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**LA THÈSE A ÉTÉ
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**Stratigraphy, Provenance and Geochronology of
Archean Supracrustal Rocks of Western
Eyapamikama Lake Area, Northwestern Ontario.**

by

Eric Anthony deKemp

A thesis submitted to
the Faculty of Graduate Studies and Research
in partial fulfillment of
the requirements for the degree of
Master of Science

Department of Geology

Carleton University

Ottawa, Ontario

January, 1987

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The undersigned hereby recommend to the Faculty of Graduate Studies and Research acceptance of this thesis, submitted by Eric Anthony deKemp, B.Sc.(Hons.), in partial fulfillment of the requirements for the degree of Master of Science.

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Abstract

The Archean supracrustal rocks of the western Eyapamikama Lake area comprise four distinct metasedimentary and metavolcanic accumulations that are flanked by 2990-2860 Ma tonalite batholiths. The oldest accumulation, the Agutua Arm metavolcanic complex, contains both mafic and felsic metavolcanic rocks that acted as a base for subsequent greenstone development. Post-2980 Ma weathering unroofed an early phase of 2990 Ma tonalite from the Weagamow batholith, along with consanguineous quartz-rich hypabyssal and volcanic rock types. This weathering facilitated the accumulation of quartz-rich sediments adjacent to highland felsic masses and produced a saprolite up to 10 m thick on pillowed mafic metavolcanics and 2980 Ma felsic fragmentals of the Agutua Arm metavolcanic complex.

Supermature quartz arenites of the Keeyask Lake metasedimentary succession were deposited in a stable basin directly above this unconformity and incorporated 2980 Ma well-rounded detrital zircons from the underlying felsic terrane. Massive, trough cross stratified and rippled quartz arenites give way upwards to finely laminated stromatolite-bearing quartz siltstones which are capped by laminated chert and iron-rich precipitates.

A phase of komatiitic volcanism ended the period of tectonic stability and initiated the accumulation of the Keeyask Lake metavolcanic pile. Spinifex- and oliphant-textured komatiite flows grade into variolitic mafic metavolcanics, pillowed flows and, finally, broken pillow and flow top breccias.

Rapid post-2960 Ma uplift of large tonalite-trondhjemite masses exposed early supracrustal rocks from the Agutua Arm meta-volcanic complex, the Keeyask Lake metasediments and the Keeyask Lake metavolcanics. The large volume of sediment derived from this uplifted mass was deposited adjacent to, active ultramafic and felsic volcanic centres. The initial phase of rapid sedimentation is represented by the basal conglomerates of the Eyapamikama Lake metasedimentary succession.

Megascopic modal analyses of the Eyapamikama Lake conglomerates suggest that the uplifted felsic terrane, although predominantly trondhjemitic tonalite, also included multiple phases of quartz-diorite, diorite and gabbro. Coarse detritus from this plutonic terrane was mixed with immature debris from local felsic and ultramafic-mafic volcanic centres. Clasts of quartz arenite, banded iron formation and spinifex-textured komatiite in these conglomerates reflect a second unconformity which cuts deeply into older stratified terrane. The presence of quartz arenite pebbles and samples of their probable source rock within Eyapamikama Lake conglomerates indicates that early 3000-2960 Ma tonalite-trondhjemite terrane was uplifted, unroofed and exposed twice before deposition of the Eyapamikama Lake metasedimentary rocks. Quartz enrichment of greywacke/mudstone turbidites of this upper sequence may be attributed to the reworking of quartz-rich sediments surrounding the old felsic masses.

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Chapter 1: Introduction

This study was conducted as part of the "Opapimiskam Lake Project", a three-year regional geologic mapping project implemented by the Ontario Geological Survey, with funding from the Ontario Ministry of Northern Development and Mines (previously Ministry of Northern Affairs). The project was initiated in response to a need for an updated and more detailed database and mineral assessment of the North Caribou Lake greenstone belt (NCLGB). The thesis study benefitted from 1:15,840 Precambrian bedrock mapping by the Precambrian Section of the Ontario Geological Survey, studies of ice movement and dispersion by the Engineering and Terrain Section and detailed mineral assessment by the Mineral Deposits Section. Full results of the Opapimiskam Lake Project study are available through the Ontario Geological Survey.

U/Pb isotopic data used in this study was provided by Don Davis of the Jack Satterly Geochronology Laboratory, Toronto Ontario.

Aim of Study

The primary purpose of this study has been to provide a stratigraphic assessment of the Archean supracrustal rocks in the western Eyapamikama Lake region of northwestern Ontario. This study emphasizes both the relative and absolute timing of depositional and intrusive episodes. Attention also is given to an evaluation of provenance for the major sedimentary units (conglomerates and quartz arenites).

Location and Access

The study area (Fig. 1) is about 180 km north of Pickle Lake, Ontario, in the western part of the North Caribou Lake greenstone belt within the Sachigo subprovince of the Superior province of the Canadian Shield. The study area is extensively covered by a predominantly coniferous forest of black spruce, tamarack, pine and poplar. Unforested areas consist of inland marshes, string bogs and barren boulder-strewn hills. Because outcrops form less than 1% of the total surface area, a high-pressure Wajax water pump was used to increase bedrock exposure in critical areas.

Eyapamikama Lake is accessible by float or ski equipped aircraft from Pickle Lake. Most of the map-area is accessible from Eyapamikama Lake by watercraft. Access from Eyapamikama Lake to the North Caribou river system and Keeyask Lake is provided by cut portage trails (Fig.2).

Figure 1: Location map, North Caribou Lake greenstone belt.

Figure 2: Western Eyapamikama Lake study area (See Fig. 1 for location).

Previous Work

The area was mapped initially for the Ontario Department of Mines at 1" to 1 mile (1:63,360 scale) in 1939 by J. Satterly (Satterly 1941), who determined the general configuration of the belt and established many of the lithologic relationships. An airborne magnetometer survey was conducted by the Ontario Department of Mines and the Geological Survey of Canada in 1960 (ODM/GSC 1960). A more recent airborne electromagnetic and total-field magnetic survey of the entire North Caribou Lake greenstone belt (OGS 1985) was conducted by the Ontario Geological Survey at 1:20,000 scale during the 1984-85 field season. Geological reconnaissance operations were conducted by Emslie (1962) and Thurston et al. (1979). Hall (in prep.) is conducting a Ph.D study of the Opapimiskau Musselwhite gold prospect southeast of the map area; Andrews and others (1981) have prepared a preliminary mineral assessment of the North Caribou Lake Area.

Two B.Sc. theses were conducted during the Opapimiskau Lake Project. One, by E.A. McLarty (McLarty 1985), examined the metamorphic and deformational history of banded iron formation in the north-central Eyapamikama Lake area. The other, by Z. Arias (1986), established a preliminary stratigraphic succession for rock units within the Keeyask Lake metasediments. Her study emphasized the biogenicity, morphological characteristics and environmental

significance of a stromatolite-bearing unit within the Keeyask Lake metasedimentary succession.

Present mineral property holders within this M.Sc. study area include Comstate Resources, Moss Resources Limited, Sulpetro Minerals Limited, and Northern Dynasty Exploration Limited. All of these exploration companies were active during the 1984-1986 period, utilizing lithogeochemical, geophysical (magnetometer) and geological mapping techniques in conjunction with new data provided through the Opapimiskan Lake project. A detailed summary of past exploration activity is presented in Breaks et al. (1985).

General Geology

Lithotectonic Assemblages

The North Caribou Lake greenstone belt is an Archean metasedimentary-metavolcanic supracrustal accumulation that is bordered by younger, predominantly tonalitic, batholiths. The belt consists of five major lithotectonic packages (Fig. 3) that are characterized by distinctive associations of lithologic units, styles of deformation and geologic age. The oldest of these is the Agutua Arm metavolcanic complex, in the western region of the belt. It is characterized by a wide range of metavolcanic and hypabyssal rock types from high-level quartz-porphyrries and extrusive felsic equivalents to massive and pillowed mafic flows.

The northern and southern margins of the belt are characterized by highly strained, upper greenschist to lower amphibolite facies mafic rocks of the North and South Rim metavolcanic complexes. Pillow-selvage strain ratios of up to 125 to 1, combined with a predominance of broad ductile shear zones, the dismemberment of marker units and conflicting top indicators, gives evidence that this terrane (especially the North Rim metavolcanic complex) forms a highly transposed package of repeated lithologic units.

Rocks of the the Keeyask Lake metasedimentary, -metavolcanic succession unconformably overlie the rocks of the Agutua Arm package in the western Eyapamikama Lake region. The base of this package contains mature quartz-arenites, *stromatolitic

* The prefix "meta" has been omitted herein for rocks that are of low grade and which megascopically exhibit evident primary structures and textures, even though all rocks have been affected by at least greenschist facies metamorphism.

Figure 3: Lithotectonic subdivisions of the North Caribou Lake greenstone belt, Eyapamikama Lake region.

mudstones and banded iron formation. This lower sedimentary succession is in turn overlain by a volcanic succession ranging from ultramafic komatiite flows to massive and pillowed mafic metavolcanic flows.

Capping the entire succession and overlying the Keeyask Lake package are the Eyapamikama Lake metasedimentary rocks which form the linear core of the belt. These rocks, representing the uppermost strata of the North Caribou Lake greenstone belt, are characterized by fluvial, submarine fan and basinal deposits of conglomerate, arenite, greywacke and slate.

The surrounding batholiths show intrusive relationships to the greenstone, as indicated by numerous xenoliths of amphibolite similar to amphibolite within margins of the belt, and by numerous trondjemite sills rimming the batholiths and intruding the greenstone terrane. The contact areas are highly deformed and only general conclusions can be drawn as to the time of the emplacement of the surrounding batholiths. The batholith margins show evidence of emplacement after at least one period of regional mafic volcanism, and before an intense phase of deformation. However, most of the batholiths beyond a 500-1000 m border are relatively undeformed and free of xenoliths. This may indicate the possibility of composite batholiths characterized by an older pre- or syn-deformational shell and a younger post-tectonic core.

The eastern part of the Weagamow batholith appears to have been emplaced, cooled, uplifted and unroofed before

deposition of the Eyapamika Lake metasediments. This is demonstrated by an increase in angularity and abundance of tonalite-trondhjemite boulders in conglomerate as the contact with the batholith is approached. Conglomerates of the Eyapamika Lake metasedimentary rocks at Keeyask Lake probably represent the unroofed talus debris from this batholith. Thus an unconformable contact separates Eyapamika Lake metasediments from tonalite of the Weagamow batholith in western Eyapamika Lake.

Metamorphism

Metamorphic conditions throughout the belt (Fig. 4) generally range from mid-greenschist facies (chlorite-bearing slates along the central axis of the belt in the Eyapamika Lake region) to lower amphibolite facies (highly strained zones in the North Rim metavolcanic complex). Kyanite-andalusite-staurolite and andalusite-staurolite-bearing metagreywacke occur within the northwestern narrow extension of the belt. Cordierite-andalusite-bearing assemblages occur within the Eyapamika Lake metasediments along the northwestern and easternmost shores of Eyapamika Lake. Metamorphic isograds are generally parallel to the lithologic outlines of the belt, with metamorphic grade increasing away from the central axis, reaching higher temperature and pressure conditions in narrow fold limbs and tectonic enclaves within batholiths. Most of the rocks have been subjected to at least two metamorphic pulses, as indicated by two

stages of garnet growth (Breaks et al. 1984, McLarty 1985). An initial (pre-D₂ and possibly syn-D₁) metamorphic pulse formed almandine garnets, now preserved as flattened pre-tectonic garnets. A later pulse formed euhedral (post-D₂) unstrained garnets. Equilibrium temperatures as deduced from biotite-garnet geothermometry, using equilibrium constants of Perchuk and Lavrent'eva (1983), for euhedral garnet rims ranges from 520°C to 550°C along the North Rim metavolcanic-metasedimentary contact.

Figure 4: Metamorphic variation in the Eyapamikama Lake region of the North Caribou Lake greenstone belt. (From Breaks and Bartlett 1986).

Structure

The structural history of the North Caribou Lake greenstone belt is difficult to ascertain due to the limited exposure in structurally complex key areas. Several distinct zones appear to be characterized by specific structural styles. The structural evolution of the North Caribou Lake Belt has involved at least three phases of folding and two shearing events. The D_1 folding event is interpreted to have been an intense period of shortening that resulted in isoclinal, rootless and intrafolial folds within a highly transposed terrane (Breaks et al. 1986). Rocks of the Eyapamikama Lake metasedimentary package may not have been affected by this event, as suggested by a lack of either macroscopic or megascopic D_1 structures in this succession in the Eyapamikama Lake area. In addition, numerous trondhjemite, tonalite, diorite, quartz porphyry and mafic metavolcanic cobbles which were intensely deformed before deposition are preserved in Eyapamikama Lake conglomerates. These deformed cobbles may be products of an early D_1 event, suggesting that D_1 records widespread compression before deposition of the entire Eyapamikama Lake succession.

D_2 deformation was the predominant phase of folding throughout the North Caribou Lake Belt (Breaks et al. 1986). This phase rotated, overprinted and in most cases completely obscured, all previous fabric elements. D_2 deformation throughout the belt typically is characterized by penetrative tight Z and S mesoscopic and megascopic

folds with near vertical axial planes. The D_2 fold geometry is generally consistent throughout the belt, and is best observed in chert-magnetite banded iron formation. Remnants of early coplanar isoclinal D_1 folds within banded iron formation have been overprinted by subsequent D_2 isoclinal folds that have produced complex interference patterns in the Castor-Pollux Lake area (McLarty 1984; see Fig.5) and Opapimiskan Lake area (Breaks et al.1985). Many of these patterns are similar to those synthesized in a study based on computer-generated interference folds by Thiessen (1986).

In more ductile rocks such as chlorite-actinolite-bearing metavolcanic strata and metapelites, D_2 produced a penetrative planar alignment of mafic minerals parallel to the regional orientation of megascopic D_2 fold axes. The dominant regional easterly trend and steeply dipping fabric of the Eyapamikama Lake area is a composite fabric of parallel $S_0/S_1/S_2$ elements, with S_2 being dominant in most places (Fig. 6).

Rocks of the Eyapamikama Lake metasedimentary succession have been affected by the D_2 event. This is evident from numerous opposing top indicators throughout the Eyapamikama Lake area, and from the presence of many D_2 -style fold structures in these rocks.

Mesoscopic D_2 folds are best observed in mudstone-wacke turbidites in the east Eyapamikama Lake area in which competent structural markers such as pre- D_2 gabbro

sills, quartz veins and quartz-rich wacke interbeds have been deformed into tight isoclinal folds.

D_2 axial planes and associated fabric generally parallel the surrounding batholith-greenstone margin. This is reflected in a predominantly easterly trend for S_2 (and S_0) in the central Eyapamikama Lake region. In the western Eyapamikama Lake area, D_2 elements are deflected from this orientation to northeasterly trends in the Center Lake area, and to northwesterly trends in the Capella Lake area. The Western Eyapamikama Lake homocline contains a D_2 fabric that is close to parallel with bedding, and has a variable strike which approximately coincides with the orientation of the easternmost margin of the Weagamow batholith.

Fabrics produced by D_3 folding are preserved only locally. F_3 folds are generally open to gentle, with a great degree of variability in orientation. Some chevron folds and kink bands are associated with these folds, along with D_2 axial planar shearing. D_3 folding is best observed along the shores of Eyapamikama Lake within slates that show well-developed crenulation lineation due to the intersection of open D_3 fold axial plane cleavage with S_0/S_2 fabric. D_3 open folds commonly overprint tight to isoclinal D_2 folds within greywackes in the northwest Eyapamikama region, and may have warped and kinked D_2 axial planes and shear fabrics associated with major fold structures in the Center Lake area.

Figure 5: Interference fold patterns in chert-magnetite-grunerite banded iron formation. Eyapamikama Lake region, Castor-Pollux Lake (From McLarty 1985).

Figure 6: Structural map of the Eyapamikama Lake area.

Shear zones and associated faults are abundant in the southwest part of the map area, in the vicinity of the North Caribou river and Center Lake areas. Three main sets of faults in this area show various orientations and displacement directions (Breaks et al. 1984) All seem to have developed during a late stage in the evolution of the North Caribou Lake greenstone belt. The first and most pervasive of these produced shear zones and associated kinematic indicators which demonstrate predominantly dextral displacement and rotation along northeast-striking surfaces. This zone is approximately parallel to the North Caribou River south of Center Lake, and is characterized by many outcrop-scale brittle-ductile shears which locally produced allochthonous segments of the Agutua Arm metavolcanic strata and Keeyask Lake metavolcanic-metasedimentary succession. Coarse-grained tectonic enclaves of quartz arenite within the shear zone may have been displaced up to 4 km east of the autochthonous Keeyask Lake segment.

Other faults in the Eyapamikama Lake Region include southeast-striking faults which cut earlier brittle-ductile shear structures and fabric elements by cm-scale offsets. These occur in the western region of Staunton Lake, along the North Caribou River and in the northern Agutua Arm area. Parts of the Keeyask Lake succession north of Center Lake are offset by another set striking 85° - 110° . This set appears to have been generated quite late, because this set cuts post-tectonic (Proterozoic ?) dykes of diabase.

All lithotectonic packages previously described are exposed within the Western Eyapamikama Lake map area (Fig. 7). Three large tonalite batholiths, the North Caribou Lake batholith to the south, the Schade Lake batholith (gneissic complex) to the north and the Weagamow batholith to the west, enclose the steeply dipping east-facing homoclinal metavolcanic-metasedimentary sequence. The structural deformation is quite minimal in comparison to the high strain state of most rocks in the North Caribou Lake greenstone belt. Metamorphic conditions reached middle to upper greenschist facies, predominantly within the chlorite zone (Breaks and Bartlett, 1986). Because of these geologic conditions, along with the ease of access to the area, this succession was chosen by the author for lithostratigraphic and geochronologic study, and is discussed in detail below.

LEGEND

Figure 7: Lithostratigraphic map of western Eyapamikama Lake area.

Chapter 2: Stratigraphy

Stratigraphic Approach

Stratigraphic relationships were determined on the basis of field relationships, map compilation, and the study of six stratigraphic sections that transect the map area (Sections A-F, Figs. 8, 9, 10). Several assumptions were made in deriving the final idealized section (Fig. 10).

These are:

1. No major tectonic breaks occur in the western Eyapamikama Lake area other than the postulated structural break between basal Eyapamikama Lake conglomerates in the Keeyask Lake area and Keeyask Lake metavolcanic rocks (see Fig. 9).
2. There is no indication of repetition of mappable lithologic units due to tectonic stacking or recumbent folding.
3. The younging directions for strataform rock units within the mainland region between Keeyask and Eyapamikama Lakes are consistently to the east or northeast. All top indicators are consistent with this observation; no west-facing indicators have been observed to date.

Because of the limited outcrop distribution within the map area (<1%), the stratigraphic assessment presented here is general and idealized. In addition, because of the lack of adequately exposed type sections, rock units have not been assigned formation and group status. Nevertheless, several rock packages that formed during distinct depositional phases can be identified and mapped in the western Eyapamikama Lake area. These depositional packages are defined on the basis of lithologic association. Several key lithologic contacts have revealed the relative age relationships between adjacent lithologic assemblages, but exposed contacts are rare in the map area, and most inferred contacts are based on extrapolation of these rare occurrences.

Figure 8: Location of lithostratigraphic sections.

Figure 9

Idealized Stratigraphic Column of West Eyapamikama Lake

Figure 10

Criteria employed in determining major stratigraphic relationships include truncating relationships at unconformity surfaces, the presence of clasts in conglomerates that can be recognized as derived from underlying terranes, and cross cutting intrusive contacts. Volcanic facing-indicators include pillow shapes, primary gas and drainage cavities in pillows, variations in pillow selvage thickness, and flow tops. Sedimentary facing-directions were determined by observing grain gradation in sandstones, basal scours, channel geometry, clast arrangement in conglomerates, penecontemporaneous deformation structures, cross-bed geometry and stromatolite morphology.

Lithologic Assemblages

Introduction

The Western Eyapamikama homoclinal succession comprises four main steeply dipping east-facing lithostratigraphic units: the Agutua Arm metavolcanic complex, the Keeyask Lake metasedimentary and metavolcanic packages and the Eyapamikama Lake metasedimentary package. These units are in contact with the Weagamow tonalite batholith to the west of the map area. The North and South Rim metavolcanic complexes are outside this homocline along the north and south margins of the NCGB belt. Due to the poor exposure and highly deformed nature of these terranes, correlation with rocks of the western Eyapamikama Lake homocline is tenuous. For a detailed description of the North and South Rim metavolcanics, the reader is referred to the 1984 O.G.S. Summary of Field Work and Preliminary Map marginal notes (Bartlett et al. 1984, OGS Map P2834).

Agutua Arm Metavolcanic Complex

Metavolcanic rocks of the Agutua Arm lithotectonic complex are exposed in the southwestern part of the map area. This supracrustal package, the oldest in the area, acted as a base for later greenstone development. It is bound to the south by the North Caribou River fault zone which separates the Agutua domain from Mafic metavolcanic rocks of the South Rim domain. To the north the Agutua complex is bound by an intrusive contact with the Weagamow batholith. In the east, rocks of the Keeyask Lake succession directly overlie the Agutua Arm metavolcanic complex along an angular unconformity. This eastern boundary represents an early regolith in which mafic and felsic volcanic rocks were subaerially exposed and altered by in situ leaching to a sericitic and hematitic saprolite (see Plate 1).

The Agutua Arm metavolcanic succession dips moderately to the southeast, but the overall younging direction is difficult to determine due to the lack of reliable top indicators. A single example of amygdule gradation within a felsic flow suggests that the Agutua package is generally southeast facing. If this is the case, the package may contain a greater abundance of felsic volcanic rocks towards the top. The original depositional thickness of the Agutua metavolcanic package is difficult to estimate due to lack of exposure. Assuming no tectonic thickening or repetition of units (an unlikely situation for most of the NCLGB), original thicknesses

could be as high as 5 km. The base of the metavolcanic complex is not exposed, it may have been tectonically removed or assimilated during subsequent mobilization stages of the Weagamow and North Caribou Lake batholiths.

Evidence to indicate that these rocks have gone through an early period of deformation before deposition of the overlying units is lacking. Preservation in some areas is in fact quite good, as seen by the occurrence of well-preserved and unstrained pillowed mafic metavolcanic rocks such as those below the Center Lake regolith (see Plate 2).

Deformation zones transect the Agutua Arm metavolcanic domain and extend into the Keeyask Lake sequences, indicating that Agutua Arm metavolcanic rocks had been affected by deformational processes that acted on younger supracrustal units as well. For example, minor shear zones at Center Lake and the North Caribou River shear zone cut through the Agutua Arm package, the Keeyask Lake rocks and South Rim metavolcanic rocks. Although this was probably a relatively late event, earlier penetrative fabric elements within the Agutua metavolcanics cut across unconformity surfaces into the overlying strata. This is the case in the Center Lake regolith where a penetrative L-S fabric in altered mafic metavolcanics of the Agutua package can be traced into a well-defined fracture cleavage within the overlying quartz arenite unit.

Plates

- 1 Quartz arenites of the Keeyask Lake metasedimentary sequence (top) in unconformable contact with Agutua Arm mafic metavolcanics. Hematite-sericite schist below hammer represents an Archean < 2980 Ma weathered zone. Hammer lying across contact is 40 cm long. Photo taken near Center Lake.
- 2 Sericitized mafic metavolcanic pillows of the Agutua Arm metavolcanic complex at the base of the weathering horizon. Compare with weathered zone on Plate 1 which is completely void of all primary structures.
- 3 Basal chert pebble conglomerate of the Keeyask Lake metasedimentary section. Note black unlaminated chert pebble at centre of photo resting on (green) sericite-hematite chlorite layer of the underlying weathering horizon.
- 4 Felsic volcanic and chert pebble conglomerate interbedded within well-rounded quartz arenites of the Keeyask Lake metasedimentary section. Note angularity of felsic volcanic fragments.
- 5 Photomicrograph of supermature well-rounded quartz arenite of the Keeyask Lake metasedimentary unit. Crossed nicols with quartz plate inserted. Sample taken from Quartzite Hill. Chemical analysis shows 99.0 % SiO_2 .
- 6 Thin layer of imbricated chert pebble conglomerate within ripple laminated quartz arenite of the Keeyask Lake metasedimentary unit.
- 7 Trough cross stratified quartz arenite layer cut into massive quartz arenite, Keeyask Lake metasedimentary unit.
- 8 Planar trough cross stratified quartz arenite interbedded within laminated quartz arenite, Keeyask Lake metasedimentary unit.

Metamorphic isograds truncate the boundary between Agutua Arm metavolcanic rocks and adjacent lithotectonic packages (see Fig. 4). A lack of contrast in metamorphic grade across the Agutua Arm-Keeyask Lake boundary indicates that Agutua Arm rocks were not subjected to significant metamorphism before deposition of the overlying units. Thus, the Agutua Arm metavolcanic rocks were not a true basement, but rather formed a temporary paleotopographic surface which in the Center Lake area was exposed to intense chemical weathering before transgression and deposition of quartz-rich arenaceous units. This could have resulted from localized weathering in a volcanically active region, although weathering could have been extensive, affecting all uplifted and exposed Agutua Arm terrane. The true basement to the NCLGB would probably be represented by rocks that underlie the Agutua Arm complex. Field evidence to indicate the nature of this basement before eruption of the Agutua Arm metavolcanic suite is lacking.

Mafic metavolcanic rocks are locally intruded by marginal portions of the Weagamow batholith along with numerous northeast-striking gabbro and diorite bodies. These intrusive rocks in the southwest part of the map area are overprinted by shear zones associated with the North Caribou River shear zone system. In the northern region of the Agutua Arm terrane, local coarse-grained quartz-rich (>60% quartz) intrusions have intruded aphanitic felsic flows and felsic lapilli tuffs. The local

felsic intrusive suite of trondhjemite and tonalite most likely is consanguineous with the Weagamow batholith to the north, a predominantly tonalitic body. This seems reasonable, because of the close proximity (< 300 m), of these small intrusions to the batholith and their similar composition to the tonalite suite of the batholith. If these local felsic intrusions were coeval with the main intrusive phase of the Weagamow tonalite body as suggested, then batholith emplacement must have occurred before a major phase of deformation in this area (D1 or D2?) because these rocks are overprinted by a penetrative foliation fabric.

Felsic metavolcanic rocks in the Pakiagama Lake area and east to Eyapamikama Lake include massive epidotized aphyric flows to coarse heterolithic fragmental flows. Because these rocks may have contributed quartz to the quartz-rich sediments of the overlying units, special attention was given to the morphology of quartz grains and quartz concentrations.

Free quartz within metavolcanic rocks of intermediate compositional range in the Pakiagama-Eyapamikama Lakes area generally makes up 5 to 10% of the rock by volume. This quartz is difficult to observe in the field. In thin section, quartz phenocryst size is generally less than .2 mm in diameter. Single quartz grains within the Agutua Arm felsic metavolcanic rocks possess a distinct crystal morphology. Quartz phenocrysts are anhedral to subhedral, with rare embayments. Crystals

are generally stubby with poorly developed terminations. Some single grains appear rounded, with poorly formed crystal faces tangent to the rounded grain. Colour can be a translucent aquamarine, light grey or clear. Quartz phenocrysts are supported by an epidote-rich matrix which shows extensive recrystallization and retrogression to chlorite and sericite bearing mineral assemblages. Common accessory minerals in these felsic volcanic rocks include prismatic apatite, zircon and minor tourmaline.

The best exposures of felsic metavolcanic rocks of the Agutua Arm terrane are just below the unconformity surface at the base of the Keeyask Lake metasedimentary sequence, about 200 m south of the mid-way point of the Pakiagama-Eyapamikama Lakes portage trail. There the felsic volcanics form a very inhomogeneous unit. An inventory of rock types would include felsic fragmentals with tightly packed clasts containing spherulitic structures, felsic lapilli tuffs and coarse crystal tuffs. Sparse angular mafic to ultramafic lapilli-size fragments are incorporated by dominantly felsic rock fragments. This inhomogeneous unit grades into quartz-rich volcaniclastic rocks to the east which are just 5 m below the overlying quartz wacke arenite units of the Keeyask Lake lithostratigraphic assemblage.

Keeyask Lake Metasedimentary Rocks

The Keeyask Lake metasedimentary rocks are predominantly quartz arenites, layered mudstones and banded iron formation. Minor constituent rock types include quartz wacke, arkosic (plagioclase) arenites and chert. The Keeyask Lake package can be observed at an exposed glaciated outcrop termed "Quartzite Hill", approximately midway along the portage trail between Eyapamikama Lake and Pakiagam Lake. For a detailed description of the sedimentary section at Quartzite Hill the reader is referred to Arias (1986). The entire section is 19 metres thick and strikes close to north-south. Rocks of the Keeyask Lake package have been traced to the south near Center Lake and into the North Caribou River fault zone. This represents a strike length of 3.5 km. The exposed beds along this section dip steeply to the east, with dips ranging from 80 degrees to vertical. Younging directions in all exposures along the strike length of the succession is consistently to the east. This has been verified from observations of cross bedding in quartz arenites, stromatolite morphology and grain gradation in the upper siltstone unit.

Well-rounded supermature quartz arenite dominates the Keeyask Lake sedimentary sequence (see Plate 5). Beige to grey-white quartz arenites are confined to the lower part of the succession and are of a uniform thickness of about 10 metres or half the entire thickness of the Keeyask Lake package.

plate

- 9 Stromatolite interbed at contact between massive well-rounded quartz arenites (below) and laminated quartz siltstones (above). Keeyask Lake metasedimentary section at Quartzite Hill. Note local inclination and outward radiation of peaked stromatolite columns.

P

Plates

- 10 Undeformed spinifex-textured komatiite of the Keeyask Lake metavolcanic accumulation. Note delicate dovetail like arrangement of relic olivine blades. Mineral assemblage now composed of tremolite+actinolite+talc+serpentine+carbonate+magnetite.
- 11 Ultramafic-mafic flow top breccia near the top of the Keeyask Lake metavolcanic accumulation. Photo taken near west shore of Eyapamikama Lake.
- 12 Slightly broken mafic metavolcanic pillows in part of Keeyask Lake metavolcanic accumulation. Photo taken on western shore of Eyapamikama Lake.
- 13 Close-up view of broken pillow selvage from unit depicted in Plate 12. Note wide cooling margin between scale card and selvage.
- 14 Closer-view of pillow margins depicted in Plate 12 showing angular selvage debris filling gaps between adjacent pillows.
- 15 Hyaloclastite zone above in situ broken pillow breccia of the upper Keeyask Lake metavolcanic accumulation. Photo taken on western shore of Eyapamikama Lake.
- 16 Variolitic zone within massive mafic-ultramafic flow. Keeyask Lake metavolcanic accumulation.
- 17 Conformable contact between upper portion of Keeyask—Lake metavolcanic accumulation (right side of photo) and the basal Eyapamikama Lake conglomerates (left side of photo). Arrow indicates conglomerate layer with rounded tonalite cobbles interstratified with mafic and ultramafic flow top breccias. Hammer at centre of photo is 40 cm long.

The lower quartz arenite beds overlies, and in some cases are interstratified with, a chert pebble conglomerate ranging from 5 to 30 cm in thickness (see Plates 3, 4). The basal conglomerate is in direct contact with altered mafic and felsic metavolcanic rocks of the Agutua Arm metavolcanic complex. Chert pebbles in these conglomerates range in size from .5 cm to 2 cm and are well rounded and spherical. Cream-coloured to light brown chert clasts commonly are internally laminated at 3-5 mm scale. Non-laminated black chert clasts form a minor component (<10%) of clast percentages. Angular greenish-brown clasts of sericite-hematite schist identical in appearance to rocks of the underlying regolith form another minor component of the conglomerate (<15%). These clasts range from granule to cobble size. Some boulder-sized sericite-hematite clasts have been subjected to only minor displacement from the regolith zone.

Quartz wacke occurs in association with quartz arenites throughout the section. These sediments are generally massive without any primary depositional structures, and in hand sample are sugary white to light green in colour. Framework grains are rounded to subrounded and show moderate sorting. Matrix fractions are 20% to 30% and are composed of microcrystalline quartz and minor muscovite. Less than 1% by volume is composed of, in order of abundance, accessory detrital grains including apatite, possible rutile, topaz, and well-rounded < .05 mm zircon. In many places, recrystallized framework quartz

grains blend into the microcrystalline matrix suggesting that these rock types may have originally been quartz arenites.

Bed forms within the quartz arenites are dominantly planar and trough cross beds, ripple cross beds and planar-stratified beds (see Plates 7, 8). These bedform geometries are defined by detrital heavy minerals and authigenic tourmaline along original depositional laminae.

Bedform geometries throughout the Keeyask Lake metasedimentary section indicate current directions that are random to bimodal. Possible herringbone crossbeds have been observed in several localities directly above reactivation surfaces cut into ripple crests.

Quartz pebble lags are common at the base of foresets and some imbricated clasts occur within 1-5cm thick interbeds (see Plate 6). Maximum foreset angles are about 25° to 30° . Also present are massive 10-15 cm coarse-grained quartz arenite interbeds which contain angular light green sericite-hematite rip up clasts. These beds sharply truncate underlying bedforms and tend to be laterally discontinuous.

Massive, planar crossbedded and ripple crossbedded units occur throughout the quartz arenite section. At some locations a zonation is evident from massive to trough crossbedded and then to rippled beds from the base of the section to the top. This is the case at Quartzite Hill (Arias 1986). Interstratified with crossbedded zones are thin black and green mudstone laminae that form planar-

stratified beds which are generally laterally continuous, for tens of metres. These beds are common along the entire strike length of the exposed Keeyask Lake metasedimentary section.

Quartz arenite framework grain size ranges from .1 to 2 mm, with a mode of .75 to 1mm. These sediments show a marked bimodality of grain size and a negative skewness, indicating a high degree of sorting and a reduced amount of fines. This is a common feature of mature sediments deposited in beach environments (Leeder 1982). Detrital quartz grains occur as single slightly strained crystals which show undulatory extinction. Extinction patterns overprint multiple grains, indicating that strain was imposed after consolidation. There is no evidence for single detrital quartz grains which were strained before deposition. Up to 20% of the framework grains are slightly strained composite polycrystalline grains with sutured crystal boundaries. Other polycrystalline grains contain more diffuse internal crystal boundaries. Composite crystal grains including plagioclase were not observed. Where preservation is poor, original grains have been completely recrystallized and annealed, forming triple-point contacts with surrounding grains. Thin black ghost rinds of fine-grained opaques define some original quartz grain boundaries.

Many detrital grains are overgrown with authigenic quartz and are surrounded by a matrix of microcrystalline quartz, chlorite and acicular tourmaline. Occasionally,

non-recrystallized quartz cement fills the original pore spaces between grains. Hornblende and muscovite are minor matrix components; X-ray diffraction data suggest that illite also forms part of the matrix (Arias 1986).

Preservation of original grain textures is variable. Near Center Lake, original detrital grains are difficult to detect because of extensive shearing which caused the framework clasts to become indistinguishable from the matrix fraction. At Center Lake, 2-3 mm porphyroclasts of quartz arenite are supported by a highly recrystallized and foliated polycrystalline quartz matrix. This is most likely due to close proximity to the North Caribou fault zone, directly to the south of Center Lake. Preservation of primary grain texture tends to improve dramatically to the north of this zone, and becomes exceptional at Quartzite Hill.

Heavy mineral fractions, forming less than 1% of the quartz arenites by volume, comprise pyrite, magnetite, zircon, tourmaline, apatite, sphene and topaz in order of abundance. Minor accessory heavy minerals include ilmenite and monazite. Most notable as detrital grains are iron oxides and zircon grains. Most iron oxides occur as euhedral authigenic crystals, but some are subrounded detrital grains up to .5mm in size. Zircon occurs as < 0.05 mm well-rounded grains and as zoned stubby prismatic euhedral crystals 0.10 - 0.18 mm along the c-axis. These euhedral zircons commonly occur as inclusions within detrital framework quartz grains. Zircon separates

taken for U/Pb age dating are made up of roughly equal proportions of well-rounded, spherical zircons and euhedral unabraded zoned single crystals. Colour in both populations range from reddish brown to clear, with pink as the dominant colour.

u A thin silicified stromatolitic mudstone interbedded, less than 15 cm thick, conformably overlies the quartz arenites; and contains columnar, stratiform and domal forms (see Plate 9). For a detailed descriptive account see Arias (1986).

Conformably overlying the stromatolitic zone is a 5-metre-thick unit composed of 1-to 5-cm interbeds of quartz siltstones and laminated cherts. The siltstones are generally graded from a coarse siltstone base to a claystone cap. In these rocks the framework grains (essentially all sub-angular quartz) have size ranges from .5 to 0.1 mm and make up only 20-25% by volume of the siltstones. The matrix is extensively silicified by recrystallized quartz, which is more abundant than chlorite and illite, the other components.

Farther up section, laminated quartz siltstone gives way to interbedded hematite-rich siltstone and finely laminated chert beds. This transition is gradational over a 3 m zone until lean oxide facies banded iron formation predominates. Intraformational slump breccias supported by a black chert matrix occur directly below and in some cases within the iron formation. Clasts within these

primary slumps are angular and have been rotated and dislodged from the underlying laminated mudstone unit.

Finely laminated chert-magnetite banded iron formation caps the sedimentary rocks of the Keeyask Lake succession. This unit, with a maximum thickness of 5 m is in gradational contact with finely laminated iron-rich metapelitic units directly underlying the banded iron formation, and appears to be conformable with overlying ultramafic metavolcanic flows of the Keeyask Lake metavolcanic sequence.

Well-preserved sections of banded iron formation show delicate alternations of magnetite-rich and silica-rich laminae. The silica-rich laminae are cream to clear and occasionally brown; The magnetite-rich laminae are dark grey to black and are hematite stained. Generally, the bedding pattern in the iron formation can be seen on two scales: first on a scale of .5 to 1 cm, consisting of alternating silica-rich and magnetite-rich laminae; second on a mm scale in which internal laminations are superimposed on the larger scale as either silica-rich microlayers within magnetite layers or as magnetite and graphitic films within chert layers. Rare chemical gradation from a silica-rich base to an iron-rich top is observed within the cm-scale laminae. Most laminations are laterally extensive for tens of metres. Bedforms within the iron formation do not indicate current influence, and scouring of laminae surfaces has not been observed.

Alteration within the iron formation is common and includes cross cutting microfractures infilled with arsenopyrite, pyrite and ankerite. Remobilization of chert-rich laminae has produced layer-parallel quartz veinlets. This locally obliterates the fine lamination textures mentioned previously, but unless fairly intense, leaves the larger cm scale laminations intact.

Obliteration of the fine laminations is a common phenomenon outside the map area in higher metamorphic grade terrane and within high-strain zones such as in the Castor-Pollux and Opapimiskān Lakes areas. There, solid-state quartz grain migration accompanied by extensive gruneritization and annealing of magnetite has produced a coarse-grained iron formation which appears quite different from the iron formation occurrences at Center Lake and Quartzite Hill. Occasionally, localized zones within these higher grade areas contain well-preserved protoliths of banded iron formation which are essentially identical in appearance to the finer laminated western Eyapamikama Lake iron formation.

The banded iron formation unit in the western Eyapamikama Lake map area represents the base of the Keeyask Lake metavolcanic pile and the top of the Keeyask Lake metasedimentary section. It is a key stratigraphic marker signaling the transition between two major lithologic assemblages.

The banded iron formation and possibly the entire Keeyask Lake metasedimentary section may extend to the

north beyond the present mapped exposures. The Keeyask Lake metavolcanics are well exposed to the north but are extensively covered with overburden just west of the section before reaching tonalite exposures of the Weagamow batholith. Considering that the basal contact of the Keeyask Lake metavolcanics would underlie this zone of overburden and that an aeromagnetic high coincides with this area (see OGS 1985 mag. map), it seems likely that iron formation of the Keeyask Lake metasediments underlie this zone. It is interesting to note that the largest sedimentary clasts of iron formation in the entire NCLGB are angular iron formation blocks identical in appearance to in situ Keeyask Lake iron formation, and occur in younger overlying conglomerates of the Eyapamikama Lake metasediments east of the area described above.

Keeyask Lake Metavolcanics

The Keeyask Lake metavolcanic assemblage is a mafic to ultramafic package which has evolved from initially erupted ultramafic komatiites and grades into a predominantly mafic pillowed sequence. At the base of the Keeyask Lake metavolcanic sequence, ultramafic metavolcanic rocks have been intensely altered to serpentine-actinolite-tremolite-chlorite-talc and carbonate bearing assemblages which are penetratively foliated. These rocks appear to rest conformably on iron-rich chemically precipitated banded iron formation of the Keeyask Lake metasedimentary package.

Preservation within the Keeyask Lake metavolcanic terrane increases dramatically from the lower base of the volcanic section and grades into well-preserved spinifex-textured and polysutured ultramafic komatiite flows (see Plate 10). Narrow ultramafic dykes less than 20 cm thick have intruded the komatiite flows and the higher level pillowed mafic metavolcanic rocks. Mafic and ultramafic rocks appear to be interstratified within the Keeyask Lake Section. Mafic metavolcanic rocks show indications of repeated intrusion by more mafic to ultramafic material. This suggests that the mafic and ultramafic end members within the Keeyask Lake package may be coeval, originating from varied fractions of a common magmatic source.

The upper part of the metavolcanic pile is predominantly mafic, and shows a gradation from massive to pillowed flows. Flow contacts are generally poorly

preserved and rarely exposed. In most cases there tends to be a gradation from a finer grained ultramafic base to a coarser grained mafic flow top (see Plate 11). The centres of flows tend to be somewhat coarse grained as well.

A variolitic zone occurs within the massive zone, just below the pillowed mafic metavolcanic zone (see Plate 16). It can be traced as a continuous marker unit parallel to the Keeyask Lake zone boundaries, and runs approximately north-south for a continuous distance of approximately 5 km. Varioles within this zone occur within massive mafic metavolcanic flows. The varioles reach sizes of up to 5 cm in diameter and range to sub-cm scale. They commonly occur in grape-like clusters. The varioles are intermediate in composition and show a zoned internal pattern.

Small varioles, less than 1 cm size, also occur in association with amygdules in the pillowed mafic zone. The amygdules are plagioclase- or quartz-filled and range up to 2 cm in size.

The maximum observed pillow size within the entire section, about 1 m by .75 m, occurs within mafic rocks of colour index near 75% (see Plate 12). The pillows generally are much smaller (10 to 20 cm).

The pillowed zone grades upward into a narrow (less than 20 m thick) zone which begins with in situ broken pillow breccia (see Plate 13, 14), grades to pillow breccia (see Plate 15) and is capped by flow top breccia.

Within the Keeyask Lake metavolcanic rocks, top indicators throughout the section indicate facing

directions to the east. From this almost vertical east-facing sequence, the stratigraphic thickness, assuming no tectonic repetition of units, is estimated to be at least 2 km.

The most abundant minerals within the mafic metavolcanics are actinolite, chlorite and plagioclase. Accessory minerals generally include titanite.

Alteration within the mafic portion of the Keeyask Lake sequence consists of extensively carbonatized and sericitized pillowed mafic metavolcanics which show disruption of selvage margins and replacement by carbonate.

Structural deformation within the Keeyask Lake zone appears to be minimal. The rocks generally show two penetrative fabric elements, but no major fold closures were mapped in the area.

The contact between the uppermost metavolcanic rocks of the Keeyask Lake section and the basal conglomerates of the Eyapamikama Lake metasedimentary succession is exposed in several localities near the shore of western Eyapamikama Lake (see Plate 17). This contact appears to grade from conformable to unconformable. At one locality the contact is well defined and almost razor sharp; in another place it appears to be gradational, with interstratified conglomeratic units incorporating coarse-grained ultramafic to mafic metavolcanic flow breccia. It is important to note that a major lithologic change occurs

over a short distance, representing a drastic and rapid environmental change. Because much of the basal conglomerate of the Eyapamikama Lake metasediments contains clast populations derived from underlying units, it is probable that a well-developed unconformity surface was present and may still be preserved within the map area.

Eyapamikama Lake Metasediments

Clastic metasediments of mid-greenschist to mid-amphibolite grade are best exposed within the axial portion of the North Caribou Lake greenstone belt along the shores of Eyapamikama Lake. These metasediments and correlative strata outside the Eyapamikama Lake area, here termed "Eyapamikama Lake metasediments", are the youngest exposed Archean supracrustal rocks of the NCLGB in the map area. They are intruded by fluorite-bearing granitoid dykes on the northwest shore of Eyapamikama Lake, and probably by a late (early Proterozoic ?) diabase dyke interpreted from a narrow linear aeromagnetic anomaly which transects the map area (OGS 1985 Mag Map).

The central part of the map area is occupied by rocks in the axial zone of the NCLGB that extends along the length of Eyapamikama Lake. Because this axial zone is predominantly of greenschist grade, primary mineralogy, primary structures and fabrics are better preserved here than along the margins of the belt where rocks were subjected to amphibolite-grade recrystallization under a higher stress regime.

The Eyapamikama Lake metasedimentary sequence in this western region of the NCLGB is composed of a suite of rock types ranging from coarse proximal alluvial conglomerates to fine-grained distal turbidite greywacke/slate couplets (see Plates 18,19,20).

The stratigraphic data necessary for a detailed basin analysis is limited due to poor stratigraphic control and insufficient structural information to allow delineation of the major fold axis. Generally, however, the stratigraphy of the Eyapamikama Lake metasediments reflects a fining upwards sequence in which basal alluvium and fan delta conglomeratic cycles grade vertically and laterally into finer grained sediments. Keeping this in mind, the siliciclastic rocks of the Eyapamikama Lake metasedimentary sequence will be discussed here as sedimentary rock types rather than as mappable units. The distribution of sedimentary rock types described herein is displayed in an OGS preliminary map (Map P2834).

Conglomerate

Conglomerates of the Eyapamikama Lake area are predominantly restricted to the basal part of the Eyapamikama Lake sedimentary cycle. Contact relationships of conglomerates with adjacent metavolcanic sequences in the map are obscured by extensive overburden and by intense transposition and shearing along this contact. Poor exposure and a high degree of attenuation common in many of the sedimentary sections precludes confident

stratigraphic correlation. However, based on close lithologic and facies similarities with less strained and better exposed sections in the northeastern Keeyask Lake area, a generalized correlation can be established for most conglomeratic units in the map area. Although some diachroneity is likely, most coarse conglomerates of the Eyapamikama Lake section probably accumulated rapidly during a specific phase of regional-scale deposition.

Clasts within the conglomerates are representative of the main underlying rock types. This includes felsic volcanics similar to the Agutua Arm felsic volcanics, ultramafic and variolitic mafic metavolcanics akin to the Keeyask Lake volcanics and laminated quartz arenites and banded iron formation identical to the Keeyask Lake metasediments (see Plates 28, 31, 33). In addition, a high percentage of trondjemite-tonalite-diorite clasts in the Eyapamikama Lake conglomerates are similar to intrusive rocks of the Weagamow batholith and other nearby intrusive complexes (see Plates 26, 29, 30, 35).

These clast types occur in conglomerates throughout the NCLGB from the extreme eastern portion of Eyapamikama Lake through to north of Seeseep Lake, and also in conglomerates south of Castor-Pollux Lake (these continue west for a strike length of 12 km), and in all coarse conglomeratic sediments on the shores of western Eyapamikama Lake. Some clasts show a wide variety of compositions and textures, and identification in highly strained areas is evident only upon subsequent investigation of polished slabs and thin sections.

Plates

- 18 Subarkosic wacke interstratified with coarser granule conglomerate. Eyapamikama Lake metasedimentary unit.
- 19 Arkosic wacke/slate turbidite couplet typical of the main phase of Eyapamikama Lake sedimentation. Note grain gradation of wackestone unit and delicate flame structures within lower mudstone unit.
- 20 Proximal marine facies polymictic pebble conglomerate and granule wackestone. Eyapamikama Lake metasedimentary unit. Hammer is 20 cm in length.
- 21 Thick massive arkosic wacke bed (top of photo) overlying finer grained layered wacke bed (bottom of photo). Note scour surface at right side of the contact surface just below 2.5 cm coin. Photo provided by F.W. Breaks.
- 22 Large-scale trough cross stratified arkosic wacke of the Eyapamikama Lake metasedimentary unit. Coin near centre of photo is 2.5 cm in dia. Photo provided by F.W. Breaks.
- 23 Trondhjemite granule (centre of photo) within subarkosic "clean" wacke of the Eyapamikama Lake metasedimentary unit near Casper Lake.
- 24 Typical quartz-rich coarse-grained subarkosic wacke of the Eyapamikama Lake metasedimentary section. Note coarse subrounded quartz sand grain at lower right of photo.

Plates

- 25 Base of sand-filled fluvial channel within Eyapamikama Lake clast-supported conglomerate. Photo taken near Keeyask Lake.
- 26 Matrix-supported polymictic boulder-pebble conglomerate of proximal marine facies, near base of the Eyapamikama metasedimentary unit. Note large trondhjemitic boulders common in "trondhjemitic" conglomerates of the western Eyapamikama Lake area.
- 27 Clast supported boulder-cobble polymictic conglomerate of fluvial facies near Keeyask Lake. Eyapamikama metasedimentary unit.
- 28 Felsic volcanic pebble conglomerate. Over 60% of total clasts by volume originated from a proximal felsic volcanic source. Eyapamikama Lake metasedimentary unit.
- 29 Close view of 2990 Ma tonalite from the western margin of the Weagamow batholith.
- 30 Close-up view of tonalite boulder within Eyapamikama Lake metasediments near Keeyask Lake. Note compositional and textural similarity to tonalite shown in Plate 29. A similar clast yielded a U/Rb age of 2960 Ma.
- 31 Quartz arenite pebble within basal Eyapamikama Lake conglomerate. A thin section of this clast shows well-rounded mature grains essentially identical to those depicted in Plate 5 from the Keeyask Lake quartz arenite.

CENTIMETRE

CENTIMETRE

Plates

- 32 Foliated quartz-diorite cobbles in clast-supported polymictic conglomerate. Note differences in orientation of foliation in cobble above scale card to that in clast just above and to the left of the card.
- 33 Banded iron formation clast (centre of photo) within basal Eyapamikama Lake conglomerate.
- 34 Quartz phyric sericite-rich clast possibly derived from chemically weathered quartz porphyry. Note large quartz phenocrysts.
- 35 Well-rounded tonalite cobble (upper-middle right of photo) in clast-supported conglomerate showing texture and composition similar to adjacent rocks of the Weagamow batholith. Photo taken near contact with eastern margin of Weagamow batholith near Keeyask Lake.
- 36 Mafic metavolcanic cobble (middle left of photo) showing possible weathering rind and eroded variole.
- 37 Clast of coarse trondhjemite intruded by diorite (upper part of photo).
- 38 Clast containing thin quartz vein that cuts a microtrondhjemite-coarse trondhjemite contact.
- 39 Well-rounded clast which was broken just before deposition, showing intrusive relationships opposite to that shown in Plate 37. Here, coarse trondhjemite has intruded diorite (lower right part of clast).

Plates

- 40 Mafic-ultramafic metavolcanic autoclastic breccia supported by quartz-rich wacke matrix. Base of Eyapamikama Lake metasedimentary unit.
- 41 Close view of Plate 40 showing extreme angularity of metavolcanic fragments.
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Plates

- 47 Mega-varioles of gabbroic composition within ultramafic metavolcanic block.
- 48 Angular-clast-supported oligomictic ultramafic conglomerate derived from proximal active volcanic source. Base of Eyapamikama Lake metasedimentary unit.
- 49 Rounded clast with internal mega-varioles similar to those depicted in Plate 47 adjacent to round felsic volcanic clast. Base of Eyapamikama lake metasedimentary unit.
- 50 Conglomerate showing deformed ultramafic clasts (upper part of photo on line with hammer) adjacent to large tonalite block. Hammer is 40 cm long.
- 51 Small-scale varioles in mafic-ultramafic clast similar to those within the underlying in situ rocks of the Keeyask Lake metavolcanic accumulation.
- 52 Angular clast with internal variole that is transected by a detritus-infilled fracture.
- 53 Contact of variolitic ultramafic clast and quartz-rich wacke matrix.
- 54 Variolitic ultramafic-mafic blocks derived from the underlying Keeyask Lake metavolcanic pile. Note random fracture pattern. The matrix is feldspathic wacke. Base of the Eyapamikama metasedimentary unit. Hammer is 40 cm in length.

In the northeast Keeyask Lake and west Eyapamikama Lake areas, matrix-supported and clast-supported conglomerates and arkosic wackes overlie a range of metavolcanic rocks that form the Keeyask Lake metavolcanic pile (see Plates 25, 27). The latter include spinifex-textured and polysutured komatiites, variolitic and pillowed mafic metavolcanics, and mafic autoclastic breccias (see Plates 40, 46, 49). The basal sediments that directly overlie the contact with these metavolcanic rocks are variable in grain size and composition. These sediments demonstrate lateral facies changes that range from coarse matrix-supported polymictic cobble to boulder conglomerates to an angular oligomictic mafic volcanic cobble conglomerate. Bed forms in these sediments include basal scours with infilled lag deposits, graded beds and inversely graded beds with stratified pebbly beds. Clasts locally show imbrication within clast-supported conglomerates such as those at the southeastern edge of Keeyask Lake. Generally, however, the conglomerate clasts tend to be chaotically arranged and matrix supported, with a high (> 50%) sand-sized matrix component (see Plate 28).

• **Arkosic arenites (Sub-arkosic arenites)**

Arenites (less than 15% matrix) are not common within the Eyapamikama Lake metasediments, which tend to be restricted to narrow interbeds within predominantly wacke-mudstone-turbidite sequences. These arenites are invariably plagioclase rich (greater than 50% of framework

grains) and most contain more than 10% matrix. Framework grains are texturally similar to the enclosing wackes, showing a range of non-sorted grain sizes, angularity of grains (especially plagioclase) and a lack of lamination. In hand specimen, the arenites are difficult to distinguish from wackes. Weathered surfaces of the arenites tend to be less lichen covered, and when scratched the arenites tend to be less chalky than wackes. At higher metamorphic grades, the wackes show a greater increase in biotite content than do the arenites. Arkosic and sub-arkosic arenites are confined to the west end of Eyapamikama Lake, and commonly occur as minor constituents in proximal conglomeratic submarine fan deposits.

In general, the arenaceous rocks of the Eyapamikama Lake area other than quartz arenites of the Keeyask Lake metasediments are considered to be marginal extensions of the more common wackes into the arenite field due to a decrease in the matrix fraction. When other features such as grain composition, angularity and sorting are taken into account, arkosic and sub-arkosic arenites are quite similar to the arkosic and sub-arkosic wackes in the area.

Wackes

Arkosic Wackes and Sub-arkosic Wackes

Arkosic wackes in the map area are abundant along the shores and islands of the western Eyapamikama Lake. They occur in close association with the sub-arkosic wackes, which are essentially identical with the exception of a higher quartz fraction (see Plate 24). Arkosic and sub-

arkosic wacke is also the main matrix constituent of pebble to boulder conglomerates in the western Eyapamikama Lake area.

The matrix fraction of this rock type ranges from 25% to 60% by volume. Chlorite, muscovite, biotite, carbonate, microcrystalline quartz and plagioclase are the major matrix constituents. Modes of matrix content commonly are difficult to estimate due to the extensive sericitic alteration of plagioclase grains, rendering some indistinguishable from the matrix. The framework grains (sand-size fraction) are poorly to/very poorly sorted and are angular to sub rounded, but on average are angular. Rounded titanite and well-rounded quartz grains occur as minor components in the framework. Because these rocks by definition contain less than 20% labile rock fragments, all sand-sized chert has been included in the quartz fraction. In some cases, chert contributes more than 10% to the rock volume. Rare euhedral zircon prisms (.025 mm x .005 mm) occur as inclusions within large sand-sized grains of phanocrystalline quartz. Some large recrystallized quartz grains contain small epidote inclusions. Doubly terminated clear quartz grains and embayed or resorbed quartz grains occur in arkosic wackes that may have been deposited proximal to felsic centres. Plagioclase grains are invariably of albite composition, although oligoclase predominates north of Eyapamikama Lake, where the metamorphic grade is higher. One zoned

plagioclase grain was noted which displayed intense sericitic alteration within the centre of the grain, suggesting a more calcic core.

Most wackes are preserved as massive beds ranging in thickness from 1 cm to 2 m. Rare bedforms associated with these rocks include large cross trough stratification (festoon bedding) and grain gradation (see Plates 21, 22). Small-scale (< 1 cm) flame structures, load casts and grain gradation are more common within 1-5 cm wacke interbeds of the mudstone/wacke couplets along the Eyapamikama Lake shoreline. These rhythmic sediments are interpreted as turbidites that formed in medial to distal fan environments. Arkosic and sub-arkosic wackes are common as matrix to both the matrix-supported and clast-supported polymictic pebble to boulder conglomerates.

Lithic Arkosic Wackes and Lithic Sub-arkosic Wackes

These rocks occur in association with previously mentioned arkosic and sub-arkosic wackes; however, their abundance is much less. Most wackes in the NCLGB tend to be "clean", containing few lithic fragments other than chert, and also tend to be quartz rich throughout all wacke fields (> 55-60 % of framework is quartz). The lithic fragments include medium-grained trondjemitic clasts, (common in wackes southeast of Casper Lake: see Plate 23), serpentized ultramafic clasts, plagioclase or quartz phyric felsic volcanics (some greater than 6 mm in size), chert clasts and chlorite-rich mafic clasts of

probable volcanic origin. Small granule-sized quartz fuchsite fragments are common in these rocks as well. The lithic fragments compose up to 25% of the frameworks and are invariably poorly sorted and angular. Of note is the near absence of potassium feldspar grains in this type of wacke (and any wacke from the area for that matter). Microcline (less than 5%) was observed in a single sample collected outside of the map area (north of Seeseep Lake).

Mudstones

This unit includes slates, siltstones and phyllites that are spatially confined to the core of the Eyapamikama Lake axial zone of the NCLGB. These are best exposed along the north and south shores of Eyapamikama Lake from $90^{\circ}50'W$ to $91^{\circ}05'W$. These rocks are black to light grey on weathered surfaces, and most are thinly coated with an organic rind which obscures primary lamination. Light to dark brown interlamination are common, and enable the delineation of primary features such as ball and pillow structures, rip up clasts, slumps and flame structures (see Plate 19). The small-scale lamination is defined by thin light to dark brown ribbon-like bands, from 1 to 10 mm thick, set against a black to light grey argillaceous matrix. The compositional differences of the contrasting laminations is not known, but may be related to grain size and to the abundance of non-phyllosilicate minerals giving a lighter colour to the rock in the browner laminae. Slates along the shores of Eyapamikama Lake are invariably

characterized by a crenulation cleavage and pronounced penetrative lineation. The rock is most fissile along S_2 planes.

Major mineral constituents include chlorite, biotite, quartz, plagioclase, sericite and muscovite. Chlorite-bearing slates and siltstones are confined to the southwestern part of Eyapamikama Lake, and give way to biotite-bearing slates as increased metamorphic conditions are reached to the north, west and east of Eyapamikama Lake (see Chapter 1 on metamorphism). Along sections perpendicular to S_2 , arsenopyrite and pyrite are flattened into small 1-2 mm lenses along cleavage planes, and locally are connected as stringers attached to late euhedra that truncate all fabrics. Grain size in the mudstones varies according to metamorphic grade. For example, biotite varies from microcrystalline in low-grade areas to 5 mm in high-grade areas. Phyllosilicate minerals anastomose and enclose tectonically rounded quartz and plagioclase grains, creating a micro-chicken-wire appearance. Grain size in the low-grade zone reaches a maximum of .075 mm and a minimum of .01 mm, with the mean falling at about .025 mm. Angular sand-size lithic fragments are embedded in the argillaceous matrix, but these clastic inclusions rarely exceed 10% by volume and are usually confined to discrete bedding planes that are grain graded.

Mudstones are often interstratified with 1-5 cm greywacke as turbidite couplets. Interbedded mudstone/wacke

has not been established as a mappable unit in the western Eyapamikama Lake map area, but is extensive in the eastern part of Eyapamikama Lake. A variety of rock types is grouped with these turbidite couplets, ranging from predominantly massive wackestone with minor mudstone as a cap to an A-B-E type Bouma sequence through to a predominantly mudstone sequence with sparse 1-2 cm wacke interbeds.

Because there appears to be a general younging direction from all belt margins towards the axial zone of the NCLGB in the Eyapamikama Lake area where these rocks are situated, the mudstones and mudstone/wacke couplets likely represent the final cap to the Eyapamikama Lake metasedimentary sequence.

Chapter 3: Provenance Studies

The Quartz Problem

A significant feature of the metasedimentary rocks of the western Eyapamikama Lake area is their high quartz content. Detrital quartz concentration within greywacke of the Eyapamikama Lake metasedimentary sequence is generally above 50% and commonly up to 75% (see Fig. 11). The lower part of the Keeyask Lake metasedimentary section is also quartz rich, with the quartz concentrations in both wackestones and arenites ranging from 80% to 99% (see Plate 5).

To produce metasedimentary rocks with such high quartz concentrations, the initial source rock must have been of a comparable quartz concentration, or and an efficient concentrating mechanism must have been operative once the quartz grains were liberated from the source rocks. Concentrating mechanisms can be quite variable and may act in combination. Prolonged exposure to intense weathering and long transport distances can result in a compositionally mature quartz-rich sediment, provided that the source terrane contains a reasonable amount of free quartz of suitable grain size. For example, a dominantly mafic-ultramafic terrane could not produce a quartz arenite no matter how intense the weathering regime, simply because there are no quartz phenocrysts to work with. For source rocks that do contain quartz grains of sufficient size, however, prolonged periods of sorting and

Figure 11: Triangular McBride plot of greywacke point counts. Each sample represents about 300 counts from individual thin sections of Eypamikama Lake metasedimentary rocks.

abrasive action can result in concentration of quartz, especially in a stable marine margin setting such as a coastal beach or barred beach environment. There, tidal reworking and degradation of detritus leaves only the most stable grains intact, while fine mud-sized particles are selectively removed. The remaining quartz-rich sands become texturally mature from constant abrasion, and also become enriched in resistant heavy minerals such as zircon, tourmaline, apatite, rutile, beryl and topaz.

Source of Keeyask Lake Quartz Arenites

Compositionally and texturally mature sediments such as the quartz arenites of the Keeyask Lake package are rare in Archean terranes of the Canadian Shield (Donaldson and Ojakangas 1977). Although quartz arenites have been located on every Archean craton in the world, they contribute only a minor percentage to the total volume of Archean rocks (Eriksson 1979). They are more abundant in some areas than others, but are extremely rare in areas of the Canadian Shield such as the southern sub-provinces of the Superior province (Lowe 1982).

From petrological evidence alone, it is difficult to discern the specific nature of the source terrane for the quartz arenites. For instance a high-grade gneissic basement or a felsic volcanic terrane can produce quartz grains that appear quite similar after extensive abrasion. Source terranes can also be quite complicated, because Archean cratons are mosaics of complex overlapping terranes that include abundant mafic components.

Some terranes show a higher probability as a source of quartz, while others are simply inadequate (Donaldson and Jackson 1965). In certain areas, for example North Spirit Lake in the northern region of the Superior province (Wood 1977,80, Donaldson and Jackson 1965, Donaldson and Ojakangas 1977) volume calculations of quartz within quartz rich wackes and quartzites showed that 30% by volume of the total sand fraction of this greenstone belt was sand-size quartz. This places impossible volume expectations on sources such as hydrothermal vein systems as a predominant source for quartz-arenites (although hydrothermal quartz may have provided a minor contribution to the quartz budget). As mentioned earlier, ultramafic and mafic terranes are not suitable as source rocks due to a lack of sand-sized phenocrysts. This leaves only phanerocrystalline plutonic rocks, porphyritic acid volcanics and older sedimentary rocks. The most felsic plutonic rocks contain up to 45% free quartz, although little of this is sand sized. The quartz porphyries contain up to 10% quartz phenocrysts, but most are less than 1.0 mm, in comparison to the average framework grains of the quartz arenites, that usually are greater than 1.0 mm. For these rocks to act as a major primary source, intense chemical weathering would be necessary to produce a sand grain fraction containing 25% quartz. Previously formed quartz-rich sediments such as cherts or quartz rich feldspathic arenites and wackes also can act as a suitable source rock for the derivation

of a quartz arenite. This is an alternative which many authors invoke when presented with good evidence for a previous sedimentary cycle already somewhat enriched in quartz.

It is generally concluded, that quartz arenites, especially if they display bedforms indicative of fluvial transport and tidal action, were formed as a result of intense chemical weathering and prolonged transport from a felsic source such as pre-existing quartz-rich sediments, quartz porphyries or quartz-rich plutonic rocks (Schau 1977, Donaldson and Jackson 1965).

Some quartzites do not show a high degree of sphericity and rounding of grains, but contain up to 99% quartz. In some instances these quartzites contain abundant euhedral embayed quartz indicative of a felsic hypabyssal or volcanic source rock. An example of felsic volcanics as a source is provided by the Strelley Pool quartzites, Pilbara block, western Australia (Barely et al. 1979). This type of quartz arenite meets the criteria for mineralogic maturity, but lacks the textural maturity needed to invoke lengthy erosion and transport for its mode of origin. Thus, to characterize properly the nature of the source terrane, all features of the rock must be examined including primary structures, quartz content, sphericity and roundness of grains, and the type of grains (embayed, euhedral, strained, inclusions within grains, authigenic overgrowths and degree of recrystallization).

Several petrological features of quartz arenites in the Keeyask Lake section aid in placing constraints on the nature of the source rock. The presence of euhedral zircons suggests an igneous source for these quartz arenites. The zircons make up less than 5% of the total zircon population, and most occur as inclusions within the detrital quartz grains. Almost all of the detrital zircons are brownish pink, show a similar lack of internal inclusions and zoning, and are well rounded. The zircon population is quite similar to that of the older Agutua Arm felsic volcanic rocks.

Felsic plutonic clasts have not been observed in any of the coarse-grained interbeds of quartz pebble conglomerates. Plagioclase-quartz aggregate grains have also not been observed in any sediments of the Keeyask Lake section. Had trondhjemite acted as a source for the quartz arenite, one would expect at least some intact plutonic grains to remain. This, however, may not have been the case if intense chemical weathering occurred in the source area. In this way a plutonic source rock could have been degraded until all feldspar grains were broken and altered into fine clay particles that were subsequently winnowed away, leaving only a residue containing little else than quartz and heavy minerals. The presence of a 10 m-thick regolith just below the quartz arenites provides evidence for a period of intense chemical weathering before deposition of the quartz arenite. The lack of strained quartz grains and

metamorphic minerals such garnet or kyanite in the quartz arenite suggests that the source rock was not an older metamorphic complex.

Quartz grains showing evidence of resedimentation from a previous sedimentary source were not observed. For instance, quartz grains with internal authigenic overgrowths formed by cementation during a previous sedimentary cycle are absent. The low strain state of much of the quartz arenite at Quartzite Hill should have allowed recognition of these types of features, had they been present. However, rare occurrences of quartz arenite pebbles in the coarser interbeds provide evidence for at least some consolidated quartz-rich sediment as a source of quartz. Although a high percentage by volume of clasts in the quartz pebble conglomerates of the Keeyask Lake section are chert, sand-sized chert grains are nearly absent in the quartz arenites. Most detrital grains are single crystals, suggesting that chert was not a large contributor in this area to the quartz budget.

Without taking the preliminary age dates obtained from the rocks into consideration, the field and petrological evidence is thus consistent with the dominant source rock being one of or a combination of the following rock types:

- quartz-phyric felsic volcanic rocks
- quartz-rich hypabyssal rocks
- quartz-diorites or trondhjemites

If the quartz arenites were derived from an individual rock type within the map area, the most obvious candidate for a source rock is the felsic metavolcanic unit directly below the unconformity.

However, the felsic metavolcanic rocks that are preserved in the map area are not a suitable source because the quartz phenocrysts are too small to provide sand-size grains. Possibly, however, a range of consanguineous igneous rock types acted as a composite source for the quartz arenite, ranging from a high-level coarse-grained quartz porphyry to a deep seated quartz-diorite or trondhjemite parent. Such a source could have been totally removed during erosion before, and during, deposition of the quartz arenite.

Source for Eyapamikama Lake Metasediments

The Eyapamikama Lake metasedimentary accumulation represents a different sedimentary environment than that of the Keeyask Lake metasedimentary section, consisting of distinctly different lithologic units with different sedimentary bedforms (see Chapter 2). The entire Eyapamikama Lake section is much thicker, probably by two orders of magnitude or more. The volume of sediment thus would necessarily be higher by this same order if deposited over an equivalent area. However, it seems that the area of deposition for the Eyapamikama Lake sediments was much greater, considering its regional occurrence in comparison to the rather local occurrence of the Keeyask

Lake metasediments. Possibly, however, the Keeyask Lake metasediments initially contained regionally extensive quartz arenites which were reduced to a local quartz arenite occurrence by erosion.

The Eyapamikama Lake metasediments were formed in an entirely different tectonic regime than were the underlying successions. The Eyapamikama Lake metasediments were initially deposited in an active volcanic environment that was surrounded by rapidly rising granitoid terrane. This contrasts sharply with the tectonically stable environment that prevailed during deposition of the Keeyask Lake stromatolite-bearing quartz arenites.

Quartz and plagioclase-rich sediments in the map area are all texturally immature and commonly occur in massive, thick interbeds suggesting that deposition was rapid throughout the area. Once the initial pulse of coarse sedimentation was activated, volcanic activity appears to have ceased.

The quartz and plagioclase-rich Eyapamikama Lake greywackes appear to have been derived almost exclusively from uplifted surrounding granitoid terrane, but some detritus was probably added from reworked upper Agutua Arm felsic volcanics and from uplifted segments of the Keeyask Lake quartz-arenites. Unroofed felsic intrusions and adjacent felsic volcanic centres probably provided the bulk of this detritus. In some areas, such as eastern Eyapamikama Lake, it appears that felsic centres have been

active during the initial stages of deposition whereas in the other areas such as western Eyapamikama Lake, coarse sedimentation was concomitant with ultramafic volcanism.

The estimated high quartz and plagioclase modes of the Eyapamikama Lake metasedimentary rocks, and the angularity and poor sorting of framework grains, indicate an immature sediment which was deposited rapidly adjacent to quartz-rich highland sources. These highland terranes may have been rapidly uplifting welts underlain by tonalitic granitoid rocks of which the lower crustal segments are preserved as enclosing batholiths such as the Weagamo batholith, the North Caribou Lake batholith and the Schade Lake gneissic complex.

Lithic arkosic and lithic subarkosic wackes of the area suggest local contamination by both mafic and felsic volcanic centres. In the Seeseep Lake area, this contamination is almost entirely from a felsic volcanic source, whereas in the Keeyask Lake area, the lithic arkosic wackes are indicative of mafic volcanic input. The arkosic wackes in the northwestern Eyapamikama Lake region southeast of Casper Lake contain only plagioclase and quartz. These wackes are texturally immature and form massive beds up to several metres thick. They commonly contain trondhjemite and tonalite granules which probably reflect derivation from the unroofed Weagamow batholith to the southwest during regional uplift (which also was responsible for deposition of most of the basal Eyapamikama Lake conglomerates.)

Megascopic Modal Analyses

Megascopic modal analyses conducted on the basal conglomerates of the Eyapamaikama Lake metasedimentary section were very useful in ascertaining provenance (see Tables 1, 2).

From these analyses it can be seen that there is a wide variation in clast populations throughout the area. The analyses suggest that there are three types of source terranes that supplied the coarse conglomerates. These are classified here according to the main clast types as;

1. Trondhjemite conglomerates, 2. Felsic volcanic conglomerates and 3. Ultramafic-mafic volcanic conglomerates.

Table 1

Summary of Clast Populations (in percent of total clast volume)

Station No. (Points counted, including matrix)*	J3008 (1000)	J3042 (200)	J3043 (100)	1-17-13 (100)	J2706 (600)	Total Mean (2000)
Felsic Intrusives	55	51	48	5	2	35
Mafic Intrusives	14	10	24	5	8	12
Mafic-Ultramafic Volc.	17	21	14	26	82	37
Felsic Volcanics	5	12	8	63	7	9
Hydrothermal Products**	6	1				3
Chemical Sediments	3	1		5	1	2
Clastic Sediments		3	6			1
Totals	100	99	100	99	100	99

* See Table 2 for Matrix content.

** Hydrothermal Products: Vein quartz, quartz fuchsite and quartz ankerite.

Table 2

Results of Megascopic Modal Counts of Basal Conglomerates

Station No. (Points Counted)	J3008 (1000)	J3042 (200)	J3043 (100)	1-17-13 (100)	J2706 (600)	Total Mean (2000)
Granodiorite	2.0	7.5	3.0			1.9
Tonalite	4.2	9.5	5.0			3.3
Trondhjemite	11.4	16.0	16.0		1.5	8.5
					Subtotal	13.7
Felsic Volcanic	.4	4.0	2.0	12.0	.7	1.5
Quartz Porphyry	.6	3.5	1.0			.7
Quartz Sericite Schist	.3	.5	1.0			.3
Hornblende Phyrlic	.2	.5				.2
					Subtotal	2.7
Quartz Fuchsite	1.1	.5				.6
Vein Quartz	.6					.3
Quartz Ankerite	.1					.1
					Subtotal	1.0
Diorite	4.3	6.5	12.0		2.5	4.2
Gabbro	.1			1.0	3.5	1.1
Ultramafic Intrusive					a .3	.1
					Subtotal	5.4
Intermediate Volcanic	.1				4.8	1.5
Mafic Volcanics:						
-Unsubdivided	4.9	13.0	6.0	4.0	60.3	22.3
-Variolitic					3.2	1.0
Ultramafic:						
-Volcanics (Komatiite)	.7	.5	1.0	1.0	1.7	1.0
					Subtotal	24.3
BIF	.6	.5			.5	.5
Chert	.5			1.0	.5	.5
Quartz Arenite	.1					.1
Possible Sediment (Reworked Felsic Tuff?)		2.0	3.0			.3
Matrix	67.8	35.5	50.0	81.0	20.5	50.0
Totals	100.0	100.0	100.0	100.0	100.0	100.0
(Pre-deformed Clasts)	.4	15.0	11.0	?	2.2	6.5

The most common clast population type occurs within trondhjemite conglomerates and is best observed at stations J3008, J3042 and J3043 (see Plate 26). In this population, nearly 50% of the total clasts by volume were derived from a felsic intrusive source. This intrusive source was predominantly trondhjemitic, probably over two thirds by volume, but included tonalitic and dioritic rocks as well. These felsic intrusive rocks are preserved as well-rounded cobble- to boulder-sized clasts, indicating extensive mechanical abrasion. Similar felsic-rich cobble to boulder conglomerates occur within the North Spirit Lake belt to the southwest (Wood 1977), suggesting that this may be a common population type throughout this portion of the Sachigo subprovince. Many of the felsic intrusive clasts within the Eyapamikama Lake conglomerates bear striking similarity to in situ granitoid rocks of the surrounding batholiths. In fact the clast types appear to be identical, and increase in angularity and size with proximity to the Weagamow batholith to the west. This suggests that at least some of the tonalite-trondhjemite batholith regions enclosing the North Caribou Greenstone Belt acted as a source for these clasts.

Batholiths in the map area show at least a pre-D₂ intrusive relationship with the enclosing greenstones, and may have acted as a source for granitoid cobbles and boulders in the sedimentary rocks that overlie the greenstone sequences. In view of this, and considering

that the exposed greenstone/sediment contact (Keeyask Lake metavolcanics/Eyapamikama Lake metasediments) reveals that there was essentially little or no time break between the end of mafic volcanism and the onset of clastic sedimentation, it is likely that emplacement of the surrounding batholiths began during active mafic and ultramafic volcanism in the belt.

It is important to note that in all three population types there is a significant number of mafic and ultramafic clasts. However, these rocks are considered to have originated from a local source proximal to the area of deposition of the conglomerates. Within the trondhjemite population type, there is about 10% or greater of quartz porphyry or quartz-phyrlic felsic volcanic rocks (see Plate 34). These rocks may represent high-level equivalents to the felsic intrusive rocks that make up most of the clast population. Quartz fuchsite, clear and milky vein quartz, quartz ankerite and carbonate-chlorite clasts occur in this population as well. This population group also contains the highest percentage of foliated (predeformed) clast types, most of which are diorite-gabbro and trondhjemite (see Plate 32). This indicates that a compressional event predated deposition of the conglomerates. This event was not necessarily regional, and may have only affected rocks within the local strain envelope of diapiric felsic intrusions.

The second most common conglomerate type is the felsic volcanic suite. It represents proximal to medial deposits adjacent to active felsic volcanic centres. These volcanic centres may have been completely removed during the tectonically unstable period before and during formation of the Eyapamikama Lake conglomerates. Alternatively, the felsic volcanic clasts may have originated from uplifted Agutua Arm terrane which contains rock types identical to those in the conglomerates. The best deposits of this type are outside the map area in the eastern Eyapamikama Lake region, just north of Seeseep Lake. Here near 90% of the conglomerate clast population is made up of angular felsic pumice and lapilli fragments supported by a matrix of felsic ash. A small island in the southwestern part Eyapamikama Lake (submerged in the summer of '85) contains predominantly felsic volcanic fragments (more than 60% of total clast population). Many of these clasts are angular pebbles distributed along bedding. This suggests that felsic debris was ejected periodically onto an existing submarine fan complex adjacent to the felsic volcanic centre.

The third population type is dominated by proximally derived ultramafic and mafic metavolcanic rock types (see Plates 40, 44, 46, 48, 54). The clasts within these conglomerates have originated from the underlying Keeyask Lake metavolcanic rocks. A minor amount of felsic intrusive and felsic volcanic rock types is included in this population (however, the total volume of all felsic

rock types is less than 10%). The felsic component of the population was probably introduced from an encroaching fan complex that had a source terrane similar to that of the trondhjemite type conglomerates (see Plate 46). The ultramafic-mafic volcanic conglomerates are composed of up to 100% clast-supported angular mafic and ultramafic blocks. These conglomerates represent alluvial and talus debris that accumulated at the base of a steep scarp. The matrix of the conglomerate is a quartz-rich wackestone that probably filled cracks between angular volcanic blocks during burial of the coarse talus deposit by a separate fan lobe. All of the lithotypes of the Keeyask Lake metavolcanic section are incorporated into this conglomerate. This includes coarse variolitic mafic metavolcanics, clasts of mafic flow breccias, spinifex boulders, and pillow-selvage debris (see Plates 47, 50, 51, 52, 53). Deposition was concomitant with the latter stages of Keeyask Lake ultramafic volcanism, because the deposit contains spinifex-textured ultramafic flows up to 2m thick. Mafic and ultramafic blocks within this conglomerate commonly form a jigsaw-like pattern, indicating that these rocks must have undergone in situ fragmentation after consolidation (see Plates 41, 42, 43, 45).

A common feature of all three conglomerate types is the exotic clast content. These clasts include banded iron formation, chert and quartz arenite (see Plates 33, 31). These clasts are distributed throughout all conglomerates, but together form less than 1% by volume of the

conglomeratic deposits. These clast types are most likely to have originated from the older Keeyask Lake metasedimentary section. Thin sections of quartz arenite pebbles and banded iron formation boulders show textural and mineralogical characteristics essentially identical to the in situ rocks from which they most probably were derived. This observation provides additional evidence to indicate that the western Eyapamikama Lake area is underlain by rocks that formed as a result of the deposition of two distinct sedimentary cycles, the Keeyask Lake metasedimentary cycle and the Eyapamikama Lake metasedimentary cycle.

To summarize, most of the basal conglomerates of the Eyapamikama Lake metasedimentary sequence can be interpreted as proximal submarine fan conglomerates that had a predominantly felsic intrusive (trondhjemite-tonalite-diorite) provenance, with some contamination from local mafic-ultramafic volcanic and felsic volcanic sources. This mixing may have been the result of clastic debris from sialic highlands being dumped into existing mafic volcanic graben depocentres and through contrasting submarine fan truncation and overlap such as that described by Lowe (1982). Such overlap would be a common feature along the leading edges of detrital aprons surrounding the active felsic centres.

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detrital zircon dates are concordant with the felsic volcanic age. In addition, the close correlation of the $^{208}\text{Pb}/^{206}\text{Pb}$ ratios (a measure of Th/U) of detrital grains to the ratio for the felsic volcanic is consistent with this interpretation.

Table 3

Preliminary U/Pb age Dates For Eyapamikama Lake Area

Rock Dated	$^{207}\text{Pb}/^{206}\text{Pb}$ Age (Ma)	Error + - (Ma)
Weagamow Batholith:		
Massive Tonalite (North of Keeyask Lake)	2990.0	1.8
Agutua Arm Metavolcanics:		
Felsic Volcanic (Fragmental below unconformity)	2981.0	1.8
Keeyask Lake Metasediments:		
Quartz Arenite (Well-rounded detrital zircon)	2978.1	3.0
Quartz Arenite (Slightly rounded detrital zircon)	2980.1	3.0
Quartz Arenite (Well-rounded detrital zircon)	2980.0	3.0
Eyapamikama Lake Metasediments:		
Tonalite Boulder (Well-rounded)	2958.7	1.8
North Caribou Batholith (Outside study area)	2869.3	3.6
Schade Lake Gneiss Complex (Outside study area)	2856.0	1.8

Table 4

Eyapamikama Lake U/Pb Chemical Data*

Sample	Weight (mg.)	ppm U (tot.)	pg Pb (common)	$^{208}\text{Pb}/^{206}\text{Pb}$	$^{207}\text{Pb}/^{206}\text{Pb}$	Discordance Age (Ma)
DD85-27	0.035	159	8	0.185	2990.0 +/-1.8	0.5%
DD85-23	0.041	97	15	0.247	2981.0 +/-1.8	0.2%
QH56a	0.010	108	11	0.214	2978.0 +/-3.0	0.3%
QH56b	0.004	116	5	0.216	2980.1 +/-3.0	3.3%
CL01	0.007	138	7	0.234	2980.0 +/-3.0	0.4%
DD85-22	0.048	139	9	0.146	2958.7 +/-1.8	3.4%
DD85-21	0.023	72	6	0.114	2869.3 +/-3.6	0.4%
DD85-26	0.004	287	5	0.068	2856.0 +/-1.8	0.4%

Sample	Lithology	Zircons Analyzed
DD85-27	Weagamow Batholith Tonalite	21 abraded zircons
DD85-23	Agutua Arm Metavolcanics: Felsic volcanic	abundant abraded zircons
QH56a	Keeyask Lake Metasediments: Quartz arenite (Quartzite Hill)	single abraded zircon (well-rounded)
QH56b	Quartz arenite (Quartzite Hill)	single abraded zircon (slightly-rounded)
CL01	Quartz arenite (Center Lake)	single abraded zircon (well-rounded)
DD85-22	Eyapamikama Lake Metasediments: Tonalite Boulder	several abraded zircons
DD85-21	North Caribou Lake Batholith Tonalite	9 abraded zircons
DD85-26	Schade Lake Gneiss	single abraded zircon (metamorphic?)

*Chemical Data Provided by D.W. Davis (Jack Satterly
Geochronology Laboratory).

Figure 12: Concordia diagram for U/Pb dates from Eyapamikama Lake. A=Weagamow Batholith, B=Agutua Arm felsic volcanic, C₁, C₂, C₃=Detrital zircons from Keeyask Lake quartz arenites, D=tonalite boulder from Eyapamikama Lake metasedimentary unit, E=North Caribou Lake Batholith, F=Schade Lake Gneiss. Figure modified from that provided by D.W. Davis (Jack Satterly Geochronology Laboratory).

The three detrital grains show a restricted age range which, considering the error involved in the analysis, is essentially identical. The 2980 Ma date obtained is close to that obtained from several abraded zircon fractions from a lower quartz arenite from North Spirit Lake ($2986.2 \pm 2.9/-2.3$ Ma) (Corfu and Wood 1986). U/Pb dates obtained from the same study, of tonalite clasts from an upper sequence conglomerate (Eyapamikama Lake equivalent?) range from 2975 Ma to 3000 Ma. These ages are similar to that obtained from the rounded tonalite boulder (2958.7 ± 1.8 Ma) from the Eyapamikama Lake basal conglomerate, and also close to that obtained for the eastern margin of the Weagamow batholith (2990.0 ± 1.8 Ma). These data may indicate that there was widespread emplacement of tonalite within this region of the Sachigo subprovince beginning at 3000 Ma and ending about 2960-2970 Ma. This terrane and its higher level felsic volcanic and hypabyssal equivalents were then uplifted and deeply eroded to provide the quartz-rich detritus necessary for the formation of quartz arenite units throughout the region.

After a brief period of mafic and ultramafic volcanism (Keeyask Lake metavolcanics), these same tonalite bodies, and/or, the somewhat younger emplaced cores, were again uplifted a second time and unroofed to act as a supplier of coarse-grained trondhjemite clasts and quartz grains for the conglomerates and quartz-rich wackes of the upper supracrustal sedimentary units. In this way the slightly younger boulder from Eyapamikama

Lake (2958.7 $\pm$ 1.8 Ma) could have originated from a younger core to the Weagamow batholith or a similar-aged tonalite-trondhjemite pluton. The old 3000-2975 Ma dates obtained from clasts of second-cycle sediments of North Spirit Lake also provide evidence that a second unroofing event had taken place. These clasts of older rock occur in the same sedimentary unit that contains quartz arenite pebbles (Donaldson and Ojakangas 1977), identical to the quartz arenites of Eyapamikama Lake. These pebbles are samples of the first sedimentary cycle that probably had an old 3000-2960 Ma tonalite-trondhjemite intrusive suite as a principal source. Thus, the source rock and its sedimentary product are both incorporated as clast types into an upper sequence conglomerate. This is the case for Eyapamikama Lake area as well, and is strong evidence for a second unroofing of the same source rock. Perhaps this provided the reworking necessary to produce the quartz-rich greywackes of the Eyapamikama Lake metasedimentary sequence. A large amount of quartz in the upper wackstones may have originated by erosion of first-cycle quartz arenites. During the second unroofing event, the first rock units to be eroded would probably be the quartz-rich sedimentary aprons surrounding the highland felsic masses. Much of this early sediment may not have been consolidated before being reworked a second time. Early erosion of these sediments accounts for the poor distribution of quartz arenites throughout most of the Sachigo subprovince, and at the same time explains the quartz enrichment of the younger supracrustal metasediments.

A minimum age of deposition for rock types that overlie the lower unconformity surface is not yet available, but assuming that deposition of the major sedimentary units (including the Eyapamikama Lake quartz arenites and conglomerates) occurred shortly after emplacement of the igneous rocks that supplied the detritus, then the entire Keeyask Lake sequence could have been deposited in less than 20 million years. All that can be concluded from the detrital age data at this time, however, is that the quartz arenites of the Keeyask Lake sequence probably were deposited as long ago as 2980 Ma, providing that uplift and erosion occurred soon after cooling of the source pluton. Similarly, the Eyapamikama Lake conglomerates could have been deposited as long ago as 2959 Ma, provided that these same conditions applied. Considering the limited data available for this geochronologic study (1 tonalite clast and 3 detrital zircon grains), it seems appropriate to postpone further speculation until more detrital zircon samples have been dated.

The age data also indicate that there were at least two major intrusive events in the NCLGB. The first, as mentioned previously, was at about 3000-2960 Ma; the second was at about 2870-2860 Ma. The later dates correspond to the age of samples from the core of the North Caribou Lake tonalite batholith (2869.3 ± 3.6 Ma) and from the southern strained margin of the Schade Lake gneissic trondhjemite (2856.0 ± 1.8 Ma). The sample

dated from the Schade Lake gneiss complex was a single brown zircon that had an extremely low $^{208}\text{Pb}/^{206}\text{Pb}$ ratio, indicating depletion in Th. Such Th depletion in a zircon is suggestive of a metamorphic origin (D.W. Davis personal communication 1986), and thus, may be younger than the primary crystallization date for the gneiss complex as a whole. This date may correspond to an early (D_1 ?) tectonometamorphic event within the NCLGB.

The preliminary U/Pb dates obtained are consistent with the stratigraphic interpretation of the area as determined through field study. Further geochronologic investigations in the Eyapamikama Lake region should greatly aid characterization of provenance for the major sedimentary units, and could reveal whether individual batholiths are composite or of uniform age.

Chapter 5: Summary

Discussion

The study of ancient sedimentary rocks provides constraints on the tectonic environment at the time of deposition. Especially useful in this regard are sedimentary bedforms and textural features that can be used as gauges to characterize sedimentary processes. Ancient sediments also can be examined on the basis of their lithologic composition. In this approach, the sediments act as "geologic windows" that offer a view of source terranes. This was the approach emphasized in the study presented herein.

Conglomerates provide excellent "geologic windows" because they contain large samples of the pre-existing terrane. The lithology of each clast can be examined to assemble a detailed geologic assessment of pre-depositional terranes that have been partially or completely erased from the rock record. In fact, sedimentary clasts within conglomerates can give an even further glimpse into the early geologic record. For example, quartz arenite pebbles from the Eyapamikama Lake conglomerates provide evidence for provenance of the pre-existing sedimentary terrane, and heavy minerals from these pebbles aid in constraining the nature of the source rocks. Furthermore, individual minerals can be separated for age dating. With a detailed survey such as this, constraints can be placed on the general composition and age of what may have been a regionally extensive terrane, for which there now are only local segments remaining in the rock record.

The megascopic modal analyses presented in the study give a semi-quantitative evaluation of the composition of the source rocks for each location examined. The analyses are limited, however, in that significant differences may not be apparent. For instance, a large angular block of tonalite originating from a young proximal batholith and a well-rounded older tonalite pebble that was transported hundreds of miles before deposition would be lumped in one compositional category, even though they may have come from separate source terranes separated by large time differences. Because of this averaging effect, the individual history of the clasts should be considered. Large multi-compositional clast types provide direct evidence of the complexity of the source terrane(s). Age relations between the main pre-depositional plutonic rock types may be revealed by documenting each intrusive contact observed during megascopic modal analysis. Observations such as this indicate that the plutonic source areas for the Eyapamikama Lake metasediments were formed of intrusive complexes that contained several magmatic phases, some of which are the same rock type (see Plates 37, 38, 39). An even more detailed assessment of the source would be possible if this study were to be combined with a geochronologic survey of the clasts representative of the various magma types and their potential extrusive equivalents.

Table 5

Geologic History of the Western Eyapamikama Lake Area

Supracrustal Unit	Intrusive Unit	Tectonic Event	Age
	Diabase dykes	(D ₃)	(Proterozoic)
	Fluorite bearing granite, trondhjemite dykes	(D ₂)	(2959 Ma Tonalite boulder)
Eyapamikama Lake Metasediments (greywacke, slate, conglomerate)			
	Unconformity		
	Schade Lake Gneiss North Caribou Lake Batholith	(D ₁ ?)	2856 Ma 2870 Ma
Keeyask Lake Metavolcanics (komatiite, mafic volcanics)			
	Center Lake Quartz Porphyry		
Keeyask Lake Metasediments (quartz arenite, stromatolitic mudstone, iron formation)			(2980 Ma detrital zircons)
	Unconformity		
Agutua Arm Metavolcanics (Mafic and felsic volcanics)			2980 Ma
	Weagamow tonalite Batholith		2990 Ma
	Extensive Trondhjemite-Tonalite Crust ?		+3000 Ma

Conclusion

The primary objective of this study was to provide a stratigraphic assessment of the Archean supracrustal rocks of the North Caribou Lake Greenstone Belt in the western Eyapamikama Lake area. This goal for the most part has been achieved, and is consistent with the geochronologic data. The proposed stratigraphic succession of the major supracrustal units of the western Eyapamikama Lake area in the context of the overall geologic history of the North Caribou Lake Greenstone Belt is shown in Table 5.

The stratigraphic succession in the western Eyapamikama Lake area established on the basis of this study can now serve as a basis for comparison with other supracrustal units throughout the North Caribou Lake Greenstone Belt and should also facilitate determination of the age relationships between similar rock units in supracrustal accumulations of comparable age in other parts of the Sachigo subprovince of the Superior province.

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APPENDIX A

Field Procedures

Field work for this study was conducted from June 1984 to Sept. 1984 and from mid-July to mid-August during the summer of 1985. Field work in the summer 1984 season concentrated on delineation of mappable rock types and the production of a preliminary bedrock geology map at 1:15,840 scale of the Eyapamikama Lake region (see OGS Map P.2834). During the 1985 field season, studies concentrated on the delineation of contacts between map units, megascopic modal analysis of conglomeratic units, geochronologic sampling and detailed stratigraphic analysis.

Traversing was undertaken by use of pace and magnetic compass. In highly magnetic areas underlain by iron formation, traversing was conducted with hand-held solar compass and solar charts. (Updated versions of these daily charts for specific latitudes and longitudes for 1/2 hour intervals were obtained from the NRC astronomy section in Ottawa). Bearings and distances were measured on 1" to 1/4 mile aerial photographs. All probable bedrock exposures identified from aerial photos were visited in the field. Distance distortion and poor resolution posed some problems, because air photos were enlarged (16 X) from 1" to 1 mile originals issued by the Geological Survey of Canada air photo library. In a few cases colour enhanced thematic maps derived from Landsat IV satellite imagery aided in locating outcrops. This proved to be beneficial in the northwestern Eyapamikama Lake area near Casper Lake. Bedrock exposures identified in the field were plotted on acetate overlays fixed to the air photographs.

Lithologic numbers were given for each outcrop based on a field legend from Breaks et al. (preliminary Maps 1984 and 1985). Station stops were made at outcrops from which detailed information was collected. This included descriptive notes concerning lithology, primary or tectonic structures, photos, sketches, and rock samples for thin section studies, geochemistry and rock slabbing. In many places oriented samples were taken to define original depositional tops subsequently determined from slabbed and polished sections and from thin sections. All samples collected are shown on a sample location map which can be viewed at the Ontario Geological Survey head office in Toronto. Station locations, structural data and lithologic codes were initially recorded on the overlay during the traverse. This information was transferred to a series of cronoflex base maps for each particular set of information.

Most field information was taken by use of microcassette tape recorder and later transcribed into field notes and journals or into a battery-operated portable NEC microcomputer. The notes and air photograph overlays with structural, lithological and sample location

data can be obtained through the Ontario Geological Survey.

Many traverses in the area were conducted by other members of the OGS crew during the 1984 summer field season because the focus of the Opapimiskana Lake Precambrian bedrock mapping project was in the Eyapamikama Lake area at that time. Traverse spacing was generally kept at a distance of 1/4 mile unless outcrop exposure was high. A high-pressure Wajax pump was used to enlarge and create exposures in key areas designated for more study. Where necessary, 10 m grids were cut to locate data in detailed study areas. This was necessary at the Keeyask Lake metavolcanic - Eyapamikama Lake metasedimentary contact near the shore of western Eyapamikama Lake.

Water levels in the summer of 1985 were extremely high, and this precluded further investigation of most lakeshore outcrops mapped the previous summer.

This study was undertaken to document field-observable rock relations, and did not involve extensive laboratory analysis. Thin sections were studied to check field assessments and classifications. Little chemical data were employed in this study other than that obtained through the Opapimiskana Lake project. Geochronologic analyses were incorporated in the study to corroborate conclusions based on field evidence. These analyses were performed for the most part through the Jack Satterly Geochronology Laboratory by Dr. Don Davis.

APPENDIX B

Rock Classification

All metavolcanic rock types have been classified in the field according to the colour index classification scheme utilized by the Ontario Geological Survey in which felsic metavolcanic rocks are composed of 0-10% by volume of mafic minerals such as hornblende, actinolite, tremolite, epidote, chlorite, talc and serpentine. 10-35% colour index would be an intermediate rock. 35-90% colour index constitutes a mafic rock and greater than 90% colour index is ultramafic.

The sandstone classification used follows that of McBride (1963), in which chert fragments are added to the quartz framework, provided that the labile rock fragments contribute to less than 20% of the total framework.

Plutonic rocks were classified in the field on the basis of estimated mineral modes according to the scheme of Steckensen (1973), with the exception that a leucocratic tonalite was referred to as a trondhjemite.

• Appendix C

Megascopic Modal Analysis

Megascopic modal analyses of conglomerates utilized the point count method suggested by Donaldson and Jackson (1965), a method which provides a semi-quantitative volume estimate of individual clast types. Modal counts of conglomerate clast populations were obtained by means a 1 m² grid with 100 points (10 cm spacing). The conglomerate matrix cut off was set at the coarse granule size (< 4mm).

Sampling of individual clast types was aided by using a portable diamond drill which readily provided 5 to 15 cm lengths of 2 cm diameter rock core.

(See Chart-A and B in the back pocket for megascopic modal data collected in the field from outcrops in the western Eyapamikama Lake region.)

APPENDIX D

Geochronology

Geochronologic analysis of the Eyapamikama Lake samples was performed by the staff of the Jack Satterly Geochronology Laboratory in Toronto Ontario. Initial heavy mineral separation of the quartz arenite samples was performed by the author using the facilities of the laboratory. All samples were initially jaw crushed, disk milled and sent over a Wilfley table to initially concentrate the heavy minerals. Samples were then sieve fractioned with a 40 mesh grid (.635 mm) and dropped through a Franz Isodynamic Magnetic Separator to remove magnetic sulfides. Heavy minerals were then bathed in 7N HNO to remove the remaining sulfides, and then sent through the Franz separator again. The remaining quartz, feldspar, muscovite and other light minerals were removed by settling the sample in bromoform (S.G. 2.85). The remaining heavy minerals including zircon were then sent through the Franz again and cleaned with hot HCl and dried. After examination of the heavy mineral population the samples were run through CH₂I₂ (S.G. 3.3), cleaned with HCl and sent for a final Franz separation. Individual zircon separates were examined with a binocular microscope to hand pick individual zircons for subsequent analysis. For a detailed account of this separation technique, see Krogh 1982b.

All zircon samples were air abraded according to the technique of Krogh (1982a) to obtain maximum concordancy. The technique was modified slightly by D.W. Davis to accommodate the single zircon analysis performed in this study. The subsequent chemical and isotopic analysis generally followed that outlined in Krogh (1973) using the regression line calculations of Davis (1982). Ages are based on the decay constants of Jaffey et al. (1971) as recommended by the IUGS (Steiger and Jaeger 1977).

ARCHEAN LITHOSTRATIGRAPHY OF THE WESTERN EYAPAMIKAMA LAKE AREA

53° 00'

* LEGEND

VOLCANIC AND SEDIMENTARY
ROCKS

PLUTONIC ROCKS

EYAPAMIKAMA LAKE METASEDIMENTS

7 Graywacke-mudstone
turbidites slates

Polymictic pebble-
boulder conglomerate

CONFORMITY - UNCONFORMITY

KEEYASK LAKE METAVOLCANICS

5 Mafic-intermediate
volcanics (pillowed,
variolitic, massive
flows, broken pillow
breccia, flow breccia)

4 Ultramafic
volcanics (massive,
spinel and olivine
textured flows,
flow breccia)

KEEYASK LAKE
METASEDIMENTS

3 Banded iron formation,
layered mudstone-chert,
quartz arenite (locally
stromatolitic, cross-
bedded),
chert pebble conglomerate

NORTH AND SOUTH
RIM VOLCANICS

Transposed
massive and
pillowed flows,
banded amphibolite
chlorite schist

Quartz
porphyry
(quartz
sericite
schist)

Granite,
granodiorite,
tonalite,
diorite

REGOLITH

AGUTUA ARM METAVOLCANICS

2 Felsic volcanics

1 Mafic volcanics
(massive pillowed flows)

Although the prefix meta has been omitted it should be
understood that all rock types have been subjected to
green schist grade metamorphism.

KEEYASK LAKE
METASEDIMENTS

banded amphibolite
chlorite schist

ARCHEAN LITHOSTRATIGRAPHY OF THE WESTERN EYAPAMIKAMA LAKE AREA

53°00'

* LEGEND

VOLCANIC AND SEDIMENTARY ROCKS

EYAPAMIKAMA LAKE METASEDIMENTS

7 Greywacke-mudstone
turbidites, slates

Polymictic pebble-
boulder conglomerate

CONFORMITY - UNCONFORMITY

KEEVASK LAKE METAVOLCANICS

5 Mafic-intermediate
volcanics (pillowed,
varioloitic, massive
flows, broken pillow
breccia, flow breccia)

4 Ultramafic
volcanics (massive,
spinel and olivine
ant textured flows,
flow breccia)

KEEVASK LAKE METASEDIMENTS

3 Banded iron formation,
layered mudstone-chert,
quartz arenite (locally
stromatolitic, cross-
bedded),
chert pebble conglomerate

REGOLITH

AGUTUA ARM METAVOLCANICS

2 Felsic volcanics

1 Mafic volcanics
(massive pillowed flows)

PLUTONIC ROCKS

2-mica
ironthymite
dikes, sills

Granite,
granodiorite,
trondhjemite,
tonalite,
diorite

* NORTH AND SOUTH RIM VOLCANICS

Transposed
massive and
pillowed flows,
banded amphibolite,
chlorite schist

Quartz
porphyry
(quartz
sericite
schist)

* Although the prefix meta has been omitted, it should be
understood that all rock types have been subjected to
greenschist - amphibolite facies metamorphism

banded amphibolite,
chlorite schist

CHART - A

CHART-B

Quartz Schist to Schist
Quartz Porphyry

CHART-B

	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Mean
							15	0	3							1.90
2		1					15	4	5	1						3.35
14	13	19	19	23			10	22	16				6	3		8.55
4		6	3			1	2	11	12	1	8	1		5		4.15
			1									6	12	3		1.15
		1					0	1	0							.10
																.05
			2			12	6	2	2		1	1		1	1	5 1.50
			3		1							10	12	6	1	1.50
1		4						1	1							.25
								7	1							.70
							2	2	3							
														1		.40
4		14	8	3	4		8	18	6	65	61	62	56	67	51	22.35
										2	11	3			3	.95
		1	1			1	1		1	1					9	1.00
												2				.10
2	1	2														.30
3		2				1					1	1			1	.45
			1													.60
																.05
																.05
																.50
70	84	50	62	73	81	40	31	50	30	18	14	14	10	34		50.00
2	?	2	?	?	?	8	22	11	1	3	1	8	?	?		6.44
100	100	100	100	100	100	100	100	100	100	100	100	100	100	100		100.00
85	30/8/85 J3008 10.9N 4E/8.5N	30/8/85 J3008 15.5W/9N OK14	30/8/85 J3008 12.3N/27W OK27	30/8/85 J3008 27W/12.4N OK27	30/8/85 J3008 12.4N/25W OK27	29/8/85 1-17-13 J3042 (a)	29/7/85 J3042 (b)	25/8/85 J3042 (b)	25/8/85 J3043 (a)	25/8/85 J2706 (a)	25/8/85 J2706 (b)	28/8/85 J2706 (c)	28/8/85 J2706 (d)	29/8/85 J2706 (e)	29/8/85 J2706 (f)	

CHART-A

6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Mean
						15	0	3							1.90
2		1				15	4	5	1						3.35
14	13	19	19	23		10	22	16				6	3		8.55
4		6	3			2	11	12	1	8	1		5		4.15
			1		1						6	12	3		1.15
						0	1	0							.10
		1													.05
			2		12	6	2	2		1	1		1	1	5 1.50
			3	1			1	1			10	12	6	1	1.50
1		4					7	1							.25
															.70
						2	2	3					1		.40
4		14	8	3	4	8	18	6	65	61	62	56	67	51	22.35
									2	11	3			3	.95
		1	1		1	1		1	1					9	1.00
											2				.10
2	1	2													.30
3		2			1					1	1			1	.45
			1				1								.60
															.05
															.05
													1		.05
															.50
													3		
70	84	50	62	73	81	40	31	50	30	18	14	14	10	34	50.00
2	?	2	?	?	?	8	22	11	1	3	1	8	?	?	6.44
100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100.00
30/8/85	30/8/85	30/8/85	30/8/85	30/8/85	29/8/85	29/7/85	25/8/85	25/8/85	25/8/85	25/8/85	28/8/85	28/8/85	29/8/85	29/8/85	
J3008	J3008	J3008	J3008	J3008	1-17-13	J3042	J3042	J3043	J2706	J2706	J2706	J2706	J2706	J2706	
0.9N 4E/8.5N	15.5W/9N	12.3N/27W	27W/12.4N	12.4N/25W		(a)	(b)	(a)	(a)	(b)	(c)	(d)	(e)	(f)	
	OK14	OK27	OK27	OK27											

CHART-B

3	1	1	10	12	6	1	1.50
4	7	1					.25

(massive, pillowed flows)

Although the prefix *meta* has been omitted it should be understood that all rock types have been subjected to greenschist to amphibolite facies metamorphism

banding amphibolite facies chlorite schist

KEEYASK LAKE METASEDIMENTS

- 3 Banded iron formation layered mudstone-chert quartz arenite (locally stromatolitic, cross-bedded) chert pebble conglomerate

REGOLITH

AGUTIA ARM METAVOLCANICS

- 2 Felsic volcanics
- 1 Mafic volcanics (massive, pillowed flows)

Although the prefix *meta* has been omitted it should be understood that all rock types have been subjected to greenschist to amphibolite facies metamorphism

Lithostratigraphic subdivisions are based on geology compiled from QGS Map P2834, unpublished maps provided by D. Pirosecco, Mineral Deposits Section, QGS, and from geologic data collected by Eric A. DeKemp

SYMBOLS

- Geologic boundary
- Bedding, inclined, vertical
- Bedding top, inclined, overturned, vertical
- Bedding top from grain gradation
- Bedding top from cross bedding
- Lava flow top direction
- S₁ or S₂ foliation
- S₂ foliation
- Microscopic folds with plunge M.Z.S. type
- Fold axial plane dip unknown, inclined, vertical
- Axial trace of syncline, anticline with plunge
- Axial trace inferred
- Bedding strike inferred

EYAPAMIKAMA LAKE

KEEYASK LAKE

* Although the prefix meta has been omitted, it should be understood that all rock types have been subjected to greenschist - amphibolite facies metamorphism

KEYYASK LAKE METASEDIMENTS

- 3 Banded iron formation, layered mudstone-chert, quartz arenite (locally stromatolitic, cross-bedded), chert pebble conglomerate

banded amphibolite, chlorite schist
Quartz porphyry (quartz sericite schist)

REGOLITH

AGUTUA ARM METAVOLCANICS

- 2 Felsic volcanics
- 1 Mafic volcanics (massive pillowed flows)

* Although the prefix meta has been omitted, it should be understood that all rock types have been subjected to greenschist - amphibolite facies metamorphism

Lithostratigraphic subdivisions are based on geology compiled from OGS Map P.2834, unpublished maps provided by D. Proschko, Mineral Deposits Section, OGS, and from geologic data collected by Eric A. DeKemp

SYMBOLS

- Geologic boundary
- Bedding, inclined, vertical
- Bedding top, inclined, overturned, vertical
- Bedding top from grain gradation
- Bedding top from cross bedding
- Lava flow top direction
- S₁ or S₂ foliation
- S₂ foliation
- Megascopic folds with plunge; M, Z, S type
- Fold axial plane, dip unknown, inclined, vertical
- Axial trace of syncline, anticline with plunge
- Axial trace inferred
- Bedding strike inferred

EYAPAMIKAMA LAKE

KEYYASK LAKE

CHART-B

Quartz-sericite schist

Quartz Porphyry

Possible Sediment
(Reworked Felsic Tuff?)

Mafic Volcanics:

Unsubdivided

Variolitic

Ultramafics:

Volcanics (Komatiite?)

Intrusives

Vein Quartz

Chert

Quartz Fuchsite

Quartz Arenite

Quartz-Ankerite

Carbonate Chlorite

BIF

Matrix

Predeformed Clasts

Total

Date of count

Outcrop location

Grid location

Thesis number

15/8/84

15/8/84

15/8/84

15/8/84

30/8/85

30/8/85

30/8/85

30/8/85

30/8/85

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30/8/85

29/8/85

29/7/85

25/8/85

25/8/85

25/8/85

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CHART-B

Count

Deformed Clast types

Tonalite

Trondjemite

Diorite-Gabbro

Granodiorite

Mafic Metavolcanic

Quartz-sericite schist

(Felsic quartz porphyry)

Felsic Volcanic

Quartz Fuchsite

Date of count

Outcrop location

Grid location

Thesis number

15/8/84

15/8/84

15/8/84

15/8/84

30/8/85

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CHART - B

[illegible]

SYMBOLS

Geologic boundary	Megascopic folds with plunge M/Z S type
Bedding, inclined, vertical	Fold axial plane, dip unknown, inclined, vertical
Bedding top, inclined, overturned, vertical	Axial trace of syncline anticline with plunge
Bedding top from grain gradation	Axial trace inferred
Bedding top from cross bedding	Bedding strike inferred
Lava flow top direction	S ₁ or S ₂ foliation
S ₁ or S ₂ foliation	S ₂ foliation
S ₃ foliation	S ₃ foliation
L ₁ or L ₂ lineation with plunge	Shear zone displacement direction inferred
L ₂ -L ₃ lineation with plunge	Shear zone or fault inferred
Jointing, inclined, vertical	Regolith
Bedding parallel foliation	

52° 51'

S₂ foliation

SYMBOLS

- Geologic boundary
- Bedding, inclined, vertical
- Bedding top, inclined, overturned, vertical
- Bedding top from grain gradation
- Bedding top from cross bedding
- Lava flow top direction
- S₁ or S₂ foliation
- S₂ foliation
- S₃ foliation
- L₁ or L₂ lineation with plunge
- L₂-L₃ lineation with plunge
- Jointing, inclined, vertical
- Bedding parallel foliation S/S, S/S, S/S
- Megascopic folds with plunge, M, Z, S type
- Fold axial plane, dip unknown, inclined, vertical
- Axial trace of syncline, anticline with plunge
- Axial trace inferred
- Bedding strike inferred
- Shear zone, displacement direction
- Shear zone or fault inferred
- Regolith

52° 51'

END

05.01.88

FIN