A STUDY OF ARCHEAN SEDIMENTS OF THE CANADIAN SHIELD

by

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APPENDIX

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Mr. H.F. Morrow, Chief Geologist of MacLeod-Cockshutt Mines, has kindly made available his collection of thin sections for examination during the course of the study.

INTRODUCTION

This thesis is based on the literature of Dominion and Provincial Surveys of Canada and other pertinent sources. In scope, this investigation does not include the Grenville Sub-province because of its indecisive geological relationship to the remainder of the Shield.

Archean rocks are classed as such because;

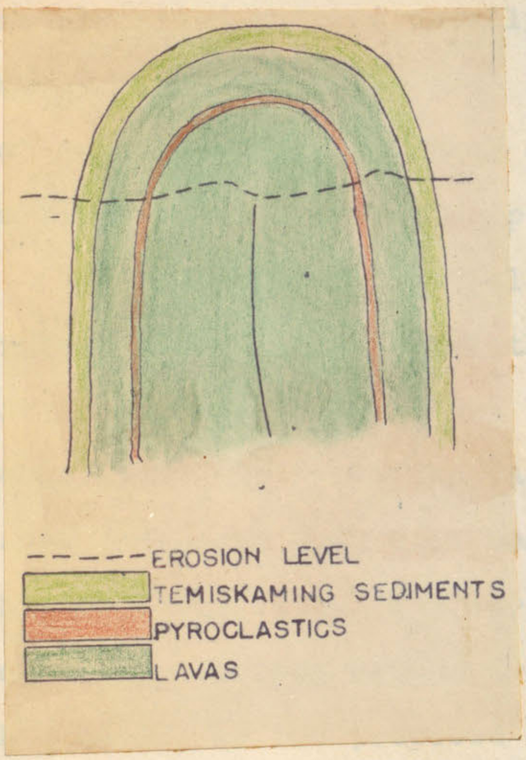
1. they consist largely of volcanics and illsorted sediments and when in contact with the less deformed (Algonkian Type) rocks are found to underlie them unconformably.

2. the sediments approximate lithologically the younger Algonkian group, but are more strongly deformed.

The purpose of this research is to render a summary of what is now known about the kinds and relative quantity of sediments comprising this ancient enigmatic rock assemblage. Time did not permit a more exhaustive examination of all reports published on these rocks; however, the writer believes the list of references of Appendix "A" (page 49) to be representative of that literature containing the better type of descriptive information. Thus, they are the basis of this thesis.

It is hoped that paths of research as suggested subsequently will be of contributory value to our knowledge of the Archean.

Rocks mapped as Archean today are merely the upended remnants of them. Erosion and peneplanation have exposed such deeply buried rocks that they are shown as usually isolated linear belts in a huge composite mass of crystalline granitic rocks. They are preserved today by virtue of their pre "Eparchean erosion" deformation, which has brought them to such attitudes as are favourable for preservation in a weathering environment. Cooke (A-23) has aptly illustrated this providence of deformation in connection with his method of estimating minimum amount of erosion. The diagram shows an erosion level truncating an upright isoclinal anticline. The younger bed in this case is not being eroded any quicker than the older, and consequently, has an equal chance of preservation. When other forms of deformation, such as faulting and intrusions, have not rendered the picture too complex, a fairly accurate idea of pre-deformation stratigraphy may be attained. However, such a simple situation, as pictured above, is seldom encountered in Archean assemblages.



DISTRIBUTION AND ATTITUDES

The distribution of Archean occurrences within the Shield is well shown on the Geological Map of Canada (Map 820A), published by the Geological Survey of Canada. In comparison with Algonkian rocks they are much more evenly distributed. Surface expressions of many Archean assemblages are elongated and are usually referred to as belts in literature. Since the rocks have been subjected to intense deformations, resulting in steep dips, a pronounced linear character is imparted to their outcrop shape.

The map on the following page depicts trends of known Archean assemblages across the Shield. This regularity of attitude in certain areas has been pointed out previously by Cooke (A-7) and Pettijohn (A-8). In a recent unpublished paper Professor J.E. Gill has shown that the Pre-Cambrian Shield is divisible into three geological provinces according to the strikes of the trends within these provinces. On this basis, he has proposed the following provinces:

THE SLAVE PROVINCE - That region of the Shield north of the line beginning south of Lake Athabaska, northeast to Chesterfield Inlet, in which Archean structure generally strikes north-south.

THE CHURCHILL PROVINCE - The area, southeast of the forementioned boundary and north of the line extending from north of Lake Winnipeg northeast to the mouth of the Nelson River, in which trends are northeast-southwest.

THE SUPERIOR PROVINCE - That part of the Shield south of the

OUTLINE MAP
Scale 1 inch = 230 miles

ARCHEAN TRENDS ACROSS THE SHIELD

Division Names According to Prof. J.E. Gill
(Unpublished Paper)

last defined boundary and including Ontario and western Quebec, exclusive of the Grenville Sub-province, in which trends are east-west.

Apparently, deformation of Archean rocks resulted from forces acting in at least three directions, presumably affecting three roughly separated areas. A systematic, detailed structural study of these trends may reveal genetic relationships between these forces and would greatly enhance our knowledge of the Archean age.

SELECTED DESCRIPTIONS OF ARCHEAN ASSEMBLAGES WHICH UNDERLIE ALGONKIAN TYPE FORMATIONS

The following is a brief descriptive resumé of Archean assemblages known to underlie unconformably less deformed Pre-Cambrian strata. On the next page is an outline map showing the order of description and distribution of areas under consideration. The object of this section is to present a concise picture of Archean stratigraphy as interpreted from the literature written about such areas.

CHIBOUGAMAU LAKE, QUEBEC

The easternmost area examined was that mapped by Norman and Mawdsley (M-21), the Chibougamau Lake region. The Archean sediments here overlie volcanic flows of intermediate composition, generally with some interbedded pyroclastics and sediments. The band of sediments is composed mainly of feldspathic clastics with lesser amounts of breccia and acid volcanics and a black coloured slate high in carbon. In outcrop they are 3500 feet wide; their thickness being approximately 3000 feet. The feldspathic sediments are medium to fine-grained. The medium-grained variety occurs in beds up to 20 feet thick and in thin section consists of sub-angular fragments of altered acid plagioclase with lesser quartz in a matrix of quartz and feldspar with some alteration minerals. This variety shows no evidence of sorting. The finer-grained variety is commonly thinly bedded and consists of a very fine-grained aggregate of quartz and feldspar

INDEX MAP
Scale 1 inch = 230 miles

SHOWING SEQUENCE OF DESCRIPTIONS OF ARCHEAN
ROCKS UNDERLYING ALGONKIAN FORMATIONS

with a little ziosite and lesser tremolite and actinolite. The authors believe the assemblage to be waterlain tuffs and pyroclastics largely derived from the underlying volcanics.

KIRKLAND LAKE TO ROUYN

Between Lake Timiskaming and Lake Abitibi a belt of east-west trending Archean sediments, beginning near Kirkland Lake in the west and ending near the Bell River in the east, is seen to be overlain by Algonkian sediments between Larder Lake and Rouyn. The easternmost area where the Algonkian sediments are present is about fifteen miles east of Dasserat Lake (M-18). Here they are underlain by two main rock groups, the mutual relations of which are in some doubt because of isoclinal folding and faulting. The older, named Keewatin, is mainly volcanic, the bulk being basalt occurring in layers 20 to 200 feet thick, with very little interbedded ash or breccia. With the basalts, but in lesser amounts, are rhyolites, dacites and trachytes. Tuffs and agglomerates are more commonly associated with the rhyolites. The authors of Memoir 166 believe the thicknesses of these lavas to be approximately 6 miles. Overlying the lavas with angular unconformity are conglomerate, greywacke and a little interbedded lava (Timiskaming sediments). The conglomerate member is at the base of the series and occurs in discontinuous lenses. It consists of pebbles and boulders of two types of syenite, a few of quartz and the rest of basic lava, embedded in a fine-grained greywacke matrix. The pebbles and boulders make up from 50% to 75% of the rock. The greywacke above the conglomerate is recrystallized into a schist and is believed to be originally composed of quartz, feldspar and mafic minerals. The lavas of this group are included with the greywacke member. Thicknesses of this group are doubtful but an estimate is about 2900 feet.

The western extension of this band from Larder Lake to Kenogami Lake has been described by Cooke (M-14). In the vicinity of Kenogami Lake, the older volcanic group contains an unusually large amount of interbedded tuffs, in mostly basaltic lavas, with some iron formation made up of bands of silica and magnetite. At Larder Lake the lavas with their associated tuffs and iron formation are similar. On the following page is a section of a tuff band south of Otto Lake to the south of Swastika Station. It illustrates the delicate banding characteristic of some tuffs.

SECTION OF A TUFF BAND SOUTH OF OTTO LAKE

Fine-grained, thin bedded tuffs, somewhat impregnated with pyrite	6'
Coarse tuffs, containing fragments up to 1"	70'
Thin bedded tuffs	22'
Basalt	93'
Coarse tuffs, basalt fragments up to 7" with an occasional granite pebble	400'
Mud rock, rather coarse-grained	30'
Coarse, pebbly tuff 20' grading downward to 5', thin bedded tuff 80'	100'
Iron formation, banded silica and magnetite	43'
Basalt	30'
Iron formation, banded silica and magnetite	35'
Thin bedded tuffs	90'
Thickly bedded, massive tuff, grain 1 mm. average	60'
Finer-grained tuff, with basalt and granite pebbles	3'
Thick bedded tuff, grain averaging 1 mm.	156'
Black Slate and greywacke impregnated with pyrite	40'
Light grey, thin bedded tuffs	40'
Sandy tuff impregnated with pyrite	57'
Fine-grained blackish tuff, contains much biotite	6'
Black slate heavily pyritized	6'
Grey thin bedded tuff	31'
Coarse breccia, heavily pyritized in lower 135'	170'
Light grey, thin bedded tuffs	90'
Total thickness	1,578'

Basalt flows at least 330'

The younger sedimentary group in the vicinity of Larder Lake is thicker than the westward extension of it at Kenogami Lake. It is made up of a basal conglomerate, the nature of which appears to vary depending on the nature of the floor on which it rests, sandy greywacke slate, basalt and soda-trachyte. Greywacke comprises the bulk of the sediments. The colour is a variable light to dark grey and texturally it ranges from a coarse angular grained sandstone to a very fine well bedded type. In thin section it is a sandy aggregate; the grains varying in size between .5 mm and .1 mm and consisting of from 5% to 50% quartz and the remainder feldspar with a little sericite. The feldspar has altered to kaolin, sericite and calcite with some secondary albite. Thomson (0-17) has gone into more detail on this region. The younger (Temiskaming) sediments are overlain by presumably conformable acid and basic lavas which make up a large percentage of the section. These may be the basalts and soda-trachyte of which Cooke speaks and they are distinguished from the Keewatin volcanics by the larger amounts of associated pyroclastics and sediments. As he describes it, the sedimentary phases of the group consist of a basal conglomerate overlain by greywacke, arkose, quartzite, slate and iron formation. The conglomerate has an arkosic matrix and the greywacke grades in individual beds, from a sandy variety at the bottom to a slate at the top.

At the same latitude and extending for about 100 miles east of the Ontario boundary is a wide continuous belt of sediments and altered derivatives collectively called the

Pontiac Series. Their westernmost occurrence underlies the Algonkian representative of the area. Lithologically the Pontiac Series is divisible into three classes:

(1) Biotite and hornblende schists

(2) Amphibolite

(3) Greywacke, arkose and conglomerate.

This series occupies the upper horizons of Wilson's (M-4) Abitibi Group (Keewatin). Subsequent studies by Gunning and Ambrose, Norman, Wilson and others show the belt to be extremely complicated by strike faults and isoclinal folding. The diverse interpretations found in the literature of this area, which are still to be solved, render the series of little value to this discussion.

MATACHEWAN DISTRICT

Approximately sixteen miles west of Kenogami Lake in the Matachewan District, Cooke (M-12) has divided the Archean rocks into two groups. The lower assemblage is volcanic, being made up of rhyolite, andesite and basalt flows with peridotite intrusive into the rhyolite flow. The so-called tuffs in the group are associated with the rhyolite and vary in thickness from 200 feet to 3000 feet. They grade in character from cherty tuffs, slates and arkoses. Cooke likens the group to the Abitibi volcanics. Unconformably above these is a sedimentary group comprising conglomerate, arkoses and slates. The conglomerate lies directly on the rhyolite varying in thickness erratically from 30 feet to 3000 feet. Pebbles are angular or rounded and occur laterally in accumulations of pebbles of dominantly one kind; that is, in places there may be accumulations of rhyolite, or of granite pebbles. The conglomerate with greenstone pebbles usually has a greenstone derived matrix. Arkoses overlie the conglomerate and some lenses of conglomerate are interbedded with it. The maximum thickness for the whole group is about 6000 feet and bedding in the arkoses shows as a change in grain size. The grains are of rhyolitic composition and are embedded in a finer-grained matrix of the same character. Between the conglomerate and arkose is a thin continuous band of greenish-black slate.

VILLEMARIE AND GUILLET (MUD) LAKE, QUEBEC

Eight miles east of Fort Temiskaming on Lake Temiskaming Henderson (M-23) has subdivided the Archean into underlying volcanics and overlying sediments. The former consists of andesites and basalts with associated tuffs and agglomerates. Iron formation, consisting of thin bands of magnetite-rich quartz, and quartz, is interbedded with the basic lavas. Overlying the volcanics with a gradational contact is a sedimentary series consisting mainly of greywacke with lesser amounts of arkose. Arkoses are composed of from 40% to 60% quartz and from 30% to 40% feldspar with a little white mica, carbonate, epidote and zoisite. The arkose is slightly conglomeratic in character.

LAKE TIMAGAMI

The Archean occurrences of the north-east portion of Lake Timagami (O-24) are mainly lavas with some schistose interbedded pyroclastics. The lowest volcanic group is mainly of rhyolites with acid tuffs, agglomerates and carbonate and sericite schist. They are overlain by basic lavas. Below all the volcanic rocks is a banded iron formation of a maximum thickness of 500 feet. It is associated with the tuffs, agglomerates and slaty rock. There has been little attempt to separate the complex.

ONAPING MAP AREA

Where exposed, the basement rock west of Lake Temiskaming (the Onaping Map Area (M-6)) has been included in a "schist complex" by Collins. This complex consists of a great variety of extrusive and intrusive rocks with minor amounts of sediments. The clastics are tuffs. Some ambiguity exists in Collins' Memoir about the relations of the tuff and its graded variations. It could not be determined whether the sedimentary bands were interbedded with volcanics or occurred as a separate unit.

NORTH SHORE OF LAKE HURON

From Falconbridge Township, northeast of Sudbury, trending south of west for 105 miles, to the shores of Lake Huron, is a belt of sediments popularly known as the Sudbury series and, presumably, of Upper Archean age. These sediments have been described as such by Quirke (M-7), Coleman (O-4), Collins (O-16 and M-15) and others. They are separated from the Huronian by what is called "the Basal Conglomerate of the

Bruce Series", with no angular discordance and include the Copper Cliff arkose and volcanics, McKim greywacke and the Mississagi (or Wanapitei) quartzite. Eskola, in 1922, was of the opinion that the Sudbury series are of Huronian age, but Collins was not convinced of this. In 1941 Cooke published two maps of the Sudbury Area with the Sudbury series classed as Huronian sediments. Fairbairn (O-20), in the same year, cited four showings, McCharles Lake, Kelley Lake, Ramsay Lake and Garson Sand Pit, where a conformable gradation between the McKim and Ramsay Lake formation was seen. He concluded, therefore, that the basal conglomerate of Collins (M-15) was not basal, if even conglomerate, and that the implication of unconformity by considering it as such was erroneous. The Archean rocks according to his findings would be represented then by what lies below the "revised Bruce Series". Collins (A-16) has described this lowest complex as an indivisible schisted complex of lavas and pyroclastics, iron formations and local sediments. The sedimentary phases of the complex comprise only a small fraction of the total. The iron formation already noted consists of grey bands of alternating fine-grained silica and black bands rich in magnetite.

LAKE NIPIGON DISTRICT

The next area in which Algonkian rocks are present is that area bordering the eastern shores of Lake Nipigon. Bruce (O-12) in his maps and description of the area subdivides the rock into a lower and upper group. The lower group is made up of lavas of basic and lesser intermediate composition with schisted interbedded tuffs and agglomerate. Iron formation occurs in thin contorted interbeds in bands about 50 feet thick. Overlying the lavas, with an unconformity of doubtful nature, is a series of sediments beginning at the base with a conglomerate and following with greywacke, slate and mica schists. The conglomerate has elongated pebbles of granite mixed with those that are more rounded, all being embedded in a greywacke matrix. The greywacke member is not well bedded except in the vicinity of iron formation lenses. It is made up of angular fragments of quartz and plagioclase in a matrix of feldspar with calcite and some sericite. Chlorite occurs in streaks, giving an overall greenish hue to the rocks.

Southwest of Lake Nipigon, Jolliffe (P-4) has mapped the Block Creek Area. Below the Eparchean Unconformity, formations which are separated by an unconformity, are similar to those found east of Lake Nipigon. The older formation is mostly andesitic lavas with interbeds of tuffaceous chert, sediments and an inferred iron formation. The base of the overlying sediments is a conglomerate containing pebbles of iron formation, granite and schist complex in a matrix of a sandy grit, probably a greywacke. The conglomerate has a minimum thickness of 3,000 feet. Above this rock are andesite lavas intercalated with sediments and silicified tuffs. The remainder of the series is made up of sediments which vary considerably in thickness and character. There is no cross bedding and well bedded phases alternate, in section, with massive ones. There are rapid variations from slate to arkose to greywacke over small areas.

LAKE SUPERIOR REGION

In the Fort William, Port Arthur district (M-14) the Archean divisions are described as a "schist complex of altered volcanic rock, chlorite, hornblende, biotite and sericite schist". The lavas are andesites and the presence of fine-grained, stratified fragmental greenstone has been noted. However, the schist complex has been generally undifferentiated.

The geology of the Pre-Cambrian areas in the district south and west of Lake Superior has been restated in the United States Geological Survey Professional Paper 184 (A-22). The lowest formation encountered in all regions is a "basement complex" dominantly made up of basaltic flows with interbeds of slate and some iron formation. In the Vermilion district (A-13) two distinct types have been found. The older one, the Ely Greenstone, is mainly of altered lavas. Overlying this is the Soudan formation, which is discordant to the lower group. It consists of a basal conglomerate with iron formation containing graphitic slates. The conglomerate pebbles are angular fragments of greenstone in a fine detrital greenstone matrix. The Knife Lake slates, previously considered to be Lower Huronian in age, now have been reclassified to an indistinct position between the basement complex and Huronian. The problem of this classification hinges on the question of where the major break (Eparchean Unconformity) of the Pre-Cambrian is to be placed in the stratigraphic column of this locality. The dominant member is a banded siliceous slate and greywacke with some intercalated conglomerate and iron formation.

LAKE ATHABASKA

Archean rocks have been given a local name (Tazin Group) by Alcock (M-22) in the Lake Athabaska region. It is dominantly sedimentary with locally interbedded greenstone volcanics. The succession has not been determined but the most abundant rock is a grey arkose grading into slaty and cherty quartzite. In thin section this rock consists of orthoclase, quartz, albite, zircon and iron oxide. Another section shows a peculiar interfingering of beds of rounded quartz grains and others of feldspar and quartz. There is a little carbonate rock, conglomerate and schisted varieties of the previously described rocks.

South of Great Slave Lake Henderson (A-23) has mapped metamorphosed sediments and volcanics. The sediments are mostly arkose and greywacke with some quartzite. Acid lavas, in one locality, were seen interstratified with the sediments; the sediments changing gradationally into schisted varieties.

GREAT SLAVE LAKE TO GREAT BEAR LAKE

On the northern shores of Great Slave Lake, east of Yellowknife Bay (P-3) the Archean division has been named the Yellowknife group. It consists of well bedded varieties of coarse and fine greywacke, slate and argillite, which overlie volcanics of intermediate composition. With the lavas are beds of breccia, tuff and agglomerate. Of the sedimentary group greywacke is the most common. It varies from fine to coarse varieties with cross bedding occurring at the base of the more well sorted varieties. They are largely recrystallized and contain quartz, some feldspar plus 20% to 30% of dark and light mica. The coarse-grained variety contains more quartz and feldspar and less mica. Conglomerate occurs separating the sedimentary beds from the volcanics.

In the Prosperous Lake Area, Yellowknife (P-2) the same Archean group has been much further sub-divided. The lowermost rock type is mostly andesite and basalt with some interbedded cherty tuff, agglomerate and carbonate rock. Overlying this, gradationally, are what are called the "Lower Sediments". The base of these consist of 700 feet of conglomeratic arkose and the next overlying 700 feet is of a fairly uniform arkosic grit. The grits are characterized by much variation in composition along and across the strike, with many beds showing crossbedding. Overlying the grits are small amounts of interbanded argillite, grit and limestone, with a few layers of conglomerate. The limestone member is very fine-grained, grey to buff coloured, and weathers in a rutted fashion. Above the "Lower Sediments" are the "Middle and Upper Sediments", with their metamorphosed equivalents. They are almost entirely interbedded greywacke and argillite, or slate with a dominance of greywacke. The greywacke is fine-grained and thinly bedded, 2 inches to 7 inches thick, and weathers grey to buff. In thin section, it is over 50% quartz and the rest are micas and chlorite with lesser feldspar and carbonate. Some beds more closely resemble impure quartzite than greywacke. Above this group are another series of andesite and dacite lavas with their associated pyroclastics.

One of the best sections across the lava-sediment contact zone of the region was obtained at Discovery Lake (P-4). The sediments here overlie two lava formations, the lower being mainly of andesite, dacite and basalt with associated tuff and the upper of dacite, rhyolite and breccia.

MAIN LAVA BODY

Sediments	450
Lavas	100 - 500
Garnetiferous tuff	0 - 50
Sediments	1,000
Lavas with intercalated sediments	100 - 1,000

MAIN BODY OF SEDIMENTS

The unaltered phases of the main sedimentary body include greywacke, argillite, slate, impure quartzite and arkose, all interbedded. Grain gradation is common and cross bedding is rare. The most common type of sediment is greywacke.

The northernmost area studied, where the Yellowknife group are present, is the Snare River and Ingray Lake Area (M-29). Here, the Archean group has four sub-divisions. The lowest is made up of andesitic lavas with lesser dacite and basalt, the upper part of which has a little interbanded rhyolitic tuff and breccia. Overlying this is another smaller group of more siliceous lavas. They are rhyolites with associated pyroclastics. Tuffs, finely bedded, comprise the bulk of the division. Above these two groups is a sedimentary group composed mainly of well bedded greywacke which grades into a slate at the top of each bed. There are also some grey arkose and quartzites which are variations of greywacke. A few thin beds of quartz-magnetite iron formation are interbedded. One peculiarity of the group is the remarkable persistence of beds along a strike. The fourth and uppermost division is the metamorphosed upper portion of the sedimentary group.

A COMPARISON OF ARCHEAN ASSEMBLAGES WHICH DIRECTLY UNDERLIE ALGONKIAN SEDIMENTS

(Below the Eparchean Unconformity, igneous intrusions excluded)

No.	Area	Succession (top to bottom)
M-21	CHIBOUGAMAU LAKE	Feldspathic sediments; breccia and acid volcanics, black slate Volcanic flows; mostly intermediate, some acid to basic lava pyroclastics and sediments
M-18	ROUYN - HARRICANAW AREA	Greywacke; with a little interbedded lava Conglomerate UNCONFORMITY Lavas; mostly basalts and lesser andesites, dasites and trachytes, rhyolite with associated tuffs
O-17	McGARRY AND McVITTIE TOWNSHIPS	Basic Volcanics and Acid Volcanics Fine-grained Sediments; greywacke, arkose, quartzite, slate, iron formation Conglomerates UNCONFORMITY Iron formation Basic volcanics Acid volcanics
M-12	MATACHEWAN DISTRICT	Arkoses Blackslate - a thin band Conglomerate UNCONFORMITY Rhyolite, andesite, basalt, tuffs
M-23	VILLEMARIE AND GUILLET (MUD) LAKE	Arkose and Greywacke with interbedded lenses of Conglomerates GRADATIONAL CONTACT Basalt, andesite, dacite, rhyolite - Tuff, agglomerate and iron formation
M-6	ONAPING MAP AREA	Schist Complex altered volcanic and intrusive iron formation and other sediments, undifferentiated
M-15	SUDBURY AND NORTH SHORE OF LAKE HURON	NO SUDBURY SERIES Complex of lavas, pyroclastics, iron formation and local sediments, highly altered and deformed
O-12	EAST OF LAKE NIPIGON	Greywacke, slate and mica schists Conglomerate, basal UNCONFORMITY? Mainly volcanics mostly basic, with a little iron formation
S-10	BLOCK CREEK S/E OF LAKE NIPIGON	Sediments, slate, arkose, greywacke Andesite flows in sediments Conglomerates with some lava flows UNCONFORMITY Schist complex, mainly andesite with some tuffs and sediments
M-19	FORT WILLIAM AND PORT ARTHUR AND THUNDER BAY	Schist complex, andesite lavas mostly, with fine-grained fragmentals
A-11	LAKE SUPERIOR REGION U.S.A.	Basement complex, mainly of basaltic flows with some slate and iron formation
A-13	SOUTH OF RAINY LAKE DISTRICT VERMILION DISTRICT	Slates; Iron formation; lenses of conglomerates Basal conglomerate UNCONFORMITY Altered Lavas (greenstone)
M-22	LAKE ATHABASKA REGION	Volcanics; mainly basic interbedded with a greater amount of sediments, conglomerate, argillite, quartzite and a little dolomite and limestone
A-22	SOUTH OF GREAT SLAVE LAKE	Sediments - mostly arkose and greywacke and a little quartzite; acid lavas interstratified
P-3	EAST OF YELLOWKNIFE BAY	Mostly greywacke Conglomerate UNCONFORMITY Volcanics - dacites, andesites, some basalt, breccias, tuffs and agglomerates
P-2	YELLOWKNIFE BAY	Upper Volcanics - andesite, dacite, tuff and agglomerate Middle and Upper Sediments - greywacke, argillite, slate, impure quartzite Lower Sediments Arkosic grit, limestone Lower Volcanics Andesite, basalt, chert, tuff, agglomerate
M-29	NORTH OF YELLOWKNIFE SNARE RIVER, INGRAY LAKE	Greywacke, slate, arkose, quartzite, phyllite Rhyolite, tuff, agglomerate, breccia Andesite, dacite, basalt, rhyolite, tuff, agglomerate, breccia

Conglomerate - Recognized rock groups which have known stratigraphic relations.

Arkose
Greywacke - Stratigraphy unknown.

STRATIGRAPHY

The foregoing descriptions, summarized in the preceding classification table, portray general variations in Archean stratigraphy. If only these areas are considered, the concept of the lower portions of Archean succession being mainly lavas and their clastic derivatives, while the upper zones are mostly sedimentary, is valid. However, this is not so. Observations of Lawson at Rainy Lake (M-3), Satterly at Dryden-Wabigoon (O-18), Bruce at the Pashkokogan-Misehkow Area (O-9), Prest at the Fort Hope Area (O-22), and Bateman at Uchi-Slate Lakes Area, show that quite often sediments of appreciable thicknesses occupy the lower horizons. It is interesting to note the concentration of this type in western Ontario.

Though the lithological aspect of the Keewatin-Timiskaming concept does not apply across the shield, many areas lend themselves to the dual classification of the concept. A cursory perusal of Archean classifications shows assemblages usually being separable by erosional unconformities and between lavas and sediments. Such divisions are of a purely descriptive nature and offer no evidence of being contemporaneous. From the viewpoint of deformation trends, there is suggestive evidence for, possibly, several periods of disturbance and, presumably, as many of erosion.

Archean sediments, when subdivided lithologically, are often misinterpreted. Geological interpretations of some areas undergo revision when adjacent mapping reveals some sedimentary divisions to be only local and representing no significant member within the sediments. Norman (A-27) has shown that the Cadillac group, east of Kirkland Lake, may be simply a lensed phase of the Kewagama group; the Kewagama and Cadillac groups geing originally defined by Gunning and Ambrose. The structure in this region is profoundly complicated by strike faults and many of the present problems of stratigraphy are due to these. In western Ontario Satterly and others have shown similar revision although these regions generally appear somewhat less complicated.

It appears then, that such revisions are the natural evolvings of geological thought as more information becomes available. Comprehension of the effects of folding, faulting and alteration is necessary before detailed stratigraphy is possible. Generally, the method of stratigraphic theorizing found in literature is to base such successions on assumptions of structure. These assumptions are biased according to the individual's geological training and experience and areas where conflicting structural evidences exist are often the bases of divergent hypotheses.

It is apparent from the literature examined, that much of this "evolving" is yet to be done.

GREYWACKE

In order to discuss this group of sediments effectively, we have to determine the variable interpretations of the term as used by field investigators. The original meaning of the term was concisely defined by Twenhofel (A-24). Greywacke, according to him, is the basic equivalent of an arkose containing a large amount of ferromagnesium minerals, and is formed in a very dry and cold region. The usage of the term in Archean literature has resulted in the corruption of its original meaning.

An examination of some of the better descriptions of greywackes (appendix B page 58) shows one textural feature predominating. They are rocks consisting of grains of sand size, of quartz and feldspar, embedded in a finer-grained, darker, mud-like, matrix. These two phases, grains and matrix, are present in extremely variable quantities.

The coarse phase is made up of grains of quartz predominately, with variable amounts of feldspar. The feldspar is usually plagioclase but quite often it is impossible to be identified as such. Angularity of grains is variable from rounded to angular but is usually described as subangular.

Greywacke matrix generally is recrystallized (see photomicrographs of Appendix E, page 71). The chemical nature of greywacke is doubtful as very few analyses were found in reports. However, it is interesting to note the comparison of the greywacke and slate of the Knife Lake series on the next page. Both contain about equal amounts of silica, but slates are

CHEMICAL ANALYSES OF ARCHEAN GREYWACKE SEDIMENTS

This table is a compilation of all the chemical analysis of the literature consulted.

	S/E PT. OF STURGEON LAKE O-7	COMPOSITE SAMPLE OF KIRKLAND LAKE, LAKE SHORE, TOUGH OAKES & CONTINENTAL PROPERTIES O-8	OLSEN BAY GNEISSES MANITOU-STORMY LAKE AREA COUCHICHING LAKE NEWATER	ANALYSES OF KITCHI SCHIST A-12		KNIFE LAKE SERIES A-10						DRYDEN AND WABIGOON O-18 GREYWACKE
						TYPICAL		JORDAN LAKE		SOUTH OF TOWER		
						SLATE	GREY	SLATE	GREY	SLATE	GREY	
SiO_2	64.04	63.55	73.17	61.35	70.76	54.71	61.39	64.05	64.37	63.88	61.44	66.65
TiO_2	.16	.48	1.01	.26	.33	.89	.62	.46	.34	.52	.53	.39
Al_2O_3	14.63	13.57	17.38	16.45	14.83	20.52	16.97	15.14	13.09	17.70	15.53	16.78
Fe_2O_3	1.07	1.31	1.03	.94	1.76	1.72	.39	1.07	.36	3.02	.97	.36
FeO	9.93	4.01	4.86	4.20	3.09	6.40	5.32	4.00	4.32	1.80	4.20	2.93
MnO	.03	-	-	-	-	-	.12	-	-	-	-	-
CaO	3.69	3.78	5.42	3.46	.36	1.63	3.21	3.65	3.49	2.72	7.06	3.25
MgO	1.81	2.50	1.57	3.12	1.99	4.76	3.84	2.10	2.98	3.72	3.74	1.86
Na_2O	4.84	5.00	3.09	5.24	.47	2.83	2.78	3.34	3.26	1.78	1.99	4.29
K_2O	.69	2.51	1.20	1.05	3.50	2.68	1.25	3.47	4.33	3.34	2.14	1.69
H_2O	2.01	1.67	1.04	2.61	2.79	3.40	2.50	1.60	1.24	1.10	1.16	.91
P_2O_5	.10	Trace	.12	.18	.26	-	.19	-	-	.58	-	.11
CO_2	.29	2.17	.29	1.98	-	-	.88	-	-	-	1.73	.49
			Total 100.18	100.18	99.84			1.70	1.92			99.78
			Sp.Gr. 2.811									

slightly higher in Al_2O_3, Fe_2O_3, FeO, and are lower in CaO.

Chemically these slates are probably similar to greywacke and, according to a recent classification of clastic rocks by Krynine (A-17), they may be a finer-grained variety of greywacke. The graph in Appendix D (page 69) shows greywacke divided into a high and a low rank type.

GREYWACKE TYPES

	High Rank	Low Rank
Quartz	47%	39%
Micas and Chlorite	23%	23%
Feldspar	20%	5%
Chalcedony	6%	21%
Carbonate	3%	7%
Clays	0%	6%
Iron Compounds	1%	1%

The high rank type usually contains two or more detrital clastic end members such as grains of chert, quartz, slate, schist or phyllite in a fine-grained matrix containing mica. Krynine believes this type to be the result of deposition in narrow, rapidly subsiding basins, frequently connected with volcanism.

The low rank variety differs in that it contains a lesser amount of feldspar and quartz grains and a higher amount of clayey material. They are formed, presumably, in broad, gently subsiding geosynclines.

If the matrix of high rank greywacke is removed the resulting type of rock, consisting of variable amounts of quartz and feldspar grains, may best be described as a feldspathic quartzite. Associations of the high rank greywacke and feldspathic quartzites are quite often found as alternating beds or as gradational features. In this respect Satterly (O-18) collectively calls the following assemblage greywacke.

> "The prevailing rock type in the sedimentary divisions is a fine to medium-grained, well bedded, light to dark rock composed ideally of alternating bands of recrystallized sandy and clayey matter or a mixture of such material. The rocks may be termed greywacke, phyllite or biotite-quartz schist."

The sedimentary member, Satterly mentions, is quite possibly the well bedded equivalent of a thick greywacke member; however, any specific band could be termed as impure quartzite or slate, etcetera.

Wilson (M-8) presented a description typically found in literature of the Archean.

> "In thin section, under the microscope the greywacke, arkose and conglomerate matrix are seen to consist of fragments of feldspar and quartz, and generally more or less corroded and granulated on their margins, embedded in a fine-grained matrix of the same minerals along with varying amounts of chlorite, sericite, carbonate and iron oxide.

The arkose differs from the greywacke merely in the smaller proportion of ferromagnesium material which it contains."

He expresses an idea which has found widespread application, that of greywacke being a gradational variant of arkose, but he has failed to define the dividing line between the two. Thomson (0-8), Horwood (0-16) and others have employed this elastic division in their field mapping.

In his report on the Geology of the Red Lake Area, Horwood has given the most complete description of greywacke found. He classifies three types; one a dark, fine-grained or slaty greywacke (normal); another a light medium-grained rock with some fragments and pebbles; and the last an arkosic type.

	Normal Dark Greywacke	Medium-Grained Rocks	Arkosic Type of Greywacke
Quartz	31%	19%	2%
Andesine	19%	55%	45%
Biotite	21%	19%	6%
Chlorite	13%		6%
White Mica	14%	6%	1%
Magnetite	2%		
Chlorite		1%	
Orthoclase			10%
Epidote			15%

This table, adapted from Horwood's report, is an illustration of how loosely the term greywacke has been applied. It appears that the original meaning of greywacke is not in keeping with what is commonly called greywacke in the Archean.

Information on thicknesses of individual beds is somewhat sketchy in reports. Such phrases as "thickly bedded", "alternating beds" and other vague connotations are generally used. It is assumed, then, that bedding, generally well shown in greywackes, is greatly variable in thickness. Two types of greywacke are apparently separable according to the nature of bedding and associations. One is the massive lithologically consistent greywacke, thickly bedded and including little of any other types of sediments; the other is the type of greywacke alternating with beds of "cleaner" varieties of feldspathic quartzite and slates, in which bedding is strikingly present and usually persistent along strike.

Grain gradation and sorting, rare in thickly bedded greywackes, are more common in thinly bedded composite types. Cross bedding is almost totally absent. Where it is found it is restricted to the "clean" type of sediment. The following are three occurrences of such types.

The Sickle Series of the Granville Lake District (S-9) are mostly quartz-feldspar sediments. They are coarse-grained, recrystallized, feldspathic sandstones and greywacke which grade into impure quartzite. There are some cross bedding and ripple marks. The Sickle Series is similar to the Missi Series 150 miles to the south. The most common sediment in the Beaulieu River Area, North West Territories (P-1) is greywacke.

Thicker beds are composed of coarser, more sandy material than those which are thinner and cross bedding is not common, but occurs at the base of more sandy beds. Rocks classified as impure quartzites and arkoses have a smaller content of mica and a larger content of quartz and feldspar and are coarser grained than greywacke. Alcock (M-22), in the Lake Athabaska region, describes one belt of sediments as a grey arkose grading into slaty and cherty quartzites. One thin section showed a peculiar interfingering of thin beds of rounded quartz grains and others of feldspar and quartz.

Where coarse-grained sediments are found comparatively free of a muddy matrix cross bedding is sometimes encountered, as in the Yellowknife Bay and Granville Lake region.

The photomicrographs of greywackes (appendix E) from the MacLeod-Cockshutt Mine, Ontario, show textures as revealed by microscopic observation compared with names assigned by megoscopic examination. Disregarding alteration effects on the rocks, the greatest primary textural variant is the relative amount of coarser grains compared to the matrix material. The classification of "high and low rank" greywacke (appendix D) as proposed by Krynine may have great practical value in the field, since it recognizes and defines this variant. It is seen that this method of classifying may encroach on the terms slate and mudstone since low rank greywacke is texturally similar. Unfortunately, chemical analyses of greywackes and slates are notably lacking in Archean literature and it is impossible to state whether or not Archean slates are true slates chemically.

sediments, therefore, would constitute a valuable and interesting study, both for general information and for evidence of genesis.

CONGLOMERATES

The character and distribution of conglomerates within Archean sedimentary rocks exhibit a varied nature. They are found in almost every formation either as a basal phase, lenses within other sediments, or as a separate horizon within a group. The shapes of the conglomerate members characteristically pinch and swell along the strike with extreme variations in thickness. Imbricate structure of primary origin has not been mentioned in the literature consulted, but many of the pebbles are deformed as a result of secondary forces.

Basal conglomerates generally are found lying unconformably above an older group. Many of these unconformities mentioned in reports are deduced from the observation of a conglomerate bed, presumably basal, which contains many granite boulders and pebbles. Pebbles and boulders in conglomerates are mostly well rounded and vary greatly in size, apparently dependent on the resistance of the rock type to erosion. Pettijohn (A-26) has compared their sphericity to those of Pleistocene gravels. Granite boulders are usually greater in size than those of other rocks. Thomson (A-4) states that rounding, sorting and heterogeneity of boulders and pebbles show they were deposited at a great distance from their source. An approximate estimate of the bouldery constituent of conglomerates, arrived at from inspections of pictures of conglomerates in reports, would be from 40% to 70%. Information on this type of estimate is scarce in literature. Cooke (M-14) gives a typical description in recording the conglomerates of the Timiskaming. He describes the rocks as variable in nature, depending on the character of the floor on which they rest. Pebbles and boulders are of basalt, gabbro, chert, cherty tuff, banded chert, red jasper, iron formation, etcetera embedded in a matrix of sandy greywacke. These pebbles are generally well rounded.

The extreme variation of pebble and boulder rock types are illustrated by the pebble-boulder counts found in appendix C (page 63). The bouldery constituent may show extreme local variance in volume per centage of the rocks and is exemplified by Bateman in the Uchi-Slate Lakes Area (O-15). Bedding in the matrix of basal conglomerates is poorly developed though there may be well bedded lenses of a finer clastic type within the conglomerate member.

Conglomerates that are known to occur as lenses and members within a sedimentary group do not differ greatly in their heterogeneous character from the basal type. In some cases, the pebble per centage of the rocks is very low. Tolman (A-19) mentions the sparse distribution of pebbles in the Opemiska series west of Lake Chibougamau. Sometimes conglomerate grades across strike into a sediment consisting of the same material as the conglomerate matrix. Wright (S-3) noted the matrix in conglomerate lenses as being well bedded in the Island Lake Area of Manitoba. Such an occurrence is strongly suggestive of the product resulting from the rafting of pebbles by ice into basins of presumably cyclic quiet deposition. It is doubtful if some of these occurrences are really conglomerate.

The matrix shows regularity in character in that it is usually the same as the sediment overlying and associated with it. In the Woman River and Ridout Area (M-17) the matrix is described as massive and banded argillite, greywacke, arkose and quartzite. This matrix passes gradationally into overlying sediments. Pettijohn (A-1) describes the matrix of both conglomerates and arkosites of the Abram Series as a coarse grit composed largely of feldspar and a little quartzite with conglomerate beds being separated in places by varved bands. Arkosic types of sediments and conglomerates show a tendency to occur together. However, the sediments associated with conglomerates depend to an extent on whether they are a gradational variant or whether conglomerates change abruptly to another type. Sometimes such a relationship depends on the character of the rocks from which it is derived. Prest (O-14) illustrates this in his recording of a conglomerate separating two volcanic horizons. The matrix is composed of fine volcanic material containing boulders of a variety of volcanic rocks. Apparently the area of derivation for this conglomerate was completely underlain by volcanics.

IRON FORMATION

Iron formation occurrences present one of the most enigmatic genetic problems of all sediments in the Archean. They are encountered at all horizons and associated with both sediments and volcanics. Only a few of the areas mapped are entirely free of them.

A typical occurrence has been recorded by Henderson (M-23) east of Lake Timiskaming. Here, the iron formation occurs interbedded with basic lavas, seldom being more than 40 feet thick. They consist of black cherty quartz, rich in magnetite, in layers up to ½ inch thick, alternating with wider bands of cherty blue quartz and occasional bands of chlorite or hornblende schist.

Collins (M-6) mentions another type seen in the Onaping Map Area. Iron formation here, is a phase of slaty rocks in which layers, rich in iron oxide, alternate with slate. The iron laminae are red or black and the whole occurrence never exceeds 100 feet in thickness. In Larder Lake District Wilson (M-2) describes them as occurring with greenstones and slate and consisting of banded jasper and magnetite. Portions of the report on the Geology of the Sandy Lake Area, Ontario (O-12A) by Satterly are worthy of reproduction here. He describes the iron formation in two sections, those occurring with lavas and the others interbedded with sediments.

> "Interbedded between andesite flows or diorite (amphibolite?) are some half-dozen bands of iron forma-

tion. These bands range from a few feet up to two hundred feet in width but average twenty feet, and are particularly abundant along the north shore of the lake from Hudson's Bay Company Post to Fishtail Point and were picked up at a few localities eastward on islands in the northeast arm.

The iron formation is of three types, one composed of interbedded magnetite and white sugary quartz; another of magnetite, chlorite and blue-grey quartz bands; and the third of black chert and magnetite. Some of the iron formation is so lean as to be merely a banded grey to black chert. The bands composing the iron formation range from paper-thin films up to one inch beds.

A typical succession is shown by the exposures from north to south on Fishtail Point, which showed the following formations in a total thickness of one thousand feet.

Black chert iron formation	12 feet
Diorite	
Black chert iron formation and bedded black cherts	200 feet
Diorite	
Iron Formation	40 feet
Diorite, fine grained andesite on south edge becoming coarser northward	
Iron formation	100 feet

Andesite	
Iron Formation	15 feet

The succession is continued after a slight gap on the west shore of the bay just west of Fishtail Point, with a thickness of 1,100 feet.

Andesite	
Pillowed grey basalt	
Iron Formation	11 feet
Pillowed grey basalt	25 feet
Andesite	

The diorites listed in the table may represent slowly cooled flows or perhaps sills. Elsewhere on the north shore andesite dikes cut across bands of iron formation and may represent feeders of flows and sills. The writer is still undecided whether or not the association of diorites and iron formation may not be explained by assuming that a given horizon of iron has been split up into a number of bands by sill-like injections of diorite.

Narrow bands of banded black chert, which in places attain a width of a few feet, were noted in several localities separating pillowed andesitic flows.

Banded, paper-thin, red jasper and black chert form a 2 inch band in black chert iron formation on the chain of islands 2½ miles east of the portage to Rahill

Lake. This material takes a good polish and can be used as a semi-precious stone."

Concerning the iron formation in the sediments Satterly has this to say:

"The variety of iron formation found as a member of the sedimentary group is very similar to that found in the volcanic group and is composed of alternating bands of sugary quartz and magnetite. On the South shore of Sandborn Bay, near the granite, the rocks consist of alternating bands composed of quartz and tremolite, and tremolite, actinolite and magnetite, with gradations and variations between these two combinations.

The above types show that the sedimentary assemblage consisted originally of conglomerate, micaceous sandstone and shale, with lesser amounts of other sediments. The interbedding of these three main varieties indicates oscillating conditions of sedimentation such as prevailed in rapid streams in continental areas. The iron formation shows that basins of quite shallow water existed locally, which gave the conditions necessary for its formation.

From the lithological character of the conglomerate and the abundance of the chert pebbles present, it is concluded that much of it was derived through the erosion of a banded cherty iron formation, the chert forming the pebbles and the iron sand being hydrothermally changed to pyrite or pyrrhotite. The presence, in two exposures, of boulders of chert-pebble conglomerate indicates the existence of older pebble conglomerates. These characters seem in keeping with their structural position."

These sections, quoted in their entirety, represent the better type of information on iron formation.

Much of the iron formation found in the Shield has been named "jaspilite" as defined by Leith and Van Hise and is thought to be formed by chemical precipitation. In appendix E a photograph shows "jaspilite" types of iron formation from widely separated areas. They are identical lithologically and structurally. They consist of delicately contorted bands of magnetite, jasper and coarser grained, probably recrystallized, clear quartz. However, some occurrences where iron formation contains no chert but is interlayered with slate, greywackes or quartzites appear to indicate a clastic origin. Quite possibly a combination of both origins could accomt for their presence. The overall consideration of this type of sediment could constitute a valuable research problem. Information in literature is abundant and usually well presented. One structural feature common to all such sediments is the characteristic layering usually persistent along strike.

CARBONATE ROCK

Sedimentary carbonate occurrences represent only a small fraction of Archean sediments. Quite often, where carbonate rock is found it is difficult to determine its origin. Such carbonate bodies as recorded in the Michipicoten (M-16) district are not of sedimentary origin. The carbonate member of the Archean in this region is located below iron formation. It is a mixture of carbonates with scattered pyrite present only in larger iron formation. Chemical and microscopic examination show the rock to be really a mixture of carbonates of Fe, Mg, Ca and mica, through which is sprinkled quartz and pyrite and remains of volcanic rocks. Wilson (M-4, page 68) offers five reasons for the origin of carbonates by thermal replacements in the following localities; Lake of the Woods, Aird Island Georgian Bay, Lake Timagami, Kenogami Lake, Lake Abitibi and Night Hawk Lake Porcupine District. He refers to the ferruginous dolomite frequently found in Archean rocks but there are other obviously sedimentary carbonate rocks.

Tolman (A-19) mentions their occurrence west of the Chibougamau District. Here, they occur as two narrow lenses in a clastic formation containing little argillaceous material. Tanton (M-10) in the Harricanaw-Turgeon River Basin describes bands of ankeritic and dolomitic carbonate alternating with slaty bands. Moore (0-13) in the Atikokan Area found a bluish limestone member in sediments underlain by a conglomerate and overlain by a ferruginous formation. The carbonate grades from buff to grey in colour and is largely recrystallized and silicified. Earlier, Lawson noted, in the same limestones, sponge-like masses which he thought were fossils. Limestone also occurs at Sandy and Spirit Lakes, North-west Ontario. It appears that Western Ontario Archean formations quite often include minor fractions of carbonate. Characteristically they are associated with sediments rather than volcanics. Stockwell (S-6), in the Reindeer Lake District of Manitoba, found impure limestone alternating with a quartzite over a maximum thickness of 10 feet. At Lake Athabaska (M-22) dolomite and limestone make up a fraction of the sedimentary series. In the Yellowknife Region Jolliffe (P-2) found limestone interbanded with grit and argillite and overlying arkosic grits.

These are some of the limestone occurrences throughout the Shield and serve to illustrate that, though their occurrence is sparse and widespread, the quantity is small. It must be remembered, however, that the origin of such carbonates is by no means clear and as pointed out by Wilson apparently much of the described limestones are replacements.

THINLY BEDDED MEMBERS

Fine-grained thinly bedded rocks occur within Archean sediments subordinate in volume to the greywackes and conglomerates. Characteristically, many occurrences closely resemble Pleistocene varved clays. Pettijohn (A-1) found them interbedded with coarse conglomerates and arkosites in North-west Ontario. They exhibit varve-like couplets with the lower half being a white weathering siltstone which grades upward into a dark grey fine-grained slate. They differ from Pleistocene types in the following ways:

- i Thickness of sections
- ii Thickness of varves which vary uniformly upward in Pleistocene clay, this not being so in Archean types
- iii No tillite nearby, only the conglomerate
- iv Greywacke gradation.

Beds of approximately the same character have been found in other areas but they comprise only a very small fraction of any formation. Perhaps the only other occurrences in the sediments with similar fine banding are iron formation. Eskola (A-18) believes the presence of such varved beds to be indicative of weathering in a temperate or cool climate. The material comprising them is mechanically ground and sorted and presents yearly evidence of banding. Most authors believe them to be indicative of a moderate to cool climate where decomposition is a subordinate weathering agent.

AN ESTIMATE OF THE RELATIVE QUANTITIES OF ARCHEAN SEDIMENTARY TYPES

Poorly sorted clastics are the dominant type of rock in Archean sediments. For purposes of estimating their relative per centages the sediments are divided into the following classes:

I "Muddy" sandstones: This term is used in a descriptive sense to include all variations of rocks called greywacke and some of the rocks termed impure quartzites. Texturally, they are inequigranular and are similar to Krynine's high rank greywacke. Where there is little of the coarser phase and the "mud" phase dominates the rock approaches a slaty type.

II "Clean" sandstone: This group is distinguished from the above by the almost complete absence of a finer grained "mud" phase and is mainly equigranular. The ratio of quartz to feldspar provides no satisfactory basis for sub-division in this class since proportions are extremely variable. However, to distinguish them from feldspar free "pure" quartzites, they may be termed "feldspathic" quartzites.

III Slates and argillites: These are fine-grained, dark grey, presumably equigranular, sediments; usually well bedded and occurring as thin lenses of variable sizes within a formation. They have never been found comprising a formation completely, though they may occur as alternating beds with greywacke and quartzite. The dividing line between this rock and low rank greywacke is indefinite.

The writer believes that some genetic relationship exists between the above groups. Frequently all three types are found in the same sedimentary assemblage although the first two may be found as separate formations with little of the other types.

IV Conglomerate and Arkose: Arkoses are included with conglomerates because they are found more often with the latter than with any other type. As opposed to "feldspathic" quartzites, they consist of inequigranular, angular grains with a bulk composition approximating that of granite. They are thick and indistinctly bedded.

V Iron Formation: Iron formation includes all sedimentary iron rich occurrences, regardless of associations with sedimentary types or volcanics. Occurrences may be subdivided as follows:

(a) "Jaspilite" - banded magnetite, jasper and chert

(b) Banded magnetite and sugary quartz

(c) Banded iron rich chert, chert and magnetite

(d) Banded magnetite and greywacke or tuff.

VI Carbonate Rocks: Only those carbonate occurrences which are reasonably thought to be of sedimentary origin are considered.

The author must caution the reader on the reliability of the following estimates. They are necessarily non-mathematical values based on literature in which such quantitative data are notably lacking. Further, it was found that estimating relative amounts by comparisons of formation thicknesses was even less reliable because:

(a) very few thicknesses are given in Archean literature;

(b) where conglomerate thicknesses are given, they usually represent maximum values of ill-defined, irregular sedimentary bodies;

(c) formations collectively called greywacke, impure quartzite, etcetera, were found often to have an appreciable amount of sediments belonging to other groups;

(d) the author had no reliable method of ascertaining the accuracy of thicknesses.

Estimated total amounts of the preceding types of Archean sediments are as follows:

Muddy sandstones	43%
Clean sandstones	25%
Slates and argillites	11%
Conglomerates and arkoses	17%
Iron formation	4%
Carbonate rocks	Trace
	100%

These figures represent an area rather than a volume consideration.

In this study, the comparison between quantities of Archean varieties and younger sediments, is one of contrasting area estimates with volume estimates. However, it is believed that the errors incumbent in such a comparison are not great enough to distort broad quantitative differences. Below is a table showing the relative amounts of various types. They are the results of a survey of sediments of the United States and representative rock suites from Europe, India, Alaska, Burma and South America.

VOLUMETRIC ESTIMATES OF SEDIMENTARY VARIETIES

(A-17)

	Quartzite Series	Greywacke Series		Arkose Series
Conglomerate & Sandstone	Ortho-Quartzite 9%	Low Rank Greywacke 14%	High Rank Greywacke 4%	Arkoses 13%
Siltstone and Shale	Quartzose Shales 2%	Micaceous Shales 21%	Chlorited Shales 6%	Kaolinitic Shales 13%
Chemical Rocks	Limestones, Dolomite, Cherts, etcetera 18%			

Contrasting with the foregoing tables the following differences in quantity of sediments are apparent.

(a) There is almost a total absence of sedimentary carbonate rock in the Archean as compared with 18% in younger rocks.

(b) The Archean comprises at least 43% of ill sorted, sandy clastics including many high rank greywackes compared with 18% including both high and low rank greywackes in the younger sediments.

(c) There is about 11% of slates and argillites in the Archean and about 42% of the shaly varieties in younger strata.

FUTURE PATHS OF STUDY IN ARCHEAN SEDIMENTS

As mentioned previously, there is a marked lack of quantitative detailed data in descriptions of Archean assemblages.

Comparisons of petrological and chemical properties of representative sediments from all parts of the Shield would be of factual value. Chemically, little is known about shaly or slaty phases of Archean sediments compared with their younger counterparts. The writer believes that chemical properties of Archean slates and greywacke may be similar and differ appreciably from the younger types.

Literature and petrological studies of iron formation may disclose evidence of their origin and also reflect the nature of the atmospheric conditions in which they were formed.

In the pursuit of evidences reflecting the nature of the atmosphere it is best to consider the finer-grained more delicately formed phases of sediments, since their exposure to atmosphere for a longer period of time would result in development of characteristics in closer adjustment to atmospheric influences. In such studies, chemical analyses are an important consideration.

Tectonic conditions are reflected more in the relative quantities of clastic types. It is interesting to find that high rank greywackes, so prevalent in Archean sediments, according to Krynine (A-17) are peculiar to deposition in rapidly subsiding basins. Ultimately such considerations may afford evidences of isostatic sensitivity in Archean times.

A P P E N D I X

APPENDIX A

LIST OF REFERENCES

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M-2	Wilson, M.E. Larder Lake District, Ontario (1912)	17
M-3	Lawson, A.C. Geology of Steeprock Lake, Ontario (1912)	28
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M-6	Collins, W.H. Onaping Map Area, Ontario (1917)	95
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M-8	Wilson, M.E. The Timiskaming County, Quebec	103
M-9	Bruce, E.L. Amisk - Athapapuskow Lakes	105
M-10	Tanton, T.L. The Harricanaw - Turgeon River Basin (1919)	109
M-11	Wilson, M.E. Geology of Amherst Township (1919)	113
M-12	Cooke, H.C. Geology of Matachewan District (1919)	115
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S-1	Bruce, E.L. Schist Lake District, Northern Manitoba	1917 Pt. D Pp. 1-7
S-2	Bruce, E.L. Knee Lake District, North-east Manitoba	1919 Pt. D
S-3	Wright, J.F. Island Lake Area, Manitoba	1922 Pt. B P. 54
S-4	James, W.F. Rouyn Area, Timiskaming County, Quebec	1923 Pt. C P. 126
S-5	Wright, J.F. Oiseau River Area, South-east Manitoba	1924 Pt. B P. 51
S-6	Stockwell, C.H. Reindeer Lake Area, Manitoba	1928 Pt. B P. 46
S-7	Wright, J.F. Kississing Lake Area	1928 Pt. B P. 77
S-8	Mawdsley, J.B. Desmeloizes Area, Abitibi, Quebec	1928 Pt. C P. 33
S-9	Norman, G.N.H. Granville Lake District, Northern Manitoba	1933 Pt. C P. 23
S-10	Jolliffe, A.W. Block Creek Map Area	1933 Pt. D P. 7

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P-1	Henderson, J.F. Beaulieu River Area, East of Yellowknife Bay	1938	No. 1
P-2	Jolliffe, A.W. Yellowknife Bay, Prosperous Lake Area, North West Territories	1938	No. 21
P-3	Henderson, J.F. Beaulieu River Area, North West Territories	1939	No. 1
P-4	Jolliffe, A.W. Quyta Lake and Parts of Fishing and Prosperous Lake, North West Territories	1940	No. 14
P-5	Fortier, Y.O. Ross Lake Map Area, North West Territories	1947	No. 16

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0-1	Coleman, A.P. The Michipicoten Iron Range	1902 Vol. 11 Pt. , Pp. 163
0-2	Miller, W.G. and Knight, C.W. Grenville Hastings Unconformity	1907 Vol. 16 Pt. 1, Pp. 221
0-3	Moore, E.S. Lake Savant Iron Range Area	1910 Vol. 19 Pt. 1, Pp. 181
0-4	Coleman, A.P. Pre-Cambrian Rocks North of Lake Huron	1914 Vol. 23 Pt. 2
0-5	Hurst, M.E. Ranger Lake and Garden River	1928 Vol. 37 Pt. 3
0-6	Moore, E.S. Lake Savant Area, District of Thunder Bay	1928 Vol. 37 Pt. 4
0-7	Graham, A.R. Sturgeon Lake Gold Area	1930 Vol. 39 Pt. 2
0-8	Thomson, J.E. Geology of the Manitou, Stormy Lakes Area	1933 Vol. 42 Pt. 4
0-9	Bruce, E.L. Pashkokagan, Misehkow Area	1933 Vol. 42 Pt. 6
0-10	Bruce, E.L. Little Long Lac Gold Area	1935 Vol. 44 Pt. 3
0-11	Thomson, J.E. Geology of the Rowan-Straw Lakes Area	1935 Vol. 44 Pt. 4
0-12	Bruce, E.L. Eastern Part of the Sturgeon River Area	1936 Vol. 45 Pt. 2
0-12A	Satterly, J. Geology of Sandy Lake Area	1938 Vol. 47 Pt. 7, P. 16
0-13	Moore, E.S. Geology and Ore Deposits of the Atikokan Area	1939 Vol. 48 Pt. 2

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0-14	Prest, V.K. Geology of the Keezhik-Miminiska Lakes Area	1939 Vol. 48 Pt. 6
0-15	Bateman, J.D. Uchi-Slate Lakes Area	1939 Vol. 48 Pt. 8
0-16	Horwood, H.C. Red Lake Area	1940 Vol. 49 Pt. 2
0-17	Thomson, J.E. McGarry and McVittie Township, Larder Lake Area	1941 Vol. 50 Pt. 1
0-18	Satterly, J. Dryden-Wabigoon Area	1941 Vol. 50 Pt. 2
0-19	Macdonald, R.D. Geology of the Hutchison Lake Area	1941 Vol. 50 Pt. 3
0-20	Fairbairn, H.W. Relation of the Sudbury Series to the Bruce	1941 Vol. 50 Pt. 6
0-21	Griffis, Q.T. and Thomson, J.E. Gauthier Township, East Kirkland Lake Area	1941 Vol. 50 Pt. 8
0-22	Prest, V.K. Fort Hope Area	1942 Vol. 51 Pt. 3
0-23	Fraser, W.H.C. Geology of Whitefish Bay, Lake of the Woods	1943 Vol. 52 Pt. 4
0-24	Morehouse, W.W. North-east Portion of the Timagami Lake Area	1942 Vol. 51 Pt. 6

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Q-1	Bannerman, H.M. Lepine Lake Area	1940 - 4
Q-2	Bell, A.M. Assup River Map Area	1932 Pt. b P. 61
Q-3	Graham, R.B. Wetetnagami Lake Area	- 29

Miscellaneous

Reference		
A-1	G.S.A. Vol. 47, Pp. 621-628 Early Pre-Cambrian Varved Slate in North-west Ontario	Pettijohn, F.J.
A-2	G.S.A. Vol. 45, Pp. 479-560 Conglomerate of Abram Lake	Pettijohn, F.J.
A-3	Master's Thesis 1940 The Metamorphism of the Gordon Lake Sediments, North West Territories	Denton, W.F.
A-4	Royal Society of Canada, Vol. 40, Sec. 4, May 1946	Thomson, J.E.
A-5	G.S.A. 50, Anniversary Vol. The Canadian Shield	Wilson, M.E.
A-6	G.S.A. Vol. 48, Pp. 1451-1458 Timiskaming Sub-Province	Collins
A-7	Royal Society of Canada, Vol. 19, Sec. 3, 1925 Progress of Structural Determination in the Archean Rocks of Ontario	Cooke, H.S.
A-8	G.S.A., Vol. 48, Pp. 153-202	Pettijohn, F.J.
A-9	Royal Society of Canada, Vol. 19, Ser. 3, Pt. 4, Pp. 43 Coutchiching Rocks of Bear Pass, Rainy Lake	Bruce, E.L.
A-10	G.S.A., Vol. 44, 1933, Pp. 992 Contact Metamorphism of Slates	Grout, E.L.
A-11	U.S.G.S., Prof. Paper 184 Pre-Cambrian Rocks of Lake Superior	Leith, C.K.
A-12	U.S.G.S., Mon. 28, Chap. 2	Bayley, W.S.
A-13	U.S.G.S., Mon. 45, Chap. 3	Clements, W.H.
A-14	G.S.A., Vol. 50, 1939, Pp. 761-776 Coutchiching of Thunder Lake, Ontario	Pettijohn, F.J.

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Reference		
A-15	G.S.A., Vol. 46, 1935, Pp. 1891-1908 Stratigraphy and Structure of Vermilion Township	Pettijohn, F.J.
A-16	G.S.A., Vol. 47, Pp. 1615-1690 Sudbury Series	Collins, W.H.
A-17	Journal of Geology, Vol. 56, Pt. 2, 1948 Studies for Students	Pettijohn, Schrock and Krynine
A-18	Ann. Acad. Sci. Fennicae, Sec. A, Vol. 36, Pt. 4 Conditions During the Earliest Geological Times	Eskola, P.
A-19	Jour. Geol., Vol. 40, Pp. 353-373 An Early Pre-Cambrian Sedimentary Series	Tolman, C.
A-20	Jour. Geol., 1909, P. 297 Evaluation of Unconformities	Blackwelder, F.
A-21	Jour. Geol. 1909, P. 102	Van Hise, C.R.
A-22	G.S.C. Map 525A Taltson Lake District of Mackenzie, North West Territories	Henderson, J.F.
A-23	Jour. of Geol., Vol. 28, No. 4 (1920)	Cooke, H.C.
A-24	Principles of Sedimentation	Twenhofel
A-25	G.S.C. Map 709A Yellowknife Bay	Jolliffe, A.W.
A-26	G.S.A. Vol. 54, Pp. 925-972 Archean Sedimentation	Pettijohn, F.J.
A-27	Roy. Soc. Can. Vol. 36, Sec. 4, 1942 The Cadillac Synclinal Belt of North-west Quebec	Norman, A.W.G.

Selected Greywacke Descriptions

Reference

0-12 Bruce, E.L. - Eastern Part of Sturgeon Lake Area

Greywacke; consists of irregular to subangualr pieces of quartz and lesser plagioclase in a matrix of small grains of feldspar with foils of sericite. Chlorite occurs in lenses, accounting for its green colour. Bedding is not noticeable except where there are lenses of iron formation.

0-10 Bruce, E.L. - District of Thunder Bay

Conglomerate Matrix; (p.13) well rounded quartz grains with biotite and calcite. Feldspar is locally abundant and chlorite and pyrite less common.

Greywacke; grey in colour, consisting mainly of angular quartz and rounded particles of quartz with oligoclase locally abundant. There are variable amounts of chlorite, amphibole, calcite, magnetite and others. Bedding is not marked and is usually best developed near iron formation.

0-8 Thomson, J.E. - Manitou-Stormy Lake Area

Arkose; in thin section shows clastic grains of quartz, plagioclase, orthoclase and occasionally titanite and apatite all embedded in a matrix of chlorite, sericite, quartz, carbonate, kaolin and iron oxide.

Greywacke; same as arkose except for more ferromagnesium minerals.

Quartzite; same as arkose except lesser feldspar.

Selected Greywacke Descriptions (Cont'd)

Reference

0-11 Thomson, J.E. - Rowan-Straw Lakes Area

Arkose; in thin section consists of sub-angular grains of quartz and orthoclase, plagioclase and cherty material.

0-18 Satterly, J. - Dryden-Wabigoon Area

Greywacke; fine to medium grained, well bedded rocks of alternating bands of recrystallized sandy and clayey material or a mixture of both materials.

0-13 Graham, A.R. - Sturgeon Lake Area

Greywacke; microscopically is made up of angular quartz fragments in a matrix of quartz, feldspar and lesser carbonate.

0-3 Moore, E.S. - Lake Savant Iron Range

Greywacke; composed chiefly of angular grains of quartz and feldspar in a finer matrix of the same. Orthoclase and plagioclase are present. Chlorite is plentiful and occasionally hornblende is seen.

0-14 Prest, V.K. - Keezhik - Miminiska Lake Area

Greywacke; poorly sorted grains of feldspar and quartz, angular to subangular, in a matrix of quartz, feldspar, micas and a little magnetite and tourmaline.

Impure Quartzites; are made up of equigranular masses of quartz and probably feldspar.

Selected Greywacke Descriptions (Cont'd)

Reference

0-16 Horwood, H.C. - Red Lake Area

Normal Dark Greywacke;

Quartz	31%
Andesine	19%
Biotite	21%
Chlorite	13%
White mica	14%
Magnetite	2%

Grades to slaty or argillaceous types commonly.

Light Medium Grained Rocks;

Quartz	19%
Andesine	55%
Biotite	19%
White mica	6%
Chlorite	1%

Arkosic Type of Greywacke; in field resembles impure quartzite.

Quartz	2%
Andesine	45%
Orthoclase	10%
Epidote	15%
Chlorite	6%
Biotite	3%
White Mica	1%

Quartzite;

Quartz	80%
Andesine	10%
Biotite	7%
White Mica	2%
Magnetite	1%

Selected Greywacke Descriptions (Cont'd)

Reference

S-5 Wright, J.F. - South East Manitoba

<u>Quartzite</u>; mostly quartz grains, a few subhedral feldspars, flakes of biotite with mica and small areas of clayey material.

S-3 Wright, J.F. - Island Lake Area, Manitoba

<u>Greywacke, Quartzite and Conglomerate Matrix</u>; all consist of both rounded and angular grains of quartz and feldspar in a finer matrix of the same minerals with variable biotite, chlorite, sericite, chert, magnetite and pyrite.

Q-3 Graham, R.B. - Wetetnagami Lake (Abitibi East)

<u>Greywacke</u>; under a microscope shows an alternation of grain size and composition in bands. Where there is no sorting within the bands, some bands are rich in hornblende and biotite and others in quartz and/or oligoclase.

M-8 Wilson, M.E. - The Temiskaming County

<u>Greywacke, Arkose and Conglomerate Matrix</u>; consist of fragments of feldspar and quartz embedded in a matrix of the same minerals with chlorite, sericite, carbonate and iron oxide. Arkose differs from greywacke in the smaller proportion of mafic material.

M-18 Cooke, James and Mawdsley - Rouyn-Harricanaw Area

<u>Greywacke</u>; now almost completely recrystallized and composed of quartz, albite and muscovite with accessory

Selected Greywacke Descriptions (Cont'd)

Reference	
M-18 Cont'd.	magnetite, pyrite and apatite. The relative amounts of minerals vary greatly. These rocks are thought to consist originally of quartz, feldspar and ferromagnesium mineral, with some weathering products such as clay, chlorite and carbonate.
M-14	Cooke, H.C. - Kenogami, Round and Larder Lakes Greywacke; composed of sand grains, ranging in size from .5 mm to .1 mm. Quartz; 5% to 50%, the rest is feldspar with a little chlorite. The feldspar is altered to kaolin sericite and calcite.

Conglomerate Descriptions

Reference

0-12 Bruce, E.L. - Eastern Part of Sturgeon Lake

Conglomerate; drawn out pebbles of granite mixed with those that do not appear to have been distorted in a greywacke matrix.

0-10 Bruce, E.L. - Little Long Lac Gold Area

Conglomerate; basal in distribution, matrix in thin section consists of well rounded quartz bodies with abundant calcite and also biotite. Feldspar is locally abundant, chlorite and pyrite less common. The pebbles in thin section show little alteration.

M-17 Emmons, R.C. and Thomson, E. - Woman River and Ridout Map Areas

Conglomerate; occurs along one horizon with the beds separated by arkosic quartzites. Pebbles are well rounded. All boulders larger than 5 inches in diameter are granite.

Boulder Count of 16 Square Feet

Granite	181	69%
Schist	56	22%
Iron Formation	12	5%
Diorite	6	3%
Quartz	4	1%
Total	259	

Matrix; massive and banded argillite, greywacke, arkose and quartzite. Conglomerate commonly rests

Conglomerate Description (Cont'd)

Reference

M-17 Cont'd. on other sediments and pass into overlying sediments gradationally.

A-1 Pettijohn, F.J. - Early Pre-Cambrian Varved Slate in North-west Ontario

Conglomerates; are thick and rudely stratified boulders of quartz, porphyry and greenstone, granite and slate. The matrix of conglomerate and arkosites is a coarse grit composed largely of feldspar and a little quartz. Conglomerate beds sometimes separated by varved beds.

O-14 Prest, V.K. - Geology of the Keezih-Miminiska Lakes Area

Conglomerate; occurs between two volcanic horizons, the lower half containing boulders of a variety of volcanic rocks, jasper, chert and a highly siliceous iron formation. No granitic or porphyry boulders seen. Matrix is a fine volcanic material.

Conglomerate at base of Timiskaming; contains boulders of granitoid rocks, volcanics, porphyries, sediments, iron formation, quartz, chert and jasper. Boulders make up from 50% to 80% of rocks and some granite boulders are angular but most are well rounded.

O-15 Bateman, J.D. - Uchi Slate Lakes Area

Conglomerates; Statistical Analysis on Two Islands in

Sawan Bay - Greenstone	38%	38%
Felsite and fine-grained porphyry	22%	35%

Conglomerate Description (Cont'd)

Reference			
0-15	Granitic types	19%	15%
	Iron formation	6%	
	Quartzite	5%	
	Coarse-grained porphyry	4%	5%
	Diorite	3%	1%
	Slate	1%	
	Vein Quartz	1%	
	Hematite	1%	
	Sediment types		2%
	Chert and Quartz		4%

This conglomerate lies above arkoses and appears to represent a local unconformity. It is not basal.

0-16 Horwood, H.C. - Red Lake Area

At the base of Timiskaming and also at various horizons is conglomerate which is always lenticular.

M-20 Wright, J.F. - South-east Manitoba

Conglomerate member occurs as lenses in fine-grained well bedded sediments. Its average thickness is 100' and where it thins the remainder is a coarse grit.

Pebble and Boulder Count

Light grey biotite granite	38%
Light brown granite	12%
Grey granodiorite	20%
Fine quartzose rocks in tabular boulders	22%
Quartz in small pebbles	8%

Conglomerate Description (Cont'd)

Reference

S-3 Wright, J.F. - Island Lake Area, Manitoba

Conglomerates; occur asssociated with the greywacke at certain horizons as lenticular beds. The matrix is greywacke in some places fine-grained and bedded. Pebbles are rounded and of quartzite. Pebbles vary to large boulders of porphyrytic granite in the vicinity of Cochrane Bay.

M-25 Stockwell, C.H. - Herb Lake Area, Northern Manitoba

Conglomerate; varies from 300' to 10' in thickness. Pebbles are well rounded up to 5" in diameter and consist of quartz and acid volcanics in an arkosic material. Within the formations are a few thin layers of cross bedded coarse arkose and greywacke.

M-16 Collins, Quirke and Thomson - Michipicoten Iron Range

Conglomerate; occupies ten times as much space as the greywacke in the Doré series and consists of well rounded porphyry and granite pebbles. Conglomerate alternates with dark, well stratified greywacke similar to alternating deposits of Pleistocene stream gravels. Coleman counted pebbles in square yard of outcrop surface:

Dark Green Schist	48
Granite	17
Iron Formation	14
Spotted Green Schist	9

Conglomerate Description (Cont'd)

Reference		
M-16 Cont'd.	Porphyry	8
	Felsite	3
	Conglomerate or Breccia	1

A-19 Tolman, C. - An Early Pre-Cambrian Sedimentary Series

Conglomerates; not as abundant as arkose. It has a typical sparse distribution of deformed roundstones throughout an arkosic matrix. Most pebbles are syenite.

M-10 Tanton, T.L. - The Harricanaw-Turgeon Basin

The Conglomerate of the Harricanaw Series is the dominant member. It contains rounded pebbles of iron formation.

M-18 Cooke, James and Madsley - Rouyn-Harricanaw Area

Pebbles are rounded fragments, up to 1" in diameter, of hornblende syenite, reddish syenite, quartz and basic lavas. The matrix is a dark grey, fine-grained greywacke which composes half the rock. Beds of conglomerate containing about 75% pebbles are interbedded in ordinary conglomerate. Conglomerate containing pebbles of greywacke contains no pebbles of any other kind.

M-14 Cooke, H.C. - Kenogami, Round and Larder Lakes

Conglomerate; at the base of Timiskaming varies in nature depending on the floor on which it rests. Pebbles are basalt, gabbro, chert, cherty tuff, banded

Conglomerate Description (Cont'd)

Reference

M-14 Cont'd. chert, iron formation, red jasper, andesite, rhyolite, etcetera in a matrix of sandy greywacke. The pebbles are generally well rounded.

A-2 Pettijohn, F.J. - Conglomerates of Abram Lake
Nature of conglomerate varies; consists of massive or obscurely bedded arkose interbedded with conglomerates.

Pebble Count Per One Square Yard

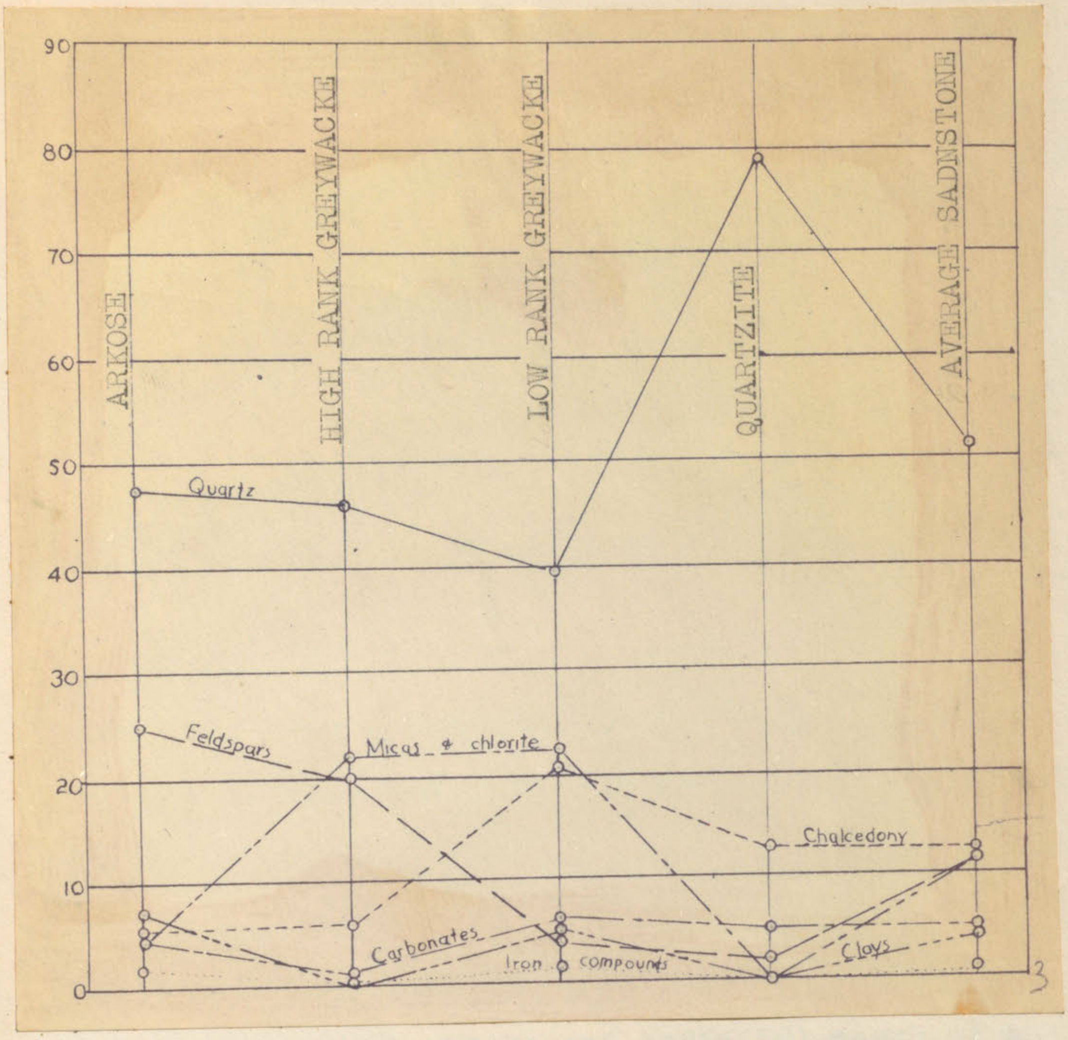
Granite and granite gneiss	18%
Greenstone and green schists	50%
Felsites and other light coloured aphanitic rock	22%
Metadiorite and coarse-grained greenstones	3%
Quartzites	7%

The conglomerate matrix is a biotite chlorite schist.

APPENDIX D

AVERAGE COMPOSITION OF SANDSTONES IN

THE THREE MAJOR SEDIMENTARY SERIES



Percentages shown refer to total compositon and include both detrital chemical constituents. (A-17, P. 151)

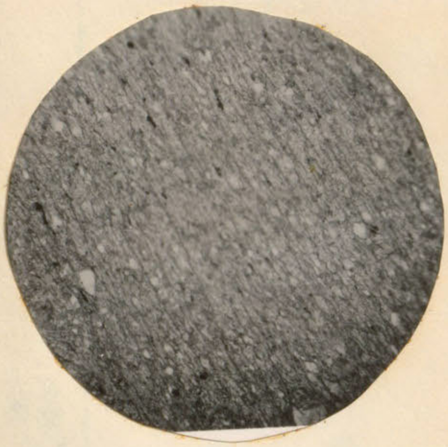
COMPARISON OF IRON FORMATION

Core from McLeod Cockshutt Little Long Lac Area - Thirteenth Level in North Ore Zone. Contributed by H.F. Morrow.

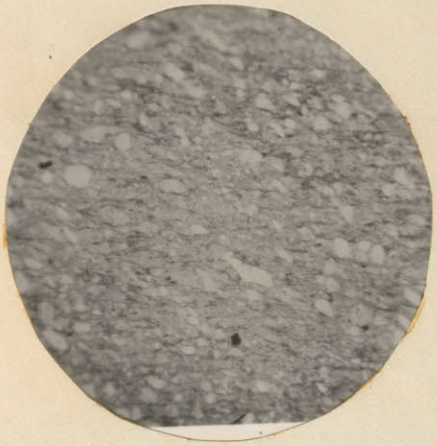
Field Specimen; from Cadillac Township iron formation in banded greywacke and tuffs 50' north of a band of conglomerate all in Cadillac Group and 1 mile west of Cadillac Township east line.

GREYWACKE VARIETIES FROM McLEOD COCKSHUTT MINE

Photomicrographs (Magnified twenty-four times under reflected light) Contributed by H.F. Morrow, Chief Geologist.

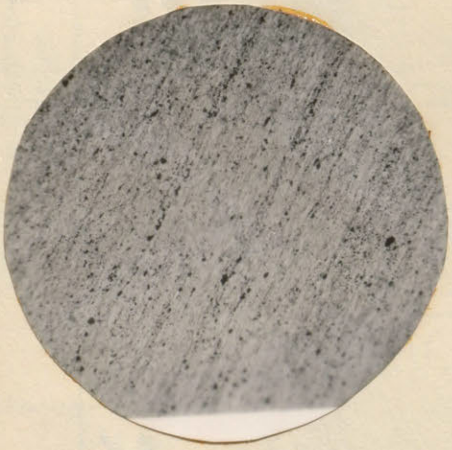


No. 20 - Greywacke from 960 West Drift.

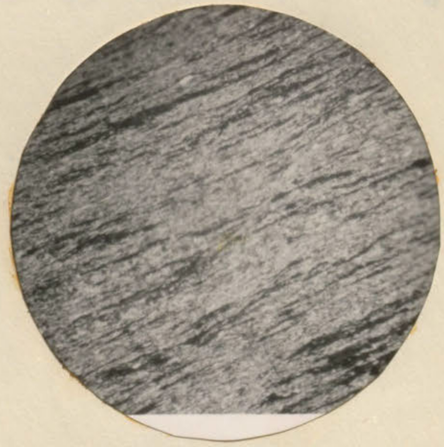


No. 16 - Comparatively fresh Greywacke from 1060 West Drift, associated with iron formation.

Thin Sections from 202 West Drift



Massive Greywacke No. 6754
(Field name)
Chlorite produces schistose structure in iron rich sediment; also associated with iron formation.



Unaltered Greywacke No. 6752
(Field name)
within 4 feet of feldspar porphyry associated with iron formation. No precise information on bedding character.

Thicknesses of Archean Assemblages

The values of the following tabulation were collected from reports. It was found that attempts at determining thicknesses on maps were not successful because of the general lack of structure and evidence of flowage in sediments. The methods by which these thicknesses were obtained were not mentioned in the literature. It is assumed, therefore, that they represent values in which dip of beds, flowage and the best available areas were considered.

LOCALITY	REF.	SIMPLIFIED CLASSIFICATION	THICKNESS	COMMENTS
West of Lake Chibougamau	A-19	Upper Volcanics Opemiska Series - Sedimentary Lower Volcanics	10,000'	
Chibougamau Lake	M-21	Felspathic Sediments Volcanic lavas	3,500'	A width and not a thickness
Malartic Area	M-28	Cadillac Group: sediments Blake River Group: lavas and pyroclastics Kewagama Group: sediments Malartic Group: volcanics	5,000' 200'-3,000' 1,000'-2,500'	Structure not yet solved, therefore, thicknesses are problematic
Rouyn-Harricanaw Area	M-18	Timiskaming - sediments and a little lavas Keewatin volcanics	3,900'	Measured on a fold
Kenogami, Round and Larder Lake At Larder Lake	M-14	Timiskaming Basalt flows Trachyte flows Greywacke Conglomerate Keewatin	1,450' 2,600' 3,606' One Mile Approximately	8900' thick Doubtful
Matachewan District at Midlothian Area	M-12	Kiask Series Arkose Arkose and Conglomerate Slate Conglomerate Keewatin Volcanics	? ≥ 6,000' 50' 300'-3,000'	
Woman River and Ridout Map Areas	M-17	Upper Volcanics Ridout Series: sediments Lower Volcanics	2,500'	Minimum thickness
Michipicoten District	M-16	Post Dore Volcanics Dore Series: Greywacke Conglomerate Pre Dore Volcanics	10,000' 400'-8,400'	Logan's estimate 7,500'-8,000'
Block Creek Area	A-10	Windigokan: Sediments and lavas Conglomerates and sediments	3,000'	Maximum thickness
Atikokan Area, Ontario	O-13	Seine and Steeprock Series Quartz-sericite schist Ferruginous Carbonate Dike and felsite Blue and grey Limestone Conglomerate	5,000' 200'-500' 00'-1,000'	According to Smyth 1891 Estimated
Dryden-Wabigoon Area	O-18	Wabigoon Volcanics ?—Fault—? Zealand Sediments Thunder River Volcanics Thunder Lake Sediments Brownridge Volcanics Brownridge Sediments	25,000' 1,700'-3,500' 1,300' 4,000'-5,000' 8,000' 18,000'	
Whitefish Bay	O-23	Keewatin Clastic sediments Volcanic fragmentals Basic Volcanics	≥ 2,000' 5,000' 20,000'	
District of Thunder Bay	O-6	Savant Group Sediments: Arkose and Greywacke Conglomerate Basaltic lava	16,000' 1,000'	
Vermilion Township, Ontario	A-15	Daredevil formation: Sediments Abram Series: Ament Bay Sediments Unconformity Keewatin: Younger Volcanics Patara Sediments Older Volcanics	2,120' 9,220' 2,100' 2,000'+ 12,500' 1,250'-1,500' 9,000'+	
Uchi-Slate Lakes Area	O-15	Uchi Series: mostly basic lava Slate Lake Series Conglomerate Arkose Iron Formation Impure Quartzite	20,000' 4,000' ? 20,000'- 500' 30,000' ?	Structure is doubtful Estimated
South-east	M-20	Rice Lake Series Wanipigow phase: sediments Beresford Lake phase: mostly volcanics Manigotagon phase: sedimentary	12,100' 16,100' 10,700' 5,400'	Not much faith placed on estimates by the Author
Yellowknife	Map 709A G.S.C. & P-2	Yellowknife Group: Sediments Volcanics	2,000'-6,000' 33,000'	Side notes on the Geological Map