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DEPARTMENT OF ENERGY,
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PAPER 70-26

STRATIGRAPHY OF THE ARCHEAN YELLOWKNIFE SUPERGROUP, YELLOWKNIFE BAY — PROSPEROUS LAKE AREA, DISTRICT OF MACKENZIE

(Report and 3 figures)

John B. Henderson

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ABSTRACT

Six new formational names and two new group names are defined. The Archean Yellowknife Supergroup (previously Yellowknife Group) in the Yellowknife Bay-Prosperous Lake area is subdivided into a predominantly volcanic Beaulieu Group and a predominantly sedimentary Duncan Lake Group. On the west side of Yellowknife Bay the Kam Formation (Beaulieu Group), a basalt and andesite unit, is unconformably overlain by the Jackson Lake Formation (Duncan Lake Group), a conglomerate and volcanic lithic sandstone unit. East and north of the bay, the intermediate volcanic Duck Formation (Beaulieu Group) is conformably overlain by the Burwash Formation (Duncan Lake Group), a turbidite unit of greywacke and slate. The Walsh Formation (Duncan Lake Group) another turbidite sequence composed of slate, siltstone and greywacke in part overlies the Burwash Formation. Elsewhere the Walsh and Burwash Formations are separated by the Banting Formation, a felsic volcanic and tuffaceous unit not assigned to either group.

STRATIGRAPHY OF THE ARCHEAN YELLOWKNIFE SUPERGROUP, YELLOWKNIFE BAY — PROSPEROUS LAKE AREA, DISTRICT OF MACKENZIE

INTRODUCTION

The purpose of this paper is to establish rock-stratigraphic units for the Yellowknife Supergroup (formerly Yellowknife Group) in the Yellowknife Bay-Prosperous Lake area, District of Mackenzie (85 J/8, J/9), following the recommendations of the Code of Stratigraphic Nomenclature of the American Commission on Stratigraphic Nomenclature (1961).

Yellowknife Bay, on the north arm of Great Slave Lake, District of Mackenzie, forms the mouth of Yellowknife River which flows into Great Slave Lake from the north. The city of Yellowknife is on the east side of the bay and is the capital of the Northwest Territories. The economic base for the area has primarily been the gold mines located at Yellowknife.

Acknowledgments

This report is part of a thesis study on the Yellowknife Supergroup carried out at the Johns Hopkins University under the supervision of Dr. F.J. Pettijohn, whose interest and advice are greatly appreciated. The assistance of the Geological Survey of Canada in supporting the field work is also gratefully acknowledged.

HISTORY OF GEOLOGICAL INVESTIGATION

The first geological survey of the area was made by R. Bell (1900) who visited Great Slave Lake to check reports of lead and gold prospects in the area. He noted the similarity of the Precambrian rocks at Yellowknife to those in Ontario. Camsell and Malcolm (1919) correlated the volcanic and sedimentary rocks in the region with the Keewatin and "Huronian" (Temiskaming) of Ontario but with some reservations. They subdivided the rocks into three groups: (1) the Early Precambrian, (2) Granites and Gneisses, and (3) Late Precambrian. J.M. Bell (1929), in discussing the rocks at Yellowknife, first referred to the Early Precambrian as the Yellowknife series and correlated it with the Tazin series in the Lake Athabasca area. Stockwell (1932) included the Yellowknife rocks in his Point Lake-Wilson Island Group. In 1938

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TABLE OF FORMATIONS

		WEST SIDE OF YELLOWKNIFE BAY			EAST SIDE OF YELLOWKNIFE BAY		
ERA	SUPERGROUP	GROUP	FORMATION	LITHOLOGY	LITHOLOGY	FORMATION	GROUP
Cenozoic				Pleistocene glacial deposits.	Pleistocene glacial deposits.		
Profound					Unconformity		
Proterozoic				Diabase gabbro.	Diabase gabbro.		
Intrusive					Contact		
Archean				Western granodiorite. Quartz-feldspar porphyry. Gabbro diorite.	Prosperous Lake granite. Southeastern granodiorite. Quartz-feldspar porphyry. Gabbro diorite.		
	Intrusive				Contact		
	Yellowknife	Duncan Lake	Jackson Lake	Volcanic lithic sandstone conglomerate.	Slate with interbedded siltstone and greywacke.	Walsh	Duncan Lake
			Unconformity		Felsic volcanics, agglomerate and tuff.	Banting	
				Diorite gabbro.			
			Intrusive contact		Greywacke with thin slate interbeds.	Burwash	
		Beaulieu	Kam	Pillowed and massive basalt, andesite and dacite flows.	Intermediate volcanics.	Duck	Beaulieu

Henderson (1938) renamed the rocks of the Beaulieu River area immediately to the east of Yellowknife, the Yellowknife Group thus establishing the group name. In the late 1930s and early 1940s Jolliffe mapped two 1-mile to 1-inch sheets - Yellowknife Bay to the south and Prosperous Lake to the north. In his preliminary report (Jolliffe, 1938) he divided the Yellowknife Group into two volcanic units and three sedimentary units. In his final maps (Jolliffe, 1942, 1946) the group was reorganized into three divisions (Fig. 2). Henderson and Brown (1952, 1966) in their detailed mapping of the Yellowknife greenstone belt, mapped only the lower two divisions of the group exposed along the west side of the bay but recognized a sedimentary unit whose stratigraphic relationships to the rest of the group was not known. Boyle (1961) in his study of gold deposits and Green et al. (1968) in their geochronological study of the Yellowknife area, grouped the upper divisions of Jolliffe into a single division and, like Henderson and Brown, left undefined the position of the problematical sedimentary formation (Fig. 2).

THE YELLOWKNIFE SUPERGROUP

The term 'Yellowknife Group' has been used for volcanic and sedimentary sequences of Archean age throughout the Slave Province. Although the type locality for the group is the Beaulieu River area within a contiguous Archean 'basin' in the southern part of the province, it has come to be used for other Archean sequences even though they are often separated from the type area by many miles of predominantly plutonic and high-grade metamorphic rocks.

The use of the term 'Yellowknife Group' for this assemblage of formations is open to question. The Code of Stratigraphic Nomenclature (1961) states that "Groups are recognized for the purpose of expressing the natural relations of associated formations having significant lithologic features in common" (Article 9a). At Yellowknife the Archean consists of at least 30,000 feet of mafic volcanics together with, on the order of, 20,000 feet of mixed sedimentary and volcanic units. This is far too diverse an assemblage to be described as a group in the strict stratigraphic sense. It is suggested that the Yellowknife Group be raised in rank to a supergroup with the intention that it be used, as before, to designate any Archean volcanic and sedimentary assemblages within the Slave Province. Within any contiguous belt or basin of these stratified rocks the Yellowknife Supergroup could then be broken down into more specific groups and formations.

In the Yellowknife Bay-Prosperous Lake area the formations are best discussed in terms of the east and west sides of Yellowknife Bay due to the major structural break along the axis of the bay (see Table of Formations).

West Side of Bay

The west side of the bay consists mainly of the Kam Formation of the Beaulieu Group but is unconformably overlain by the relatively thin Jackson Lake Formation of the Duncan Lake Group.

Kam Formation

The Kam Formation forms the northerly trending greenstone belt on the west side of Yellowknife Bay between latitudes 62°20'N and 62°47'N. The name of the formation comes from Kam Lake - a lake southwest of the city of Yellowknife on the contact between the Kam Formation and the western granodiorite. This formation was mapped on a scale of 500 feet to the inch by Henderson and Brown (1952, 1966) and Baragar (1966) has made a detailed geochemical study of these volcanics.

The type section is between Negus Point (latitude 62°26'N, longitude 114°21'W) on Yellowknife Bay and the western granodiorite to the northwest (latitude 62°29'N, longitude 114°23'W).

The formation consists of approximately 30,000 feet of predominantly basaltic to andesitic volcanic flows. In the sequence, massive and pillowed flows occur in about equal abundance and vary in thickness from a few feet to a maximum of 500 feet. Interbedded with the flows are tuffs, agglomerates, and breccias of various types. At certain levels in the sequence there are distinctive variolitic flows that are useful marker beds. Rare porphyritic flows are also reported. A 1,200-foot-thick metadacite unit occurs north of the city of Yellowknife and its equivalents occur in other fault blocks to the north. Towards the top of the section there is an increase in the tuffaceous material, agglomerate, breccia and porphyry intrusions. The formation is intruded by sills, dykes and irregular bodies of gabbro which are believed to be almost penecontemporaneous with the extrusion of the flows (Henderson and Brown, 1966). The whole section has undergone regional metamorphism that is related to the intrusion of the western granodiorite (Boyle, 1961). Metamorphic facies parallel to the contact of this body include an amphibolite facies next to the granodiorite, an intermediate epidote-amphibolite facies and an outer greenschist facies.

The formation has been disrupted by large wrench faults with displacements of up to 3 miles as well as by older shear zones. The base of the formation has been cut out due to the intrusion of the western granodiorite and the top of the sequence has been lost due to erosion. No single complete section of what is left is possible without correlating across various fault blocks. The Kam Formation is unconformably overlain by the Jackson Lake Formation.

Jackson Lake Formation

The Jackson Lake Formation is named after Jackson Lake, a small elongate lake north of the head of Yellowknife Bay and northwest of the larger Walsh Lake. It is almost continuously exposed from the northernmost exposure of the Kam Formation to the Akaitcho Fault west of the head of Yellowknife Bay. It also occurs along the west shore of the bay for about 1 mile and is present on the west side of Jolliffe Island. To the south it is not seen again until the Sub Islands in the southern part of the bay. The top of the formation is never seen due to concealment by drift or lake cover.

The formation consists of two parts. The basal portion is a conglomerate which lies with angular unconformity above the Kam Formation. Its thickness depends on the relief of the sub-Jackson Lake topography, which is up to 800 feet. In the northern area of outcrop, the conglomerate just above the unconformity is composed predominantly of very coarse (up to 3 feet)

angular blocks of mafic volcanics with lesser amounts of smaller more felsic varieties. Higher in the section the clasts become smaller and better rounded, the mafic clasts become less common and the felsic varieties more abundant. Small quartz cobbles and scattered chert pebbles are present as well. In one of the conglomerates exposed farther south along Yellowknife Bay northwest of Latham Island, well-rounded pink granitic boulders occur with the much more angular mafic volcanic clasts. Granitic cobbles are also found in the conglomerates on Jolliffe Island and on the southernmost of the Sub Islands. There is considerable variation in the composition of the cobbles from place to place.

Overlying the conglomerate-filled depressions are light yellow-brown to light greenish grey weathering, commonly well crossbedded, thick- to thin-bedded sandstones with thin interbeds of dark siltstone to black shale. Thin discontinuous beds of pebbly conglomerate are common particularly in the lower part of the section. Scattered pebbles are also found in the thicker sandstone beds. The sandstones vary from thick, medium-grained, massive beds to thin laminations of sand and silt in black shale, to extensively scoured and crossbedded gravelly beds. Almost all the coarser clasts are felsic volcanic pebbles. In hand specimen medium sized quartz grains occur in a pasty, fine-grained, light green to grey 'matrix'. In thin section, however, the 'matrix' is seen to be deformed volcanic rock fragments that in most cases have lost their original outlines due to shearing.

The top of the Jackson Lake Formation is never exposed and where not covered by Yellowknife Bay is faulted against the Banting Formation.

The type section is on the southwest bay of Walsh Lake on the southwest side (latitude 62°33'N, longitude 114°19'W). At this locality a conglomerate-filled depression 200 feet deep in the Kam Formation is overlain by 800 feet of mainly thick, well-exposed crossbedded sandstones which in turn are faulted against the Banting Formation.

Like the volcanics it overlies, this formation has also undergone regional metamorphism as indicated by the development of chloritoid, chlorite and muscovite in the 'matrix' of the sands.

East Side of Bay

At the base of the section on the east side of the bay is the Duck Formation of the Beaulieu Group. Conformably overlying it is the Burwash Formation of the Duncan Lake Group. The Walsh Formation (Duncan Lake Group) in part overlies and in part is separated from the Burwash Formation by the Banting Formation which is not assigned to either group.

Duck Formation

The Duck Formation of volcanic flows of intermediate composition is exposed in the core of a northeast-trending anticline north of the south-eastern granodiorite. These flows are well exposed at Duck Lake, from which the formation takes its name. The type section is at the southwest shore of Duck Lake (latitude 62°25'N, longitude 114°14'W). The total thickness of this unit is not known as only the upper portion of it appears in the core of the anticline. Jolliffe (1942) placed it in his 'Division A' (Kam Formation). Due

to the extensive faulting in the area the formation is disrupted but probably the volcanics underlying Horseshoe Island, the volcanics north and south of the west end of Duck Lake and those 4 miles east of Duck Lake are all equivalent. The flows are light greyish green in colour, of intermediate composition and are commonly pillowed. Pillows are smaller than those in the Kam Formation and appear to have more hyaloclastic debris associated with them. They are commonly vesicular with abundant quartz-filled amygdules. The contact relations with the overlying Burwash Formation, though commonly obscured by shearing, appear to be conformable. The Duck Formation may be an eastern lateral extension of the Kam Formation found on the west side of the bay.

Burwash Formation

The Burwash Formation is named after Burwash Point on the east side of Yellowknife Bay, northeast of Yellowknife. It is best exposed between Walsh Lake and Akaitcho Bay, although its equivalents are found as far east as the East Arm of Great Slave Lake, a distance of 70 miles and as far north as Fishing Lake and Gordon Lake, 50 miles and 70 miles respectively. Throughout most of this region these sediments have undergone relatively high-grade metamorphism, but along Yellowknife Bay the rocks have been only slightly metamorphosed and primary sedimentary features are excellently preserved.

The type section is 1/2 mile south of Burwash Point, due east of a small island in Yellowknife Bay (latitude 62°27 1/2'N, longitude 114°18 1/2'W).

The Burwash Formation, estimated to be about 15,000 feet thick, consists of interbedded greywackes and slates that exhibit all the features characteristic of turbidites. Individual greywacke beds are laterally continuous, have sharp bases, commonly exhibit graded bedding and show all or part of the sequence of structures of the Bouma cycle (Bouma, 1962) (graded interval, lower parallel laminated interval, rippled interval, upper parallel laminated interval and massive shale). The beds range in thickness and character from thin rippled units less than 1/2 inch thick to massive units up to 10 or more feet thick. The average bed is 1 foot thick. Throughout most of the section greywacke greatly predominates over shale with the shale portion of the bed typically being less than 2 inches thick. In the upper part of the Burwash Formation shale becomes more abundant, individual beds much thinner, and due to the decreased competency of the rock, they are much more deformed. The sandstones are typical greywackes with a framework of quartz, volcanic rock fragments and plagioclase feldspar in that order of abundance. The coarsest material of most beds is medium sand but coarse sand occurs at the base of some thick units.

The formation is offset, more or less perpendicular to strike, by a series of wrench faults (Fig. 1). Thus the top of the formation west of the Akaitcho Fault is in Yellowknife Bay just north of Burwash Point. For the next fault block east, the top of the formation is at the head of the bay where it grades into the Walsh Formation and for the block between the Hay-Duck and Ptarmigan Faults the top is at the conformable contact with the Banting Formation. The Burwash Formation is conformable with the underlying Duck Formation. A few flows and tuffaceous beds are present in the contact area north of Duck Lake.

As with the other formations in the Yellowknife Supergroup the Burwash Formation has undergone low-grade metamorphism. Along the east shore of the bay, the rocks are generally below biotite grade. The matrix of the greywacke and the slate is composed primarily of chlorite and muscovite. To the east the grade increases with the appearance of biotite, cordierite and garnet.

Banting Formation

The Banting Formation is named for Banting Lake which lies west of the north half of Prosperous Lake and is underlain by this formation in its central part. It occurs in the south against the Akaitcho Fault at the west side of the head of Yellowknife Bay and extends north through Walsh, Banting and Jackson Lakes until it is cut off by faulting at latitude 62°44'N. At Walsh Lake it is repeated in the limbs of a syncline whose axis parallels the lake. The north half of Latham Island and the east half of Jolliffe Island are also underlain by the Banting Formation and the rocks there are particularly well preserved due to the lack of shearing that is more prevalent in the northern exposures.

The type section is between the southwest bay of Walsh Lake and Yellowknife River (latitude 62°33'N, longitude 114°19'W).

The formation is volcanic in origin but is highly variable in composition being composed of porphyritic dacite flows, felsic agglomerate, pillowed andesites and crystal tuffs. Weathered surfaces of the volcanic rocks, especially the felsic varieties, are light grey to pinkish grey. In the northern exposures, much of the rock has a streaked appearance suggestive of shearing. Many of the agglomerate clasts are stretched. Euhedral crystals of feldspar are abundant in many of the flows and commonly occur in the matrix of the agglomerates. Quartz is also present in some of the more felsic units. The strata are best preserved on the west limb of the syncline; on the east limb they are commonly relatively sheared, particularly near the contacts with the sediments, and also more metamorphosed. Near the top of the formation, west of Yellowknife River, is a 200-foot-thick member of conglomerate composed mainly of rounded cobbles of impure sandstone, similar to those of the Jackson Lake Formation, and cobbles of shale, siltstone and felsic volcanics. This member is conformable with the volcanic agglomerates and tuffs both above and below.

The formation has a maximum thickness of about 4,000 feet but thins towards the southeast to about 2,500 feet. The base is not exposed on the west as it is faulted against the Jackson Lake and Kam Formations. On the eastern limb shearing obscures the relationship with the underlying Burwash Formation, and in places the overlying Walsh Formation, but they appear to be conformable. West of the Hay-Duck Fault the unit does not appear on the southeastern limb of the fold, suggesting that this formation may not have been laterally persistent. To the north extensive faulting and shearing make it difficult to estimate thicknesses but it appears to be much thinner.

Walsh Formation

The Walsh Formation lies stratigraphically above the Banting Formation along the shores of Walsh Lake, for which it is named. It also occurs along the Yellowknife River west of the Hay-Duck Fault.

The type section is on the large island at the southern end of Walsh Lake (latitude 62°34'N, longitude 114°18'W).

This formation is composed of turbidites but differs from the Burwash in the much greater proportion of shale to siltstone and greywacke. The greywacke and siltstone portions of the beds are generally much thinner and finer grained. As in the Burwash, the lateral continuity, sharp base, graded nature and Bouma sequence of structures typical of turbidites are present in these beds.

Due to its predominantly argillaceous composition and location close to the axis of the syncline, the formation is much more highly deformed and because of this structural complexity it is impossible to estimate the thickness of this formation. There is no evidence of any formation overlying it. Along the east and west shores of the lake there is evidence that the Walsh strata conformably overlie the Banting volcanic rocks for in some places there is a gradational contact with interbedding of tuffs with the normal greywackes, siltstones and slates of the Walsh Formation. Unfortunately the contact between the Walsh Formation and the Burwash Formation is covered by the sand plain along Yellowknife River. There is no evidence that the Banting rocks are present. The most reasonable interpretation is that the Walsh and Burwash Formations have a gradational contact in this area.

Definition and Use of Group Names

The Yellowknife Supergroup (previously Yellowknife Group) has always been mapped with at least a two-part breakdown corresponding to the fundamental volcanic and sedimentary units. Any further breakdown, usually based on variations in composition or degree of metamorphism, involved the subdivision of these two basic units. This procedure is continued in the formal definition of group names within the Yellowknife Supergroup at Yellowknife.

Beaulieu Group

The Kam and Duck Formations constitute the predominantly volcanic Beaulieu Group. The group name is taken from the Beaulieu River which flows through a large volcanic area on the eastern side of the Archean basin.

Duncan Lake Group

The Duncan Lake Group consists of the Jackson Lake, Burwash and Walsh Formations, the sedimentary units in the area. Duncan Lake, for which the group is named, is a large lake in the east central part of the Archean basin.

Although these formations are restricted to the Yellowknife Bay area, other formations of similar lithologies are found throughout the Slave Province. As already mentioned the Burwash Formation, or sediments identical to it or its metamorphic equivalent, are continuously exposed between Yellowknife and Gordon Lake 50 miles to the northeast. East and southeast of Gordon Lake is a relatively thin sequence of basaltic and andesitic volcanics that resemble the Kam Formation in many respects. Southeast of these volcanics is another volcanic belt overlain by a conglomerate (Henderson, 1939) very similar to that seen at the base of the Jackson Lake Formation. In the Arseno Lake area (McGlynn and Ross, 1963) 150 miles northwest of Yellowknife and separated from it by miles of granodiorite, a similar relationship is seen with Kam-type volcanics overlain by a Jackson Lake-type conglomerate that grades up into the Burwash-type sediments. When other parts of this Archean basin are studied in greater detail it might be useful to include the sedimentary and volcanic formations in, for example, the Gordon Lake-Ross Lake-Cameron River area on the easterly side of the basin in the Duncan Lake and Beaulieu Groups respectively. It would not be expected however, that the extension of these group names beyond this particular Archean basin would serve any purpose unless a definite association could be demonstrated among the component formations of the two areas. Unless otherwise shown, they would be related only in that they are stratified Archean formations in the Slave Province and hence are part of the Yellowknife Supergroup.

Although the Archean formations in various parts of the Slave Province have a lithological and sequential similarity to those in the Yellowknife Bay-Prosperous Lake area there is no proof that they are time equivalents. It is worth noting however that analogous conditions must have existed over a wide part of the Slave Province in space if not in time.

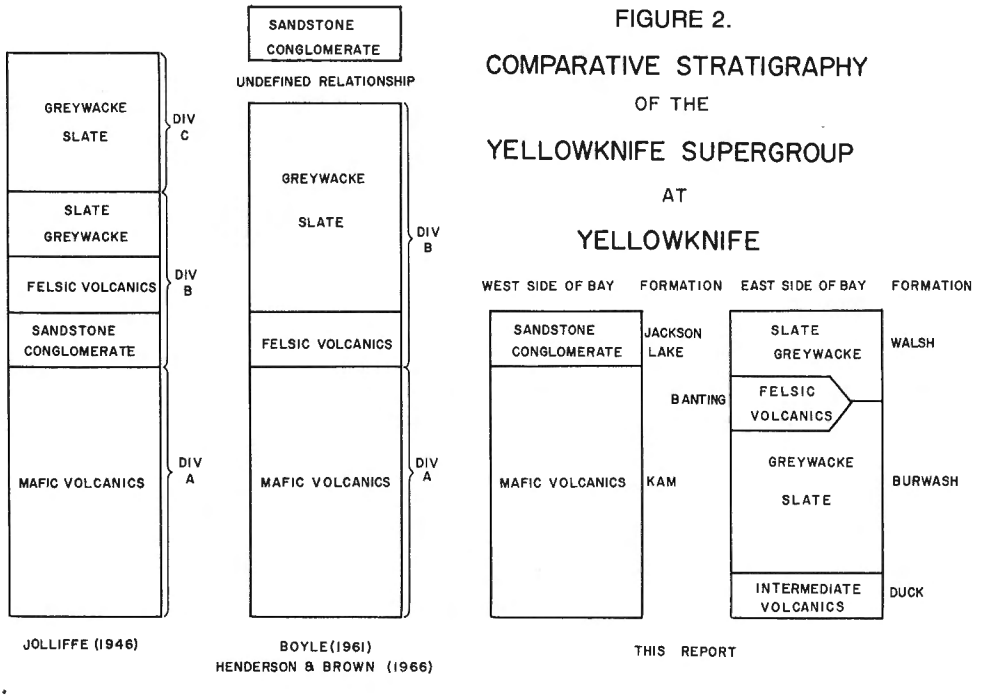

FIGURE 2.

COMPARATIVE STRATIGRAPHY OF THE YELLOWKNIFE SUPERGROUP AT YELLOWKNIFE

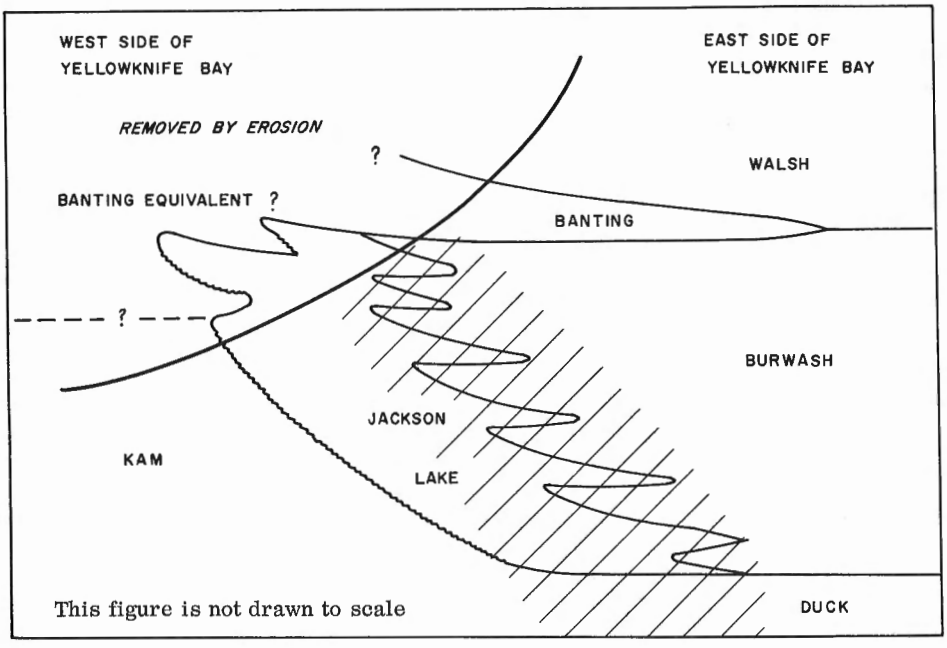

Figure 3. Suggested stratigraphic cross-section of the formations of the Yellowknife Supergroup at Yellowknife. The heavy line indicates the approximate present day level of erosion. The cross hatched area represents the area now covered by Yellowknife Bay or missing due to faulting. On the east side of the bay the volcanic Duck Formation, a possible lateral extension of the Kam Formation, is conformably overlain by the Burwash greywackes and shales. The silicic volcanic Banting Formation, possibly representing a tongue of a silicic cap on the main mafic volcanic pile (Kam Formation) that has subsequently been eroded, lies conformably between the Burwash Formation and the Walsh Formation shales and greywackes. On the west side of the bay, the Jackson Lake conglomerates and volcanic lithic sandstones unconformably overlie the mafic volcanics of the Kam Formation. The Jackson Lake Formation, derived largely from a silicic volcanic source, may represent the shallow water equivalent of the deeper water turbidites of the Burwash and Walsh Formations.

CONCLUSION

In the immediate area around Yellowknife Bay, the Yellowknife Supergroup can be broken down into six formations: the Kam and Duck Formations of the Beaulieu Group, the Burwash, Jackson Lake, and Walsh Formations of the Duncan Lake Group and the Banting Formation. These formations more or less correspond with the original map units of Jolliffe (1942, 1946) although the order of the sequence has been somewhat revised (Fig. 2). The Kam and Duck Formations are equivalent to Division A of Jolliffe; the Jackson Lake Formation (lowermost part of Division B)

unconformably overlies the Kam Formation. In this study, however, the Banting Lake and Walsh Formations (middle and upper units of Jolliffe's Division B) are considered to lie stratigraphically above the Burwash Formation (Division C). Because the Kam and the Jackson Lake Formations are always in faulted contact with the older formations in the group, it is difficult to state unequivocally what the stratigraphic relationships are between the two sequences in the group. It is thought, however, that the Duck Formation represents an eastern extension of the main volcanic sequence at Yellowknife. The two formations are possible correlatives and both are included in the Beaulieu Group. The Banting Formation has not been included in either group but is most likely related to the volcanic Beaulieu Group. It may represent an eastward extension of a silicic volcanic cap on the main volcanic sequence as is seen in several other Archean volcanic piles (Goodwin, 1968). Evidence for the presence of this formation above the Kam Formation has been removed due to extensive erosion in Archean time (Fig. 3). However the Jackson Lake Formation which unconformably overlies the Kam is primarily composed of silicic volcanic debris and indicates that an extensive silicic volcanic source was available in the area.

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