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GEOCHRONOLOGICAL STUDIES OF PRECAMBRIAN ROCKS FROM THE SOUTHERN DISTRICT OF KEEWATIN

W.D. Loveridge
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GEOCHRONOLOGICAL STUDIES OF PRECAMBRIAN ROCKS FROM THE SOUTHERN DISTRICT OF KEEWATIN

Abstract

Results and conclusions are presented of U-Pb, Rb-Sr and K-Ar studies in three areas of southern District of Keewatin. The results of U-Pb studies on zircon are generally complex and age interpretations are not necessarily unique. The geology, more fully described elsewhere, is summarized in this report.

Angikuni-Yathkyed lakes area. U-Pb age results on zircon indicate that the age of the volcanic-granitoid basement is in the range 2650 to 2680 Ma. K-Ar ages on hornblende and biotite in the Archean basement rocks are commonly ca. 1700 Ma, typical of ages re-set by the Hudsonian Orogeny. There is, however an area of at least 7000 km² where K-Ar ages on hornblende approximate 2450 Ma and K-Ar ages on biotite range from 2425 to 1975 Ma, indicating minor or no effect of the Hudsonian Orogeny. The age of the Christopher Island formation of the Dubawnt Group is bracketed by a previously published U-Pb zircon age of 1753 + 3/-2 Ma on granite intrusive into the formation and by a K-Ar age of 1984 ± 78 Ma on hornblende from a pre-Dubawnt Group quartz monzonite pluton.

Edehon-Hyde lakes area. U-Pb age results on zircon from the granulite terrane are interpreted as follows. 1. Granodiorite gneiss, age of emplacement of plutonic precursor to gneiss, 2544 + 11/-8 Ma. 2. Granodiorite gneiss 2 km northeast, age of plutonic predecessor to gneiss, possibly 3190 Ma (minimum age 2702 Ma). 3. Well banded paragneiss adjacent to granodiorite gneiss (2, above), age of migmatization of paragneiss, 2786 ± 41 Ma. North of the granulite terrane, weakly foliated granodiorite gneiss yields a U-Pb zircon age of 2737 + 13/-9 Ma. Rb-Sr measurements on the Archean rocks did not generally provide diagnostic results. A Rb-Sr isochron age of 1912 ± 42 Ma was obtained on granite to quartz monzonite stocks intrusive into the basement rocks. K-Ar ages on the Archean rocks in this region are generally in the range 1700 to 1785 Ma.

Kasba gneiss area. East of Kasba Lake, U-Pb measurements on zircon from two locations of Kasba gneiss, supported by Rb-Sr whole-rock model ages, provide an early Archean age ca. 3270 Ma. Less than 20 km distant, two additional specimens from the same unit yield less reliable zircon ages ca. 2780 Ma, and Rb-Sr whole-rock model ages of 2037 and 2457 Ma suggesting rejuvenation by Proterozoic events. Biotite and hornblende K-Ar ages range from 1740 to 1891 Ma.

Résumé

Dans cet article sont présentés les résultats et conclusions d'études de datation effectuées par les méthodes U-Pb, Rb-Sr et K-Ar dans trois régions du district sud de Keewatin. Les résultats des études de datation par le procédé U-Pb sur le zircon sont généralement complexes et les interprétations d'âge ne sont pas nécessairement uniques. La géologie, qui est décrite plus en détail ailleurs, est présentée brièvement dans ce rapport.

Région des lacs Angikuni-Yathkyed: les datations U-Pb sur le zircon indiquent que l'âge du socle volcanique et granitoïde est de l'ordre de 2650 à 2680 Ma. Les datations K-Ar, faites sur la hornblende et la biotite, des roches du soubassement archéen indiquent généralement que celles-ci ont aux alentours de 1700 Ma, valeur typique des terrains dont l'âge a été remis au zéro par l'orogenèse de l'Hudsonien. Il existe toutefois une zone d'au moins 7000 km² où les datations K-Ar faites sur la hornblende indiquent un âge approximatif de 2450 Ma et les datations K-Ar faites sur la biotite indiquent un âge compris entre 2425 et 1975 Ma, donc où l'orogenèse de l'Hudsonien a eu des effets mineurs ou nuls. L'âge de la formation de Christopher Island, dans le groupe de Dubawnt, est compris entre deux limites: un âge auparavant publié, déterminé par la méthode U-Pb sur du zircon

provenant d'un granite intrusif dans la formation en question (1753 + 3/-2 Ma) et un âge déterminé par la méthode K-Ar sur de la hornblende provenant d'un pluton de monzonite quartzifère antérieur au groupe de Dubawnt.

Région des lacs Edehon-Hyde. Les résultats des datations U-Pb sur le zircon du terrane granulitique sont interprétés comme suit: 1) gneiss granodioritique, âge de la mise en place du précurseur plutonitique du gneiss, 2544 + 11/-8 Ma; 2) gneiss granodioritique, à 2 km au nord-est; l'âge du précurseur plutonique du gneiss est peut-être de 3190 Ma (âge minimum 2702 Ma); 3) paragneiss nettement rubané jouxtant le gneiss granodioritique (2, ci-dessus), âge de la migmatisation du paragneiss 2786 ± 41 Ma). Au nord du terrane granulitique, l'âge d'un gneiss granodioritique faiblement feuilleté a été estimé par la méthode U-Pb appliquée au zircon, à 2737 + 13/-9 Ma. Les mesures faites selon la méthode Rb-Sr sur les roches archéennes n'ont généralement pas donné de résultats concluants. On a déterminé au moyen des isochrones relatives à Rb-Sr que des stocks constitués de granite, de monzonite quartzifère et de roches intermédiaires, et intrusifs du socle, avaient un âge de 1912 ± 42 Ma. Dans cette région, en général, les âges déterminés selon la méthode K-Ar se situent entre 1700 et 1780 Ma pour les roches archéennes.

Région du gneiss de Kasba: à l'est du lac Kasba, les datations du gneiss de Kasba prélevé en deux endroits, effectuées selon la méthode U-Pb sur du zircon, et confirmées par les âges obtenus par la méthode Rb-Sr sur la roche entière, indiquent que ce gneiss date de l'Archéen inférieur (environ 3270 Ma). A moins de 20 km de distance, l'analyse de deux échantillons supplémentaires provenant de la même unité indique la date moins fiable, obtenue par la méthode du zircon, d'environ 2780 Ma, et les dates modèles, obtenues sur la roche entière par la méthode Rb-Sr, de 2037 et 2457 Ma, ce qui suggère un rajeunissement par des événements ayant eu lieu au Protérozoïque. Les résultats des datations faites par la méthode K-Ar sur la biotite et sur la hornblende sont compris entre 1740 et 1891 Ma.

SUMMARY

Geochronological studies have been carried out on rocks from three separate areas in the southern district of Keewatin: the Angikuni-Yathkyed lakes area, the Edehon-Hyde lakes area and the area of Kasba gneiss east of Kasba Lake. The geology of the three areas, more fully described elsewhere, is summarized in this report.

Results and conclusions of the geochronological studies are summarized below, but it is noted that the results of the U-Pb studies on zircon are generally complex and age interpretations presented are not necessarily unique.

Angikuni-Yathkyed lakes area. U-Pb age results on zircon from two tuffs, an orthogneiss, a quartz monzonite to granodiorite pluton and a granulite facies granodiorite gneiss indicate that the age of the volcanic-granitoid basement is in the range 2650 to 2680 Ma.

The age of the Christopher Island Formation of the Dubawnt Group is bracketed by a previously published U-Pb zircon age of 1753 + 3/-2 Ma on a coarse grained granite which intrudes the Christopher Island, and by a K-Ar age on hornblende of 1984 ± 78 Ma. The hornblende age is interpreted as the closing age of hornblende, on cooling of a quartz monzonite pluton which predates Dubawnt Group rocks.

K-Ar ages on these Archean basement rocks show a distinct pattern. In the easternmost part of the area, K-Ar ages on hornblende and biotite range from 1696 ± 17 to 1739 ± 18 Ma, typical of ages re-set by the Hudsonian Orogeny; 40 km to the west of the area, K-Ar ages on hornblende and biotite are somewhat older at 1834 ± 59 and 1815 ± 25 Ma respectively. However, in the centre of the area, in a band about 70 km wide extending at least 100 km southwest of Yathkyed Lake, K-Ar ages on hornblende approximate 2450 Ma and K-Ar biotite ages range from 2425 ± 54 to 1975 ± 19 Ma showing minor or no effects of the Hudsonian Orogeny.

Edehon-Hyde lakes area. U-Pb measurements on zircon from rocks of the granulite facies terrane, occupying the southern third of the area, are interpreted as follows:

1. Granodiorite gneiss, age of emplacement of plutonic precursor to gneiss, 2544 + 11/-8 Ma.
2. Granodiorite gneiss 2 km northeast, age of plutonic predecessor to gneiss, possibly 3190 Ma (minimum age 2702 Ma).
3. Well banded paragneiss adjacent to granodiorite gneiss (2 above), age of migmatization of paragneiss, 2786 ± 41 Ma.

SOMMAIRE

On a réalisé des études géochronologiques sur des roches provenant de trois régions distinctes du district sud de Keewatin : la région des lacs Angikuni-Yathkyed, la région des lacs Edehon-Hyde et la région du gneiss de Kasba à l'est du lac Kasba. Dans ce rapport, on présente de façon sommaire la géologie des trois régions, qui est décrite plus en détail ailleurs.

On présente ci-dessous de façon sommaire les résultats et conclusions des études géochronologiques, mais on indique que les résultats des études de datation par la méthode U-Pb conduites sur le zircon sont généralement complexes et que les interprétations que l'on donne à propos des âges ne sont pas nécessairement les seules possibles.

Région des lacs Angikuni-Yathkyed. Les résultats des datations faites par la méthode U-Pb sur le zircon provenant de deux tufs, d'un orthogneiss, d'un pluton de composition comprise entre une monzonite quartzique et une granodiorite, et d'un gneiss granodioritique du faciès des granulites, indiquent que l'âge du soubassement volcanique-granitoïde se situe entre 2650 et 2680 Ma.

L'âge de la formation de Christopher Island, qui appartient au groupe de Dubawnt, se situe entre deux valeurs, à savoir une datation de 1753 + 3/-2 Ma antérieurement publiée, faite par la méthode U-Pb sur des zircons provenant d'un granite à grain grossier intrusif dans les terrains de l'île Christopher, et une datation de 1984 ± 78 Ma effectuée par la méthode K-Ar sur une hornblende. On interprète l'âge donné par la hornblende comme étant l'âge final de cette hornblende, au moment du refroidissement d'un pluton de monzonite quartzique qui précède la formation des roches du groupe de Dubawnt.

Les datations par la méthode K-Ar effectuées sur ces roches du socle archéen montrent une configuration particulière. Dans la partie la plus à l'est de la région, les âges déterminés par la méthode K-Ar sur la hornblende et la biotite se situent entre 1696 ± et 1739 ± 18 Ma, âges typiques du rajeunissement du terrain par l'orogénèse de l'Hudsonien; à 40 km à l'ouest de la région, les âges déterminés par la méthode K-Ar sur la hornblende et la biotite sont légèrement plus élevés, soit 1834 ± 59 et 1815 ± 25 Ma respectivement. Toutefois, au centre de la région, dans une bande d'environ 70 km de large qui s'étend au moins à 100 km au sud-ouest du lac Yathkyed, les âges déterminés par la méthode K-Ar sur la hornblende se rapprochent de 2450 Ma, et les âges déterminés par la méthode K-Ar sur la biotite sont compris entre 2425 ± 54 Ma et 1975 ± 19 Ma, ce qui indique que dans cette région, l'orogénèse de l'Hudsonien a eu des effets sans importance ou nuls.

Région des lacs Édehon-Hyde. Les mesures réalisées par la méthode U-Pb sur du zircon provenant de roches du terrane à faciès granulitique, qui occupe le tiers sud de la région, ont été interprétées de la façon suivante :

1. Gneiss granodioritique, âge de la mise en place du pluton précurseur du gneiss, 2544 + 11/-8 Ma.
2. Gneiss granodioritique à 2 km au nord-est, âge du pluton prédécesseur du gneiss, peut-être 3190 Ma (âge minimum 2702 Ma).
3. Paragneiss bien rubané, jouxtant le gneiss granodioritique (2 ci-dessus), âge de la migmatisation du paragneiss, 2786 ± 41 Ma.

North of the boundary of granulite facies metamorphism a U-Pb zircon age of 2737 + 13/-9 Ma on weakly foliated granodiorite gneiss is interpreted as the age of intrusion of the plutonic predecessor to this gneiss.

Rb-Sr measurements on 3 sets of whole-rock samples from the (Archean) granulite facies metamorphic terrane generally did not provide diagnostic age results, because the Rb-Sr systems had been variably disturbed by events subsequent to emplacement.

In the western part of the area, a Rb-Sr isochron age of 1912 ± 42 Ma (initial $^{87}Sr/^{86}Sr = 0.7034 \pm 0.0018$) was obtained on granite to quartz monzonite stocks which intrude the basement rocks.

K-Ar ages on seven biotite samples from (Archean) rocks within the granulite facies terrane range from 1785 ± 42 to 1696 ± 40 Ma. North of the granulite facies boundary similar K-Ar ages of 1731 ± 66 and 1776 ± 41 Ma were determined on hornblende and biotite from the weakly foliated granodiorite gneiss dated by U-Pb on zircon at 2737 + 13/-9 Ma.

Kasba gneiss area. U-Pb measurements on zircon from two specimens of granitic gneiss located in the southern Kasba gneiss area provide early Archean ages about 3270 Ma. These results are supported by Rb-Sr model ages on single whole-rock samples from each location.

Zircon from two specimens of granodioritic gneiss mapped as the same unit, 5 km northwest and 19 km to the north, yields less reliable ages about 2780 Ma. However, there is no indication in these zircon results of the older ages found to the south. Zircon from a third sample of granodioritic gneiss, collected only 1 km north of the granitic gneiss, yields U-Pb systematics hybrid between those of the more northerly and more southerly samples. Rb-Sr results on whole-rock samples from the three granodiorite gneiss locations yield model ages ranging from 2037 to 2457 Ma suggesting rejuvenation by Proterozoic events.

K-Ar ages on biotite samples from the five locations range from 1740 ± 32 to 1818 ± 42 Ma. K-Ar ages on hornblende from the two granitic gneiss locations are 1884 ± 74 and 1891 ± 79 Ma.

Au nord de la limite du métamorphisme dans le faciès des granulites, l'âge de 2737 + 13/-9 Ma déterminé par la méthode U-Pb sur du zircon provenant d'un gneiss granodioritique faiblement feuilleté a été interprété comme étant l'âge de l'intrusion du pluton prédécesseur de ce gneiss.

Généralement, les datations effectuées par la méthode Rb-Sr sur trois ensembles d'échantillons de roche entière prélevés dans le terrane métamorphisé dans le faciès des granulites (Archéen) n'ont pas donné de valeurs d'âge diagnostiques, parce que les systèmes Rb-Sr avaient été plus ou moins perturbés par des événements ultérieurs à leur mise en place.

Dans la partie ouest de la région, on a déterminé d'après des courbes isochrones Rb-Sr un âge de 1912 ± 42 Ma (initialement $^{87}Sr/^{86}Sr = 0,7034 \pm 0,0018$) pour des tocks dont la composition se situe entre un granite et une monzonite quartzique, et qui sont intrusifs dans les roches du socle.

Les âges déterminés par la méthode K-Ar sur sept échantillons de biotites provenant de roches archéennes prélevées dans le terrane métamorphisé dans le faciès des granulites, sont compris entre 1785 ± 42 et 1696 ± 40 Ma. Au nord de la limite du faciès des granulites, on a déterminé par la méthode K-Ar des âges similaires de 1731 ± 66 et 1776 ± 41 Ma, sur de la hornblende et de la biotite provenant du gneiss granodioritique faiblement feuilleté, que l'on a daté par la méthode U-Pb sur le zircon à 2737 + 13/-9 Ma.

Région du gneiss de Kasba. Les mesures effectuées par la méthode U-Pb sur du zircon provenant de deux échantillons de gneiss granitique prélevés dans la région sud du gneiss de Kasba nous indiquent un âge d'environ 3270 Ma, qui correspond à l'Archéen inférieur. Ces résultats sont confirmés par les déterminations d'âges modèles par la méthode Rb-Sr, faites sur des échantillons de roche entière prélevés en chaque lieu.

En employant le zircon provenant de deux échantillons de gneiss granodioritique cartographié comme faisant partie de la même unité, à 5 km au nord-ouest et à 19 km au nord, on a obtenu une valeur moins faible de l'âge, soit 2780 Ma. Toutefois, ces résultats obtenus pour le zircon ne correspondent en rien aux âges plus élevés déterminés au sud. En étudiant le zircon provenant d'un troisième échantillon de gneiss granodioritique, recueilli à 1 km seulement au nord du gneiss granitique, on a obtenu dans le système U-Pb une valeur hybride intermédiaire entre celles des échantillons prélevés plus au nord et plus au sud. Les résultats de la datation par la méthode Rb-Sr appliquée à des échantillons de roche entière provenant des trois lieux de gneiss granodioritique nous donnent des âges modèles compris entre 2037 et 2457 Ma, ce qui suggère que durant le Protérozoïque, certains événements ont provoqué le rajeunissement du terrain.

Les âges déterminés par la méthode K-Ar sur des échantillons de biotite provenant des cinq lieux susmentionnés, sont compris entre 1740 ± 32 et 1818 ± 42 Ma. Les âges déterminés par la méthode K-Ar sur de la hornblende provenant des deux régions de gneiss granitique sont 1884 ± 74 et 1891 ± 79 Ma.

INTRODUCTION

As a part of regional geological studies in southern District of Keewatin, U-Pb isotopic ages of zircon, Rb-Sr studies and K-Ar age determinations have been done over a period of time (1974-87) on rocks from three separate areas (Fig. 1), the Angikuni-Yathkyed lakes area, the Edehon-Hyde lakes area and the much smaller area of Kasba gneiss east of Kasba Lake. All three areas are part of an Archean craton within the Churchill Structural Province, consisting of volcanic and sedimentary supracrustal rocks (in part metamorphosed to gneisses), granitoid gneisses, and intrusive rocks ranging in composition from gabbro to quartz monzonite that are in part orthogneisses. During the Aphebian, supracrustal rocks were deposited on the craton, plutons ranging from granodiorite to granite were emplaced here and there, and regional metamorphism affected both older and younger rocks in restricted areas.

The majority of the results of K-Ar age determinations have been reported previously but, for the most part, the U-Pb data on zircon and the Rb-Sr studies are unpublished. Many of these results are inconclusive but are reported as a record of the work and as a guide to future studies. Decay constants and isotopic abundances used in calculating ages are those recommended by Steiger and Jager (1977). Ages quoted from published papers have been recalculated when necessary using these constants.

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R.K. Wanless, who retired in 1979 from the Geochronology Section, Geological Survey of Canada, collected some of the samples used in this study, was involved in the analytical work, and provided much stimulating discussion of the problem.

R.D. Stevens, who retired in 1984 from the Geochronology Section, Geological Survey of Canada, was involved in the analytical work and provided much help in examining the results.

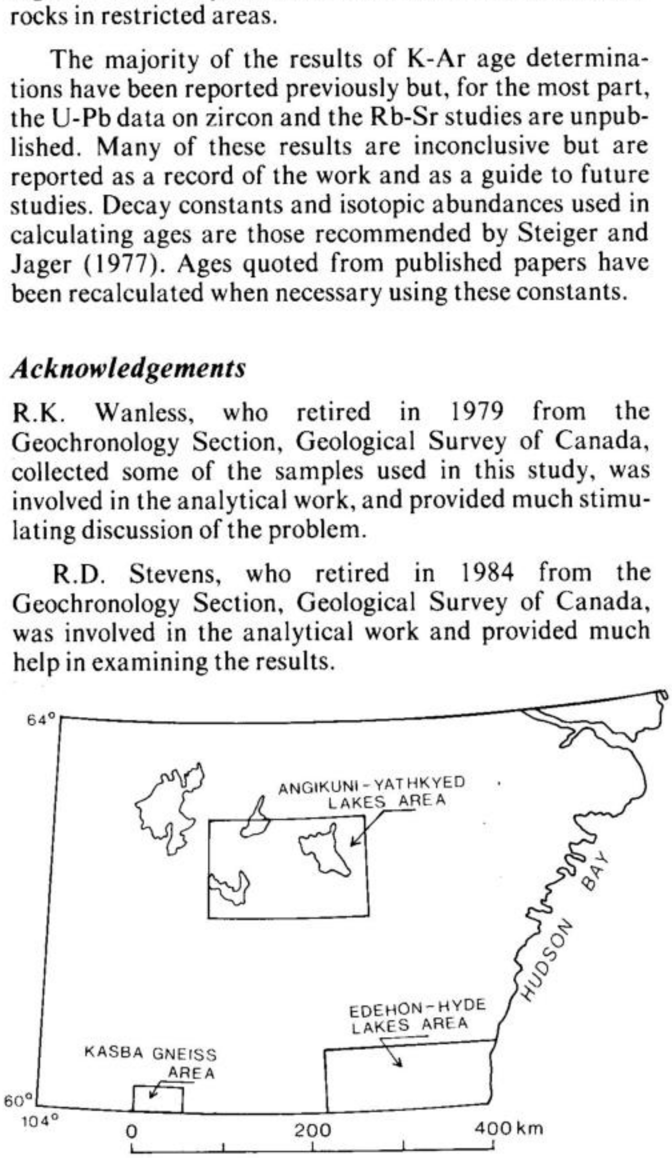


Figure 1. Index map of areas.

ANALYTICAL PROCEDURES AND DATA REDUCTION

Results of U-Pb analysis on zircon and Rb-Sr analyses on whole-rock and biotite are presented in Tables A1 and A2 (Appendix). Most analyses were carried out between 1974 and 1982 and generally followed collection of the individual samples by less than two years. Thus, the last two digits of the sample numbers, which specify the year of collection, also indicate the time frame of analysis. In 1987, U-Pb analyses were carried out on additional fractions from some zircon samples which had previously yielded inconclusive results. In all such analyses the zircon was abraded. The designation, A, Table A1, distinguishes the 1987 analyses.

Procedures for Rb-Sr analysis on rock and mineral samples and particularily for U-Pb measurement on zircon evolved and were refined over that period of time. A description of the procedures used toward the end of the initial analytical period for the concentration and preparation of zircon fractions, the chemical extraction of U and Pb from zircon and the isotopic analysis of U and Pb is given in Sullivan and Loveridge (1980). In general, the technique of hand picking zircon fractions was not in use during that period; other means such as sieving and magnetic separation were used to obtain relatively pure concentrates. Fractions which were hand picked are so designated in Table A1. Zircon fractions processed before mid-1979 were relatively large, 15 to 20 mg, whereas those processed later weighed less than 5 mg. Due to the associated minaturization of procedures, Pb extraction blanks dropped from 2-5 ng Pb to 1-2 ng at that time. The measured Pb blanks comprise less than 2.5% of zircon lead in all analyses except those on fractions 2 and 3 of WN-511-78 where they contribute approximately 4%, and in fractions 2 to 5 of WN-18-75 where a misadventure resulted in Pb blanks of up to 25%. Analytical techniques available in 1987 (Parrish et al., 1987) allowed analysis of much smaller zircon fractions, generally less than 0.1 mg. This permitted careful selection of superior zircon fractions by handpicking which, together with zircon abrasion and improved magnetic separation techniques, invariably yielded less discordant results.

Analytical uncertainties (1 sigma) in results obtained prior to 1982 are estimated at: $^{206}Pb/^{238}U$ and $^{207}Pb/^{235}U$, 0.35%; $^{207}Pb/^{206}Pb$, 0.075%. Analytical uncertainties were precisely calculated for analyses performed in 1987 (Parrish et al., 1987) and usually approximate: $^{206}Pb/^{238}U$ and $^{207}Pb/^{235}U$, 0.1%; $^{207}Pb/^{206}Pb$, 0.04% (except for WN-18-75, fractions 2 to 5, where the uncertainties average $^{206}Pb/^{238}U$, 0.13%; $^{207}Pb/^{235}U$, 0.34%; $^{207}Pb/^{206}Pb$, 0.32%).

The U-Pb studies on zircon presented in this report do not generally yield simple collinear sets of data points. Therefore the model of a single period of Pb loss affecting an otherwise undisturbed U-Pb system is not usually valid and the age estimates are dependent on the interpretation of the observed systematics.

Ages and uncertainties based on fitting a chord to three or more data points have been calculated in the following manner:

1) If the array of data points is collinear or if the array contains a data point less than 5% discordant, the method of Davis (1982) is used.
2) If neither of these conditions apply, a method based on that of York (1969) as described by Parrish and van Breemen (1985) is employed.

Estimates of age derived from only two relatively concordant U-Pb data points are useful in distinguishing broad age relationships but do not necessarily provide precise ages. In this case analytical uncertainties are not stated as there are insufficient points to determine whether the assumed single stage model of Pb loss is valid.

General techniques for the extraction and analysis of Rb and Sr from rocks and minerals during the early part of the project are described in Wanless and Loveridge (1972), with the following exception. Use of a more highly enriched (99.89%) ^{84}Sr tracer allowed determination of sample $^{87}Sr/^{86}Sr$ ratios directly from isotope dilution analyses, eliminating the requirement for separate Sr isotopic composition analyses.

Techniques for the mass spectrometric analysis of Rb and Sr in use in 1977 are described in Wanless and Loveridge (1978). Rb and Sr samples collected in 1976 and later were analyzed on a rebuilt and improved 10 inch radius mass spectrometer. Selection and switching of the magnetic field were automated in 1980; Rb-Sr measurements on the Kasba gneiss samples and some of the granulite samples from southwest of Hyde Lake were obtained in the automated mode.

In the measurement of Rb-Sr results 1 sigma analytical uncertainties are estimated at: Rb ppm, 1%; Sr ppm, 0.5%; $^{87}Rb/^{86}Sr$, 1%; $^{87}Sr/^{86}Sr$, as indicated in Table A2 (Appendix).

Sample locations are presented in the summary tables of geochronological results, Tables 1, 2 and 3, for the Angikuni-Yathkyed lakes area, the Edehon-Hyde lakes area and the Kasba gneiss area respectively. References to previously published K-Ar ages for samples included in this study, are also listed in these tables. References to other relevant K-Ar ages are given in the text.

ANGIKUNI - YATHKYED LAKES AREA

General geology

The simplified geological sketch map, Figure 2, adapted from Eade (1985) and Tella and Eade (1985), shows the general distribution of rock types in the area. Archean supracrustal rocks, the Henik Group, composed of metamorphosed volcanic and sedimentary rocks and amphibolite and gneisses derived from them, occur as a major northeast-plunging synclinorium in the southern two thirds of this area. The volcanic rocks are largely mafic composition, massive to pillowed meta-andesite or metabasalt with some associated mafic to intermediate pyroclastic rocks. Here and there, near Angikuni Lake and southwest of Yathkyed Lake, rhyolitic volcanics, chiefly pyroclastics with minor flows, are intercalated with the mafic volcanics. Southwest of Yathkyed Lake, iron-formation associated with the volcanic rocks is most commonly quartz magnetite or quartz pyrite with minor quartz ankerite.

Migmatized paragneiss and paragneiss, with some intercalated amphibolite, derived from metagreywacke and metatuff, constitutes the greater part of the supracrustal rocks in the south central-part of the synclinorium.

The abundant Archean granitoid gneisses in the region range from gneisses of granodiorite composition containing abundant inclusions or layers of metamorphosed supracrustal rocks to homogeneous, well foliated orthogneiss. A small area of granulitic granitoid gneiss occurs southwest of Yathkyed Lake. East of the Tulemalu Fault the Archean gneisses and supracrustal rocks have a pronounced northeast structural trend but west of this fault the trend in the granitoid gneiss ranges from north-northeast to north.

Small Archean age plutons ranging from quartz monzonite to gabbro composition intrude all the above described rocks.

Northeast-trending metagabbro to amphibolite dykes, the Kazan Dykes, are considered to be Archean age as for the most part they are metamorphosed. A swarm of east trending gabbro or diabase dykes, the Tulemalu Dykes, are unmetamorphosed except in the northeast part of the area. The Tulemalu Dykes post-date the deformation of the Archean gneisses and supracrustal rocks, and are Aphebian.

Only the upper part of the Hurwitz Group, meta-arkose and quartz mica schist of the Tavani Formation and dolomite, phyllite and calc-silicate rocks of the Watterson Formation, are present in a small fault block in the southeast part of the area.

In the southeast corner of the region granitoid gneisses, consisting of nebulitic to banded gneiss with abundant bands and irregular masses of quartz monzonite, are considered to be Aphebian. They are probably largely derived from Archean rocks that have been reworked, with the original texture destroyed and are characterized by abundant potassium feldspar content.

Aphebian plutonic rocks are confined to the northern half of the map area. They consist of two different suites, one pre-Dubawnt Group and the other, post- Dubawnt Group. The former are commonly associated areally with faults, either east- or northeast-trending. For the most part they consist of granite to quartz monzonite and syenite but some small bodies of diorite or quartz diorite are also present.

Dubawnt Group rocks occur in three distinct areas. The easternmost area, the Yathkyed Lake Basin, is separated from the central area, the Angikuni Lake Basin by a major northeast-trending fault that is a subsidiary of the Tulemalu Fault. The latter fault forms the western

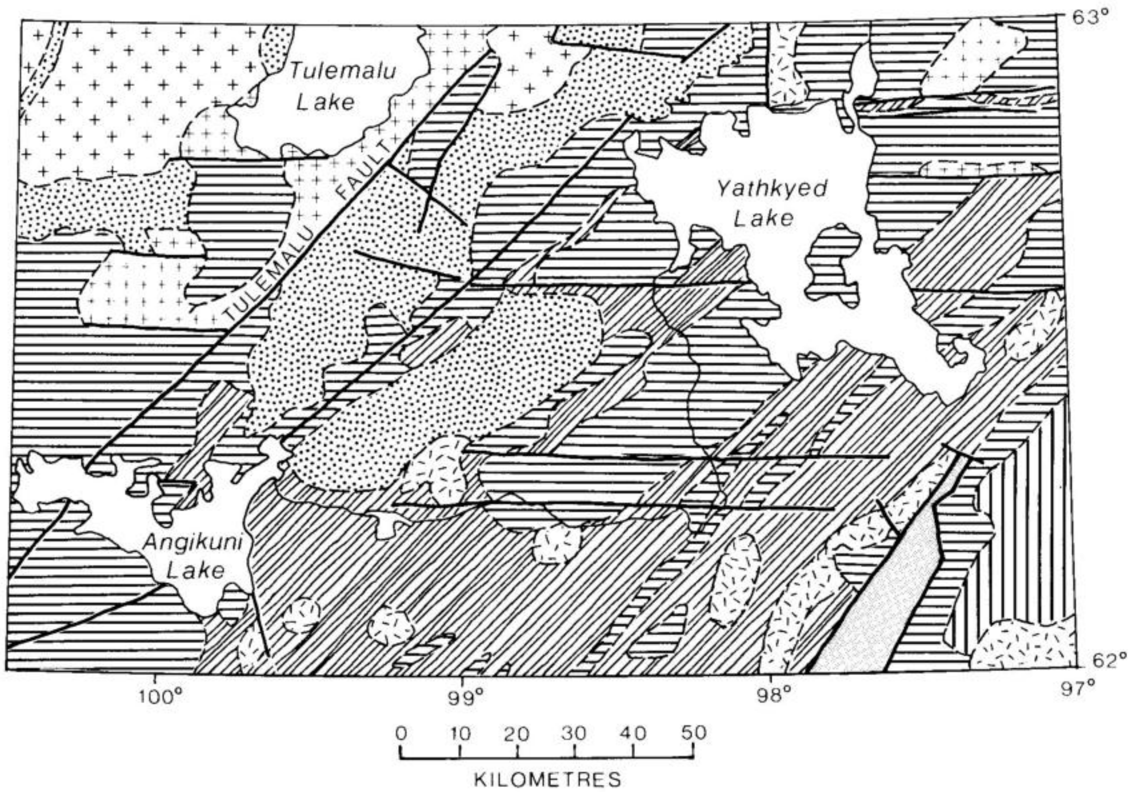
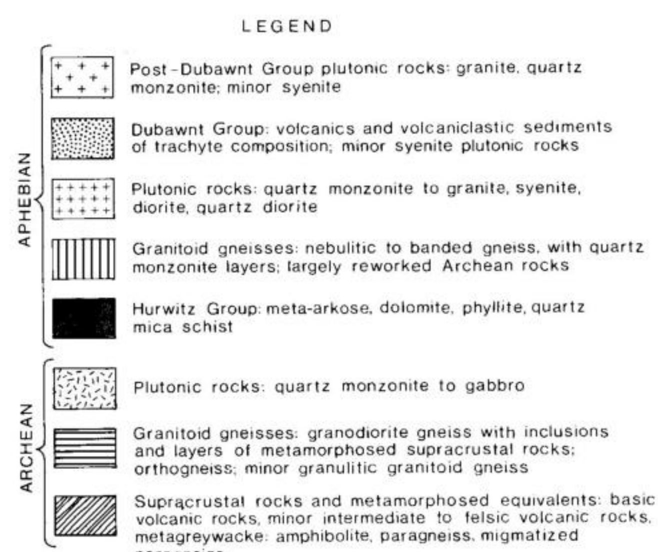


Figure 2. Geological sketch map, Angikuni-Yathkyed lakes area.

margin of the Angikuni Lake Basin. West of the Tulemalu Fault, the Dubawnt Group rocks are part of the major Baker Lake Basin extending to the northeast, but within this area the Basin is dismembered by younger intrusive plutonic rocks. Mafic trachytes, flows and pyroclastics and derived volcaniclastic sediments, of the Christopher Island Formation comprise the majority of the Dubawnt Group rocks in this area, with minor occurrence of sandstone and conglomerate of the South Channel Formation present here and there at margins of the basins, and a small area of siltstone and sandstone of the Angikuni Formation at the southwest end of the Angikuni Lake Basin. Small lamprophyre dykes, assumed to be genetically related to the mafic trachytes of the Christopher Island Formation, are common in the older rocks adjacent to the Dubawnt Group basins.

The post-Dubawnt Group plutonic rocks present in the northwest part of the area are mostly granite, commonly a distinctive coarse grained porphyritic rock with rapakivi texture that is fluorite bearing. The granite intrudes trachytes of the Christopher Island Formation.

Scattered northwest-trending diabase dykes of the Mackenzie swarm are present in the area.



Geochronology

Archean volcanic rocks

Two samples of finely layered felsic tuff, WN-210-76 from 5 km west of the northeast arm of Angikuni Lake

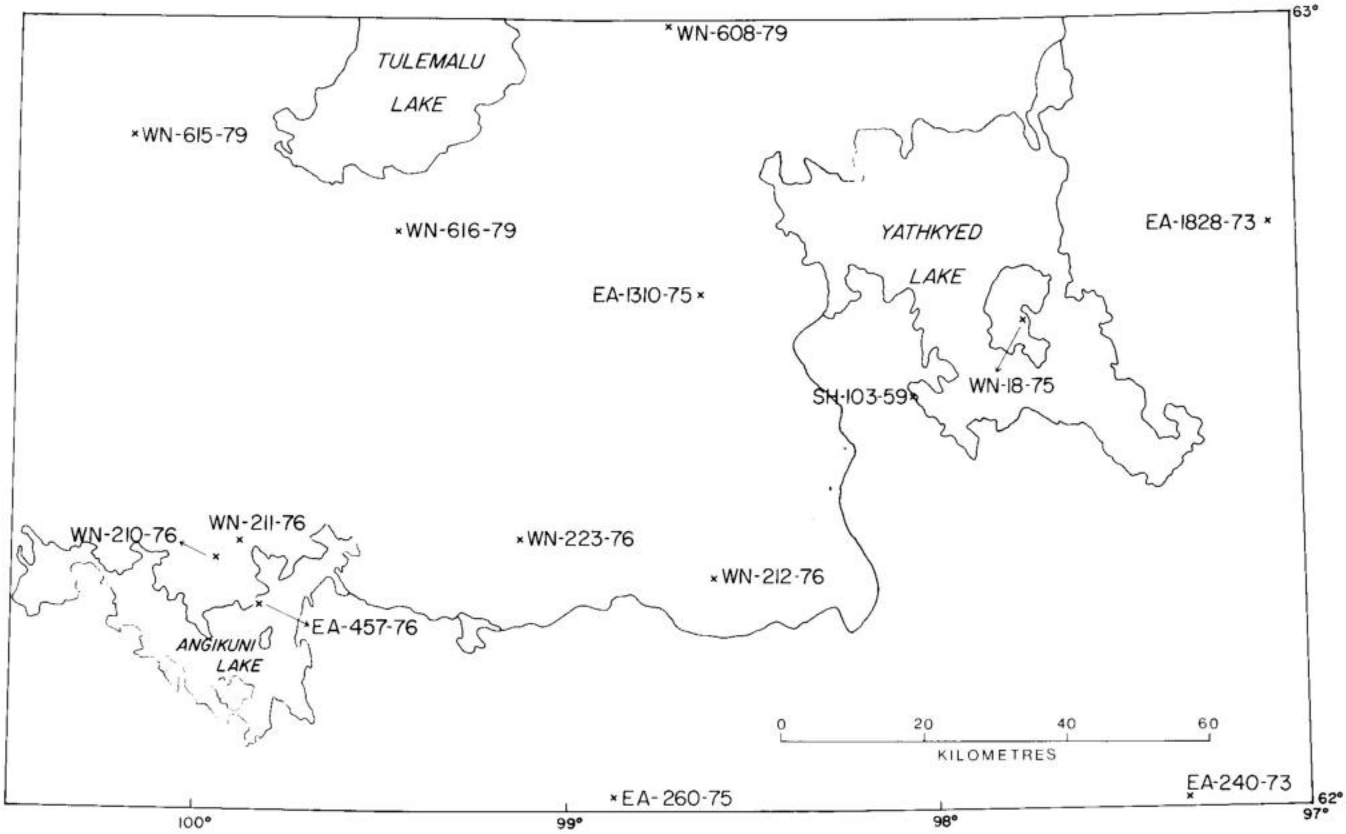


Figure 3. Sample location map, Angikuni-Yathkyed lakes area.

and WN-211-76 from 2 km northwest of the northeast arm of the lake (Fig. 3) were found to contain zircon. These volcanic rocks are from the northwest part of an extensive band of Archean Henik Group volcanics. The rocks are described in Eade (1985). The finely banded crystal and lapilli tuffs are apparently in the upper part of the Henik Group and grade upward into a unit consisting of arkose to quartzite with some black slate. The Henik Group volcanics are considered to be equivalent to the Kaminak Group volcanics occurring to the east.

WN-210-76: U-Pb analyses were carried out on three zircon fractions from sample WN-210-76 (Table A1, Fig. 4). Fractions 2 and 3 of bulk zircon, yielded two highly discordant data points. Fraction 1, magnetically separated, hand picked and abraded, resulted in a less discordant point not quite collinear with the other two. Regression analysis yielded intercept ages 2605 ± 4 and 849 Ma, MSWD = 3.2.

Euhedral zoning of the zircon grains suggests zircon growth in a silicate melt prior to extrusion (Silver, 1969). However, 2605 ± 4 Ma is interpreted as a minimum age for the time of zircon growth because of the likelihood of secondary (recent) Pb loss from the higher U fractions. Fractions 2 and 3 are more susceptible to secondary Pb loss not only due to their higher U contents (739 and 1020 ppm U vs 502 ppm for fraction 1) but also because abrasion of fraction 1 has removed surficial zircon most prone to secondary Pb loss. Appreciable recent Pb loss from fractions 2 and 3 would have the effect of rotating the chord in the direction of younger concordia intercept ages, hence 2605 ± 4 Ma is considered a minimum age for the time of extrusion.

WN-211-76: Initial analyses of bulk zircon from WN-211-76 resulted in a cluster of four, highly discordant data points (Fig. 4, Table A1). Four additional fractions, magnetically separated, hand picked and abraded yielded a linear set of data points above and to the right of the bulk zircon cluster. This pattern is interpreted as a two stage Pb loss trend.

An estimate of the primary (first stage of Pb loss) concordia intercept ages is given by regression of data from collinear points 2, 3 and 7: 2680 + 28/-24 and 1903 Ma. Point 1, although from a strongly abraded fraction, falls below this chord. This is tentatively attributed to secondary Pb loss, since fraction 1 has the highest measured U content (303 ppm) of zircon from WN-211-76. The cluster of bulk zircon points also shows secondary Pb loss, probably from surficial zircon which was not removed from these fractions by abrasion.

Zircon grains from WN-211-76 are generally clear and rounded with only a few more euhedral members showing internal euhedral zoning. In polished sections etched with HF vapour, euhedral zoning of U content is visible with surficial rounding cutting the zonation. The age of 2680 + 28/-24 Ma is interpreted as that of zircon

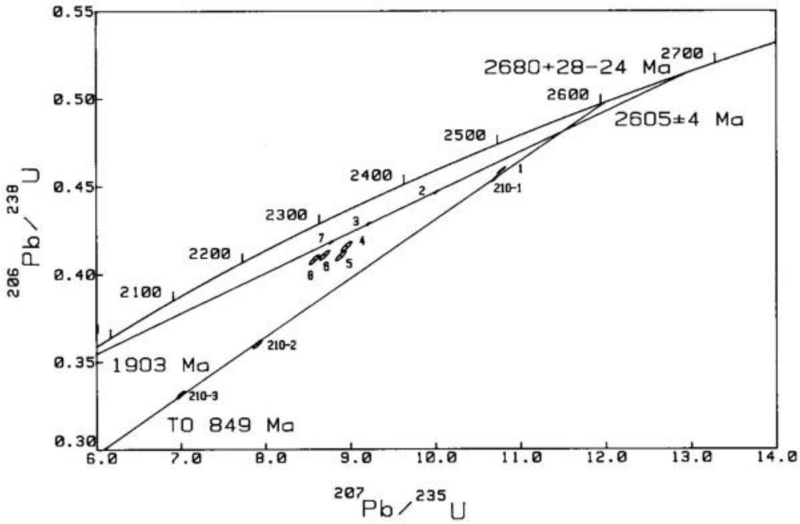


Figure 4. Concordia diagram showing the results of U-Pb analyses on zircon from WN-210-76 (210-1 to 210-3) and WN-211-76 (1 to 8).

growth within a silicate melt; i.e. the age of extrusion. Surficial rounding is probably due to late magmatic corrosion.

The two sample sites are 4 km apart, and are from the same rock unit. The apparent 2680 Ma upper intercept age for WN-211-76 is in the range expected as the Henik Group volcanics are probably closely related in age to the granitoid gneiss basement rocks in this region (WN-18-75, WN-212-76). The minimum age for extrusion of WN-210-76 is in general agreement with the result on WN-211-76.

These results are comparable to those obtained by Mortensen and Thorpe (1987) on volcanic rocks from the Kaminak Lake portion of the Rankin-Ennadai belt, 250 km to the east. They determined U-Pb zircon ages of 2697.5 ± 1.4 Ma and 2692 ± 1.0 Ma on felsic volcanic rocks in the middle and top, respectively, of the stratigraphic section.

An earlier attempt to date felsic volcanic rocks of the Henik Group was carried out on zircon from a sample (EA-1814-73) of sheared rhyolitic tuff from just south of Yathkyed Lake. The $^{207}Pb/^{206}Pb$ ratio provided a minimum age of 2449 Ma (Wanless and Eade, 1975). A K-Ar age on muscovite from the sample gave 1616 ± 49 Ma. The strong shearing in this sample is parallel to a nearby major northeast-trending fault and the K-Ar age may approximate the final major movement on this fault.

Archean granitoid gneisses and plutonic rocks

WN-212-76: Hornblende granodiorite orthogneiss, sample WN-212-76, from 43 km southwest of the mouth of Kazan River at Yathkyed Lake, is a medium grained, grey rock with a light grey to white weathered surface. A moderate foliation is marked by streaky mineral segregations. Quartz, oligoclase, hornblende and biotite are essential mineral constituents, with minor microcline and accessory opaques, apatite, sphene, and zircon. Both hornblende and biotite are slightly chloritized. A more complete description of this rock is given in Eade (1985).

Two fractions of zircon from WN-212-76 were analyzed, yielding two relatively concordant, closely spaced data points (Fig. 5). Calculated upper and lower intercept ages are 2671 and 1177 Ma. The granodiorite orthogneiss is thought to be derived from a syntectonic plutonic rock, with foliation developed during the later stages of the late Archean orogeny. We interpret the upper intercept age, 2671 Ma, as an indication of the age of intrusion of the plutonic rock.

A K-Ar date of 2473 ± 184 Ma was obtained on hornblende from this sample. A nearby sample of the granodiorite orthogneiss, at the contact with an east-trending gabbro dyke, gives K-Ar dates on hornblende of 2471 ± 62 Ma, and on biotite of 2118 ± 47 Ma (GSC 78-154 and GSC 78-153, Wanless et al., 1979). In the latter pair, the biotite age probably reflects the contact effects of the dyke intrusion.

WN-223-76: Sample WN-223-76 is from a quartz monzonite to granodiorite pluton approximately 22 km east of Angikuni Lake and was taken approximately 2 m from an east-trending gabbro dyke cutting the pluton. Only a vague foliation is present in the pink to grey, medium grained rock. It is composed of quartz, oligoclase, microcline, hornblende, and biotite, with accessory apatite, sphene, zircon and opaques. The rock is described in Eade (1985).

Two fractions of zircon from WN-223-76 were analyzed, resulting in two reasonably spaced, relatively concordant data points defining a chord of upper intercept age, 2659 Ma, and lower intercept age, 588 Ma (Fig. 5). These points fall in the same general location as the two WN-212-76 data points and yield a similar age result.

A K-Ar date on hornblende from this sample yields 2429 ± 203 Ma. Adjacent samples, from the contact with the gabbro dyke, give K-Ar dates on hornblende of 2270 ± 100 and 2242 ± 114 Ma (GSC 78-149 and GSC 78-151, Wanless et al., 1979), indicating the approximate age of intrusion of the dyke.

WN-18-75: Sample WN-18-75 of medium grained, pyroxene-bearing granodiorite gneiss, varying to swirled or nebulitic gneiss, is from the large island on the east side

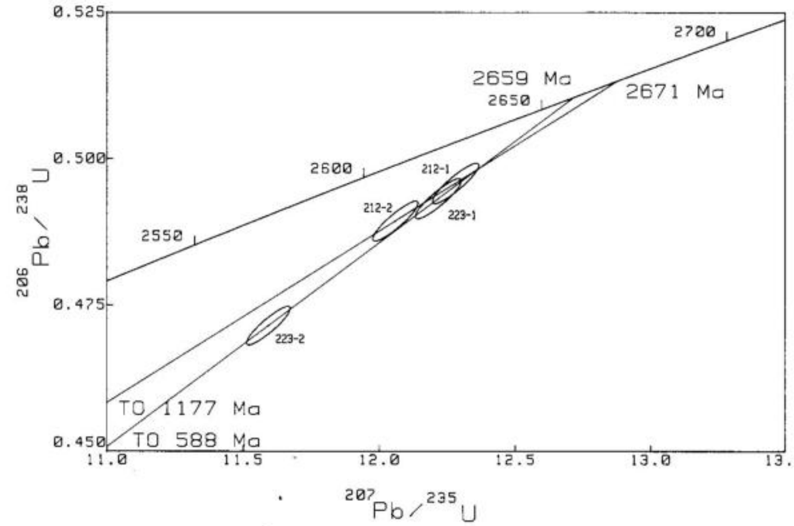


Figure 5. Concordia diagram showing the results of U-Pb analyses on zircon from WN-212-76 and WN-223-76.

of Yathkyed Lake. Rocks of this map unit, Āngr (Eade, 1985) are of interest as they are the only granulite facies gneisses in this part of the District of Keewatin. It is postulated that the granulite gneiss occurs in a part of the basement uplifted adjacent to a major fault.

Five zircon fractions from WN-18-75, magnetically separated, hand picked, and abraded, yielded a tight, relatively concordant, linear cluster of data points (Fig. 6, Table A1). Although collinear within analytical uncertainty, the data do not yield to regression analysis because of overlapping uncertainty envelopes. $^{207}Pb/^{206}Pb$ ages range from 2636 ± 11 to 2646 ± 2 Ma providing a minimum age of 2644 Ma. Other basement gneisses in the area, containing zircon with comparable U contents, have yielded lower concordia intercept ages as follows: WN-212-76, 1177 Ma; WN-223-76, 588 Ma. These relatively low results are consistent with the relatively low measured U contents in zircon from these samples, 160 to 232 ppm.

The K-Ar age on biotite from WN-18-75 is 2425 ± 54 Ma. This age shows no effect of the Moranian or Hudsonian orogenies (closing dates about 1860 and 1750 Ma respectively, Stockwell, 1982), thus the effects of these orogenies in this area were probably too weak to have initiated Pb loss from WN-18-75 zircon.

Based on these considerations, it is estimated that a range of 1500 to 500 Ma provides reasonable limits for the lower intercept age of WN-18-75 zircon. For these lower intercept ages regression analysis yields the following upper intercept ages: 1500 Ma, 2658 ± 3 Ma; 500 Ma, 2648 ± 2 Ma. Resultant limits on the upper intercept age are 2661 and 2646 Ma. This is equivalent to an upper intercept age of 2653 + 8/-7 Ma.

Zircon in WN-18-75, although rounded, retains internal euhedral zoning. Thus the age of 2653 + 8/-7 Ma is interpreted as the time of zircon growth under magmatic conditions; ie. the age of the granodiorite from which the granulite facies orthogneiss is derived.

Aphebian intrusive rocks

WN-615-79: A zircon concentrate was obtained from a sample of a young granite pluton, WN-615-79, collected approximately 20 km west of the southwest end of Tulemalu Lake. The granite is a coarse grained, porphyritic, rapakivi textured rock that is fluorite-bearing. Compositionally it is an alkali granite, hornblende-bearing, and is part of a widespread post-tectonic intrusive suite. It is unmetamorphosed and the only structural dislocation is some late faulting, for the most part at the margins of the pluton. A brief description of the granite is included in Tella and Eade (1980).

A concordia intercept age of 1753 + 3/-2 Ma (Loveridge et al., 1987) was obtained on zircon from WN-615-79. This age is critical as granite WN-615-79 intrudes the alkaline mafic trachytes and volcaniclastic sediments of the Christopher Island Formation of the Dubawnt Group, and hence this result establishes a minimum age for the Christopher Island Formation. Also, it is possible that the calc-alkaline igneous suite of which the granite is a part includes the felsic volcanic rocks of the Dubawnt Group, Pitz Formation. The age of this granite could therefore be very close to the age of extrusion of the Pitz Formation.

Hornblende from sample WN-615-79 yields a K-Ar age of 1793 ± 53 Ma, in agreement with the U-Pb zircon age. A fluorite-bearing granite, WN-608-79, similar to WN-615-79, occurring to the east-northeast, gives a K-Ar age on biotite of 1747 ± 32 Ma. Muscovite from a granite considered to be part of the same intrusive suite occurring west of the area of Figure 2 gives a K-Ar age of 1757 ± 23 Ma (GSC 81-148, Stevens et al., 1982b).

The granite is very similar to the Nueltin Lake granite occurring approximately 220 km to the south, differing only in that rapakivi texture is more pronounced in the northern rocks. Both granites are characteristically coarse grained, porphyritic, fluorite-bearing, post-

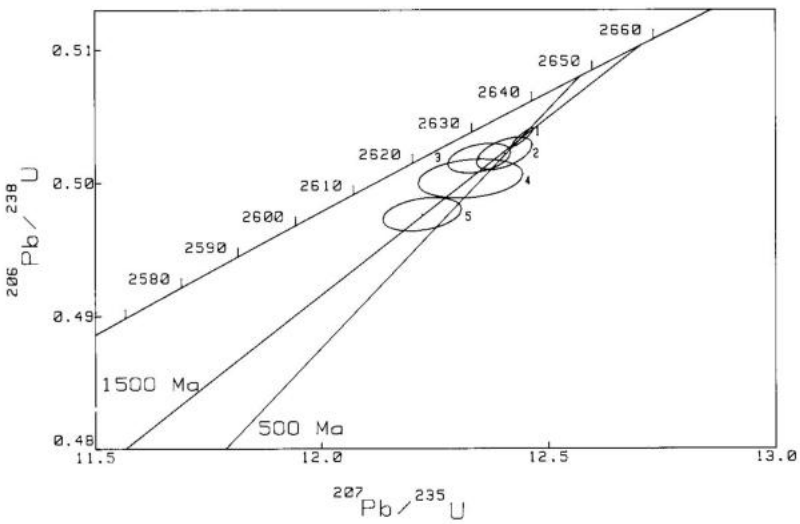


Figure 6. Condordia diagram showing the results of U-Pb analyses on zircon from WN-18-75.

tectonic plutons. Two Rb-Sr whole-rock isochron age measurements on the Nueltin Lake granite (Wanless and Loveridge, 1972, p. 33 and 37) resulted in ages of 1760 ± 16 Ma, initial ratio 0.7052 ± 0.0018 and 1775 ± 61 Ma, initial ratio 0.7060 ± 0.0040. Both ages have been recalculated using $1.42 \times 10^{-11} a^{-1}$ for the ^{87}Rb decay constant.

WN-616-79: Sample WN-616-79 was collected from a young, pink, probably syntectonic, hornblende-quartz monzonite to quartz syenite pluton, 7 km south of Tulemalu Lake. This medium grained, chiefly massive rock has local cleavage, and minor alteration or perhaps slight metamorphism is shown in saussuritization of plagioclase and minor chlorite development. A K-Ar age of 1984 ± 78 Ma was obtained on hornblende from WN-616-79. A U-Pb age on zircon was not attempted due to the unsuitable nature of the zircon.

EA-457-76: A lamprophyre dyke, sample EA-457-76, is located on a small island in the northeast arm of Angikuni Lake near the west shore (Eade, 1985). The dyke trends 010°, dips 70° west, and cuts metagabbro and granodiorite gneiss. It is approximately 1 m thick and contains abundant elliptical granodiorite gneiss xenoliths, with their long axes oriented parallel to the dyke contacts. No chilling is evident in the dyke rock and no contact metamorphism in the country rock. Mica phenocrysts, phlogopite or biotite, form 25% of the rock, with feldspar, carbonate, and altered pyroxene other major constituents. The carbonate is, in part at least, secondary.

A Rb-Sr biotite age (Table A2) of 1568 ± 33 Ma, initial ratio 0.7048 ± 0.0001, determined on lamprophyre from this dyke, is somewhat lower than the K-Ar age of 1687 ± 41 Ma on the same material. A similar lamprophyre dyke in the area to the north of Figure 2 gave a K-Ar age on phlogopite of 1821 ± 34 Ma (GSC 81-161, Stevens et al., 1982b) and on hornblende of 1836 ± 101 Ma (GSC 81-162, op. cit.). The lamprophyre dykes are the final stages of the alkaline igneous suite composed of the Christopher Island Formation volcanic rocks and the Martell syenites, both of the Dubawnt Group. Considering the lower age limit of 1753 + 3/-2 Ma for the Christopher Island Formation, indicated by the U-Pb age on zircon from granite WN-615-79, both ages indicated for sample EA-457-76 are too young to be the age of intrusion. The presence of probable secondary carbonate in the sample, and the possibility of the sample being affected by minor tectonism associated with the major northeast-trending fault traversing Angikuni Lake may account for the low ages.

Discussion

Results of age measurements on rocks from the Angikuni-Yathkyed lakes area are summarized in Table 1. Although none of the zircon age measurements on individual specimens of Archean rocks in the Yathkyed-Angikuni lakes region are conclusive, as a group, results from WN-212-76, WN-223-76, WN-18-75, and WN-211-76:2671, 2659, 2653, and 2680 Ma respectively, indicate the age of the volcanic-granitoid basement is in the range of 2650 to 2680 Ma. Stockwell (1982) suggested 2670 Ma as the boundary between the end of the Laurentian Orogeny and the epi-Laurentian.

K-Ar hornblende ages from Archean basement rocks range from 2506 ± 115 to 1739 ± 18 Ma; K-Ar biotite ages show a similar range, 2425 ± 54 to 1696 ± 16 Ma. The youngest ages (EA-240-73 and EA-1828-73) are from the easternmost part of the area in Figure 2. It is apparent that the Hudsonian Orogeny there had sufficient effect to re-set the K-Ar systems of both biotite and hornblende. Approximately 40 km west of the area in Figure 2, on the northwest side of the major northeast-trending Tulemalu Fault, granodiorite orthogneiss yields K-Ar ages on hornblende of 1834 ± 59 Ma (GSC 81-146, Stevens et al., 1982b) and on biotite of 1815 ± 25 Ma (GSC 81-147, op cit.). It is suggested that there, both

Table 1. Geochronology data, Angikuni-Yathkyed lakes area

Sample no.	Location	Map unit		Lithology	Zircon U-Pb Ma		Rb-Sr Ma		K-Ar Ma (GSC no.)	
WN-210-76	62°19′12″N, 99°57′00″W	Āf	(1)	felsic tuff	2601 (min.)	(8)				
WN-211-76	62°20′31″N, 99°53′12″W	Āf	(1)	felsic tuff	2680 + 29/-25	(8)				
EA-1814-73	62°13′45″N, 97°50′10″W	Āf	(1)	felsic tuff	2449 (min.)	(7)		(m)	1616 ± 49 (78-168)	(5)
WN-18-75	62°37′00″N, 97°44′30″W	Āngr	(1)	pyroxene-bearing granodiorite gneiss	2653 + 8/-7	(8)		(b)	2425 ± 54 (78-169)	(5)
WN-212-76	62°18′00″N, 98°35′50″W	Āngo	(1)	granodiorite orthogneiss	2671	(8)		(h)	2473 ± 184 (78-159)	(5)
WN-223-76	62°20′57″N, 99°08′07″W	Āqm	(1)	quartz monzonite	2659	(8)		(h)	2429 ± 203 (78-150)	(5)
SH-103-59	62°31′30″N, 98°04′00″W	Āng[1]	(1)	quartz diorite gneiss				(b)	2365 ± 125 (61-104)	(4)
EA-1310-75	62°39′00″N, 98°38′30″W	Āngo	(1)	granodiorite orthogneiss				(h)	2458 ± 21 (87-75)	(10)
								(b)	2020 ± 19 (87-74)	(10)
EA-150-73	61°55′10″N, 99°30′45″W	Āg	(3)	metagabbro				(h)	2443 ± 21 (87-68)	(10)
								(b)	1975 ± 19 (87-67)	(10)
EA-260-75	62°01′10″N, 98°52′45″W	Āng	(1)	granodiorite gneiss				(b)	2055 ± 19 (87-73)	(10)
EA-1828-73	62°44′10″N, 97°04′25″W	Āsn	(1)	migmatized paragneiss				(h)	2506 ± 110 (87-70)	(10)
								(b)	1726 ± 17 (87-69)	(10)
EA-240-73	62°00′01″N, 97°19′40″W	Āng	(1)	granodiorite gneiss				(h)	1739 ± 18 (87-72)	(10)
								(b)	1696 ± 17 (87-71)	(10)
WN-616-79	62°43′15″N, 99°22′30″W	Aqm	(1)	quartz monzonite				(h)	1984 ± 78 (81-150)	(6)
WN-615-79	62°51′05″N, 100°11′25″W	Agp	(2)	granite	1753 + 3/-2	(9)		(h)	1793 ± 53 (81-149)	(6)
WN-608-79	62°59′43″N, 98°42′49″W	Agp	(1)	granite				(b)	1747 ± 32 (81-152)	(6)
EA-457-76	62°16′15″N, 99°49′30″W	ADMd	(1)	lamprophyre			1568 ± 33 (8) (0.7048)	(b)	1687 ± 41 (78-145)	(5)

References:

(1) Eade, 1985
(2) Tella and Eade, 1985
(3) Eade and Chandler, 1975
(4) Lowden et al., 1963
(5) Wanless et al., 1979
(6) Stevens et al., 1982b
(7) Wanless and Eade, 1975
(8) This paper
(9) Loveridge et al., 1987
(10) Hunt and Roddick, 1987

(m) - muscovite
(b) - biotite
(h) - hornblende

biotite and hornblende K-Ar systems have been re-set by a slightly older event, perhaps the Moranian Orogeny of Stockwell (1982). In the central part of the area of Figure 2, K-Ar ages on biotite from Archean basement rocks fall in the range 1975 ± 19 to 2425 ± 54 Ma and K-Ar hornblende ages average 2450 Ma. Thus the K-Ar systems in these rocks show only slight or no effect of younger events since the systems closed in the epi-Kenoran (Stockwell, 1982). The relatively young 1616 ± 49 Ma K-Ar age on muscovite from a sheared felsic tuff is thought to result from shearing associated with late movement on a northeast-trending fault.

K-Ar data on gabbro dykes in this region have been published (Wanless et al., 1979) and the results are discussed in detail, by Fahrig et al.(1984). In summary, metamorphosed northeast-trending Kazan Dykes are Archean and the K-Ar ages are metamorphic ages that in part at least have been reset by later tectonism associated with late movements on the Tulemalu Fault zone. The east-trending Tulemalu Dykes are Aphebian, with some variation in the K-Ar ages, but the best approximation of age is 2150 Ma.

We consider the K-Ar age on hornblende WN-616-79, 1984 ± 78 Ma, to be the closing age of hornblende on cooling of the quartz monzonite pluton and, due to the massive and unmetamorphosed nature of the pluton, not a metamorphic age. The pluton is thus Aphebian and probably younger than the Tulemalu Dykes, occurring just to the south. However, the pluton is on the northwest side of the Tulemalu Fault and its intrusion may be associated with the regional metamorphism affecting the older gneisses, resulting in the previously mentioned metamorphic K-Ar ages on granodiorite orthogneiss of 1834 ± 59 and 1815 ± 25 Ma. According to the classification of Stockwell (1982) this pluton would be associated with the Moranian Orogeny and the ages on the granodiorite orthogneiss would represent cooling ages in the epi-Moranian. Presently available data seem to indicate that in this region the effects of the Moranian Orogeny occur largely northwest of the Tulemalu Fault.

This quartz monzonite to quartz syenite pluton (WN-616-79) pre-dates Dubawnt Group rocks and provides an upper limit on the age of the Christopher Island Formation. The U-Pb, zircon age of the coarse grained granite, WN-615-79, 1753 + 3/-2 Ma, provides a lower limit to the age of the Christopher Island Formation. The K-Ar ages on the lamprophyre in the area to the north, hornblende, 1836 ± 101 Ma, phlogopite, 1821 ± 34 Ma, probably date the intrusion of the dykes.

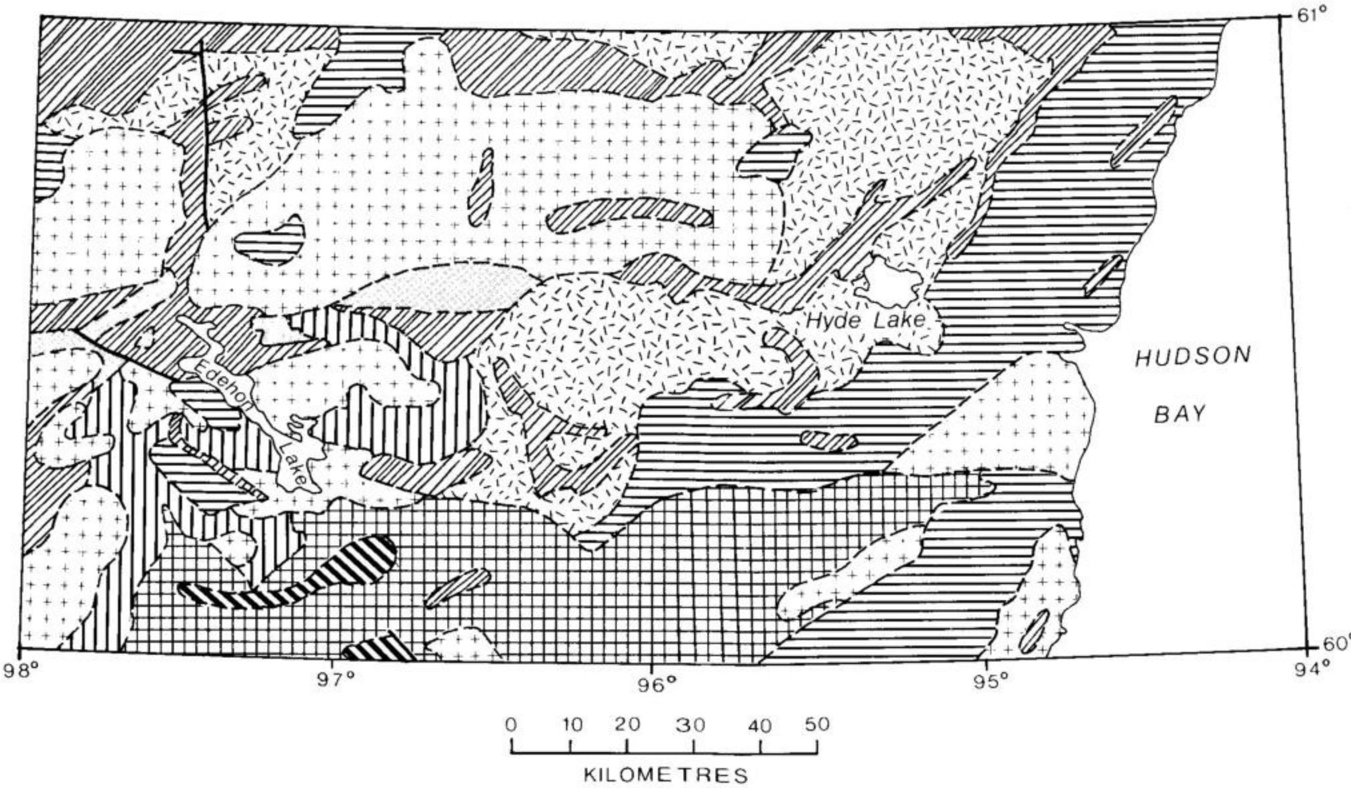
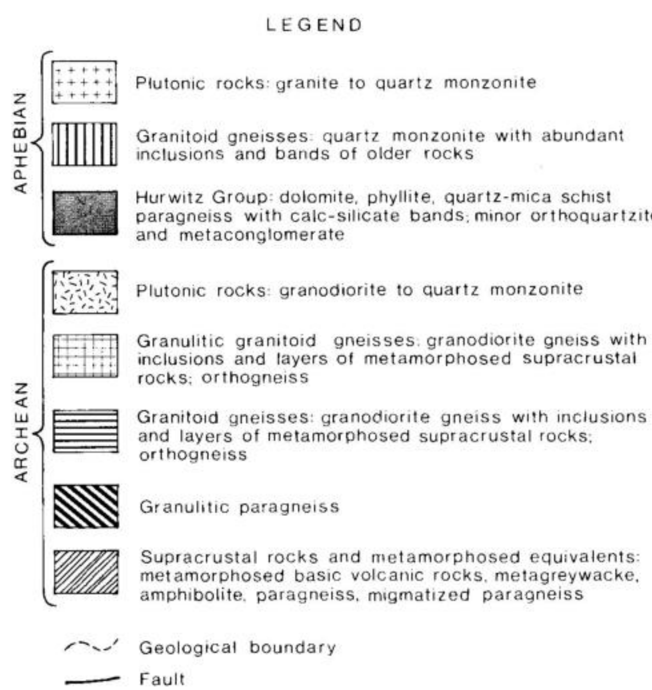


Figure 7. Geological sketch map, Edehon-Hyde lakes area.

EDEHON-HYDE LAKES AREA

General geology

The sketch map of the geology in this area, Figure 7, adapted from Eade (1973) and Fraser (1983) illustrates the distribution of the major rock types. The supracrustal rocks, metamorphosed basic lavas and pyroclastics, metagreywacke, phyllite, amphibolite, paragneiss and migmatized paragneiss, are most prominent in the north part of the area with thin sinuous bands extending into the central and southern parts of the region. The rocks are all regionally metamorphosed but as well commonly show some effects of contact metamorphism adjacent to younger plutonic rocks. Granulitic paragneiss is limited to two small areas in the south but some other small bands, not shown on Figure 7, occur within the granulitic granitoid gneiss. The granulitic paragneiss appears to be derived from rocks similar to the metagreywacke present to the north. Granitoid gneiss is most abundant in the eastern part of the region where outcrop is scarce. It is a mixed unit ranging from orthogneiss to nebulitic or banded gneiss. Similarly the granulitic granitoid gneiss in the south is variable, ranging from relatively homogeneous orthogneiss, to banded gneiss, to a heterogeneous mixture of granodiorite gneiss with inclusions and bands of supracrustal rocks. Archean plutonic rocks, ranging from granodiorite to quartz monzonite, commonly show a vague foliation.



The Hurwitz Group rocks present in the west-central part of the region in several small areas, consist largely of quartz-mica schist to paragneiss with calc-silicate bands and minor orthoquartzite and metaconglomerate. Both regional metamorphism and contact metamorphism, the latter induced by younger plutons, have affected these rocks. In places it is difficult to distinguish paragneiss derived from Hurwitz Group rocks from the Archean paragneiss.

Aphebian granitoid gneiss is associated with the Aphebian plutons, consisting of contact zones with intermixed older rocks. Compositionally, the gneiss is quartz monzonite to granodiorite with abundant bands and inclusions of paragneiss, granodiorite gneiss and granulitic granitoid gneiss.

The Aphebian plutonic rocks, which range from granite to quartz monzonite or rarely, granodiorite, form one large pluton and a number of smaller bodies forming a significant part of bedrock in this region.

Gabbro dykes are rare, limited to a single northwest-trending, diabase dyke (a member of the Mackenzie swarm) and a north-to north-northeast trending segment of a gabbro dyke of unknown age outcropping in the northwest corner.

Geochronology

Archean granitoid gneisses

WN-511-78: Sample WN-511-78, collected approximately 32 km southwest of Hyde Lake (Fig. 8) is from a grey, medium grained, weakly foliated, biotite-hornblende granodiorite gneiss. This orthogneiss was derived from a large granodiorite pluton that was probably syntectonic. A full description of the rock is contained in Fraser (1983). The pluton intrudes gneisses affected by amphibolite facies metamorphism and the sample location is approximately 25 km north of the boundary of the granulite facies metamorphism (Fig. 8).

U-Pb analyses of zircon from this sample resulted in three reasonably concordant, collinear data points (Fig. 9) defining a chord that yields upper and lower concordia intercept ages of 2737 + 13/-9 and 657 Ma. These results

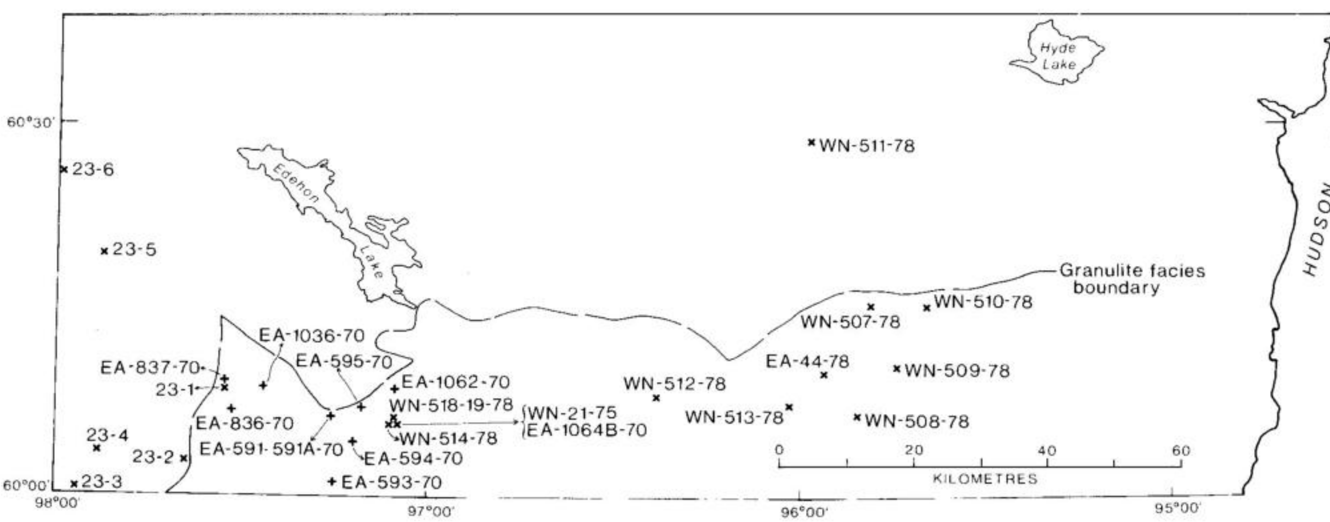


Figure 8. Sample location map, Edehon-Hyde lakes area.

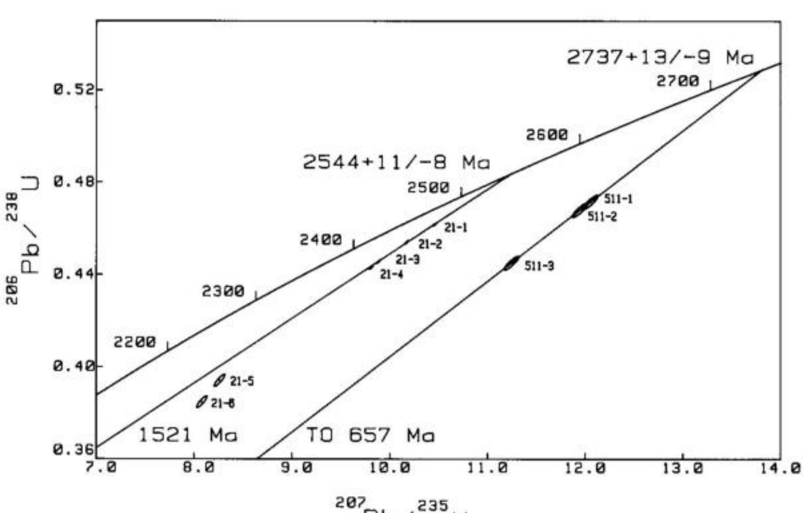


Figure 9. Concordia diagram showing the results of U-Pb analyses on zircon from WN-21-75 and WN-511-78.

must be interpreted in light of the hybrid nature of the zircons analyzed. A high proportion of zircon grains (about 70%) have rounded inner domains (cores) with euhedral overgrowths. Either the cores are essentially the same age as the overgrowths, in which case the measured age is that of the granodioritic precursor to the gneiss, or the cores are appreciably older than the overgrowths and the alignment of data points is fortuitous.

The similarity of results from fractions 1 and 2 indicates that the cores and overgrowths are essentially of the same age. Both fractions comprise the least magnetic split of bulk zircon but fraction 2 is of very fine grain size, -37 μm, while fraction 1 is the coarsest available, -105 + 64 μm. It is highly unlikely that zircon fractions of such dissimilar grain size would have the same proportion of overgrowth to core, yet uncertainty envelopes for these two data points overlap. If the cores and overgrowths were not of the same age, these points would be expected to differ markedly.

The extreme prevalence of cores in these zircons is interpreted to indicate that zircon growth was not continuous but was interrupted by a period of resorption. When zircon growth resumed, the residual rounded zircon grains would have acted as nuclei for further euhedral crystallization. This postulated history of zircon growth would also explain the presence of parallel zircon twins. Jocelyn and Pidgeon (1974) concluded that parallel zircon growth results from sudden variation in the rate of crystallization and/or a high proportion of zircon xenocrysts in the melt. In this case the xenocrysts would be residual zircon grains from an earlier period of crystallization in the same melt.

Therefore, we consider the upper intercept age, 2737 + 13/-9 Ma, to be the age of intrusion of the syntectonic granodiorite pluton. K-Ar dates of 1731 ± 66 Ma on hornblende and 1776 ± 41 Ma on biotite which were also obtained from this sample reflect a regional updating of K-Ar systems.

WN-21-75: Hypersthene-bearing granodiorite gneiss, sample WN-21-75, from south of Edehon Lake, (Fig. 8) is a medium grained, moderately well foliated granodiorite gneiss, grey to greenish-grey on fresh surfaces and rusty brown on weathered surfaces. It is composed of quartz, plagioclase (oligoclase-andesine), biotite and hypersthene, with minor microcline. Minor veins or stringers of younger quartz monzonite cut the gneiss. These rocks are described by Eade (1973).

Two fractions of bulk zircon from WN-21-75 were analyzed plus four fractions magnetically separated, hand picked and abraded. The latter yielded three collinear data points (1 to 3, Fig. 9) plus a fourth point falling below the chord through the other three points. Regression of the collinear data set provides intercept ages of 2544 + 11/-8 and 1521 Ma. Data points 5 and 6, which were not abraded, fall well below this chord, probably showing the effects of secondary (recent) Pb loss from the zircon surfaces. The data point for fraction 4 also appears to be drawn in this direction by minor secondary Pb loss even though fraction 4 was strongly abraded.

Euhedral zoning in WN-21-75 zircon indicates that zircon growth took place in a magmatic environment; the age of 2544 + 11/-8 Ma is interpreted as the age of emplacement of the granodioritic precursor to the gneiss.

WN-518-78, WN-519-78: Well banded hypersthene-bearing paragneiss from about 17 km south of Edehon Lake is also described by Eade (1973). The rock is medium grained, with characteristic rusty brown weathered surface and a dark grey to greenish-grey to light grey fresh surface. Quartz, plagioclase, biotite, and hypersthene are essential constituents, with minor hornblende and garnet present here and there. The rock is probably a migmatized paragneiss, with dark paleosome layers and light neosome layers.

Samples of this paragneiss were collected from two locations. A large block of well layered paragneiss, WN-518-78, was sawed into slabs for Rb-Sr analyses with a separate portion removed for U-Pb analyses on zircon. The portion of this block from which zircon was concentrated contained both the dark paleosome and the light neosome layers. U-Pb analyses were performed on four zircon fractions and the results are plotted in Figure 10.

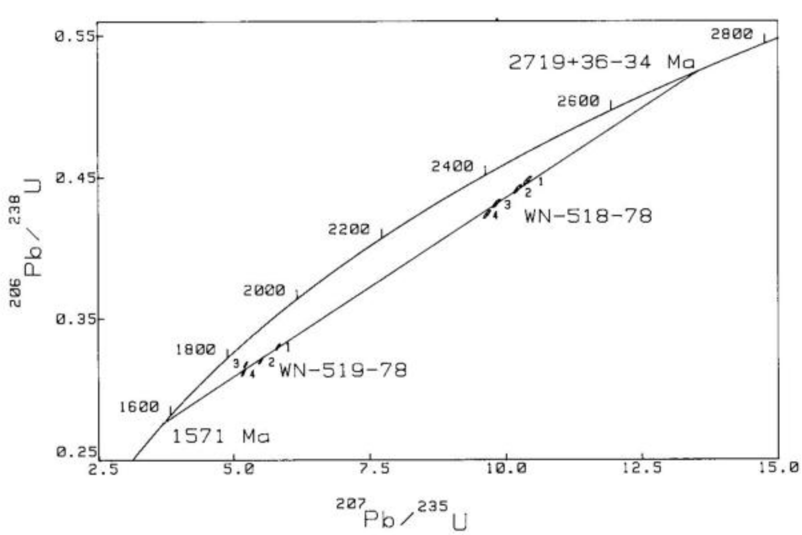


Figure 10. Concordia diagram showing the results of U-Pb analyses on zircon from WN-518-78 and WN-519-78.

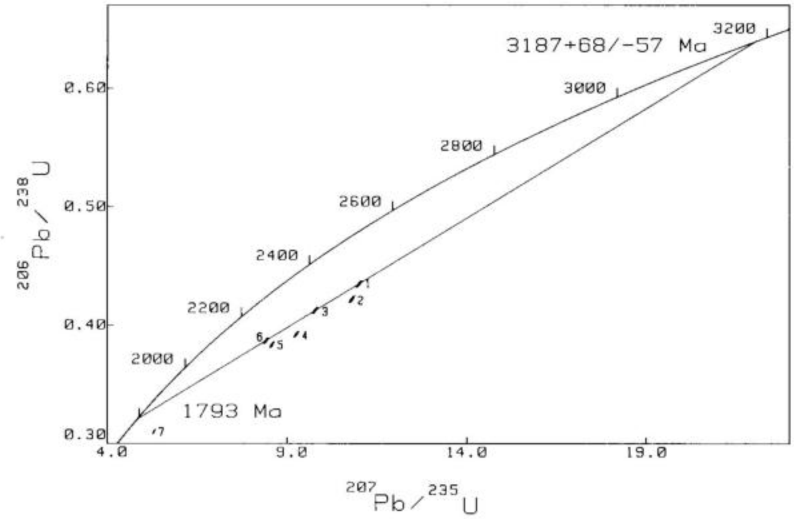


Figure 11. Concordia diagram showing the results of U-Pb analyses on zircon from WN-514-78.

Approximately 15 m from the WN-518-78 sample location, layering is coarser and a sample, WN-519-78, consisting only of the light neosome layer was obtained. The results of four U-Pb analyses on zircon fractions from this sample are also plotted in Figure 10.

The measured uranium contents of the WN-518-78 zircon fractions are quite high (662-824 ppm) but those of the WN-519-78 zircon fractions have twice that level (1248-1706 ppm). The data points for WN-519-78 are about 80% discordant reflecting high primary Pb loss due to the very high uranium content, whereas the data points for WN-518-78 are about 35% discordant. These disparate uranium contents would probably also have resulted in differential secondary Pb loss.

Although neither of the two sets of four data points are collinear within analytical uncertainty, the eight points taken together form a linear array. The chord through the array yields upper and lower concordia intercept ages of 2719 + 36/-34 and 1571 Ma. Assuming appreciable secondary (recent) Pb loss from WN-519-78 zircon, the calculated lower intercept age (1571 Ma) would be too low for the time of primary Pb loss.

The K-Ar age on biotite from WN-518-78 is 1700 ± 40 Ma; from WN-514-78 biotite 100 m south, the K-Ar age is 1736 ± 41 Ma. It is improbable that WN-518-78 zircon would have survived this metamorphic event without suffering appreciable Pb loss. Accordingly, by fixing the lower intercept ages at 1695 and 1740 Ma (the overlap in the two K-Ar biotite ages) a range in upper intercept age of 2827 to 2745 Ma is calculated, equivalent to an age of 2786 ± 41 Ma.

This age is adopted as on estimate of the primary age of WN-518-78 zircon. Although the zircon grains are clear in transmitted light, polishing and etching with HF vapour reveals a euhedral growth pattern for U concentration. This is interpreted as indicative of zircon growth in a silicate melt; therefore the zircon age dates the age of migmatization of the paragneiss. A detrital origin is considered unlikely due to the elongate habit and minor rounding of the zircon grains.

It is noted that if appreciable secondary Pb loss was also experienced by WN-518-78 zircon, the calculated age of 2786 ± 41 Ma would be an overestimate.

WN-514-78: Sample WN-514-78 was collected from foliated pyroxene- bearing granodiorite gneiss approximately 100 m south of the sample site for WN-518-78. The granodiorite gneiss is typically vaguely or poorly foliated and massive in part (Eade, 1973) and is medium grained with a rusty brown or white weathered surface. Essential constituents are quartz, oligoclase-andesine, biotite, and hypersthene, with minor hornblende and microcline. Where sampled, the rock is free of any dykes or stringers of younger quartz monzonite. This granodiorite gneiss is thought to be an orthogneiss derived from an older plutonic rock.

The seven data points obtained from zircon from this sample are not collinear (Fig. 11) but fall on a linear trend with considerable scatter. A chord fitted to this linear trend (not shown in Fig. 11) has upper and lower concordia intercepts of about 3050 and 1616 Ma. Many of the zircon crystals from WN-514-78 contain distinct cores and it is useful to consider whether the apparent 3050 Ma age is associated with these cores.

Three of the fractions which were analyzed were hand picked from zircon of the largest grain size (+ 149 μm) and are representative of three specific zircon types. Fraction 7 contained only zircon grains with large evident cores, fraction 6 contained clear, rounded-euhedral grains and fraction 4 consisted of whole, more translucent, prismatic crystals. Zircon grains with evident cores were excluded from fractions 4 and 6.

Analyses of these fractions yielded the following results. Fraction 7, zircon grains with evident cores, produced by far the most discordant data point and contains 1849 ppm U which is more than twice that of any other fraction. This is a clear indication that the cores have a very high U content. Conversely, fraction 6, clear zircon grains and fragments, contains only 491 ppm U, second lowest of the seven fractions analyzed. Fraction 4 contains 626 ppm U suggesting that the more translucent zircon material is higher in uranium content than is the clear material.

Additional comments:

i) Zircon with the finest grain size (fractions 1 and 2, -37 μm) yields the most concordant data points and the maximum $^{207}Pb/^{206}Pb$ ages (2686 and 2705 Ma respectively). Cores are not visible in these fine zircon grains.

ii) Uranium contents of all zircon fractions are moderately high. Both the more magnetic zircon material and the finer grain size fractions show relatively higher U contents than the non-magnetic and coarser material.

iii) In three high U lower U zircon size fraction pairs (1 and 2, 3 and 5, 6 and 4), the lower U data points lie closer to the concordia curve than the higher U points, which appear to fall slightly toward the origin.

iv) The cores in the zircon crystals are of very high U, translucent material and have clearly been corroded prior to overgrowth of new zircon suggesting a period of zircon resorption under magmatic conditions. The existence of euhedrally zoned, parallel and end to end zircon twins indicates secondary zircon growth, also under fluid magmatic conditions (Jocelyn and Pidgeon, 1974).

v) One hornblende and eight biotite K-Ar ages on rocks from the Edehon-Hyde Lakes area fall in the range 1695 to 1785 Ma (Table 2) suggesting a major metamorphic event at that time. A K-Ar date of 1736 ± 41 Ma was obtained on biotite from WN-514-78, falling in the middle of the above range.

Based on these considerations the following interpretation is presented. The $^{207}Pb/^{206}Pb$ age of fraction 2, 2705 ± 3 Ma, provides a minimum age of 2702 Ma for zircon in WN-514-78. Since fractions 1 and 2, which are composed of zircon of the finest grain size, also have relatively high U contents (589 and 786 ppm U) it is likely that they would have suffered major lead loss relatively early in their existence. Thus the primary age of this zircon material may well be above 3000 Ma as suggested by the chord through the linear trend of the 7 data points, with about 36% lead loss at about 1600 Ma. A primary age of about 2700 Ma would imply Pb retention by these fine grained zircons to the present, an unlikely occurrence.

The cores appear to be from a different zircon regime considering their much higher uranium contents. Unfortunately we have no indication of the age of this regime due to the extremely discordant nature of the core material. The corroded nature of the core surfaces and the parallel and end to end zircon twins suggest a magmatic condition for the rock during zircon crystallization (Jocelyn and Pidgeon, 1974). The rock thus formed would have been the plutonic predecessor of the granodiorite gneiss.

There appears to have been some recent, secondary lead loss from the zircons under study, as indicated by the staggered locations of the data points of the high uranium versus the lower uranium members of the fraction pairs. The higher uranium fractions appear to have suffered some minor lead loss in recent times, thereby falling closer to the origin than do their lower uranium pairs. Data points from the three zircon fractions (1, 3, and 6) with the lowest U contents are collinear within analytical uncertainty and define a chord with an upper intercept age of 3187 + 68/-57 and lower intercept age of 1793 + 43/-42 Ma. There is no guarantee that these data points have not also been displaced due to recent lead loss (leading to overestimation of the upper intercept age). However, the 1793 Ma lower intercept age is similar to the higher K-Ar ages (1770-1785 Ma) measured on biotite from rocks in the Edehon-Hyde lakes area and lends some credibility to the age results as it links the primary lead loss event with a major metamorphic period.

Therefore the U-Pb results on zircon from WN-514-78 are tentatively interpreted as indicating an age perhaps as old as 3190 Ma for the plutonic predecessor of the granodiorite gneiss with a major period of lead loss having occurred at about 1790 Ma. Minor, more recent lead loss, particularly from the more uranium-rich zircon, has disturbed the original U-Pb isotopic systematics. The darker, translucent, uranium-rich cores are evidence of an even earlier regime which was not dated due to the extreme discordance of the U-Pb systems in the cores.

The authors recognize that this model attributes no obvious effects to the major 2600-2700 Ma event clearly evident in much of the other U-Pb zircon work described in this paper. This is a comparable situation to that of the approximately 3270 Ma Kasba gneisses 200 km to the west, discussed later. Three collinear, U-Pb zircon data points from one Kasba gneiss sample define a chord with upper and lower intercept ages of 3274 and 1449 Ma, yet in lithologically similar rocks 4 km to the northwest the zircon data points indicate a 2777 Ma age.

Clearly the suggested 3190 Ma age for zircon in WN-514-78 is somewhat speculative; further investigation to test this interpretation is recommended. Alternative interpretations involving multiple lead loss events can also be fitted to the data but are less useful as points of departure since they generally do not yield primary ages.

Rb-Sr: As previously mentioned, Rb-Sr analyses were carried out on the large sample of pyroxene bearing paragneiss from south of Edehon Lake, WN-518-78, which was sawed into eleven slabs of thickness 2.5 to 13 cm parallel to the banding, separating the individual layers for Rb-Sr analysis. In addition, three multiple specimens, WN-515, 516 and 517-78 which were collected from the same rock at essentially the same location yielded eight samples for Rb-Sr analysis.

The Rb-Sr analysis on the eleven slabs from WN-518-78 resulted in 14 data points (Fig. 12) as three slabs broke in half and both halves were analyzed. The results form an elongated cluster of points which do not show sufficient linearity to be indicative of a geological age. The limited expanse of the cluster is due to the restricted range in Rb and Sr contents which average 65 and 283 ppm respectively, with no measured Rb or Sr content differing from the mean by more than 13%. Such a limited range in both

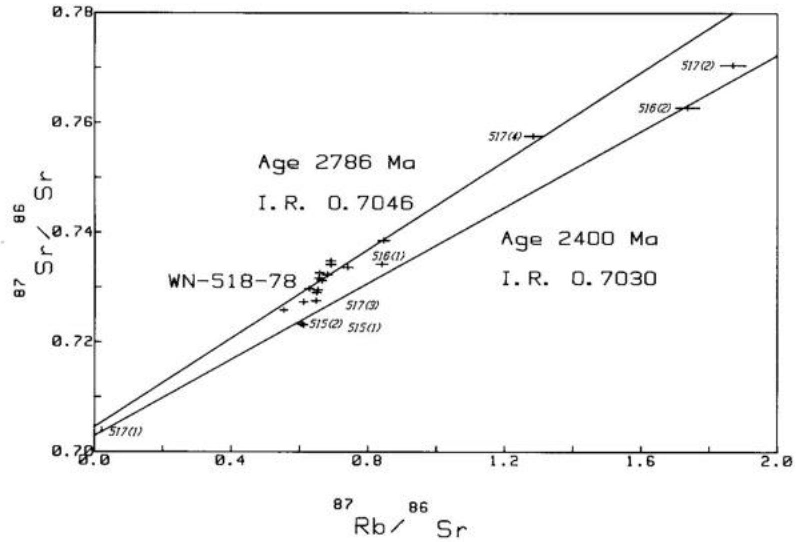


Figure 12. Rb-Sr results on multiple specimens WN-515 to 518-78. All samples were collected from the same rock at essentially the same location. WN-518-78 was sawed into slabs parallel to the banding; analyses are on individual slabs. Reference isochrons are discussed in the text.

Rb and Sr contents suggests homogenization of the elemental Rb and Sr contents between the paleosome and neosome layers.

Some information can be obtained from this study by considering the midpoint of the cluster (co-ordinates given by the average of the co-ordinates of the 14 data points weighted by their associated Sr contents: $^{87}Rb/^{86}Sr$ = 0.664, $^{87}Sr/^{86}Sr$ = 0.7314). Age/initial $^{87}Sr/^{86}Sr$ pairs can be calculated for the midpoint, such as the reference isochron in Figure 12 which employs the 2786 Ma U-Pb zircon age result for WN-518-78, discussed previously. The calculated initial $^{87}Sr/^{86}Sr$ of 0.7046 is compatible with a sedimentary origin for the gneiss, being much higher than the 2700 Ma mantle ratio of about 0.701. Conversely, fitting a reasonable mantle ratio to the age curve results in a 3200 Ma, 0.7005 pair, which suggests that the primary age of the precursor to the sedimentary material may be as old as 3200 Ma.

Results of Rb-Sr analyses on the samples collected at WN-515, 516 and 517-78 are also plotted in Figure 12. A reference isochron of age 2400 Ma and initial ratio 0.7030 provides a rough fit to four of the eight data points. Considering the scatter of the points about this line, it is unlikely that this reflects a primary 2400 Ma age as suggested by the relatively low initial ratio of 0.7030, but rather indicates updating of the Rb-Sr systems by events which took place more recently than 2400 Ma.

Our first Rb-Sr study on granulite facies gneisses located south and southwest of Edehon Lake employed hand specimens collected in 1970 in the course of geological mapping (Eade, 1973). Eight of the ten samples are from map unit 5c, hypersthene-bearing granodiorite gneiss and biotite hornblende pyroxene gneiss to massive granodiorite, Table A3 (Appendix). The other two samples 591 and 591A are of map unit 4b, hypersthene-bearing paragneiss. In 1975, new, larger samples were specifically collected for Rb-Sr geochronology at five of these same sites and at one new site (all map unit 5c). The sample sites are shown on Figure 8 and details of locations are given in Table A3.

Results of Rb-Sr analyses on both series of samples are plotted in Figure 13. Data points for eight of the eleven 1970 samples form a linear trend for which regression analysis yields an errorchron, age 2599 ± 201 Ma, initial $^{87}Sr/^{86}Sr$ 0.7044 ± 0.0023 and MSWD 9.2. Measurements on the larger samples specifically collected from fresh material for Rb-Sr geochronology were expected to yield a collinear set of data points but instead, these points scattered much more widely about the errorchron than did the 1970 hand specimen results.

Our interpretation of these results is based on the consideration of two subsets of data from the 1970 samples (Fig. 13). Data points 591A, 1044, 1064B, 1062 and 593 form an approximately linear suite from which can be calculated the following errorchron parameters: age 2800 ± 193 Ma, initial ratio 0.7024 ± 0.0020 and MSWD 4.1. Conversely data points from samples 594, 837 and 595 yield a three point isochron of much younger age 1922 ± 51 Ma, initial ratio 0.7186 ± 0.0012 and MSWD 0.90. This younger age is very similar to the Rb-Sr isochron age (1917 ± 42 Ma) presented later in this section for the granite to quartz monzonite immediately west, north, and northwest of the granulite gneisses (Fig. 7) under discussion, and indeed sample locations EA-595-70 and EA-837-70 are very close to the contact with this unit.

We interpret the 2800 ± 193 Ma errorchron age as an indication that the primary age of these rocks approximates the 2786 Ma U-Pb age on zircon from WN-518, 519-86. As indicated by the 1922 ± 51 Ma isochron age, the Rb-Sr systems of most of these rocks have probably been disturbed by the effects of the Aphebian intrusions of granite to quartz monzonite to the west and northwest.

It is noted that the Rb-Sr point for WN-21-75 falls essentially on the $^{87}Sr/^{86}Sr$ axis at 0.7184, approximating the intercept of the isochron through points 594, 837 and 595. The age of this isochron, 1922 ± 51 Ma, is much younger than the U-Pb age on zircon from WN-21-75, 2544 + 11/-8 Ma, and indicates that the Rb-Sr systematics of WN-21-75 have also been updated by the younger plutonic activity to the west and northwest.

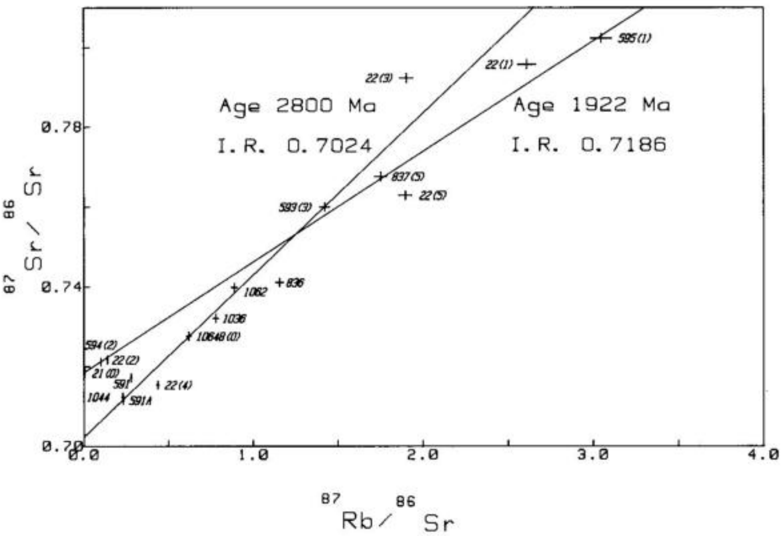


Figure 13. Rb-Sr results on 1970 hand specimens (591 to 1064B) and duplicate 1975 samples of Edehon Lake granulites. Numbers in brackets after the 1970 sample numbers are provided to facilitate correlation with duplicate 1975 samples. Sample 22(4) does not have a 1970 duplicate. Reference isochrons are discussed in the text.

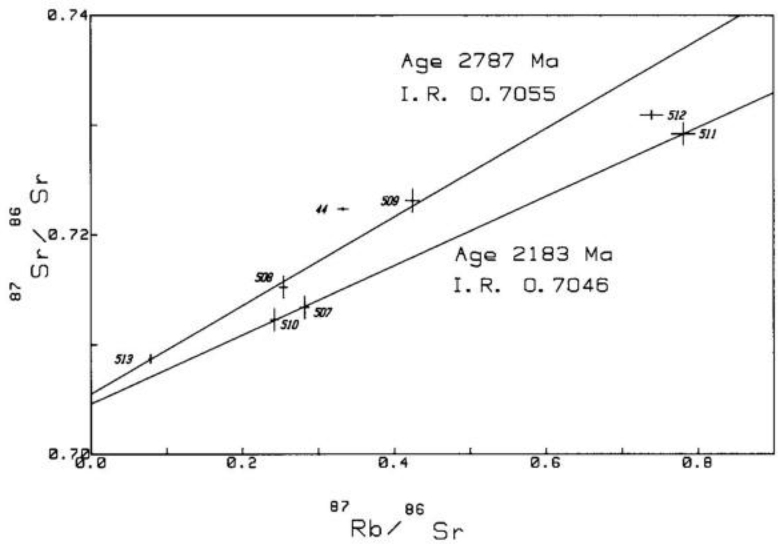


Figure 14. Rb-Sr results on samples from the eastern part of the Edehon-Hyde lakes area. Reference isochrons are discussed in the text.

Rb-Sr results on four samples do not fit this interpretation. Data points 22(4), 22(5) and 836 fall below the region defined by the intersecting isochron and errorchron of the above models. The Rb-Sr systems of these rocks may all have been updated by the 1700-1800 Ma event that reset most of the K-Ar ages in this region (Table 2).

Of particular interest is the result on 22(3). Assuming a reasonable initial $^{87}Sr/^{86}Sr$ (about 0.701) for an early Archean mantle source, the age indicated by the Rb-Sr measurements on this sample is approximately 3300 Ma. Even a higher initial ratio of 0.7100 leads to an age of 2980 Ma. Since 22(3) was a large fresh sample collected specifically for Rb-Sr dating, these results may provide a valid indication of early Archean basement in this area.

The U-Pb zircon results on the granulitic gneisses south of Edehon Lake suggest an approximate 2786 Ma for migmatization of the paragneiss and possibly 3190 Ma as the age of some of the rocks predating the metamorphism. The Rb-Sr results are compatible with these events, however, the Rb-Sr systematics of most rocks analyzed appear to have been variably updated by events more recent than 2400 Ma.

Rb-Sr analyses were performed on the following samples from the eastern part of the Edehon-Hyde lakes area: WN-507, 508, 509, 510, 511, 512, 513-78 and EA-44-78. The locations of these samples are shown on Figure 8 and details are given in Table 2. All the samples are from granulite facies rocks, part of the same band extending eastward from south of Edehon Lake, with the exception of WN-511-78 which is from granodiorite.

The samples can be divided into two groups by considering the Rb-Sr results (Fig. 14) in light of the geographical division (Fig. 8). Data points from the three more northerly samples, the granulites 507 and 510 and granodiorite 511, yield an "isochron" of age 2183 ± 77 Ma, initial $^{87}Sr/^{86}Sr$ 0.7046 ± 0.0003 and MSWD 1.2. The validity of this "isochron" is doubtful since it is based on only three data points of mixed lithology.

Three of the five more southerly samples, 508, 509, and 513, yield data points that also form a linear trend for which regression analysis yields an errorchron age of 2787 ± 348 Ma, initial $^{87}Sr/^{86}Sr$ 0.7055 ± 0.0009 and MSWD 28.4. The data point for EA-44-78 falls well above the errorchron. Sample WN-512-78, the most westerly of these samples, yields a data point falling between the two linear arrays.

We presented earlier (Fig. 9) a well defined U-Pb age on zircon from WN-511-78 of 2737 + 13/-9 Ma and interpreted this as the age of intrusion of the granodiorite pluton (which lies well to the north of the extent of granulite facies metamorphism). Thus the apparent Rb-Sr isochron age of 2183 ± 77 Ma, on three rocks including WN-511-78, is probably a metamorphic age caused by an event intense enough to reset the Rb-Sr whole-rocks. This could be related to the intrusion of younger quartz monzonite to granite and/or movements along a major tectonic zone separating granulite facies rocks on the south and amphibolite facies rocks to the north. Both WN-507-78 and WN-510-78 are from localities close to the probable fault that is the metamorphic boundary.

K-Ar ages on hornblende and biotite from these rocks range from 1785 ± 42 to 1696 ± 40 Ma and are presented in Table 2.

Aphebian intrusive rocks

Rb-Sr analyses were done on six samples of granite to quartz monzonite, map unit 15 (Eade, 1973) from west, north, and northwest of the area of granulite gneisses south of Edehon lake (Fig. 7). Locations of sample sites are shown on Figure 8 and details are listed in Table A4 (Appendix).

The granite to quartz monzonite is a medium grained, pink rock, characterized by a low (commonly less than 5%) mafic content, chiefly biotite, with only minor hornblende. The rock is massive for the most part, with some foliation close to contacts of the bodies and locally with some schistosity. These rocks occur commonly as stocks intruding the basement and also as dykes, stringers or small irregular masses in the older rocks. Partially assimilated inclusions or schlieren of older gneiss (e.g. pyroxene-bearing granodiorite gneiss) are present here and there. These rocks are considered to be syntectonic to late tectonic intrusions associated with a late Aphebian orogeny.

The data points for four of the six samples (Fig. 15) fit an isochron of age 1917 ± 42 Ma, initial ratio 0.7034 ± 0.0018 and MSWD 2.1. The results from the other two samples fall considerably above this isochron (assuming an initial ratio of 0.7034 as above, their ages would be, WN-23-75(2), 2630 Ma; WN-23-75(4), 2210 Ma). This may be attributed to the assimilation of older material as indicated by the prevalence of inclusions in these plutons. The rather high uncertainty associated with the initial ratio precludes its use in determining whether the rocks are primary or have a crustal prehistory.

Discussion

A summary of age measurements on rocks from the Edehon-Hyde lakes area is presented in Table 2. The zircon U-Pb results obtained on samples WN-514-78 and WN-518/519-78 (Fig. 10) are of considerable interest. The samples, the former a relatively massive granodiorite orthogneiss, the latter a very well banded paragneiss, are both granulite facies rocks and sample sites are approximately 100 m apart. If the 2786 Ma age ascribed to the paragneiss approximates the primary age, that is the age of migmatization, the U-Pb systematics of zircon from the nearby orthogneiss do not show direct evidence of this metamorphism. Uranium contents of zircon from the banded paragneiss sample WN-518-78 and the orthogneiss are comparable but the zircon in the orthogneiss appears to have retained evidence of an earlier primary age even though P-T conditions must have been essentially the same as for the paragneiss. Zircon grains from both gneisses are elongate and/or euhedral with some rounding, typical of igneous zircon. None of the zircons from either gneiss are the typical small, ovaloid and multifaceted type associated with granulite metamorphism. Thus it is postulated that neither age represents the granulite metamorphism.

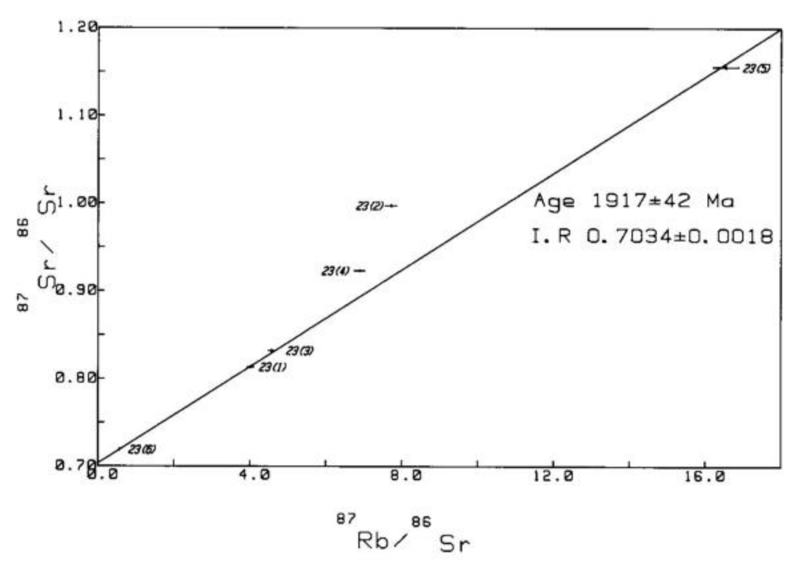


Figure 15. Rb-Sr isochron, Edehon Lake Aphebian quartz monzonite.

Table 2. Geochronology data, Edehon-Hyde lakes area

Sample no.	Location	Map unit		Lithology	Zircon U-Pb Ma		Rb-Sr Ma			K-Ar Ma (GSC no.)	
WN-21-75	60°06′12″N, 97°06′25″W	5c	(1)	pyroxene-bearing granodiorite gneiss	2544 + 11/-8	(4)					
WN-518/519-78	60°06′12″N, 97°04′24″W	4b	(1)	pyroxene-bearing paragneiss	2786 ± 41	(4)			(b)	1700 ± 40 (80-130)	(3)
WN-514-78	60°06′12″N, 97°04′24″W	5c	(1)	pyroxene-bearing granodiorite gneiss	3190 ? (2702 min.)	(4)			(b)	1736 ± 41 (80-129)	(3)
WN-515 to 517-78	60°06′12″N, 97°04′24″W	5c	(1)	pyroxene-bearing granodiorite gneiss							
WN-507-78	60°15′45″N, 95°48′50″W	la	(2)	hypersthene-bearing quartz monzonite to granite					(b)	1770 ± 41 (80-123)	(3)
WN-508-78	60°06′30″N, 95°50′25″W	la	(2)	as above					(b)	1785 ± 42 (80-125)	(3)
WN-509-78	60°10′40″N, 95°43′40″W	lad	(2)	as above, intruded and partly assimilated by granite/granodiorite					(b)	1733 ± 41 (80-124)	(3)
WN-510-78	60°15′30″N, 95°39′40″W	la	(2)	as above					(b)	1755 ± 42 (80-122)	(3)
WN-511-78	60°29′00″N, 95°58′00″W	5ac	(2)	foliated granodiorite intruded and partly assimilated by granite	2737 + 13/-9	(4)			(h) (b)	1731 ± 66 (80-128) 1776 ± 41 (80-127)	(3) (3)
WN-512-78	60°08′25″N, 96°23′00″W	la	(2)	as above					(b)	1696 ± 40 (80-126)	(3)
WN-513-78	60°07′30″N, 96°01′27″W	la	(2)	as above							
EA-44-78	60°09′45″N, 95°55′45″W	lad	(2)	as above							
WN-23-75(1) to (6)	Table A4	15	(1)	Table A4			1917 ± 42	(4)			

References:

(1) Eade, 1973
(2) Fraser, 1983
(3) Stevens et al., 1982a
(4) This paper

(b) - biotite
(h) - hornblende

These observations may be explained in two ways. Either the orthogneiss is indeed older than 3000 Ma and the primary age of the paragneiss is about 2786 Ma or the U-Pb systematics registered for the orthogneiss are the result of a multi-stage history and the apparent older age is an artifact of the multiple stages of lead loss. We favour the former explanation but further work will be required to substantiate this interpretation.

The U-Pb ages on zircon from samples WN-511-78 and WN-518/519-78, 2737 + 13/-9 and 2786 ± 41 Ma, are similar. The former is on foliated granodiorite within the zone of amphibolite metamorphism and the latter is on pyroxene-bearing paragneiss from the granulite facies zone to the south. We suggest that the primary origin of the paragneiss and the intrusion of the granodiorite are part of the same orogeny.

In terms of the classification of Stockwell (1982) this is the Laurentian Orogeny. The relict age apparently retained in the granulitic orthogneiss, WN-514-78, may represent the Wanipigowan Orogeny (Stockwell, 1982).

As indicated above, the age of granulite metamorphism is not determined. It predates intrusion of the Aphebian quartz monzonite (tentative Rb-Sr age 1917 ± 42 Ma), as inclusions of granulitic granodiorite gneiss occur in the quartz monzonite. Rb-Sr analysis on the granulite facies rocks give inconclusive results. Grey and Compston (1978) point out that in Rb-Sr total rock systems of such rocks, both the physical nature and the chemical uniformity of a lithological unit affect the measurable migration of Sr. They conclude that chemically layered lithologies are more liable to record metamorphic disturbances than are rock units that are chemically uniform. In the present study on the layered paragneiss WN-518-78, Rb-Sr measurements on the separate layers revealed unexpectedly homogenous Rb and Sr contents, precluding any estimate of metamoprhic age.

Measurements on samples collected both on outcrop and regional scale also failed to yield diagnostic isochrons. The patterns evident in the data suggest that open system behaviour during events subsequent to emplacement is the primary reason for these effects. However, there is some evidence for the existence of a component of much older material in this band of granulite facies rock; isochrons would not be expected if the rocks in the suites under study were not all of equivalent age.

Rb-Sr analysis on six samples of the younger quartz monzonite results in four collinear points yielding an isochron age of 1917 ± 42 Ma. We consider this to be a

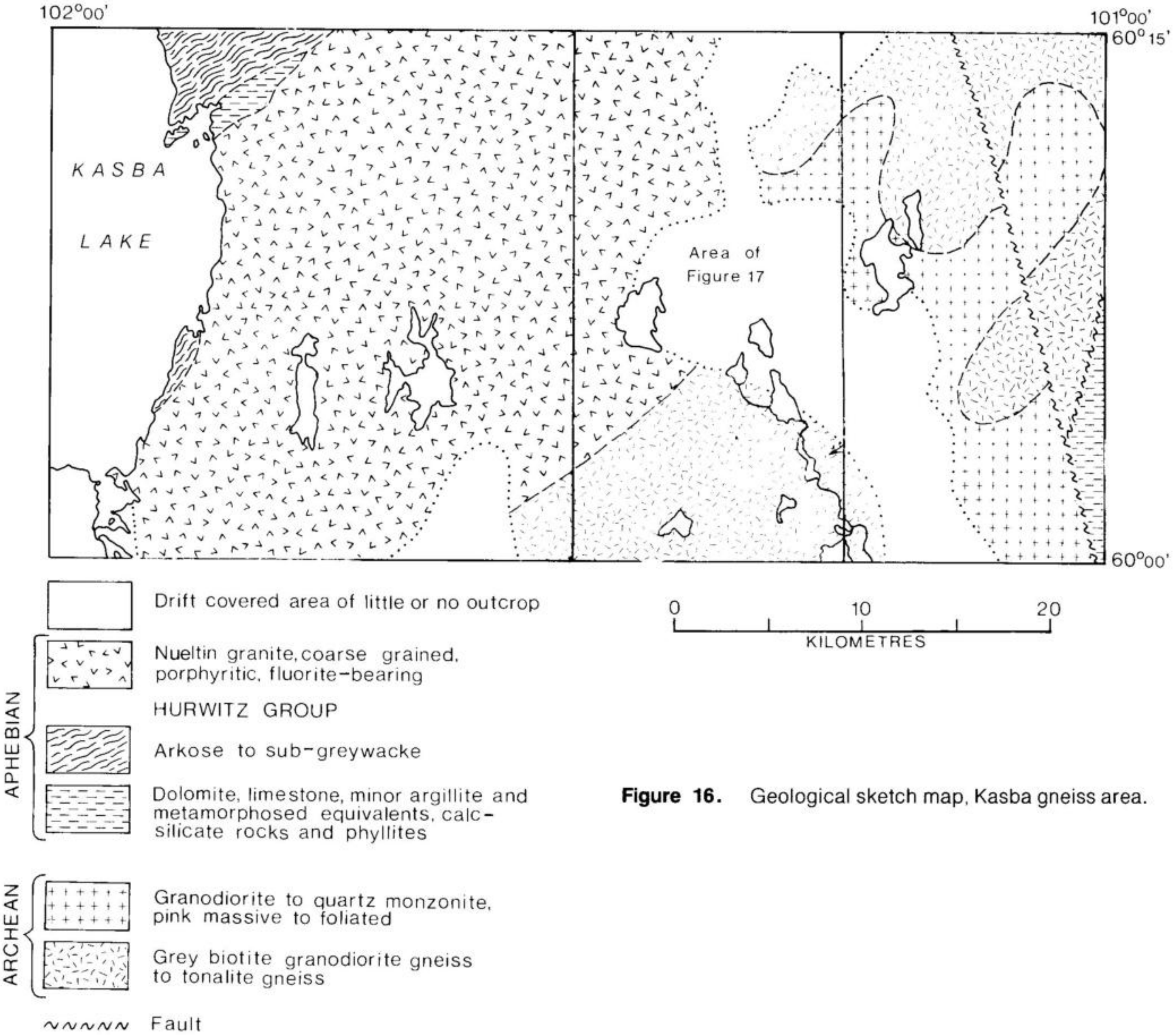


Figure 16. Geological sketch map, Kasba gneiss area.

reasonable approximation of the age of the plutons, but due to the limited data further confirmation is required. These rocks are abundant in the extreme southern part of the District of Keewatin and on the basis of this single isochron, they belong to the Moranian Orogeny according to the classification of Stockwell (1982).

Results of K-Ar age measurements on one hornblende and eight biotite samples from the Edehon-Hyde lakes area are presented in Table 2 together with lithology and locations. Age results range from 1785 ± 42 to 1696 ± 40 Ma and may be related to the same event as the poorly defined U-Pb zircon lower intercept ages of WN-514-78 and WN-518, 519-78. Some Rb-Sr samples may also have been updated by this event. The K-Ar ages, both in the granulite facies rock of the Edehon-Hyde lakes area and from the single sample from the amphibolite facies area to the north are quite consistent and are probably cooling ages of Stockwell's epi-Hudsonian.

KASBA GNEISS AREA

General geology

The general geology of the southwest corner of District of Keewatin, adapted from Eade (1971) as shown on the sketch map (Fig. 16) illustrates the regional setting of the smaller sample area (Fig. 17). All the rock samples studied are from a single map unit, a grey biotite granodiorite to tonalite gneiss. Thick glacial drift covers much of this region and outcrops are scarce, so relations between rock units are generally obscured.

The granodiorite to tonalite gneiss, informally named the Kasba gneiss, is the oldest rock in the area. It contains some bands and irregular bodies of pink massive to slightly foliated granodiorite to quartz monzonite that intrude and partly assimilate the gneiss. The gneiss is medium grey on fresh surface and lighter grey on weathered surface with a pink tinge close to bands or dykes of the granodiorite - quartz monzonite. It is medium grained and well foliated due to orientation of biotite and elongate quartz and feldspar grains. The gneiss of the sample locations contains minor compositional layering with biotite concentrations in alternating layers. Quartz, plagioclase (oligoclase-andesine), biotite, and in some samples, hornblende, are the major constituents. Microcline is a minor constituent although in some places it forms up to 15% of the rocks. Magnetite, apatite, zircon, and sphene are accessories. Biotite and hornblende are slightly altered to chlorite, and plagioclase to clinozoisite and epidote, due to slight retrogressive metamorphism. The samples are all from the same gneiss mass and are lithologically the same, except for variation in mafic mineral content. Hornblende is abundant in samples from the south (WN-601-79 and WN-602-79) but is a minor constituent in those to the north (WN-603-79, WN-604-79, WN-605-79). The origin of the gneiss is uncertain; local compositional layering suggests that it is a paragneiss, but the unlayered, although foliated character indicates it is an orthogneiss.

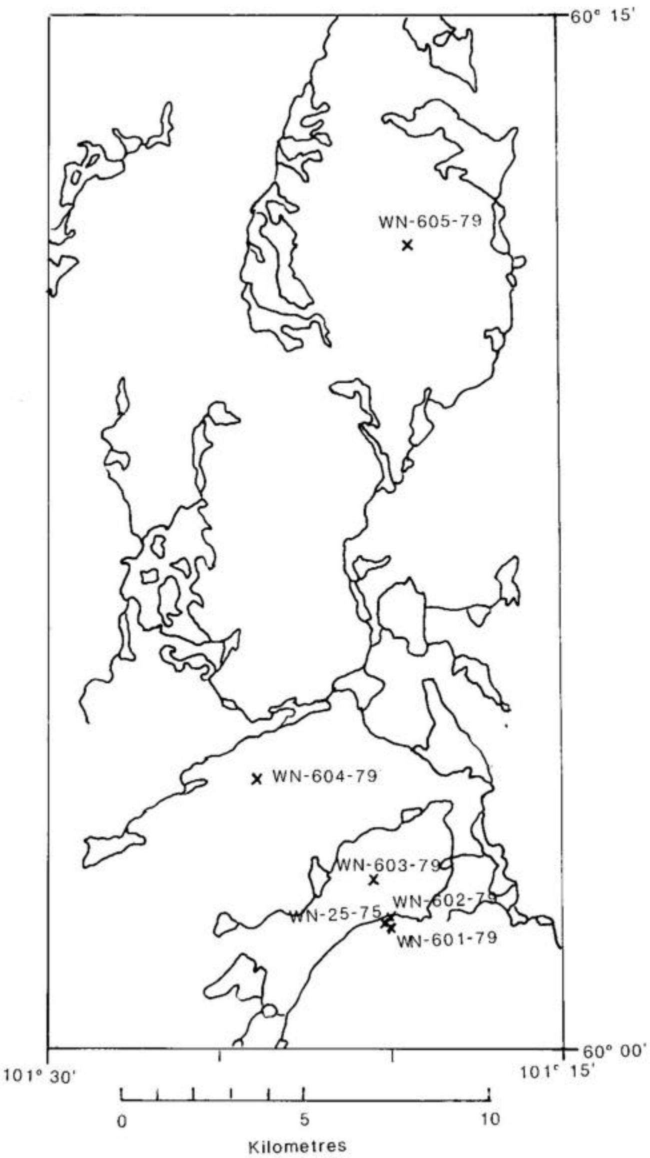


Figure 17. Sample location map, Kasba

The massive to slightly foliated quartz monzonite to granodiorite intrudes the grey granodiorite gneiss as a discrete pluton east of, and between, the sample locations, as well as in dykes and irregular bodies within the gneiss. Although typically pink and massive, foliation due to alignment of biotite flakes is present in places. Bands or inclusions of Kasba gneiss occur in the quartz monzonite to granodiorite and the contacts of the pluton with the gneiss are typically gradational. Biotite is the major mafic constituent but hornblende is present here and there although always less abundant than biotite. Microcline, as individual grains and perthitic intergrowths, varies in amount from place to place.

In the eastern part of the area dolomite or calc-silicate rocks with minor interbedded phyllite of the Hurwitz Group Watterson Formation are in fault contact with both Kasba gneiss and the granodiorite to quartz monzonite. The degree of metamorphism of the sedimentary rocks increases southward, from greenschist to lower amphibolite facies. In the western part of the area, adjoining Kasba Lake, dolomite with minor phyllite of the Watterson Formation is overlain, apparently conformably, by arkose to subgreywacke of the Ducker Formation. The medium- to fine-grained, grey to pinkish grey arkose or subgreywacke is commonly finely bedded and rarely massive.

The Nueltin Granite intrudes Hurwitz Group rocks, the granodiorite to quartz monzonite and the Kasba gneiss. It is a course grained, porphyritic, fluorite- bearing pink granite, varying to quartz monzonite in part. This distinctive granite is similar to the post-Dubawnt Group granite of the Angikuni - Yathkyed lakes area, as mentioned previously.

Geochronology

A sample of granodioritic gneiss, WN-25-75, was collected in 1975 from a locality very close to that of WN-601-79. U-Pb analyses of zircon from this sample were plagued with analytical problems but provided a preliminary indication of the antiquity of the rocks, which led to the collection of additional samples in 1979. K-Ar ages on hornblende (1676 ± 49 Ma) and biotite (1626 ± 40 Ma) from WN-25-75 were interpreted as the time at which the hornblende and biotite passed their blocking temperatures near the end of the metamorphic event associated with the Hudsonian Orogeny (GSC 78-142 and 78-143, Wanless et al., 1979), the epi- Hudsonian of Stockwell (1982).

Five large, fresh samples of the Kasba gneiss, free of dykes or veins of the pink granodiorite to quartz monzonite, were collected in 1979 for study. Sample locations are shown in Figure 17 and listed in Table 3.

U-Pb: For the purpose of U-Pb age determination, zircon was concentrated from each of the five samples.

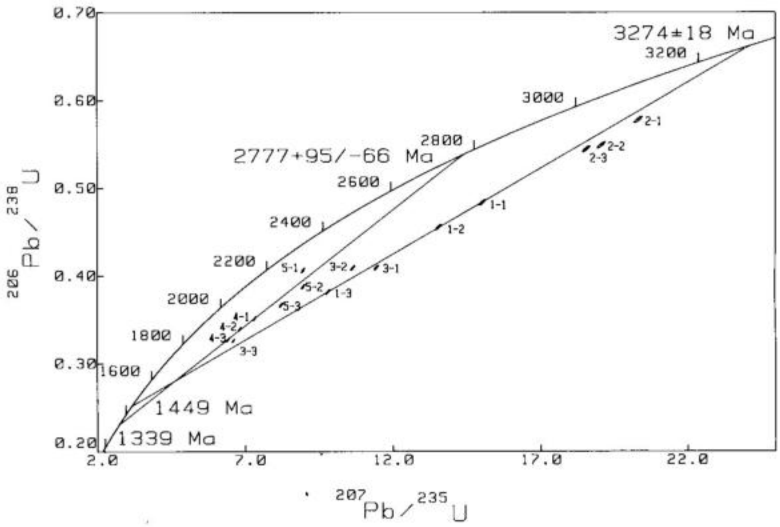


Figure 18. Concordia diagram showing the results of U-Pb analyses on zircon from WN-601-79 (1-1 to 1-3) to WN-605-9 (5-1 to 5-3).

Three fractions of differing physical characteristics were separated from each zircon concentrate and hand picked for 100% purity. The results of the U-Pb measurements on these zircon fractions are listed in Table A1 and displayed on a concordia diagram (Fig. 18). Zircon morphology is discussed in Appendix B.

Two different methods were used for separating zircon concentrates into fractions of different magnetic properties for this study. The first was by repeated passes through a Frantz isodynamic separator and the resulting relatively magnetic and non-magnetic cuts are denoted M and N in Table A1 (followed by a number denoting degrees of tilt of the Frantz). The second was by the pin and magnet method described by Krogh (1982), and the more and less magnetic fractions separated in this manner are denoted MM and LM respectively in Table A1.

WN-601-79: The three data points are collinear within analytical uncertainty (Fig. 18) with a probability of fit of 64% to a chord which intersects the concordia curve at 3274 ± 18 and 1449 + 30/-29 Ma. This chord divides the results of zircon analyses from the remaining four samples into two fields. Those which we interpret as being of equivalent age or older age than 601 fall to the right of the chord whereas those interpreted as being younger fall to the left.

An interesting feature of the radiogenic lead isotopic compositions of the three fractions of 601 is the relatively high $^{208}Pb/^{206}Pb$ ratios of 0.107 to 0.119 (Table A1) suggesting a correspondingly high Th content of the 601 zircon.

WN-602-79: The three experimental points from 602 form a flat triangle to the right of the 601 chord (Fig. 18) but are more concordant than the 601 data points. All three 602 zircon analyses yield $^{207}Pb/^{206}Pb$ ages greater than 3150 Ma confirming the antiquity of the zircon of the Kasba gneiss at this location. A chord through points 2-1 and 2-2, intersects concordia at 3262 and 842 Ma agreeing within analytical uncertainty with the 601 upper intersection age of 3274 ± 18 Ma but yielding a much reduced lower intercept age, consistent with the lower U content of 602 zircon.

The $^{208}Pb/^{206}Pb$ ratios from the three 602 zircon fractions are even higher than those from the 601 zircons, ranging from 0.166 to 0.175, again suggesting a relatively high Th content in the zircon of both of these two more southerly samples. (WN-603-79 will be discussed after WN-604-79 and WN-605-79).

WN-604-79: The three data points from 604 form a collinear closely spaced group with a 41% probability of fit to a chord which cuts the concordia curve at 2777 + 95/-66 and 1339 + 77/-70 Ma (Fig. 18). The 604 points all fall to the left of the 601 chord and provide no indication of the older ages associated with 601 and 602. In contrast to the 601 and 602 results, the radiogenic $^{208}Pb/^{206}Pb$ ratios of the three 604 zircon fractions are comparatively low, 0.053 to 0.066, suggesting a much lower Th/U for zircon in sample 604.

WN-605-79: The three data points from 605 form a flat triangle to the left of the 601 chord. Chords joining data point 5-1 with either 5-2 or 5-3 yield negative lower intercept ages and are therefore uninterpretable. Only the chord through points 5-2 and 5-3 yields a positive lower intercept age, of 1155 Ma with a corresponding upper intercept age 2768 Ma. Together with the 604 results, this age pattern is comparable to that of the more southerly sample pair 601-602; the agreement between the 2777 + 95/-66 Ma upper intercept age of 604 and the 2768 Ma age from fractions 5-2 and 5-3 of 605 is inviting but not conclusive. We interpret the 605 results as qualitatively supporting the existance of a younger, about 2780 Ma, terrane in the north. Radiogenic $^{208}Pb/^{206}Pb$ ratios in the three 605 zircon fractions, 0.063 to 0.070, are similar to those of 604 but much lower than in 601 and 602.

WN-603-79: This sample location is geographically between those of 601/602 to the south and 604 to the northwest-605 to the north; not surprisingly, the zircon analytical results are hybrid in nature. Two of the three 603 zircon fractions were separated by colour rather than by grain size or magnetic properties and this separation has produced one fraction (3-1, clear) in which the U-Pb systematics are comparable to those in the 601/602 zircons and another fraction (3-3, orange) in which they are more characteristic of 604/605 zircons.

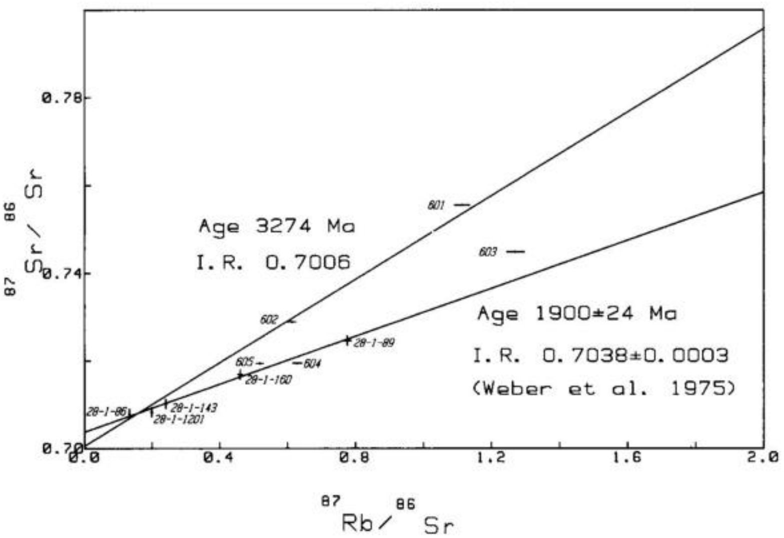


Figure 19. Results of Rb-Sr measurements on samples WN-601-78 to WN-605-78 from the Kasba gneiss compared with measurements by Weber et al. (1975) on a similar gneiss in northern Manitoba. Two points obtained by Weber et al. from Rb-rich samples fall outside the limits of this plot.

The 3-1 data point falls to the right of the 601 chord (Fig. 18) and is collinear with data points 2-1 and 2-3 of 602; additionally the radiogenic $^{208}Pb/^{206}Pb$ ratio for fraction 3-1 is relatively high at 0.125, midway between the 601 and 602 values and much higher than seen in the 604 and 605 results.

Conversely, the 3-3 data point falls to the left of the 601 chord, in the general field of the 604 and 605 data points, and the $^{208}Pb/^{206}Pb$ ratio of the 3-3 radiogenic lead is 0.078, just slightly higher than the 604-605 range of 0.053 to 0.070, but much lower than the 601-602 values. The U content of fraction 3-3 is 50% greater than that of fraction 3-1. This may also account for the more discordant result.

The third 603 fraction, 3-2, has a similar radiogenic $^{208}Pb/^{206}Pb$ ratio (0.125) to that of fraction 3-1, and the result falls close to the 3-1 data point but to the left of the 601 chord. These features suggest that fraction 3-2 is composed predominantly of ancient zircon similar to fraction 3-1 but with a smaller proportion of the younger zircon similar, perhaps, to fraction 5-1. Since this fraction was not specifically separated by colour, having had only the more magnetic zircon grains removed by the pin and magnet method (Krogh, 1982), a mixture of ancient and younger zircon might have been expected. The more or less clear (see Appendix) nature of the resulting concentrate is consistent with the similarity in U-Pb systematics to fraction 3-1.

Many zircon crystals in the WN-603-79 concentrate consist of rounded cores with euhedral overgrowths (Appendix B). It is possible that the cores represent ancient zircon and the overgrowths are composed of younger material similar in age to WN-604-79. Since zircon containing cores occurs in both the clear (3-1) and orange (3-3) fractions, the presence of cores is not alone responsible for the separation of these data points. More probably, the overgrowths in the orange fraction are high in U, as indicated both by the high U content of these zircons, and the red-orange domains, and the results for this fraction are dominated by the high U overgrowths.

The zircon morphologies of the five samples (Appendix B) are generally similar and cannot obviously be used to differentiate between zircon of the two different age groups. Lower concordia intercept ages bear no apparent relationship to the known geochronology of the Kasba gneiss area. All lower intercept results (601: 1449 Ma; 602: 842 Ma; 604: 1339 Ma; 605: 1155 Ma) are much younger than the lowest measured K-Ar age of biotite, 1626 ± 40 Ma on WN-25-75.

Rb-Sr: A representative portion of each sample was processed for Rb-Sr whole-rock isotopic measurements and the same powders were used for chemical analyses. Rb-Sr results are listed in Table A2 and plotted in Figure 19.

The Rb-Sr results do not form a linear trend (Fig. 19) so we have interpreted them individually based on the U-Pb age measurements on zircon from the same samples. Table 3 gives the Rb-Sr ages of the individual samples based on an assumed initial $^{87}Sr/^{86}Sr$ of 0.7010 (chosen as an approximate average mantle $^{87}Sr/^{86}Sr$ over the age range 2700 to 3300 Ma). The two more southerly samples, 601 and 602, yield Rb-Sr ages greater than 3100 Ma, in general agreement with the antiquity of the about 3270 Ma U-Pb ages, while the three more northerly samples all yield much younger apparent Rb-Sr ages. This age pattern is shown graphically in Figure 19 where the data points of this study are compared with the results of Weber et al. (1975) for similar granodioritic gneisses about 40 km south in northern Manitoba. They obtained a Rb-Sr whole-rock isochron of 1900 ± 24 Ma[1] with initial $^{87}Sr/^{86}Sr$, 0.7038 ± 0.0003. This result was interpreted as contradicting a postulated Archean age for the lateral extension of the gneisses in Saskatchewan and the Northwest Territories (the Kasba gneiss) and precluding an Archean age for the emplacement of the gneiss in Manitoba. For the purpose of more direct comparison with the 601 and 602 results, a reference isochron of age 3274 Ma (U-Pb result on zircon from 601) and initial $^{87}Sr/^{86}Sr$, 0.7006 (mantle $^{87}Sr/^{86}Sr$ at 3274 Ma derived from the present day bulk Earth parameters of Jacobsen and Wasserburg, 1979) has also been shown.

[1] Recalculated using ^{87}Rb decay constant = $1.42 \times 10^{-11} a^{-1}$

The data points from the present study do not provide a precise fit to either isochron. However, the 601 and 602 results flank the 3274 Ma reference isochron and are clearly more closely associated with that age range than with the 1900 Ma isochron of Weber et al. (1975). Conversely the $^{87}Sr/^{86}Sr$ results from 604 and 605 both fall within 0.0016 of the 1900 Ma isochron (one above and one below). Since the zircon U-Pb measurements on 604 and 605 suggest an emplacement age of approximately 2770 Ma, it appears the Rb-Sr systems of these samples have been variously degraded by open - system behaviour related to events around 1800 - 1900 Ma. We suggest that the primary age of the comparable gneiss in northern Manitoba might also be considerably older than indicated by the Rb-Sr results. This suggestion is contrary to the conclusions drawn by Weber et al. (1975) who thought that the 1900 Ma isochron age and 0.7038 initial ratio precluded an Archean emplacement age for these gneisses.

The Rb-Sr age of 2392 Ma, presented in Table 3 for 603, is a maximum age, as more realistic initial $^{87}Sr/^{86}Sr$ ratios would probably be higher than 0.7010. Thus the Rb-Sr results of this sample show no indication of the hybrid nature indicated by the U-Pb results on zircon, although the data point does fall between the 1900 and 3274 isochrons.

K-Ar: For the purposes of K-Ar age determinations, biotite and hornblende concentrates were separated from 601 and 602 but, due to a deficiency of hornblende, only biotite was obtained from 603, 604 and 605. K-Ar age results on these concentrates are listed in Table 3.

K-Ar ages on biotite from the five samples collected in 1979 fall within the range 1740 to 1818 Ma. Limits of analytical uncertainty associated with these ages generally overlap, so that the apparently lower dates from 603 (1740 Ma) and 604 (1748 Ma) do not differ significantly from the three apparently higher dates.

The biotite results fall within the range of ages obtained by all methods on the coarse grained Nueltin Granite to the west (Fig. 16) and may have been updated during emplacement of the granite. The granite is late- to post-tectonic relative to the Hudsonian Orogeny and yielded Rb-Sr whole-rock isochron ages of 1760 ± 17 and 1775 ± 61 Ma (Wanless and Loveridge, 1972) and K-Ar biotite ages of 1802 Ma (GSC 60-63, Lowdon, 1961) and 1738 Ma (GSC 61-113, Lowdon et al., 1963). The granite from the Angikuni-Yathkyed lakes area, WN-615-79, is similar in all respects to the Nueltin Granite and, as mentioned previously, has a U-Pb age on zircon of 1753 + 3/-2 Ma.

The biotite-hornblende pair from WN-25-75 (Wanless et al., 1979) yielded K-Ar ages more than 100 Ma younger than the corresponding K-Ar ages from the above five samples. Sample WN-25-75 has experienced minor shearing not seen in the other samples which might have caused argon loss subsequent to the Hudsonian Orogeny, resulting in the lower K-Ar ages.

Chemical analyses

The results of the chemical analyses (Table A6, Appendix) also indicate a difference in composition between 601/602, and the more northerly samples. The major element compositions of 601 and 602 are more granitic (cf. "granitic rock", Ahrens, 1965, p. 28; "high calcium granitic rock", Turekian and Wedepohl, 1961, Table 2) compared to the granodioritic composition of 603, 604 and 605 (cf. "granodiorite", Turner and Verhoogen, 1960, p. 344). The latter samples contain more SiO_2 and Na_2O but less TiO_2, MnO, MgO and CaO than do 601 and 602. In the trace elements measured, 601 and 602 contain more Ba, Cu, U and Zr. $^{208}Pb/^{206}Pb$ ratios of radiogenic lead from zircon in 601 and 602 are roughly twice those in zircon from 604 and 605. This suggests that the Th/U, as well as the U content, is higher in 601 and 602 than in 604 and 605.

In future studies designed to delineate the extent of the about 3270 Ma terrane it may be possible to identify the older rocks by their chemical content if these differences prove to be consistent.

Discussion

A summary of age measurements on rocks from the Kasba gneiss area is presented in Table 3. The Kasba gneiss of the southwest corner of the District of Keewatin has been mapped as a single entity based on field evidence. However, U-Pb age measurements on zircon, supported by Rb-Sr results on individual whole-rock samples, indicate a bimodal age distribution with the two more southerly samples of this study, WN-601-79 and WN-602-79, giving an age of about 3270 Ma, and the two more northerly samples, WN-604-79 and WN-605-79, a much younger age about 2780 Ma. The geographically intermediate sample, WN-603-79, contains a hybrid zircon population with members having U-Pb systematics typical of both age groups. The older samples, WN-601-79 and WN-602-79, have chemical compositions which are granitic in character whereas samples WN-603-79, WN-604-79 and WN-605-79 are more granodioritic.

The results of these and related studies yield three possible ages for the time of gneiss formation:

1. At about 2780 Ma, the upper intersection U-Pb age of zircon from 604 and 605. In this interpretation, all younger K-Ar ages would be attributed to metamorphic effects of the Moranian or Hudsonian orogenies.
2. At about 1900 Ma, the time found by Weber et al. (1975) for the most recent closure of the Rb-Sr system in the similar gneiss of northern Manitoba. This age is in close agreement with the K-Ar ages of 1891 ± 74 and 1884 ± 74 Ma on hornblende from 601 and 602.
3. At about 1780 Ma, the average K-Ar age on biotite from the five samples of this study (omitting the WN-25-75 K-Ar biotite age of 1626 Ma which appears to have been lowered as a result of minor shearing).

Table 3. Geochronology data, Kasba gneiss area

Sample no.	Location	Map unit		Lithology	Zircon U-Pb Ma		[1]Rb-Sr Ma	K-Ar Ma (GSC no.)		
WN-25-75	60°01.8'N, 101°19.8'W	4	(1)	biotite granodiorite gneiss				(h) (b)	1676±49 (78-143) 1626±40 (78-142)	(2) (2)
WN-601-79	60°01.8'N, 101°19.8'W	4	(1)	biotite granodiorite gneiss	3274±18	(4)	3367	(h) (b)	1891±79 (80-132) 1782±42 (80-131)	(3) (3)
WN-602-79	60°02.0'N, 101°19.8'W	4	(1)	biotite granodiorite gneiss	3262 ?	(4)	3134	(h) (b)	1884±74 (80-134) 1818±42 (80-133)	(3) (3)
WN-603-79	60°02.4'N, 101°20.0'W	4	(1)	biotite granodiorite gneiss			2392	(b)	1740±32 (80-135)	(3)
WN-604-79	60°03.3'N, 101°23.4'W	4	(1)	biotite granodiorite gneiss	2777+95/-66	(4)	2037	(b)	1748±41 (80-136)	(3)
WN-605-79	60°12.0'N, 101°19.7'W	4	(1)	biotite granodiorite gneiss	2768 ?	(4)	2457	(b)	1811±42 (80-137)	(3)

[1] Calculated employing initial $^{87}Sr/^{86}Sr = 0.7010$

References:

(1) Eade, 1971
(2) Wanless et al., 1979
(3) Stevens et al., 1982a
(4) This paper

(b) - biotite
(h) - hornblende

Outside of the limited area sampled, the extent of the 3270 Ma terrain is unknown. It does not appear to extend much more than 1 km to the north of sample locations 601 and 602 where the U-Pb results on zircon from WN-603-79 indicate mixing with the 2780 Ma gneiss. Four kilometres west and 18 km to the north, the U-Pb systematics of zircon from samples WN-604-79 and WN-605-79 show no evidence of a 3270 Ma component.

Further work is required to define the extent of this ancient terrane. A reconnaissance survey employing chemical and Rb-Sr whole-rock analyses backed up by selected U-Pb zircon age measurements would probably be most efficient considering the high cost of U-Pb zircon studies.

COMPARISON OF RESULTS FROM THE ANGIKUNI-YATHKYED LAKES AREA, THE EDEHON-HYDE LAKES AREA, AND THE KASBA GNEISS AREA

The Edehon-Hyde lakes area is within the Nejanilini lithostructural domain depicted on the Geological Map of Manitoba (Manitoba Mineral Resources Division, 1979), approximately 125 km north of the boundary of the Wollaston - Seal River lithostructural domain and 200 km north of the boundary of the Chipewyan lithostructural domain. The Wollaston - Seal River domain consists of remobilized Archean basement rocks interfolded with overlying Aphebian supracrustal rocks, the Chipewyan domain of a Hudsonian 'Cordilleran-type' arc massif (Lewry, 1981). The Kasba gneiss area is approximately 160 km north of the boundary of the Chipewyan domain. Thus both the Edehon-Hyde lakes area and the Kasba gneiss area are continuous to the south or southeast margin of the craton, the continental crustal terrain of Lewry (1981). In contrast, the Angikuni-Yathkyed lakes area is well within the core of the Archean craton in the southwest part of the Churchill Structural Province.

The geochronology results are summarized in Tables 1, 2 and 3 for the Angikuni-Yathkyed lakes area, the Edehon-Hyde lakes area and for the Kasba gneiss. Certain features are readily apparent from a comparison of these results.

1. In the northern Angikuni-Yathkyed lakes area, there is a cluster of U-Pb ages on zircon at approximately 2650-2680 Ma, whereas to the south in the Edehon-Hyde lakes area and in the Kasba gneiss, ages of 2730-2790 Ma are prominent.
2. Parts of the Kasba gneiss are very old, about 3270 Ma. In the Edehon-Hyde lakes area there is equivocal evidence for an old U-Pb, zircon age of possibly 3190 Ma in some of the pyroxene-bearing granodiorite gneiss. There are also indications of ages greater than 3000 Ma from the Rb-Sr work in this area. In the northern area there is little strong evidence for old Archean rocks.
3. In both the Angikuni-Yathkyed lakes and the Edehon-Hyde lakes areas there is Rb-Sr or K-Ar evidence for quartz monzonite plutons intruded in the 1900-2000 Ma range. No zircon U-Pb dates are available on these plutons. In the Kasba gneiss area, the Rb-Sr and K-Ar systems have been re-set due either to the above-mentioned event or to the younger (about 1760 Ma) post-tectonic Nueltin Granite activity. Only in the Angikuni-Yathkyed lakes area has it been possible to distinguish the Aphebian quartz monzonite plutons (1900-1950 Ma) and the post-tectonic granite suite (1753 Ma).
4. In the Angikuni-Yathkyed lakes area, in the central part of the Archean craton, there is a distinct area of at least 7000 km^2, extending from Yathkyed Lake 100 km or more to the southwest, in which K-Ar ages on hornblende or biotite from the Archean rocks approximate 2400 Ma, whereas elsewhere, K-Ar ages on the Archean rocks are in the 1700-1800 Ma range. The Kasba gneiss appears to yield slightly older (1740-1820 Ma) biotite K-Ar ages than obtained in the

Edehon-Hyde lakes area (1700-1780 Ma).

5. U-Pb age measurements on zircon indicate a bimodal age distribution, at about 3270 and 2780 Ma, for the Kasba gneiss which was mapped as a single entity based on field evidence. This indicates that in areas of limited outcrop, correlations can not be confidently made over distances in the order of a few kilometres on the basis of lithology alone.
6. Rb-Sr studies on whole-rock samples from granulite terranes have not produced diagnostic ages. Not only have these samples been variable updated by the multiple events which have been recognized in the Edehon-Hyde lakes area (implying mobilization of radiogenic ^{87}Sr) but there is also some indication of mobilization of elemental Rb and Sr. In banded gneiss sample WN-518-78, the variation of Rb and Sr content between the neosome and palaeosome layers does not exceed 13% from the mean, implying a homogenizing mechanism.

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Table A1. U-Pb isotopic data

Sample Size fraction	Weight (mg)	U (ppm)	Pb* (ppm)	Measured $^{206}Pb/^{204}Pb$	Isotopic abundance, $^{206}Pb = 100$			$^{206}Pb/^{238}U$	$^{207}Pb/^{235}U$	$^{207}Pb/^{206}Pb$ age (Ma)
					^{204}Pb	^{207}Pb	^{208}Pb			
Angikuni-Yathkyed lakes area										
WN-18-75										
1. + 74N + 0.5°A	0.0330	194.7	118.6	3698	0.0092	18.042	22.888	0.50341	12.444	2646
2. -74N + 0.5°A	0.0458	284.9	171.6	251	0.0600	18.653	23.217	0.50218	12.404	2645
3. -74N0°A	0.0340	296.7	180.1	217	0.0350	18.278	23.728	0.50184	12.349	2639
4. + 74N + 0.5°A	0.0330	241.4	149.1	127	0.0858	18.931	28.001	0.50030	12.329	2641
5. -105 + 74N0°A	0.0392	224.2	133.8	170	0.0456	18.376	22.846	0.49763	12.223	2636
WN-210-76										
1. Comb. N + 4°A	0.0300	502.3	261.8	3598	0.0237	17.374	16.906	0.45441	10.701	2565
2. -149 + 105N + 5°	14.06	739.1	289.3	2675	0.0353	15.358	11.516	0.36020	7.905	2447
3. -149 + 105M + 5°	18.61	1020	363.0	2076	0.0469	15.910	11.032	0.33131	6.998	2382
WN-211-76										
1. + 74NM0°A E	0.0470	303.0	152.4	3361	0.0220	17.302	11.068	0.45899	10.775	2560
2. + 74NM0°A	0.1000	174.4	83.93	6060	0.0100	16.380	9.370	0.44652	10.007	2482
3. -105 + 74NM + 1°A	0.0335	261.2	117.5	1988	0.0428	16.123	7.882	0.42847	9.205	2411
4. -149 + 74M-1°	17.42	213.7	95.05	2632	0.0307	16.004	9.687	0.41590	8.960	2415
5. -74 + 62M-0.7°	17.05	240.2	105.8	3159	0.0213	15.970	9.713	0.41048	8.890	2424
6. -74 + 62N-0.7°	20.29	192.1	84.32	3173	0.0120	15.502	9.209	0.41088	8.698	2386
7. -74 + 62NM + 1°A	0.0115	265.7	116.3	1990	0.0282	15.575	7.393	0.41803	8.771	2370
8. -149 + 74N-1°	17.47	178.4	77.51	3192	0.0230	15.525	9.215	0.40833	8.580	2373
WN-212-76										
1. -149 + 105N-0.7°	16.96	283.3	160.1	2653	0.0350	18.393	15.606	0.49578	12.281	2650
2. -37N-0.5°	10.77	348.8	192.9	9866	0.0059	17.946	13.647	0.48931	12.060	2641
WN-223-76										
1. -105 + 74NM-2°	16.84	315.3	181.5	1013	0.0938	19.116	20.545	0.49317	12.218	2650
2. -44NM-2°	5.55	419.7	232.3	2124	0.0308	18.212	19.499	0.47143	11.593	2638

Pb isotopic abundances follow subtraction of Pb blank;
Size fractions are given in μm;
Pb* = radiogenic Pb;
comb = all remaining size fractions combined;

N = non magnetic at given angle;
M = magnetic at given angle;
LM = less magnetic with magnet and pin (see text);
MM = more magnetic with magnet and pin;
H = hand picked;

WT = whole, translucent;
CR = clear, rounded;
E = elongate;
A = Handpicked and abraded;
B = best after abrasion;
W = worst after abrasion.

Table A1 (cont.).

Sample Size fraction	Weight (mg)	U (ppm)	Pb* (ppm)	Measured $^{206}Pb/^{204}Pb$	Isotopic abundance, ^{206}Pb = 100			$^{206}Pb/^{238}U$	$^{207}Pb/^{235}U$	$^{207}Pb/^{206}Pb$ age (Ma)
					^{204}Pb	^{207}Pb	^{208}Pb			
Edehon-Hyde lakes area										
WN-21-75										
1. -74 + 62N0°A B	0.0226	166.7	86.85	3557	0.0118	16.582	15.024	0.46170	10.461	2501
2. -74 + 62N0°A W	0.0198	275.0	139.3	2760	0.0248	16.567	14.227	0.45394	10.174	2482
3. -105 + 74N0°A B	0.0485	214.1	106.9	6175	0.0101	16.220	14.421	0.44570	9.890	2466
4. -105 + 74N0°A W	0.0272	203.5	100.5	4917	0.0088	16.172	13.742	0.44300	9.810	2462
5. -149 + 93N + 2°	18.95	377.4	159.7	3954	0.0059	15.278	9.832	0.39410	8.261	2369
6. -93 + 74	17.61	532.0	219.9	10731	0.0004	15.236	9.696	0.38469	8.079	2372
WN-511-78										
1. -105 + 64N-0.5°	17.92	275.6	144.1	2088	0.0226	18.821	11.126	0.47133	12.052	2702
2. -37N-0.5°	7.30	271.6	141.9	896	0.0384	18.981	12.434	0.46794	11.946	2699
3. -105 + 64M-0.5°	3.83	312.7	154.0	898	0.0291	18.679	11.228	0.44496	11.244	2683
WN-514-78										
1. -37N + 1°	4.14	589.3	284.0	7333	0.0071	18.448	10.766	0.43454	11.003	2686
2. -37M + 1°	5.43	785.8	370.4	9878	0.0067	18.654	11.527	0.42170	10.801	2705
3. -149 + 105N-0.7°	4.43	400.1	179.6	6335	0.0100	17.332	9.668	0.41222	9.783	2578
4. + 149 H WT	2.84	626.1	262.8	4601	0.0103	17.249	7.675	0.39201	9.256	2570
5. -149 + 105M-0.7°	3.50	762.2	311.9	4653	0.0154	16.424	8.356	0.38321	8.579	2480
6. -149 H CR	3.69	490.9	201.6	9434	0.0007	15.788	7.740	0.38658	8.411	2432
7. + 149 H cores	4.10	1849	571.8	5233	0.0157	12.605	4.096	0.31000	5.304	2016
WN-518-78										
1. + 62N-0.5°	14.72	622.3	302.3	9998	0.0045	16.921	9.456	0.44746	10.406	2544
2. + 62M-0.5°	15.05	801.0	385.3	13467	0.0043	16.857	10.070	0.44115	10.222	2538
3. -62N + 1°	3.61	566.3	268.3	9862	0.0065	16.623	11.385	0.43105	9.832	2512
4. -62M + 1°	1.36	824.2	388.8	3607	0.0185	16.778	13.481	0.42349	9.663	2512
WN-519-78										
1. -74 + 62N0°H	1.63	1248	422.7	3328	0.0204	13.048	7.217	0.32997	5.817	2069
2. -74 + 62M0°H	2.49	1579	516.0	4545	0.0139	12.637	6.719	0.32011	5.498	2023
3. + 149N + 1°H	3.64	1646	528.0	14098	0.0033	11.971	5.737	0.31735	5.219	1945
4. + 149M + 1°H	4.18	1706	539.8	13493	0.0046	12.121	6.213	0.31138	5.179	1965

Table A1 (cont.).

Sample Size fraction	Weight (mg)	U (ppm)	Pb* (ppm)	Measured $^{206}Pb/^{204}Pb$	Isotopic abundance, $^{206}Pb = 100$			$^{206}Pb/^{238}U$	$^{207}Pb/^{235}U$	$^{207}Pb/^{206}Pb$ age (Ma)
					^{204}Pb	^{207}Pb	^{208}Pb			
Kasba gneiss area										
WN-601-79										
1. + 149N-1°H	5.22	501.8	277.2	5861	0.0131	22.687	10.694	0.48331	15.022	3020
2. + 149M-1°H	4.96	584.4	301.1	4722	0.0168	21.760	10.368	0.45539	13.544	2949
3. -62	4.14	566.8	240.9	2450	0.0332	19.009	11.914	0.38137	9.793	2709
WN-602-79										
1. -105 + 74N-1°H	4.98	338.4	239.0	9361	0.0066	25.582	16.733	0.57761	20.318	3217
2. -105 + 74M-1°H	2.00	392.5	263.8	3346	0.0145	25.534	17.511	0.54883	19.068	3197
3. + 149 H	7.38	432.2	284.2	2876	0.325	25.076	16.597	0.54422	18.555	3167
WN-603-79										
1. + 105 H clear	4.28	527.2	244.9	3415	0.251	20.558	12.466	0.40909	11.434	2848
2. -105 + 74 LM H	1.36	158.9	73.16	1568	0.0167	19.055	12.511	0.40878	10.631	2730
3. + 105 H orange	2.70	794.5	270.3	2706	0.0326	15.060	7.764	0.32582	6.588	2307
WN-604-79										
-149 + 105N-2°H	2.37	269.6	99.0	2493	0.0062	15.187	6.641	0.35104	7.3139	2358
2. + 149 LM H	4.33	272.9	95.8	3270	0.0168	14.764	6.382	0.33911	6.8043	2294
3. + 149 MM H	1.88	311.3	104.8	2424	0.0033	14.263	5.334	0.32702	6.4126	2254
WN-605-79										
1. -74 + 62 N-2°H	0.99	264.4	112.2	1869	0.0203	16.242	6.210	0.40610	8.9537	2455
2. + 74 LM H	1.24	340.4	139.5	1901	0.0253	17.075	7.015	0.38751	8.9570	2534
3. + 74 MM H	1.79	420.4	161.5	3281	0.0170	16.447	6.260	0.36639	8.2022	2480

Table A2. Rb-Sr isotopic data

Sample no.	Rb ppm	Sr ppm	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	Uncertainty $^{87}Sr/^{86}Sr$
Angikuni-Yathkyed lakes area					
Lamprophyre dyke					0.007%
EA-457-76	166.1	3065	0.1567	0.70830	
EA-457-76 Bi	510.8	615.0	2.401	0.75884	
Edehon-Hyde lakes area					
Granulites collected 1970 and duplicate 1975 samples					0.07%
EA-591-70	33.76	349.1	0.2796	0.7172	
EA-591A-70	29.16	363.2	0.2321	0.7115	
EA-593-70	111.7	226.7	1.424	0.7600	
WN-22-75(3)	135.8	206.2	1.904	0.7923	
EA-594-70	18.54	532.9	0.1006	0.7212	
WN-22-75(2)	24.69	512.5	0.1393	0.7217	
EA-595-70	175.1	166.1	3.048	0.8023	
WN-22-75(1)	150.3	166.4	2.611	0.7957	
EA-836-70	114.9	268.8	1.158	0.7411	
EA-837-70	113.0	186.5	1.752	0.7676	
WN-22-75(5)	132.4	201.7	1.898	0.7629	
EA-1036-70	87.15	322.2	0.7820	0.7321	
EA-1044-70	31.47	396.2	0.2296	0.7124	
EA-1062-70	74.59	242.0	0.8911	0.7399	
EA-1064B-70	62.18	288.7	0.6227	0.7276	
WN-21-75(0)	0.794	428.2	0.0054	0.7184	
WN-22-75(4)	73.31	483.1	0.4387	0.7154	
Edehon-Lake Aphebian quartz monzonite samples					0.07%
WN-23-75(1)	215.8	155.3	4.020	0.8133	
WN-23-75(2)	220.3	82.57	7.718	0.9971	
WN-23-75(3)	190.6	120.5	4.575	0.8320	
WN-23-75(4)	216.2	90.79	6.888	0.9231	
WN-23-75(5)	216.0	37.77	16.54	1.1557	
WN-23-75(6)	212.7	1078	0.5707	0.7190	
Granulites and granodiorite SW of Hyde Lake					
WN-507-78	54.49	557.6	0.2825	0.71338	0.00005
WN-508-78	50.99	579.3	0.2545	0.71523	0.00005
WN-509-78	65.89	449.1	0.4242	0.72309	0.00005
WN-510-78	39.55	471.6	0.2425	0.71227	0.00005
WN-511-78	55.85	206.8	0.7808	0.72919	0.00005
WN-512-78	85.99	336.4	0.7390	0.7309	0.0002
WN-513-78	15.91	583.4	0.0788	0.7087	0.00005
EA-44-78	43.94	381.9	0.3326	0.72234	0.00005
Granulites from south of Edehon Lake					0.03%
WN-515-78(1)	73.15	345.4	0.6123	0.7231	
WN-515-78(2)	73.30	349.8	0.6058	0.7233	
WN-516-78(1)	82.80	284.5	0.8414	0.7342	
WN-516-78(2)	156.0	259.6	1.737	0.7626	
WN-517-78(1)	4.64	629.6	0.0213	0.7040	
WN-517-78(2)	130.5	201.8	1.870	0.7705	
WN-517-78(3)	66.46	296.1	0.6489	0.7275	
WN-517-78(4)	102.2	230.2	1.284	0.7576	
Paragneiss from S of Edehon Lake, sawed into slabs					0.03%
WN-518-78(1)	65.78	278.9	0.6819	0.7323	
WN-518-78(2)	72.06	281.0	0.7414	0.7336	
WN-518-78(3A)	62.41	274.6	0.6571	0.7316	
WN-518-78(3B)	61.47	269.6	0.6592	0.7326	
WN-518-78(4A)	62.44	261.1	0.6914	0.7348	
WN-518-78(4B)	56.60	269.0	0.6083	0.7317	
WN-518-78(5)	73.36	250.6	0.8463	0.7385	
WN-518-78(6)	62.68	261.8	0.6922	0.7341	
WN-518-78(7)	64.53	280.3	0.6656	0.7312	
WN-518-78(8)	66.91	307.8	0.6285	0.7297	
WN-518-78(9)	68.41	304.1	0.6504	0.7290	
WN-518-78(10A)	68.82	304.3	0.6538	0.7295	
WN-518-78(10B)	58.68	306.0	0.5544	0.7258	
WN-518-78(11)	66.32	313.1	0.6125	0.7273	
Kasba gneiss area					0.007%
WN-601-79	89.69	232.8	1.114	0.75555	
WN-602-79	68.79	324.5	0.613	0.72890	
WN-603-79	81.66	185.7	1.271	0.74491	
WN-604-79	73.04	335.9	0.629	0.71946	
WN-605-79	51.59	287.5	0.519	0.71943	

Uncertainty in $^{87}Sr/^{86}Sr$ presented as % for each group except Granulites and granodiorite southwest of Hyde Lake.
Uncertainty in $^{87}Rb/^{86}Sr$ is 1%. (Uncertainties presented at 1 sigma level.)

Table A3. Locations, Edehon Lake granulites, 1970 and duplicate 1975 samples

Sample		Location	Map unit (Eade, 1973)
EA-591-70		60°06′33″N,97°15′50″W	4b
EA-591A-70		60°06′33″N,97°15′50″W	4b
EA-593-70	WN-22-75(3)	60°01′10″N,97°15′10″W	5c
EA-594-70	WN-22-75(2)	60°04′30″N,97°12′08″W	5c
EA-595-70	WN-22-75(1)	60°07′00″N,97°10′45″W	5c
EA-836-70		60°07′05″N,97°31′20″W	5c
EA-837-70	WN-22-75(5)	60°08′50″N,97°32′25″W	5c
EA-1036-70		60°08′45″N,97°26′35″W	5c
EA-1062-70		60°08′43″N,97°05′40″W	5c
EA-1064B-70	WN-21-75(0)	60°06′00″N,97°06′00″W	5c
	WN-22-75(4)	60°05′35″N,97°28′00″W	5c
EA-1044-70		60°08′30″N,97°12′40″W	5c

Table A4. Locations, Edehon Lake Aphebian quartz monzonite samples

Sample	Location	Lithology
WN-23-75(1)	60°08′50″N,97°32′25″W	Small granite mass within pyroxene-bearing granodiorite gneiss.
WN-23-75(2)	60°02′45″N,97°38′45″W	Near the northeast contact to a small granite pluton intruding pyroxene-bearing granodiorite gneiss.
WN-23-75(3)	60°06′15″N,97°57′00″W	Within a granite to quartz monzonite pluton, containing some gneiss inclusions.
WN-23-75(4)	60°03′25″N,97°53′15″W	Massive felsic granite, the same pluton as sample (3).
WN-23-75(5)	60°19′28″N,97°53′00″W	Small quartz monzonite to granite pluton, north of the pluton of samples (3) and (4).
WN-23-75(6)	60°25′30″N,97°59′45″W	Within a pluton to the north of the pluton of sample (5); (possibly the same pluton with a metasedimentary screen separating two parts).

Table A5. Results of chemical analyses of Kasba gneiss samples

	601	602	603	604	605	*Method
SiO_2	68.9	68.1	73.4	71.3	72.3	1
TiO_2	0.45	0.51	0.17	0.20	0.26	1
Al_2O_3	14.6	15.1	14.8	15.8	15.6	1
Fe_2O_3	2.4	1.2	1.6	2.2	1.0	1
FeO	1.0	2.8	0.0	0.0	1.3	2
MnO	0.07	0.08	0.04	0.04	0.04	1
MgO	1.13	1.70	0.48	0.70	0.64	1
CaO	2.91	3.72	1.90	2.82	3.02	1
Na_2O	3.6	4.0	4.0	5.1	4.8	1
K_2O	3.22	1.85	3.07	1.65	1.24	1
H_2O_T	0.6	0.8	0.5	0.6	0.5	2
CO_2	0.1	0.0	0.0	0.1	0.0	2
P_2O_5	0.11	0.13	0.05	0.06	0.08	1
S	0.00	0.00	0.00	0.00	0.00	2
Ba(ppm)	630	570	420	220	200	1,3
Cr(ppm)	<5	9.3	<5	<5	<5	3
Cu(ppm)	33	22	8.8	9.8	12	3
Rb(ppm)	89.7	68.8	81.7	73.0	51.6	4
Sr(ppm)	233	325	186	336	288	4
U(ppm)	60	70	30	31	39	3
Yb(ppm)	8.9	5.3	5.4	4.0	4.1	3
Zr(ppm)	210	110	53	41	75	3

*Method: 1, X-ray flourescence, fused; 2, rapid chemical; 3, optical emission spectroscopy; 4, isotope dilution.
The following elements were not determined (optical emission spectroscopy) at the listed detection levels (ppm); Ag, 5; As, 2000; B, 50; Be, 3; Ce, 200; Co, 10; La, 100; Mo, 50; Ni, 10; Pb, 700; Sb, 500; Sn, 200; Y, 40; Zn, 200.

APPENDIX B

Zircon morphology

Angikuni - Yathkyed lakes area

WN-210-76: Zircon grains are translucent and stubby, averaging 2:1 elongation but ranging from equant to (rarely) 5:1. Grains appear somewhat corroded, generally euhedral prismatic with slightly rounded terminations. Euhedral zoning is visible in most; cores are noted in a few. Internal fractures are prevalent. Parallel twinned crystals and compound growths are common.

WN-211-76: Zircon grains are rounded, ranging from those which appear to have been once euhedral (elongations 2:1 to 5:1) to those which are highly rounded and are equant triangular or polygonal . Roughly half are clear and the remainder translucent. A few show euhedral zoning. Rare black spot and bubble inclusions are present and fewer than 20% exhibit internal fractures. Grains are colourless to pale orange.

WN-212-76: This zircon concentrate consists mostly of short, prisimatic, slightly rounded crystals. Elongations range from equant to 4:1, averaging 2.5:1. Most crystals are tan, some with dark brown interiors. Internal euhedral zoning is common; a few crystals contain distinct small cores. Granular, rod and bubble inclusions are noted as are a few twinned crystals. Some internal fractures are present.

WN-223-76: Zircon in this population consists of short, prismatic, euhedral crystals averaging 2:1, but ranging from equant to (rarely) 5:1 in elongation. Internal euhedral zoning is common. Cores, which are also common, usually have subhedral rounded outlines and are sometimes lighter in colour than the brownish orange outer zones. Bubble inclusions are observed and radial and transverse cracks are noted in a minority of the crystals.

WN-18-75: This zircon concentrate consists of short, rounded, clear to translucent grains ranging from equant to (rarely) 5:1 in elongation. Some grains are rounded triangular to polygonal. Internal euhedral zoning is visible in most grains and rod and bubble shaped inclusions are common. Cores are noted in a few grains but are rare. Colour ranges from amber to light brown.

Edehon-Hyde lakes area

WN-511-78: This zircon concentrate is composed of clear to translucent euhedral crystals with rounded to relatively sharp terminations. Elongation ranges from equant to 6:1 with most crystals averaging 2.5:1. Internal euhedral zoning is visible near the terminations of most crystals. Many contain rounded cores upon which the euhedrally zoned terminations have grown. Parallel zircon twins and (fewer) end to end twins and "globs" of zircon growth on crystal faces are present. Granular, bubble and dusty inclusions and moderately intense fracturing are all prevalent.

WN-21-75: Zircon in this concentrate ranges from euhedral grains (elongation to 7:1) with minor rounding to equant, rounded, potato shaped grains. Most grains have irregular curved sides; surfaces are corroded, frosted and pitted. Euhedral zoning is common and parallel and end to end twins are noted. Internal fractures and inclusions are normally present. Colour ranges from pale honey through amber to orange brown in reflected light; grains are clear in transmitted light.

WN-518-78: Zircon crystals are elongate (3:1 to 6:1) and clear, with rounded terminations. Some have embayed sides and some necked outlines; parallel twins are also present. A few bubble inclusions are noted plus a few dark inclusions in the more magnetic fractions. Grains are clear and colourless to light brown.

WN-519-78: Similar to WN-518-78, but includes:
1. Clear grains
2. Clear grains containing red-orange domains
3. Translucent grains containing plentiful red-orange domains

WN-514-78: This concentrate consists of clear to translucent, rounded euhedral shaped crystals ranging in elongation from equant to 4:1, with most about 2.5:1. Euhedral zoning is evident in most grains and many contain distinct corroded cores which range in size from tiny remnants to more than 75% of the crystal. Parallel twins are common with end to end twins less common. Necked crystals were observed and others showed random outgrowths. Most grains show networks of surface fractures. The majority of grains are clear to tan with a few reddish brown.

Kasba gneiss area

WN-601-79: Zircon crystals are short and prismatic with elongations averaging 2.5:1 but ranging from equant to (rarely) 6:1. Terminations are slightly to completely rounded and some crystal sides and terminations are embayed. Crystals are clear to (more frequently) translucent. Euhedral zoning is observed in many of the clearer crystals. Internal fractures are noted in most; some contain bubble and black speck inclusions. Colour ranges from white to tan, light brown and yellow-red with some crystals containing reddish orange domains.

WN-602-79: In this concentrate, zircon crystals are short to slightly elongated prismatic with typical elongations 3:1 but ranging from equant to 4:1. Shorter crystals are rounded, more elongate ones have slightly rounded to sharp terminations, some crystal sides are embayed. Euhedral zoning is visible in most crystals; most are clear but a few are translucent. Fewer than half contain black speck inclusions but bubble and rod inclusions and internal fractures are common. Colour ranges from clear and colourless through tan to a few yellow-red grains.

WN-603-79: Zircon crystals are mostly short prismatic with a typical elongation of about 2:1, ranging from equant to (rarely) 5:1. Terminations are generally rounded in the longer grains and the equant grains are quite rounded. Euhedral zoning is observed and distinct core/overgrowth structures are visible in many crystals (both clear and orange). Some grains contain black speck and/or bubble inclusions and minor fracturing is present. Colour ranges from clear colourless through light yellow or tan to "orange" consisting of red-orange domains in tan crystals.

WN-604-79: The zircon crystals in this concentrate are mostly clear, short, prismatic, slightly rounded euhedral crystals with elongations averaing 2:1 but ranging from equant to 3:1. Fine euhedral zoning is noted; black speck, rod and bubble inclusions are prevalent as are large cracks. A few of the more magnetic crystals are "necked" similar to end to end twins. Colour ranges from clear colourless to light purple with the more magnetic fraction being more translucent.

WN-605-79: Zircon is mostly clear, slightly rounded to well rounded, prismatic, euhedral with elongation averaging 2.5:1 but ranging from equant to 5:1. Euhedral zoning is visible in most crystals and a few show possible translucent core/clear overgrowth features. Black speck, bubble and rod inclusions are noted; fractures are prevalent. Colour ranges from clear colourless to light tan.