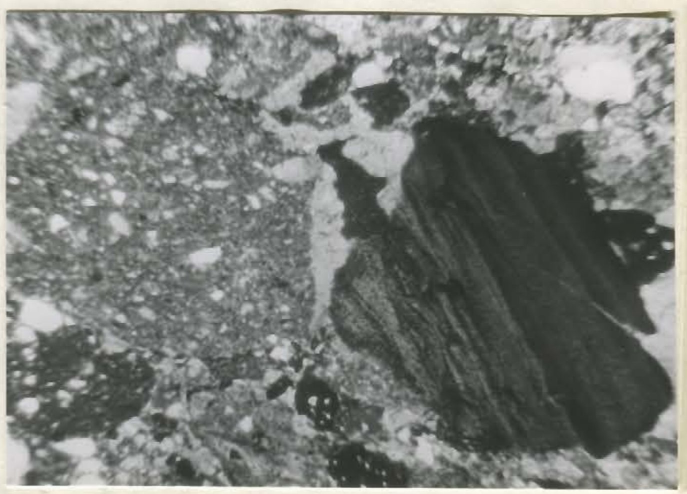

PLATE 7

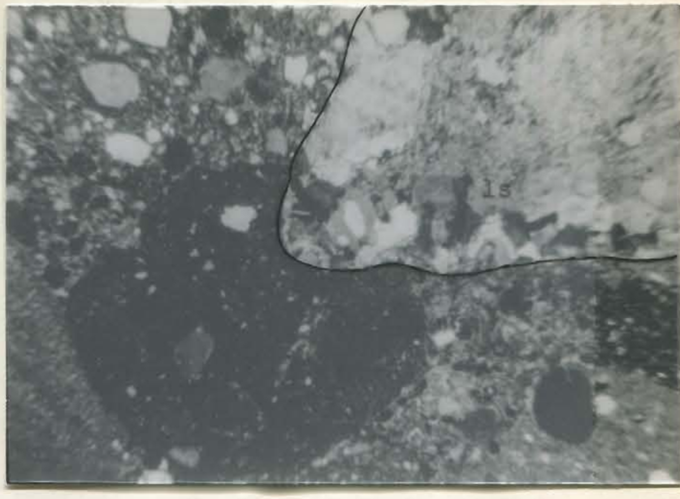

Fig. 1 Limestone(ls) clast intruding into dark red mudstone clast. Dark red mudstone was probably derived from inside the basin of sedimentation.
X 20 Low. Rapitan, Section UB 3, 335 feet above base of section.

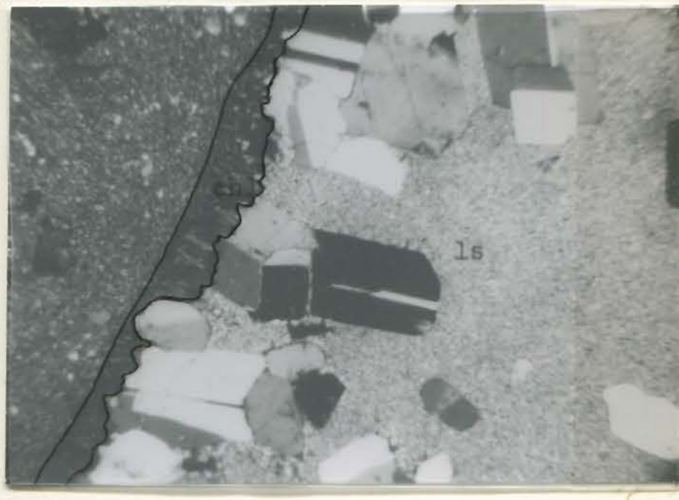

Fig. 2 Authigenic, euhedral albite crystals growing into a limestone(ls) clast. Outer rim is chlorite(chl).
X 20 Low. Rapitan, Section UB 3, 126 feet above base of section.

Fig. 3 Albite and chlorite almost completely replacing limestone clast. White is limestone. Matrix is slightly silty mud.
X 20 Low. Rapitan, Section UB 3, 126 feet above base of section.

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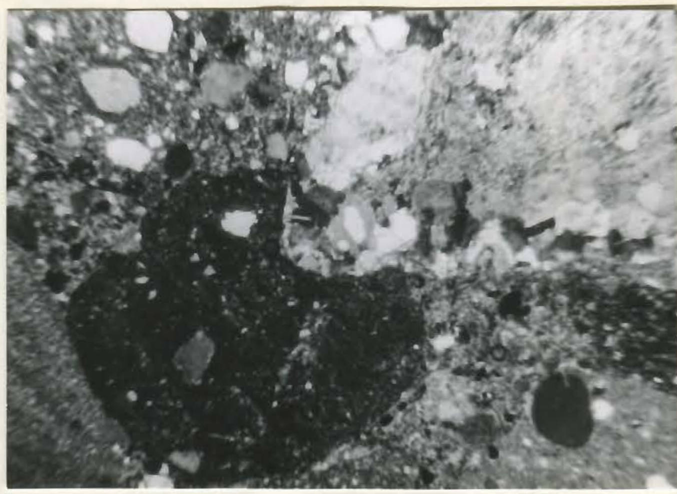

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PLATE 8

Fig.1 Lithic sandstone. Subangular to subrounded grains of quartz, orthoclase with shale or mudstone clasts in an altered clay matrix. Lower part of photo is mudstone. X 20 Low. Rapitan, Section UB I, 1,700 feet above base of section.

Fig.2 Lithic sandstone. Subangular to rounded quartz and feldspar grains, shale or mudstone clasts and rounded "rimmed" grains in altered clay matrix. Note poor sorting.
X 20 Low. Rapitan, Section UB 3, 300 feet above base of section.

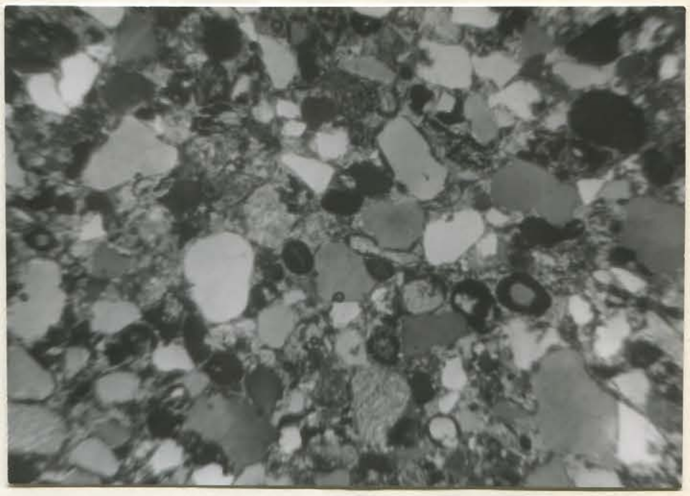

Fig.3 Lithic sandstone. Poorly sorted subangular to rounded quartz and feldspar grains, minor shale or mudstone clasts, two volcanic(v) fragments. Quartz overgrowth upper right(q).
X 20 Low. Rapitan, Section UB 3, 300 feet above base of section.

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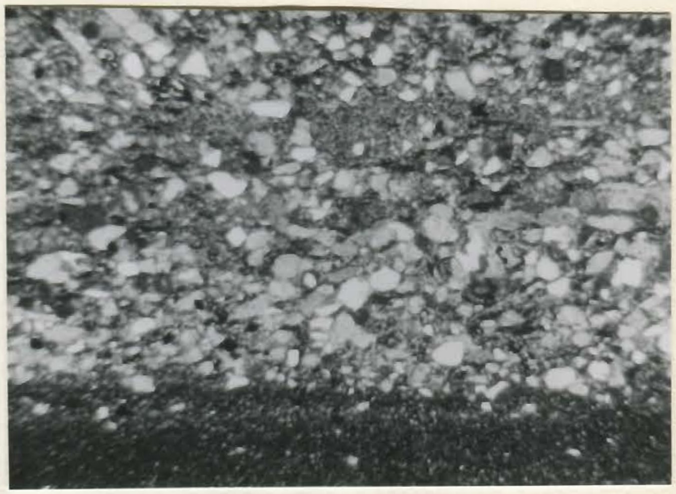

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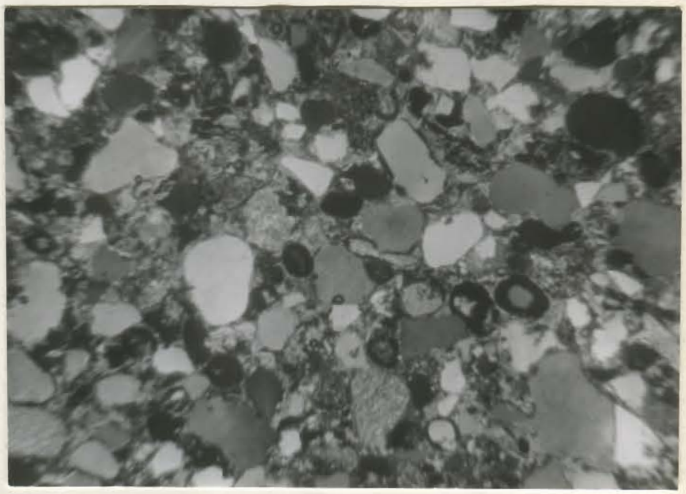

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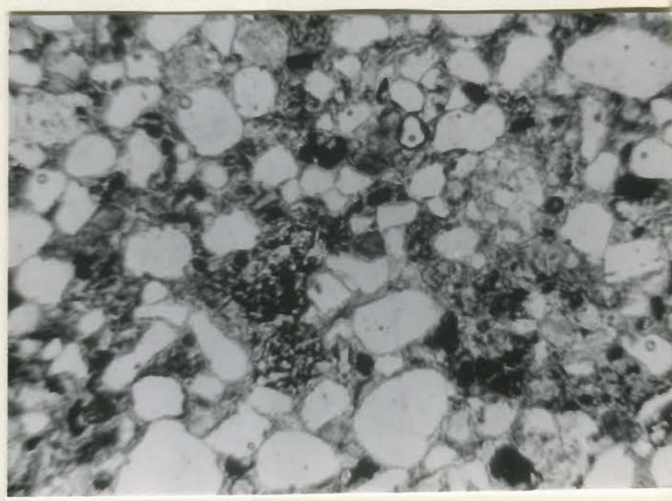


geneous mixture of few rock clasts, less than 2 mm. in size and mineral grains of all sizes with a maximum of 3 mm. The nature of the matrix is shown in Plate 9, Fig.1 and 2. It is composed of about 5 to 15 percent rock fragments, 15 to 30 percent mineral grains and the rest finer argillaceous material.

Of the mineral grains quartz and feldspar predominate. Three main types of quartz in decreasing order of abundance are:

1) clear quartz with abundant vacuoles and gas bubbles
2) composite quartz grains
3) quartz with rutile(?) needles (rare)

Grains are angular to rounded, with some well rounded. Some of the well rounded grains are fractured resulting in "half moon" shaped fragments. Detrital quartz grains range in size from .04 to 3 mm. Smaller less distinct grains are also present in the finer matrix. Most grains except the better rounded ones are somewhat corroded by calcite and recrystallized matrix minerals.

Orthoclase is the dominant feldspar but it is only about one third as abundant as quartz. It is generally clear, unaltered and somewhat smaller than quartz, not showing as great a range in size. Largest grains are about 1 to 1.5 mm. in diameter.

Lesser quantities of feldspar are perthite, microcline, and very minor plagioclase. These grains are partially altered to sericite especially their margins. Perthite is also replaced by irregular calcite patches, which in places almost completely supplants the feldspar.

Both sericite and calcite often replace individual feldspar grains.

Chert grains, igneous rock fragments, limestone fragments, and volcanic fragments less than 2 mm. in size are present in very small amounts. Most are partially replaced by calcite.

The shaly portion of the matrix is composed of rock detritus up to the silt grade with clay minerals sericite, chlorite and muscovite(?). Calcite occurs as small microscopic patches and as particles up to sand grade. The larger ones are obviously clastic being subangular or subrounded. Small pyrite grains, generally less than .01 mm. in diameter but reaching .5 mm., are scattered throughout the calc-shale matrix. Irregular "stringers" or darker patches of mudstone are in places in various stages of mixture with the shaly matrix.

The proportions of shaly matrix, sand fraction and coarser clasts vary noticeably throughout the section.

UPPER RAPITAN

Sandstone

Constituent minerals

Quartz

Detrital quartz comprises from 31 to 52 percent of the sandstones. Grains range in size from .08 to .32 mm., averaging .20 mm., but tend to vary greatly in size. Generally grains are subangular to angular with few rounded grains. Quartz grains with authigenic overgrowths have subrounded to rounded "dust rings". Generally encroachment and partial replacement by matrix and secondary calcite also has altered the grain shapes with the result that many are partially serrated. The predominant quartz type is either clear or has a slightly "dusty" appearance in thin section with straight or slightly undulose extinction. Quartz with abundant vacuoles and bubbles is common whereas quartz with rutile(?) needles is present in small quantities. Composite quartz grains are present in amounts varying from 0 to 1.6 percent and generally are interstitial. Quartz grains display three unique habits:

1) original detrital shape
2) locally interlocked grains showing irregular boundaries
3) irregular quartz overgrowths either giving the quartz grain a somewhat denticulated margin or welding more than one grain together.

The true amount and distribution of the secondary quartz has not been determined, because of the fine grained nature of the sandstones.

Feldspar

Orthoclase is the dominant feldspar, varying from 30 to 44 percent and being present in nearly equal proportion to quartz. Perthite and microcline are clearly subordinate being present from .5 to 2 percent. Plagioclase is present in amounts less than 2 percent and most often less than 1 percent.

Feldspar grains are generally subangular to subrounded with few larger grains being rounded. Plagioclase tends to be very small, .02 to .16 mm., interstitial and very angular. It is possible that some of the smaller angular ones especially "half-moon" shaped grains were probably formed by the refracturing of larger rounded grains along cleavage planes.

As a whole feldspar is fresh, especially orthoclase and perthite. Some alteration is present and is probably primary in that grains of the same feldspar types are found in different stages of the alteration process. Alteration is either by sericitization, kaolinitization, or calcitization. Sericitization is the dominant form of alteration with numerous sericite flakes either randomly scattered in the feldspar or aligned along cleavage planes. Some smaller grains, consisting of aggregates of sericite flakes generally randomly oriented, could represent completely altered feldspars. These are, however, rare. Very few feldspars are kaolinitized or have small scattered calcite patches in them.

Orthoclase is also present in minor quantities as authigenic overgrowths, which together with the quartz overgrowths act as a cement.

Minor Constituents

Chert, muscovite, and igneous (?) rock fragments are present in amounts varying from .2 to 1 percent. Chert and igneous rock fragments are generally interstitial. Muscovite occurs as flakes, averaging .1 mm. long, either interstitially or as elongate grains bent between quartz and feldspar grains.

Matrix

Matrix is clearly subordinate varying from 8 to 18 percent (Plate 9, Fig.3). It is a fine grained clayey matrix, altered to light green chlorite and sericite (Plate 10, Fig.1 and 2). In part it is probably an association of extremely fine feldspar, quartz, sericite and possibly muscovite representing the diagenetic reorganization of a feldspathic detrital mud. The matrix tends to be interstitial, the detrital grains generally being in contact with each other and being partially cemented by authigenic quartz and orthoclase. Occasionally some grains are surrounded by matrix.

Secondary Cement

Calcite and siderite are both present as secondary cements. Generally one is present at the exclusion of the other, but if both occur they are present in very small amounts. If alone, calcite forms up to 13 percent and siderite up to 11 percent, though both generally average about 6 percent of the rock.

Calcite occurs in irregular patches and is rarely uniformly oriented over an area so that it encloses many grains. Occasionally it has formed between fractures or cleavages in detrital grains and has wedged them apart. Chert and sometimes composite quartz grains are especially susceptible to replacement by calcite.

Siderite also occurs in patches but these show an euhedral development on the edges (Plate 10, Fig.1). It may have infilled small pore spaces in the sandstone.

Classification

Quantitative mineralogical classifications can be defined rigorously only on the basis of provenance and mineralogical maturity (Klein, 1963). Texture and textural maturity are recognized to be independant in these classifications. In classifying the Upper Rapitan sandstones, the mineral composition is determined by the detrital silt-sand fraction and chemical cements and detrital clays are disregarded. The author has followed van Andel's (1958) classification of sandstones largely because of its simplicity. The three major constituents have been recalculated to 100 percent from values obtained in point counting.

Considered as a whole the sandstones have a relatively narrow range in mineralogical composition (see Fig.5). It is evident that arkoses are the dominant sandstone type though probably authigenic feldspar growth on the clastic grains has increased the amount of feldspar.

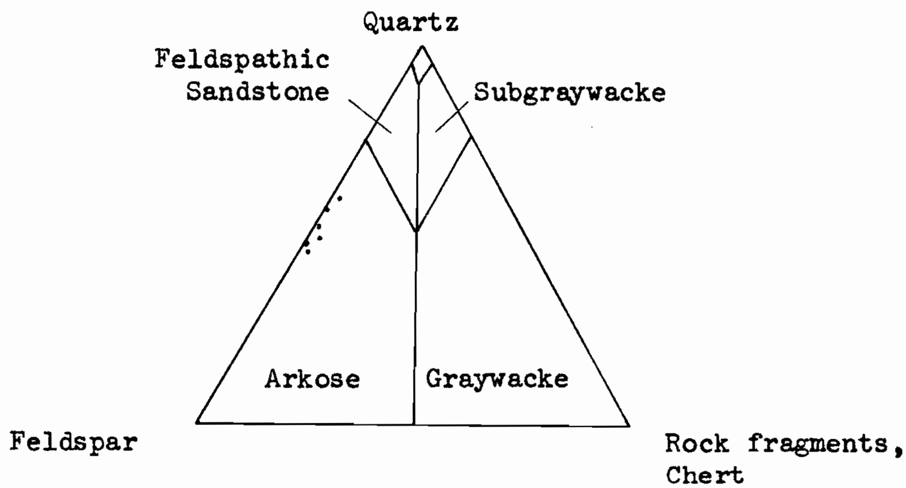


Fig.5 Mineralogical classification of Upper Rapitan sandstones (van Andel, 1958)

Constituent grains in the arkoses are subangular to subrounded with very few rounded. Sorting is poor to fair and matrix is always present. These sandstones are immature (Folk, 1951).

Shale

The Upper Rapitan shales, studied in thin section, consists of a heterogeneous assemblage of clay and silt size non clay minerals. These can be divided into two fractions: a silty fraction and a clay fraction. The silt fraction is made up of small angular grains of quartz, feldspar and muscovite(?). These are identifiable only when they are greater than .01 mm. in size. They are scattered throughout the clay minerals or are concentrated in thin, sometimes poorly graded laminae.

The clay fraction is generally altered to extremely fine, unoriented sericite flakes and pale green chlorite. Both fractions can be distinguished at times as fine silt laminations in a predominantly clay shale and vice versa. Some of the laminations in the pure clay mineral shales may be due to small amounts of carbonaceous material.

Calcite is rare to common occurring as irregular aggregates reaching a maximum diameter of .05 mm. Siderite is also present but reaches crystalline aggregates up to .1 mm. Both are noticeably less abundant or are completely absent in the clay fraction and calcite is only recognizable in the silt fraction.

Spectrochemical Analysis

Several selected shale samples were crushed into 1/8 to 1/4 inch fragments using a jaw crusher and a portion of these samples were ground to -200 mesh fineness with a Braun ceramic disc pulverizer. The powder from one sample was scanned on a General Electric XRD-3 X-ray spectrometer. The X-ray spectrometer used in the analytical work was equipped witha tungsten target X-ray tube and a lithium fluoride analyzing crystal. X-ray tube excitation was 50 kv and 35 ma.

A preliminary scan of the shale indicated that several trace elements were present. These were iron, manganese, chromium and titanium. Tungsten, zinc and copper were also present but peaks were probably due to background intensities in the apparatus.

Further trace element work is beyond the scope of this thesis. Future work might merit such investigations, but only upon completion of mapping in the southeastern Yukon and southwestern Northwest Territories. Such work might prove useful for economic mineral exploration.

Fig. 1 Middle Rapitan matrix. Rock and mineral fragments in a fine calcareous shaly matrix. Grains are angular to well rounded.
X 20 Middle Rapitan, Section UB 2, 3,150 feet above base of section.

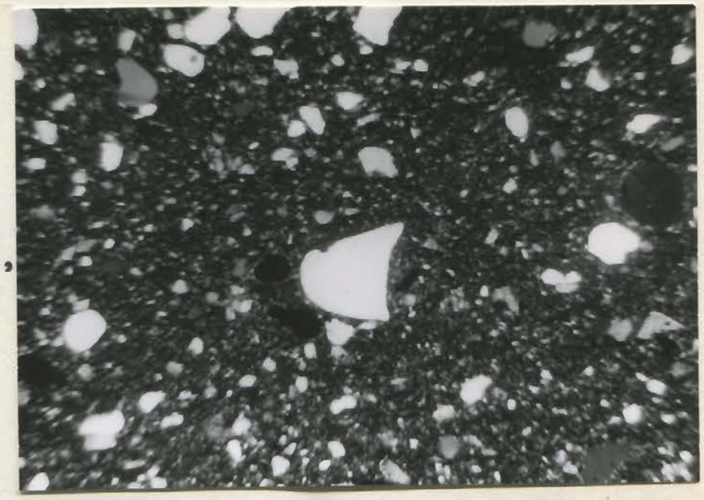


Fig. 2 Middle Rapitan matrix. Large volcanic clast (v), upper left, with subangular to rounded quartz and feldspar grains in a calcareous shaly matrix.
X 20 Middle Rapitan, Section UB 2, 3,150 feet above base of section.

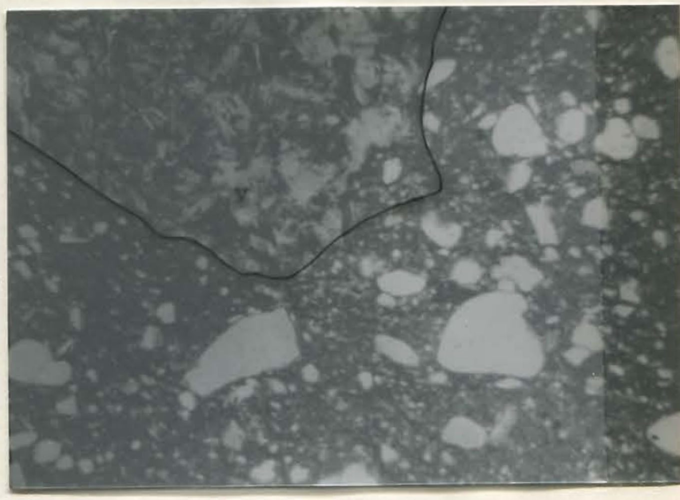
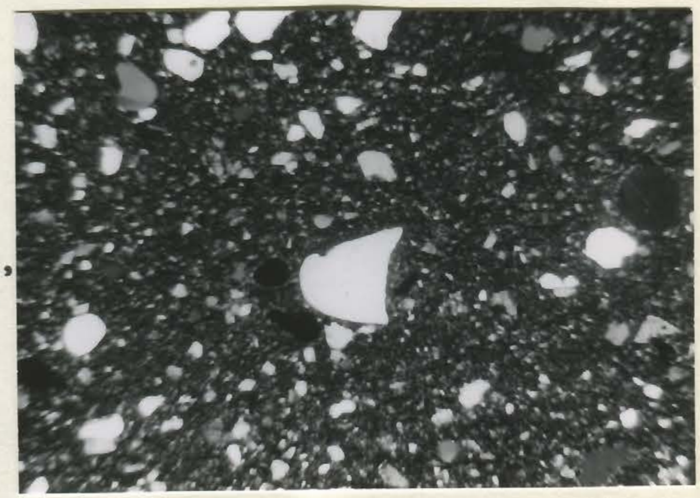


Fig. 3 Upper Rapitan arkoses. Note subangular to subrounded poorly sorted grains. Matrix is subordinate.
X 20 Upper Rapitan, Section UB 1, 5,945 feet above base of section.



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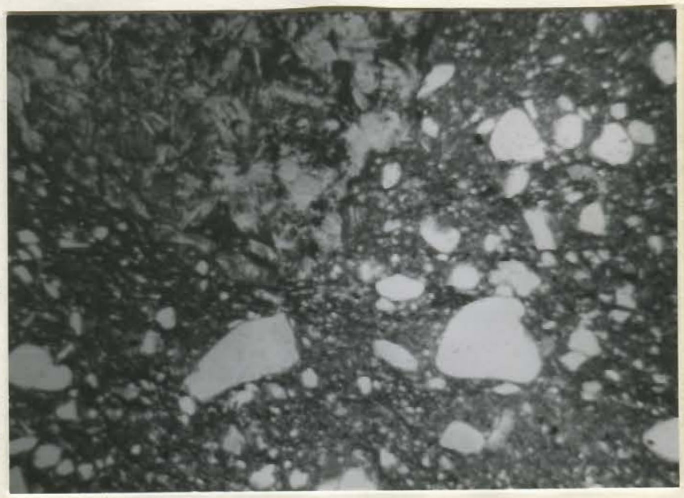

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X 20 Upper Rapitan, Section UB 1, 5,945 feet above base of section.

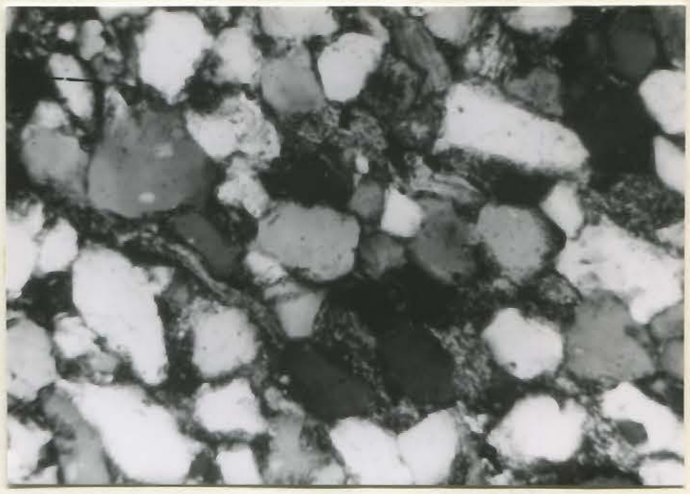


Fig. 1 Upper Rapitan arkose. Subangular to subrounded quartz and feldspar grains in altered clay matrix. Note overgrowths on some grains and calcite(c) and siderite(s) cement.
X 80 Upper Rapitan, Section UB 1, 5,945 feet above base of section.

(X nicols)

Fig. 2 Poorly sorted arkose. Quartz, orthoclase and minor plagioclase grains in sericitized clay matrix.
X 20 Upper Rapitan, Section UB 3, 5,617 feet above base of section.

(X nicols)

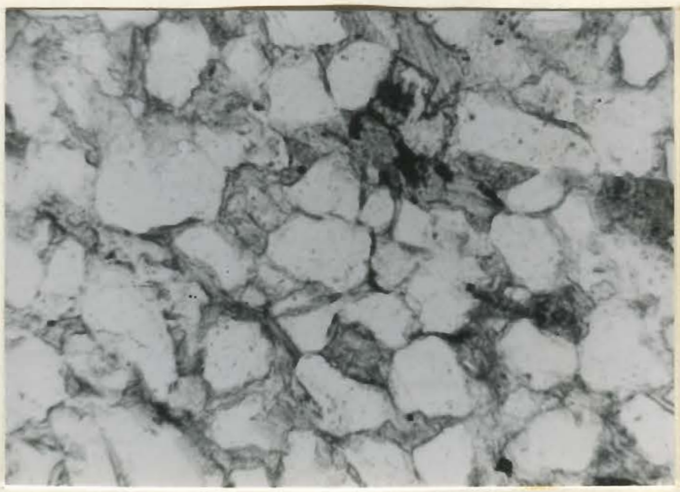
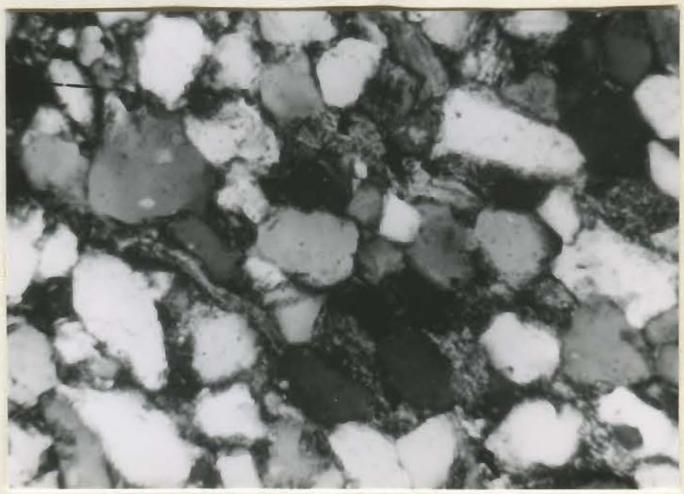


Fig. 1 Upper Rapitan arkose. Subangular to subrounded quartz and feldspar grains in altered clay matrix. Note overgrowths on some grains and calcite(c) and siderite(s) cement.
X 80 Upper Rapitan, Section UB 1, 5,945 feet above base of section.



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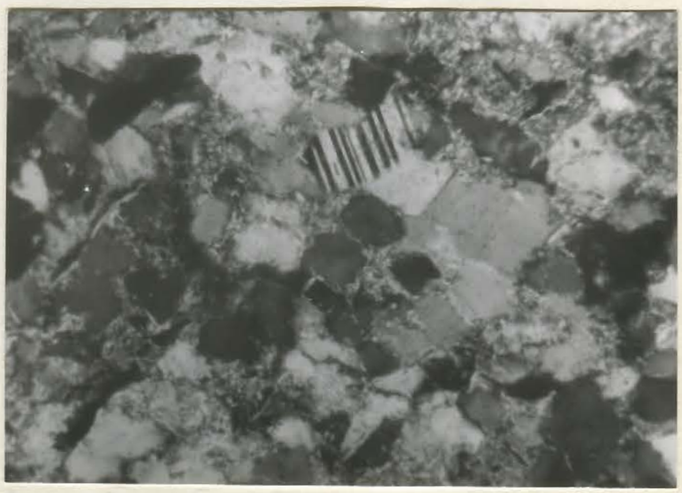

Fig. 2 Poorly sorted arkose. Quartz, orthoclase and minor plagioclase grains in sericitized clay matrix.
X 20 Upper Rapitan, Section UB 3, 5,617 feet above base of section.

(X nicols)

CHAPTER IV

PROVENANCE AND ENVIRONMENT OF DEPOSITION

LOWER RAPITAN

Interpretation of the provenance of the Lower Rapitan must be considered in terms of the predominant lithologic type, that is, maroon mudstone with interbeds of poorly sorted graded and nongraded conglomerates, the sedimentary structures present and the presence of iron formation.

Source

Limestone, dolostone, chert, sandstone and siltstone clasts within the conglomerates were derived from underlying strata. Uplift of the source land also initiated "cannabalistic" erosion of carbonates and mudstones which formed on stable shelves nearby as well as erosion of the older underlying carbonates and mudstones. The volcanic clasts are evidence of a period or periods of volcanism. Gabrielse (personal communication, 1965) reported that minor volcanics were interbedded with the Rapitan Group in the southeastern Thundercloud Range and other volcanics have been reported from the Tatonduk-Nation district in Alaska (Mertie, 1932; Brabb and Churkin, 1964, 1965). A volcanic source was present nearby, possibly to the west and southwest. Some volcanic and many carbonate and mudstone clasts were incorporated into the conglomerates in a semi-plastic state and thus were probably derived from an intra-basinal source.

Quartz and feldspar, mainly orthoclase and perthite, indicate an igneous source. Possibly some of this material was derived from the Canadian Shield to the east or from younger igneous plutonic bodies of unknown origin. Many quartz and feldspar grains have argillaceous and hematitic coatings and appear pseudo-oolitic but unlike oolites they possess no concentric or radial structure. These coated grains could indicate either rolling to and fro in a shallow shelf environment before later incorporation into conglomerates and sandstones or they could simply indicate enough current action to roll the grains over a muddy substratum.

Direction of source of most of the clastic material is not known at present. Several scour channels measured in the more conglomeratic beds show a north-south orientation.

Environment of deposition

Dominant mudstones and fine silts, few small scale ripple marks, suggest a low current velocity environment. Thin delicate laminations are abundant and are indicative of quiet water, and possibly deep water, deposition where the absence of bottom turbulence did not disturb such laminations. Sandstones, lithic sandstones and fine silts, when interbedded with the mudstones, often show graded bedding and individual sedimentation units tend to be thin, varying from less than 1 cm. to several inches. The thin silty graded and nongraded beds give the rock a distinct varve-like appearance in places. The uniformity of thickness of individual varve-like laminae, and the slight change in coloration could even suggest an annual control for these units. The main objection for each cycle being deposited seasonally would be their great thickness, which would imply very rapid deposition. Similar graded and varve-like beds have been reported by Pettijohn (1943) in the Archean sediments of the Canadian Shield.

Graded bedded siltstones and sandstones are the product of settling through comparatively still bottom water. Absence of current bedding and large-scale ripple marks support such a quiet bottom water. Some of these sandier and siltier graded beds possibly represent the last fine fractions of turbidity currents to be deposited, all the coarser material having settled out previously. Potter and Pettijohn (1963) suggested that turbidity currents, hydrodynamically distinct but closely related to mass flow, can deposit repetitious graded sand or silt layers, which closely resemble seasonal Pleistocene glacial varves. They may deposit coarser clastics as well.

Sandstones containing "rip-up" clasts of underlying strata, coated quartz and feldspar grains, as well as angular and poorly sorted grains indicate short distance of travel and rapid deposition. These grains and clasts were introduced by weak currents or turbidity flows into a muddier environment.

The periodic occurrence in the stratigraphic succession of coarse material, fine and coarse conglomerate, in a sense represent foreign intrusions into this zone of sedimentation. Generally conglomerates are poorly sorted, contain angular to subangular fragments and have a poorly sorted matrix. Most conglomerates are not laterally persistant either along strike or dip and are probably wedge-shaped basin margin accumulations that were deposited by turbidity currents having the characteristics of both slump and flow. Some vertical gradation of the thinner conglomerates is explained by progressive dilution with water and resultant loss of carrying power of the mixture as it passes any one given point. The abrupt lower contacts between conglomerates and mudstones or sandstones, with minor channel scouring indicate erosion of underlying beds. Further evidence for redeposition by turbidity currents is the presence of pseudo-oolites in poorly sorted conglomerates, which sometimes graded upward into mudstones. These were possibly of shallow water origin and were later mixed with coarser conglomeratic material when slumps or flows occurred. Grooves and flutes, considered by many geologists as typical of turbidity currents, are absent but their absence need only imply extremely low velocity turbidity currents rather than fast currents which would erode more easily.

The origin of the iron beds cannot be determined from the present rather regional study. The iron beds consist of thin layers of alternating steel gray hematite and red jasper with irregular fine sandstone and conglomerate interbeds. Gross (1965) concluded that the iron may have formed due to the alternating chemical deposition of silica and hematite rich layers in depressions on the ocean floor. Conglomerate and sand layers resulted from slumping and flowing of unconsolidated rocks from the basin shelf or adjacent fault scarps. Gross (ibid) observed that "some of the fine-grained clastic beds impregnated with hematite have the appearance of tuff or volcanic ash that has settled in soft hematite ooze. The hematite and silica are believed to have been carried in in solution by fumarolic waters and precipitated when these solutions were discharged on the sea floor along fault zones".

Condon (1964) favored the theory that the iron was deposited by precipitation of colloidal ferric oxide. He suggested that fresh tuffs and other igneous rocks supplied the iron to streams under rapid weathering conditions and that the iron was then deposited in marine waters by electrolytic action. Condon also has found that thin conglomerate and sandstone beds, interbedded with the jasper and hematite appear tuffaceous. The writer did not find such lithologies in the Rapitan Group at the stratigraphic sections studied.

The writer partially agrees with the views held by Gross (1965). Iron beds south of the North Redstone River and in the Thundercloud Range are of limited extent both vertically and laterally and may have formed in depressions in the ocean floor. They occur in the eastward and hence probably deeper part of the sedimentary basin but the occurrence of mud cracks, observed by the writer to be in close association with the iron beds, would imply relatively shallow water conditions. The ultimate source of the iron was volcanic, yet it was deposited by sedimentary processes.

MIDDLE RAPITAN

Any origin of the Middle Rapitan must satisfactorally explain the following observations:

1) probable subaqueous deposition of directly underlying and overlying strata

2) 250 mile lateral extent of the Middle Rapitan

3) thickness of the unit

4) lack of sorting and bedding of boulders and matrix

5) the preponderance of sandy matrix as compared to the relative sparseness of pebbles, cobbles and boulders

6) sudden beginning and end of the deposition of the coarse detritus, which do not grade upwards into finer deposits

7) the minor interbeds of finer sandstone within the coarse debris

8) the flat iron and faceted shape of some of the cobbles and pebbles

9) derivation of the coarse debris from a succession of underlying strata

Previous Interpretations

Norris, Price, and Mountjoy (1963) considered that the conglomeratic mudstone succession in the Snake River area occurs as a wedge-shaped unit and that pebble composition, locally derived from underlying units suggests that the succession represents a fanglomerate. In the south-east MacKenzie Mountains the Middle Rapitan is not wedge shaped but appears continuous throughout. Its reduction to a 50-foot thickness in the Thundercloud Range is not due to gradual pinching out but to erosion and truncation by Ordovician or Silurian carbonates of the Whittaker Formation.

Ziegler (1959) ascribed a tillite origin to two rock units from the Bonnet Plume River area and the Snake River area which were assigned to the early Paleozoic but which are now known to belong to the Middle

Rapitan. He concluded that these rocks were deposited by glaciers of continental or alpine proportions, extending into the sea. This would, in his opinion, account for boulders in such a fine shaly matrix and for the weak stratification of the deposits.

A glacial origin of the Middle Rapitan has much in its favor. The presence of mountainous relief has been indicated by Wheeler (1954) and such mountains are likely to possess glaciers. The conglomeratic mudstone was deposited by an agency which began and ended suddenly. It is inferred that boulders, blocks, cobbles and pebbles fell from cliffs or rolled down steep slopes onto the ice surface of glaciers or were plucked from the sides of an ice-filled valley. The fragments dropped from blocks of ice, either grounded or floating in shallow water resulting in a completely heterogeneous assemblage of unsorted fragments. At some later time deeper water could have encroached upon this environment permitting the deposition of sandstone beds. The deposition of underlying fine-grained detritus, interrupted during the formation of the Middle Rapitan conglomeratic mudstone, was resumed upon the cessation of such a possible period of glacial activity.

Pettijohn (1957) suggested that isolated pebbles, cobbles or boulders in fine grained evenly laminated sediments constituted strong evidence in favor of ice rafting and indicated a cold climate. Such pebbles, cobbles and boulders are present in the Lower Rapitan. However it is important to note that ice rafting need not invoke glaciation since it could result from seasonal freezing in temperate latitudes. Very abundant, widespread pebbles, cobbles and boulders, such as found in the Middle Rapitan, are difficult to explain by ice rafting, since such a process would require the ice to be extremely rich in encorporated clasts.

The evidence for a hypothesis of ice transportation is strong but one very important criteria for such an origin is lacking and that is a striated rock pavement. There is a possibility that such a pavement may be discovered with further mapping of areas to the north and northwest.

Other theories that have been proposed to explain such heterogeneous conglomeratic mudstones involve terrestrial mudflows, turbidity currents or turbidity flows or turbidity slumps.

Environment of Deposition

The writer concludes that the Middle Rapitan was laid down in a rapidly subsiding trough with a tectonically unstable and probably faulted borderland on the west side of the basin. Cobbles, boulders and few blocks could have been derived from distant and nearby exposures and subsequently rounded in streams or along beaches. Periodic mudflows or flash floods in high regions could provide debris that was in part faceted and striated. (Blackwelder, 1928). The clasts are predominantly composed of carbonates, most of which occur in strata beneath the pre-Rapitan unconformity. The volcanic clasts suggest that the source area was in part volcanic and the relatively small number of igneous and metamorphic clasts do not indicate a nearby plutonic source. The unstable shelves thus provided the boulders, rounded cobbles and pebbles along with some muds. This debris was subsequently carried into the trough by subaqueous slumps which developed into thixotropic turbid flows. Churning would destroy stratification and produce a heterogeneous unsorted till-like conglomeratic mudstone (Crowell, 1957).

There is no gradual decrease in the maximum size of the boulders from the bottom to the top of the Middle Rapitan as would be expected if a high fault scarp had been formed and later been worn down by erosion. Instead the evidence suggests that repeated uplift of the source, including movement along block faults, must have kept pace with sedimentation and provided a fairly steady but intermittent source for the material. The minor amounts of interbedded sandstones within the sequence could have been deposited during an interval of tectonic inactivity when there was perhaps an advance of the sea.

Evidence for and against a glacial origin of the conglomeratic mudstone as contrasted with a tectonic margin-slump and flow origin can best be summarized in the form of a table (Table 1).

TABLE I

Evidence	Glacial-Marine origin(GM)	Tectonic margin-slump origin(TM-S)	Evidence Favors
1) Subaqueous origin of underlying and overlying strata	Possible	Possible	-
2) 250 mile lateral extend of Middle Rapitan	Expected	Possible	-
3) Thickness of unit	Difficult to explain	Expected	TM-S

4) Lack of sorting and poor bedding of boulders and matrix	Expected	Expected	-
5) Sudden beginning and end of deposition of coarse debris	Expected	Expected	-
6) Minor interbeds of sandstone	Possible	Possible	-
7) Flatiron and faceted shape of some cobbles and pebbles	Could be explained by glacial origin	Such cobbles and pebbles could form in mud flows	-
8) Derivation of most of coarse debris from directly underlying strata	Difficult to explain	Can be explained by faulted or uplifted margin	TM-S
9) Lack of striated pavement	Difficult to explain	Expected	TM-S

The evidence presented in Table 1 shows 3 items in favor of a tectonic margin-slump and flow origin of the Middle Rapitan and 6 that could be expected of both origins. As mentioned previously, mountainous relief appears to have occurred in the Bonnet Plume area during Rapitan time (Wheeler, 1954). Personal communication (1966) with officers of Operation Porcupine, plus information obtained from an unpublished summary prepared by Dr. R.A. Price of the Geological Survey of Canada indicated that north-south or northwest-southeast trending faults and folds controlled in part the deposition of the Middle Rapitan. Geological relationships suggest that the area south of approximately 65°N, in the Bonnet Plume River area, stood high and may have acted as a source of much of the pebbles in the Rapitan Group, with the result that the Middle Rapitan gradually wedged out northward. There does not remain, in any part of the area observed by the writer in the southeastern Mackenzie Mountains, a trace of such a source envisaged above. The direction of original source is postulated from the west and northwest and the remains of block faults in the source area must be buried.

Rocks similar to the Middle Rapitan are widespread in the Late Proterozoic. They occur in southeastern British Columbia and southwestern Alberta (Toby conglomerate) and in the Wasatch Ranges of Utah (Walker, 1926; Blackwelder, 1932). If these rocks are correlative it might be possible to argue for a Cordillera wide period of glaciation, since Blackwelder (1932) attributed a glacial origin to the conglomeratic mudstones in Utah. Dott (1963) has reinterpreted these rocks and it has been suggested that they probably represent a rapidly subsiding negative tectonic trough stretching the length of the Cordillera (White, 1959).

UPPER RAPITAN

Paleocurrent Measurements

Directional sedimentary structures are numerous in the Upper Rapitan but due to the recessive and weathered nature of the outcrops only a limited number of observations were obtained.

In field observations, the pitch (angle between the line of strike and the lineation in the plane of the bedding) of the structure was measured rather than the plunge. The problem of rotating the observations back to the horizontal is much simpler with pitch than plunge. Transverse ripple marks, and scour channels indicate a line of movement whereas cross bedding and flute marks indicate a direction of current movement. Orientations of crests and troughs of ripples can be measured easily and the author has assumed that currents were oriented perpendicular to the associated orientations of crests and troughs.

All directional measurements made in the field for the Upper Rapitan are plotted in Fig.6. Lineations have been extended into two quadrants whereas current bedding and flute casts are confined to one quadrant.

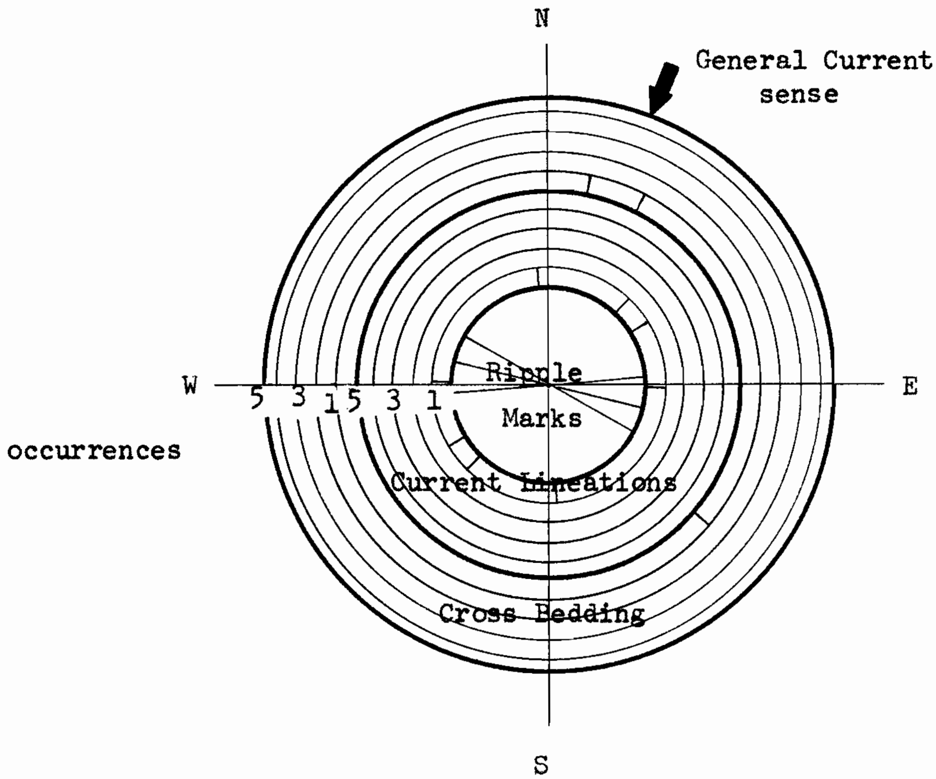

Fig.6 Paleocurrent measurements in the Upper Rapitan (10 measurements).

Although the data is extremely limited, Fig.6 shows a general current direction from about 020 degrees (azimuth).

Source Area

The mineralogy of the constituent grains of the sandstones indicate that they come from a terrain composed chiefly of acid plutonic rocks and possibly metamorphic rocks. The likely source of the chert and odd shale fragments is intrabasinal.

Paleocurrent measurements indicate a source roughly east of north for the Upper Rapitan. This data, together with an acid plutonic rock source, suggest that the Canadian Shield may have been the region from which these sediments were derived. Since the number of paleocurrent measurements is limited perhaps more current measurements might change the general current sense. Coarse feldspathic grits (Green and Roddick, 1960) which may be correlative to the Rapitan Group occur to the west (see Fig.7) and some feldspar may have been contributed to the Upper Rapitan from this source area.

Environment of Deposition

The Upper Rapitan is envisaged as having formed in a slope environment between a shallow shelf and a deeper bottom environment.

The clay forming the dominant shale lithology was probably carried in suspension. From time to time silty and perhaps slightly sandy clay was deposited with the shale. There were prolonged periods during which only clay and fine silty clay sized material was settling from suspension, resulting in fine even thin beds.

Sand generally of arkosic composition periodically flowed down the slope, perhaps set in motion by periods of turbulence of the water, and formed lenticular and thinly wedge-shaped beds. Flowage and slumpage phenomena such as load casts and recumbent folds would obviously be more likely to occur on a slope environment where the sands might be in a metastable state and thus be more susceptible to the effects of gravity. Except for the larger recumbent folds all direct evidences of flowage were within the sandstone beds.

Structures such as load casts, convolute laminations and slump or slide structures (recumbent folds), can occur in many kinds of sediments ranging from non-marine eolian, fluvial to shallow and deep marine. Ripple marks, current bedding and grooves indicate current action and nothing more (Dott and Howard, 1962). Most convolute laminations show evidence of plastic flow, generally on a small scale, and perhaps even some sliding of oversteepened laminae. Rich (1950) thought that convolute laminations were suggestive of slope deposits whereby water gradually squeezed out of overlying shale by the weight of later accumulations, found its way into the sand and the sand became a fine grained thixotropic mixture resulting in crumpled and distorted laminations in the beds. Stewart (1956), on the basis of laboratory experiments concluded that modern beach laminae, which closely resemble convolute laminae, were caused by disturbances due to vertical pore-fluid or air pressure gradients in newly-deposited sediments. Further studies by Williams (1960) found that water saturated silt and sand size grades are commonly deposited in a metastable, loosely packed condition due to intergranular adhesion and that after burial under considerable load, failure would result causing downslope gravity driven flow. Lateral laminations would result because the material would temporarily be in a state of very viscous fluid suspension. As stated earlier, convolute laminations alone cannot safely be regarded as conferring evidence of a slope environment, because they do occur under varied conditions. All subaqueous gravity movements imply bottom slope, but exact minimum angles cannot be established completely, although movements induced solely by loading would suggest slopes from 1/2 to 3 degrees (Boswell, 1961).

Some of the lenticular beds probably represent deposition as irregular beds on an uneven shale bottom, whereas few, especially those containing rare "rip-up" clasts of underlying shale represent partial erosion channels formed by slight turbid flows of the sand. Absence of flutes and grooves could reflect the presence of a traction carpet rather than slow currents.

The minor limestone interbeds represent shallowing and possibly stabler conditions. Water must have been shallow enough to allow light penetration for the growth of few stromatolites. Since the limestone is only a few feet thick, and present in only one section (UB 2) it probably represents a restricted environment of short duration since the underlying and overlying sediments are shales of probable deep water affinities. It also suggests the basin of deposition was quite variable in character.

Windermere Sedimentation, Southern Yukon and Northwest Territories

The full extent of Windermere (Late Proterozoic) sedimentation in southern Yukon and southwestern Northwest Territories is not fully known and is subject to change. Warren and Stelck (1958), thought that the eastern shoreline of the Windermere sea extended northward from Watson Lake to Ross River and then toward the Mackenzie River delta. The stratigraphic evidence presented here and more recent mapping indicates that this sea extended much further eastward, at least as far as the Cap Mountain area (Douglas and Norris, 1963).

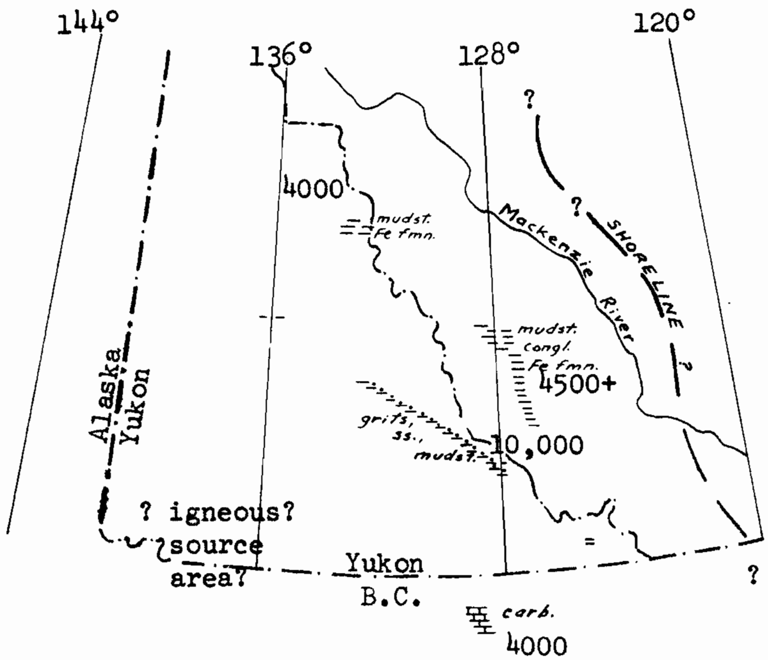

Fig.7 An approximate paleofacies map during Windermere time, southern Yukon, southwestern Northwest Territories and northern British Columbia. Abbreviations indicate predominant lithologies. Thicknesses are in feet.

Fig.7 shows an approximate paleofacies map during Windermere time in the southern Yukon, northern British Columbia and southwestern Northwest Territories. Dominant lithologies as well as approximate thicknesses show several fairly distinct lithologic zones. Great thicknesses, perhaps as much as 10,000 feet, of coarse feldspathic grits and green and maroon shales and mudstones extend in an arcuate belt northwest from near the Yukon-British Columbia border toward the Alaska border. These are probably in part a facies equivalent of the Rapitan but more definite relationships will be established with additional field studies. Carbonate sediments (Good Hope Group) are present in the McDame map-area and represent stable, relatively shallow water conditions (Gabrielse, 1963).

A location of a source area for the coarse grits is at present difficult to envisage. A source from the Canadian Shield to the north-east and east would involve too great a distance of transport for such coarse sediments. An alternate possibility is the presence of a crystalline source to the west (Fig.7). Again this presents problems in that the carbonate sediments, though not occupying a wide area (Fig.7), lie between such a source area and the grits. White (1959) also suggested that the Windermere sequence of sediments of British Columbia were in part derived from uplifted older strata nearby and in part from more distant older unknown Precambrian lands to the west.

Future work on a more regional scale westward and northwestward, toward the Bonnet Plume River area, is necessary to explain the provenance of these clastics.

CHAPTER V

CONCLUSIONS

Stratigraphic and petrographic study of the Rapitan Group, in the Southeastern MacKenzie Mountains indicate:

1) A major angular unconformity separates the Rapitan Group from underlying Precambrian (Beltian) strata.
2) The Rapitan Group can be divided into three units, each of formational rank, and separated by unconformities(?). In this thesis these units were designated the Lower Rapitan, Middle Rapitan and Upper Rapitan.
3) The Lower Rapitan is predominantly maroon mudstone, with some conglomerates, lithic sandstones and iron formation. The Lower Rapitan is considered as having formed in a rather deep water environment, periodically disturbed by turbidity currents that formed conglomerates and some sandstones.
4) The Middle Rapitan is a poorly sorted heterogeneous conglomeratic mudstone, that was probably laid down in a rapidly subsiding trough with a faulted unstable borderland.
5) The Upper Rapitan, predominantly shales with minor sandstone were formed in a slope environment where sand could periodically flow down the slope, forming thin lenticular beds.

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APPENDIX A

Thin section composition

LOWER RAPITAN SANDSTONE COMPOSITION (percent)

Thin Section	Quartz	Orthoclase	Plagioclase	Mudstone or Shale Fragments	Volcanic Fragments	Red Mudstone Fragments	Calcite Cement	Mudstone Matrix	Chert
UB 1-1750	19.2	6.6	.4	17.2	.2	4.6	23.8	26.6	-
UB 1-1770	7.2	9.6	-	4.6	-	3.4	39.0	35.0	-
UB 1-2625	15.0	6.8	.4	25.8	-	13.6	28.8	9.8	-
UB 3-300	31.2	13.0	1.4	8.6	.2	5.7	23.4	17.4	.2
Rd 63.135-900	21.4	9.2	.6	9.6	.6	3.8	5.4	47.2	2.2

UPPER RAPITAN SANDSTONE COMPOSITION (percent)

Thin Section	Quartz	Orthoclase	Plagioclase	Microcline	Comp. Quartz	Ign. Rock Fragments	Muscovite	Chert	Matrix	Calcite Cement	Siderite
UB 2-5950	40.4	44.6	1.4	-	.6	-	-	-	8.6	-	4.4
UB 2-4525	35.6	39.6	.3	1.6	.6	3	-	-	11.0	-	11.0
UB 1-5945	31.3	30.3	.3	1.0	.3	1.0	1.0	-	18.3	12.6	3.6
UB 2-6300	48.8	25.0	2.2	.8	.8	.4	-	.4	18.2	4.0	-
UB 2-3850	52.0	36.8	.8	-	1.6	-	-	-	8.0	.4	.4
UB 2-4700	43.0	36.8	2.6	-	.4	-	.2	-	10.6	-	6.4

Recalculated Percentages (100 percent)

	Quartz	Feldspar	Rock fragments and Chert
2-5950	47.1	52.9	-
2-4525	46.3	53.0	.7
1-5945	48.4	48.4	3.2
2-6300	63.0	35.7	1.3
2-3850	58.7	41.3	-
2-4700	52.1	47.3	.6

APPENDIX B

Stratigraphic section description

Abbreviations used in the following stratigraphic sections are:

cryptogr.	-	cryptograined
dk	-	dark
f	-	fine
gr	-	grained
lt	-	light
med	-	medium
v	-	very
x'llne	-	crystalline

SECTION UB I

This section is well exposed approximately I0 miles northwest of Hayhook Lake, Northwest Territories (63°34'N, I27°02'W). The base of the section (map-unit 3 of Gabrielse et al, 1965) is truncated by a westerly dipping thrust fault.

Siltstone, lt. to med. green, v.f. grained, bedding ¼-I', weathers green-gray to buff and buff-red.

Sandstone, lt. green-gray, v.f. to f. gr., bedding I"-I½', weathers green-gray to gray, stained buff, cross bedded.

Covered interval.

Dolostone, lt. gray to whitish gray, f. gr., stromatolitic in part, weathers buff, orange and yellowish orange.

Sandstone, lt. gray to whitish gray, f. gr., bedding 6"-I½', weathers lt. gray, poor crossbeds, minor shale, black.

Covered interval.

Shale, black; siltstone, green-gray, v.f. gr., bedding ½-6", weathers dk. green-gray and brownish green.

Covered interval.

Shale, blue-black, cryptograined, slightly silty, bedding ¼-I", weathers dark gray to dark greenish brown in small angular fragments. Interbedded with thin lenses and beds of sandstone, light blue-gray to green-gray, very fine grained, laminated in part, some load structures, bedding 2"-I', weathers medium brown, greenish brown, whitish in places, platy.

Covered interval.

Sandstone, light blue-gray to dark gray, very fine grained, bedding I"-I½', finely laminated in part, minor ripple marks, poor cross bedding, load casts. Up to 40% interbeds of shale, blue-black, cryptograined, very slightly silty in places, fissile, weathers dark gray. Minor shaly sandstone.

Shale, blue-black, cryptograined, slightly silty in places, finely laminated, platy. Top of unit more resistant, siltier.

Covered interval. Shale talus.

Covered interval. Appears to be the same lithology as unit I9.

Mudstone, conglomeratic, matrix gray to brownish gray, slightly silty, calcareous, with 5-30% pebbles, cobbles and some boulders of gray limestone, dolostone, greenstone, black and gray chert, brown sandstone, minor granite, gneiss. Few pebbles, cobbles are faceted, with flat iron shapes. Most are sub rounded to rounded, few well rounded. Unit weathers brown, brownish gray, orange-brown, recessive. From 3280-3300 sandstone, calcareous, light gray, very fine grained, bedding I-2' (?), minor pyrite cubes scattered throughout, weathers brown to gray.

Mudstone, green, cryptograined, platy, weathers green-gray. Minor greenish gray limestone near top of unit.

Mudstone, reddish brown, cryptograined, finely laminated inpart, bedding I"-I' or more, weathers dark reddish brown, resistant. Few thin interbeds of reddish brown sandstone and fine pebbly conglomerate. Pebbles are gray limestone and dolostone, gray chert, brown mudstone, green mudstone, some have thin chlorite "skins", matrix red-brown mudstone. In places isolated cobbles, pebbles and boulders in mudstone matrix. Ripple marks at I975, 23I0. Mudcracks at 2440. Rather platy near top of unit. From 2870-2900, interbeds of red and purple jasper, reddish brown mudstone and thin gray hematite, weathering red, reddish brown and gray brown, resistant.

Covered interval. Red-brown mudstone talus.

Covered interval. Laminated red-brown mudstone talus.

Dolostone, lt.-med. gray, cryptogr.-v.f.gr., bedding ¼-2", platy in part, minor chert, weathers lt.-med. gray, stromatolitic at I580.

Limestone, dk. gray to black, v.f.gr., x'llne, bedding ¼-I", platy, weathers v.dk. gray, recessive. Minor dolostone.

Dolostone, lt. to med. gray, v.f.gr., x'llne, bedding ¼-I½", platy, weathers light orange to yellowish orange. Minor black limestone interbeds in upper I0 feet.

Conglomerate, coarse cobbles and boulders, sub rounded to well rounded, mainly dolomite, chert, matrix sandy dolostone, weathers gray.

Dolostone, lt. to purplish gray, cryptogr., bedding ½-I0", weathers orange, yellowish orange and reddish brown.

Dolostone, lt. to med. gray, cryptogr. to v.f.gr., x'llne, bedding 8"-I', laminated in places, weathers med. gray, minor chert nodules, lenses.

Dolostone, lt. gray to buff, cryptogr. to v.f.gr., x'llne, bedding I-I0", laminated in places, minor chert, stromatolitic at II25-II45, weathers light gray to light buff.

Dolostone, lt. gray, v.f.gr., bedding I0"-I', laminated in places, weathers gray. Minor orange dolostone interbeds. Stromatolitic at 945-949, I030-I060. Few nodules of purplish chert.

Dolostone, lt. to yellowish gray, v.f.gr. to cryptogr., bedding 4"-I0', laminated, weathers orange, gray, reddish orange. Dark gray chert lenses make up 20% of rock. Stromatolitic at 898-902, 904-905.

Dolostone, lt. gray, bluish gray and gray, cryptogr. to v.f.gr., crystalline, bedding ½-I0", wavy, finely laminated in part, weathers orange, buff, reddish brown and gray. Mudcracks at 500.

Dolostone, lt. blue-gray to gray, pisolitic, v.f.gr., weathers lt. gray.

Dolostone, lt. blue-gray, cryptogr., bedding ½-I', weathers orange.

Dolostone, blue-gray, cryptogr., bedding I-3', weathers gray with pink and buff stains. Stromatolitic at 220-228, 305-320.

Dolostone, dk. gray to blue-gray, cryptogr., bedding I-4', weathers lt. to dk. gray. Stromatolitic from I8-22. Minor black shale from 22-52. Quartzite from 52-92, white to greenish white, f.gr., bedding I-3', laminated in part, weathers light gray.

THRUST FAULT

SECTION UB 2

This section is exposed about 6 miles north of the Redstone River, District of Mackenzie at 63° I4' N, I27° 05' W.

Limestone,medium to dark gray,very f. gr. to med. gr.,crystalline, bedding $\frac{1}{4}$-2",wavy,weathers buff-gray from 7234-7290,gray above that. Shaly siltstone from 7380-7398,green gray,v.f.gr.,weathers brown to buff-brown.

Covered interval,shale and dark gray limestone,shaly
Dolostone,lt.to med. gray,med.gr.,x'llne,bedding I-2',weathers orange, Limestone from 7085-7090,7I33-7I74,med.to dk.gray,v.f.to med.gr., green gray shale from 7090-7095,7II5-7I30,7I74-7I89,bedding $\frac{1}{2}$-2", minor sandstone from 7095-7II5,lt.gray,v.f.gr. to f. gr.,bedding 6"-I
Sandstone,lt.gray,v.f.to coarse gr.,bedding $\frac{1}{2}$-2',weathers light gray, slightly recessive,cross bedded.

Mudstone,green-gray,cryptogr. to v.f.gr. silty,finely laminated in places,bedding $\frac{1}{4}$-6",platy,weathers green gray,stained brown,minor sandstone from 6280-63I0, fine to coarse gr.,green-gray,bedding I-4",weathers light to medium gray.

Partially covered interval.Minor gray to black limestone,v.f.gr., bedding 6"-I',weathers gray to buff-brown to orange,recessive.

Shale,green-gray,silty,cryptogr. to v.f.gr.,bedding $\frac{1}{2}$-2",platy,weathers green-gray,dolostone from 6035-6040,gray,v.f.gr.,stromatolitic, weathers orange and reddish orange.Minor green gray shaly siltstone.
Sandstone,med. greenish gray,v.f.gr.,bedding I0"-I$\frac{1}{2}$',weathers green-gray,resistant,minor green gray shale interbeds,recessive.

Shale,dark gray to green gray,cryptogr. to v.f.gr.,silty,bedding $\frac{1}{4}$"-4" platy,finely laminated in part,weathers gray and green-gray,many sandy and silty lenses,nappe-like slump folds in shale at 4785 and 5I65.
Sandstone from 4I50-4230,4525-4535,4550-4575,4685-4700,4704-4709, light gray to green gray,v.f.gr.,bedding I to 4" platy,weathers greenish brown,greenish gray and gray,many shale interbeds.Load cast s fairly common,few convolute laminations in thinner sand beds, ripple marks at5577.Sandstone often occurs in lenses.

Shale,black to green-black,bedding $\frac{1}{4}$-I",fissile,weathers dark green gray to brownish green in thin plates.At 4050 becomes greener,siltier and more resistant.

Sandstone,lt.gray to green-gray,f.gr.,feldspathic,bedding 8"-I$\frac{1}{2}$', weathers light gray to light green-gray in large 6-I0" fragments.

Shale,gray to green-gray,cryptogr.,silty in places,bedding $\frac{1}{4}$-3",finely laminated in places,weathers green-gray,yellowish in places,platy and recessive,minor conglomerate at 3505,shale clasts in sandy matrix.

Covered interval.Shale talus.

Conglomeratic mudstone,gray to green-gray,matrix sandy,calcareous, v.f.gr.,bedding not apparent,appears massive,contains 4-35 % clasts greater than $\frac{1}{4}$",and up to 2 feet in diameter. Pebbles,cobbles and boulders are limestone,gray dolostone,brown sandstone,greenstone, gray and black chert,subrounded to rounded,very few striated, faceted,weathers gray,green-gray,buff-brown in rather platy fragments. Minor sandstone from 2440-2442,green gray,v.f.gr.,slightly calcareous,appears to be a lens.

Mudstone,buff-brown,maroon,green,cryptogr., bedding I"-4',finely laminated in places,weathers gray,green and dark reddish brown. Thin interbeds and lenses of conglomerate ,fine to coarse,clasts are gray limestone,dolostone,green mudstone,sandstone,subangular to subrounded,matrix sandy mudstone,beds $\frac{1}{2}$-I0". Upper 150 feet are mudstone,with some isolated and scattered pebbles.
Limestone,black,med.gr.,x'llne,2'bed,contains few mudstone clasts.
Dolostone,lt.gray,f.gr.,20% cht nodules,gray and black,weathers buff.
Limestone,lt.gray,v.f.gr.,laminated in part,weathers light gray.
Dolostone,lt.gray.,v.f.gr.,x'llne,laminated in places,minor chert nodules,partially stromatolitic,weathers buff to orange.

Covered interval.Talus.

Limestone,dk.gray-black,v.f.gr.,x'llne,laminated in part,bedding 6"-I weathers light gray to medium gray.

Covered interval.Talus
Dolostone,lt.gray,v.f.gr.,laminated,weathers buff,mudcracks in places
Dolostone,reddish brown,v.f.gr.,lam.in places,bedding 6"-I$\frac{1}{2}$',weathers dark red-brown,shaly near top.
Covered interval.Talus

Dolostone,lt.greenish gray,v.f.gr.,bedding 4-I0",interbedded with shaly red-brown dol.,bedding $\frac{1}{4}$-$\frac{1}{2}$",fissile,recessive,weathers yellowish gray and reddish brown.

Dolostone,lt.gray,f.gr.,slightly silty,weathers buff to yellow-brown.
Sandstone,lt.gray,v.f.gr.,bedding 4"-I',weathers gray,buff,yellow.

Dolostone,med.gray,v.f.gr.,laminated in part,bedding I-I0",approx. I0 % black chert nodules,lenses,weathers buff to yellowish,slightly sandy in places.

Dolostone,lt.gray to blue-gray,v.f.gr.,bedding 4"-I',weathers light gray,minor black chert nodules and lenses.

Covered interval.Talus.

Dolostone,lt.gray,v.f.gr.,x'llne,bedding 2-I0",minor black chert,weathers gray.
Covered interval.Talus.

Dolostone,lt.gray,v.f.gr.,x'llne,laminated in part,bedding 4-8", no chert,weathers gray to slightly buff.

Dolostone,lt.blue-gray,v.f.gr.,bedding 2"-I$\frac{1}{2}$',laminated in part, weathers light gray,buff in parts.

Beginning of good outcrop.Base of section not exposed.

SECTION UB 3

This section is exposed west of the Keele River, Northwest Territories, at 63° 45' N, I28° I5' W . The Lower, Middle and Upper Rapitan were measured on nearby ridges and this represents a composite section. The base of the section is an angular unconformity.

20 Shale, black, cryptogr., slightly silty in places, bedding indistinct, recessive, weathers dark gray to black in small elongate fragments. Estimated thickness is I500 feet.

I9 Dolostone, light-med. gray, v.f.gr., x'llne, laminated in part, poorly exposed, weathers bright orange-brown to orange. Distinctive marker unit. Minor sandy dolostone, black shale and conglomerate with dolostone clasts, matrix gray dolostone.

I8 Covered interval. Green-gray shale talus, minor outcrop.

I7 Covered interval. Green-gray shale talus.

I6 Shale, green-gray to dark gray, cryptogr., bedding I-5", weathers green-gray, slightly buff, platy and fissile. Minor partings and thin (¼-½) interbeds dolomitic limestone, weathers buff brown, slightly orange.

I5 Covered interval. Shale talus.

I4 Shale, dark gray, black to green-gray, cryptogr., bedding ¼-2", platy, fissile, weathers dark green-gray and brown. Minor silty interbeds and lenses, shale also has silty "streaks" in it.

I3 Shale, green-gray, cryptogr., bedding ¼-I", finely laminated in part, weathers dark green-gray in thin "plates", minor light gray silty "streaks" and lenses. Lithology fairly uniform.

I2 Shale, med. gray, cryptogr., bedding ½-I", platy, weathers brown and orange, minor sandstone, wavy limestone partings (?).

II Covered interval.

I0 Shale, green-gray, cryptogr., slightly silty, bedding ¼-I", weathers gray, brown and buff-brown. Minor sandstone interbeds, gray to green-gray, v.f.gr., bedding ½-4", weathers green-gray.

9 Sandstone, Light green-gray to brown, v.f.gr., laminated in part, bedding ¼-I½', platy when thin bedded, weathers brown, gray, orange-brown. Minor shale partings.

8 Shale, dark green-gray, cryptogr., finely laminated in part, bedding ¼-I", platy, weathers buff and brown, some orange streaks. Minor sandstone interbeds, generally ½-2", some show convolute laminations.

7 Covered interval. Shale talus.

6 Shale, black to green-gray, cryptogr., silty in places, bedding ¼-5", weathers dark gray, green-gray, with orange and brown stains, some slumpage folds, with sandstone interbeds, reddish-browngreen-gray, v.f.gr., bedding I-2', weather green-gray, brown. Shale often has silty and sandy "streaks" and lenses.

5 Covered interval. Shale talus.

4 Conglomeratic mudstone, light green-gray, gray and dark gray, matrix f.gr., silty and sandy, minor pyrite crystals, bedding not evident, appears massive Pebbles, cobbles and odd boulders, subangular, subrounded, few rounded, few striated, faceted, make up 5-35 % of rock. Predominant pebble lithology is dolostone, limestone, greenstone, sandstone, gray and black chert, green mudstone, and igneous and metamorphic rock fragments. An unusual red "spotted" volcanic appears common near the top of the unit. Weathers brown and orange-brown, generally fairly recessive. Minor sandstone from 6I5-635 buff-brown, v.f.gr., with pyrite crystals, bedding (?), weathers brown with yellow stains.

3 Mudstone, maroon, laminated and "varved" in part, cryptogr., silty in places, bedding ½-4", isolated pebbles and cobbles scattered throughout in minor amounts(less than 2 %), weathers dark reddish brown. Minor sandy and fine pebble conglomerate interbeds and lenses.

2 Conglomerate, green-gray, clasts angular to subrounded, limestone, green mudstone, sandstone, chert, poorly sorted, matrix sandy mudstone, weathers gray. matrix subordinate, about I0-20 %. Average clast size ½-I".

I Mudstone, maroon, cryptogr., laminated in part, slightly silty in part, bedding ½-5", weathers red-brown, minor I-4" conglomerate interbeds.

UNCONFORMITY.