GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

PAPER 60-17

AGE DETERMINATIONS BY THE GEOLOGICAL SURVEY OF CANADA

Report 1 Isotopic Ages

Compiled by J. A. Lowdon

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The age determination program is a team effort involving the following officers of the Geological Survey of Canada:

R.K. Wanless J.A. Lowdon R.D. Stevens	Argon extraction, mass spectrometry, and age calculation
R.J. Traill J.Y.H. Rimsaite	Mineralogy, X-ray analysis, and mineral separation
Sidney Abbey	Potassium determination

CONTENTS

INTRODUCTION AND OUTLINE OF PROGRAM

This publication is the first of a proposed series of annual releases of geological age determinations carried out in the laboratories of the Geological Survey of Canada. It includes all potassium-argon age measurements completed at December 31, 1959.

The report is presented in two parts: In part I are listed all pertinent experimental data as well as reference to the geological setting and brief remarks by the geologist responsible for field selection and interpretation. In part II are more detailed discussions of the significance and application of age measurements to specific geological problems.

The potassium-argon age determination program of the Geological Survey has developed through three phases. First, a calibration phase was undertaken, during which potassium-argon measurements on micaceous minerals were compared with lead-uranium and lead-thorium age determinations on uraniferous minerals occurring in the same pegmatitic body. This provided an opportunity for the comparison of age measurements based on three separate elemental-decay systems. Generally speaking the results (included in Part I) agree closely, although the mica ages appear to be a few per cent lower than the average of the lead-uranium and lead-thorium ages.

The second phase embodied a detailed investigation of a batholithic complex, its pegmatites, and surrounding metamorphic rocks. The study was carried out by N. J. Snelling during his tenure of a National Research Council postdoctorate fellowship. The age results of this study are included in Part I of this report, but a report on the other details of the project is being prepared.

The results of the second phase were sufficiently encouraging to precipitate the third phase, which has taken the form of a crash program for the reconnaissance dating of the Canadian Shield. This program has three objectives: (1) to date and assist in outlining major orogenies; (2) to give information useful in time-stratigraphic classification; and (3) to point to problems requiring more detailed study. Many of the required samples were specifically collected during the summer of 1959, and the first available results are included in this compilation. Plans now call for the completion of approximately 150 additional determinations during 1960, mostly for Shield areas.

Procedure

The age measurements are the cumulative result of detailed work carried out in three separate laboratories of the Geological Survey of Canada. Mineral separations and mineralogical examination of the mica concentrate are handled by the Mineralogical Section. All concentrates are analysed by X-ray diffraction to determine the degree of chloritization. Potassium determinations are carried out in the Analytical Chemistry Section using flame-photometric techniques. The argon extraction, mass spectrometric analyses, and age calculations are completed in the Isotope and Nuclear Research Section.

To date, mica age measurements have been based on potassium-argon ratios only, but plans are being made to augment these with determinations of the rubidium-strontium ratio, thereby providing a check based on an independent elemental-decay system. A new solid-source mass spectrometer, which will eventually be employed in this work, is being assembled in the Survey laboratories. This instrument will also be equipped to handle analyses of the lead and uranium in zircons, thereby providing a third independent age calculation for selected key localities.

Accuracy of Determinations

The analytical error has not been quoted for each determination but is considered to be approximately ± 8% at 100 m.y. decreasing to approximately ± 5% at 2,500 m.y., for individual determinations of this nature. This is based on a comparison of ages determined by the potassium-argon and lead-uranium methods and on such replicate analyses as have been carried out.

The limits to be applied to the calculated values are therefore:

Range	Limits
100 m.y.	± 8 m.y.
500 m.y.	± 35 m.y.
1,000 m.y.	± 60 m.y.
2,500 m.y.	± 125 m.y.

Geological Significance

The calculated ages are assumed to be the age of crystallization of the mineral unless the normal ratio of decay products has been altered by contamination at the time of crystallization or by other causes during the subsequent history of the mineral.

Constants Used

All argon determinations have been carried out using isotope-dilution techniques and age calculations have been based on the following constants:

$$\lambda_e = 0.585 \times 10^{-10}\ yr^{-1}$$

$$\lambda_{total} = 5.30 \times 10^{-10}\ yr^{-1}$$

-- PART I --

GEOLOGICAL AGE DETERMINATIONS

British Columbia

GSC 59-1 -- Biotite, K 6.38%, Ar^{40}/K^{40} .00512, K-Ar age 86 m.y.
Radiogenic argon 100%. Concentrate contained a trace of chlorite.
From Nelson granodiorite; map-unit 12, GSC PS Map 3-1956, British Columbia; 49°29'N, 117°18'W. Collected and described by H.W. Little.

The Nelson plutonic rocks cut early Middle Jurassic rocks and are probably older than rocks yielding plants of probably Upper Cretaceous, possibly Early Tertiary age. The Nelson is the earliest of the granitic intrusions of the Nelson area and is thought by indirect evidence to be related to the orogeny that gave rise to Late Jurassic (Portlandian) sedimentation east of the Rocky Mountain Trench. It is, however, possible that the sample of Nelson granodiorite submitted for age determination is younger than the Nelson as a whole, or that metamorphism of the rock occurred after emplacement.

GSC 59-2 -- Biotite, K 6.35%, Ar^{40}/K^{40} .0553, K-Ar age 765 m.y.
Radiogenic argon 100%. Concentrate contained more than 10% chlorite.
From lamprophyre; Sullivan Mine, G.S.C. PS Map 15-1957, British Columbia; 49°43'N, 116°00'W. Sample GSC 1A. Collected by A.C. Freeze for G.B. Leech.

GSC 59-3 -- Biotite, K 5.06%, Ar^{40}/K^{40} .0397, K-Ar age 580 m.y.
Radiogenic argon 88%. Concentrate contained no chlorite.
From lamprophyre; Sullivan Mine, GSC PS Map 15-1957, British Columbia; 49°43'N, 116°00'W. Sample GSC 2. Collected by A.C. Freeze for G.B. Leech.

GSC 59-4 -- Biotite, K 7.52%, Ar^{40}/K^{40} .00075, K-Ar age 13 m.y.
Radiogenic argon 67%. Concentrate contained no chlorite.
From mafic-rich, porphyroblastic, augen granodiorite-gneiss, veined with anastomosing network of pegmatite, leucogranite, and leucogranite-gneiss of very heterogeneous texture, Valhalla complex; map-unit 12, GSC PS Map 3-1956, British Columbia; 49°51'N, 117°37'30"W. Sample 47-RA-4. Collected by J.E. Reesor.
For interpretation see GSC 59-6.

GSC 59-5 -- Biotite K 7.11%, Ar^{40}/K^{40} .00067, K-Ar age 11 m.y.
Radiogenic argon 29%. Concentrate contained 5% chlorite.
From leucogranite-gneiss, fine- to coarse-grained, Valhalla complex; map-unit 13, GSC PS Map 3-1956, British Columbia; 49°51'N, 117°41'W. Sample 230-RA-2. Collected by J.E. Reesor.
For interpretation see GSC 59-6.

GSC 59-6 -- Biotite, K 7.44%, Ar^{40}/K^{40} .00097, K-Ar age 16 m.y.
Radiogenic argon 14%. Concentrate contained no chlorite.
From mafic-rich porphyroblastic augen granodiorite-gneiss; Valhalla complex; map-unit 12, GSC PS Map 3-1956, British Columbia; 49°51'30"N, 117°37'W. Sample 51-RA-3. Collected and interpreted by J.E. Reesor.

All three ages - GSC 59-4 (13 m.y.), GSC 59-5 (11 m.y.), and GSC 59-6 (16 m.y.) - are much younger than expected from the inferred geological age of Late Jurassic or Early Cretaceous for Nelson granitic rocks.

GSC 59-7 -- Biotite, K 6.92%, Ar^{40}/K^{40} .0219, K-Ar age 340 m.y.
Radiogenic argon 71%. Concentrate contained no chlorite.
From light syenite dyke containing coarse tablets of biotite. The dyke cuts transition types (ijolite,

urtite) of the Ice River complex, but is genetically related to the intrusion. Map-unit 2, GSC Map 142A, Ice River, British Columbia; 51°12'N, 116°29'W. Sample Ice 5-RA-1. Collected by J. E. Reesor.
For interpretation see GSC 59-8.

GSC 59-8 -- Biotite, K 7.12%, Ar^{40}/K^{40} .0209, K-Ar age 330 m.y.
Radiogenic argon 77%. Concentrate contained no chlorite.
From pyroxene-rich melanocratic rock of the Ice River complex. Carries irregularly oriented coarse tablets of biotite, commonly along boundaries of pyroxene grains. Map-unit 2, GSC Map 142A, Ice River, British Columbia; 51°12'N, 116°29'W. Sample Ice 4-RA-1A. Collected and interpreted by J.E. Reesor.

The K-Ar age indicates that the Ice River complex, intrusive into the Lower Ordovician Goodsir formation, is clearly mid-Palaeozoic in age and not post-Cretaceous as noted by Allan (GSC Mem. 55, p. 192) on structural grounds.

Yukon Territory

GSC 59-9 -- Muscovite, K 4.25%, Ar^{40}/K^{40} .0133, K-Ar age 214 m.y.
Radiogenic argon 54%.
From mica schist; map-unit 1, GSC Prel. Map 54-20, Teslin map-area, Yukon; 60-61°N, 132-134°W. Composite sample. Collected and described by R. Mulligan.

The rocks concerned are from a regionally metamorphosed group that, in part at least, underlies Mississippian limestone, and are much more highly metamorphosed than Permian and Mesozoic rocks.

GSC 59-10 -- Biotite, K 4.13%, Ar^{40}/K^{40} .0138, K-Ar age 223 m.y.
Radiogenic argon 100%.
From hornblende-biotite granodiorite; map-unit 6, GSC Map 52-30, Paper 52-30, Whitehorse area, Yukon; 60°53'N, 135°33'W. Sample WB-55-A-1.

Collected by J. O. Wheeler and submitted by R. Mulligan. Described and interpreted by J. O. Wheeler.

The hornblende-biotite granodiorite is from an outcrop isolated by drift from an extensive surrounding area of granite. The granite, which contains only about 2% biotite, intrudes the Laberge group of Lower Jurassic and later age.

The hornblende-biotite granodiorite within the much larger area of granite is probably an inclusion of older rock in a late Lower Cretaceous or younger granite. From the abundance of granite debris in the Laberge group, granitic rocks older than Jurassic are inferred to have been exposed in this region in early Jurassic time. Granite blocks 4 feet in diameter occur in the Laberge conglomerate 12 miles northeast of the 'older' granodiorite. These blocks are regarded as having come from a source about 10 miles southwest of their present location (Wheeler, GSC Memoir 312, in press). Such a source may therefore have been granitic rocks 223 m.y. old.

GSC 59-11 -- Biotite, K 4.89%, Ar^{40}/K^{40} .0085, K-Ar age 140 m.y.
Radiogenic argon 75%. Concentrate contained less than 8% chlorite.
From plagioclase-biotite-garnet schist, Yukon group; Map-unit, GSC PS Map 19-1958, Paper 58-9, west of Venus Creek, Yukon; 68°17'N, 138°07'W. Sample 425H. Collected and described by J.E. Muller.

The rock is typical of the 'Yukon group' metamorphic complex. It had generally been considered to be of Precambrian or lower Palaeozoic age. This assumption was based solely on the degree of metamorphism of the complex and is therefore invalid, as the time of metamorphism is shown to be Mesozoic. It appears now that the rocks of the Yukon complex were metamorphosed during the early part of the Mesozoic orogeny. The K-Ar age may be a little low, as the schists grade through gneisses into quartz-monzonite, GSC 59-12, determined to be 176 m.y. old.

GSC 59-12 -- Biotite, K 5.28%, Ar^{40}/K^{40} .0108, K-Ar age 176 m.y.
Radiogenic argon 91%. Concentrate contained less than 5% chlorite.
From biotite-quartz-monzonite intrusion within the Yukon group schists and gneisses, with a gradational

contact; map-unit 4, GSC PS Map 19-1958, Paper 58-9, south of Gladstone Lake, Yukon; 61°21'N, 138°3'W. Sample 430C. Collected and interpreted by J.E. Muller.

The age would correlate this intrusion very well with the Lower Jurassic or earlier Topley and Guichon batholiths in British Columbia (170 m.y. and 180 m.y. according to H. Baadsgaard, R.E. Folinsbee, and J. Lipson, 1959, Bull. Geol. Soc. Amer., vol. 70, p. 1564).

GSC 59-13 -- Biotite, K 5.98%, Ar^{40}/K^{40} .00346, K-Ar age 58 m.y.

Radiogenic argon 49%. Concentrate contained only trace of chlorite.

From gneissic biotite granodiorite, Yukon group; map-unit 4, GSC map 19-1958, Paper 58-9, west of Talbot Arm, Yukon; 61°25'N, 138°45'W. Sample 415A, B. Collected and described by J.E. Muller.

This gneissic rock was mapped as a marginal zone of the same batholith as that of sample GSC 59-12. The age of 58 m.y. would correlate it with the early Tertiary intrusions of the Cordillera, generally known to be small stocks and dykes of syenitic character, entirely different from the rock being considered. The age is therefore not as expected, but in a general way it corroborates the conclusion drawn from the other two samples (GSC 59-11, and GSC 59-12), that metamorphism of the Yukon complex occurred after the Palaeozoic.

GSC 59-14 -- Biotite, K 6.44%, Ar^{40}/K^{40} .00352, K-Ar age 59 m.y.

Radiogenic argon 27%. Concentrate contained trace of chlorite.

From leuco-quartz monzonite, Seagull batholith; map-unit 16, GSC PS Map 22-1957, Wolf Lake Area, Yukon; 60°02'32"N, 131°10'11"W. Sample 5-1-2/P. Collected and described by W.H. Poole.

The Seagull batholith cuts and metamorphoses rocks as young as Mississippian, and metamorphoses nearby rocks thought to be Mesozoic (Triassic?). With the exception of Pleistocene(?) lavas in valleys, no younger rocks occur in the vicinity of the batholith. In general, the age determination agrees with the field geology, but there is insufficient stratigraphic control for a precise field determination. It is almost certainly younger than the Cassiar batholith.

District of Franklin, Northwest Territories

GSC 59-15 -- Biotite, K 7.45%, Ar^{40}/K^{40} .0371, K-Ar age 545 m.y.
Radiogenic argon 89%. Concentrate contained only a trace of chlorite.
From migmatite gneiss, garnetiferous in part, with abundant biotite-rich layers. Here and there augen gneiss is well developed. Map-unit 1, GSC Paper 53-10, District of Franklin, Northwest Territories; 83°07'N, 72°00'W. Sample No. R9E. Collected and interpreted by R.G. Blackadar.

As the biotite is of metamorphic origin the results of this determination tend to support the view that these rocks are early Palaeozoic or older and not, as has been postulated, merely metamorphosed middle Palaeozoic strata.

District of Mackenzie, Northwest Territories

GSC 59-16 -- Biotite, K 7.63%, Ar^{40}/K^{40} .1746, K-Ar age 1,790 m.y.
Radiogenic argon 96%. Concentrate contained no chlorite.
From granodiorite and quartz monzonite; Map-unit 5b, GSC PS Map 16-1958, Fort Enterprise Area, District of Mackenzie, Northwest Territories; 64°03'N, 112°08'W; composite of samples FD-124-57, FD-125-57 and FD-113A-57. Collected and described by J.A. Fraser.

From a massive, homogeneous, inclusion-free body that exhibits concordant contacts with the surrounding gneisses whose minimum age is represented by GSC 59-19 (2,070 m.y.).

GSC 59-17 -- Biotite, K 8.13%, Ar^{40}/K^{40} .2284, K-Ar age 2,115 m.y.
Radiogenic argon 99%. Concentrate contained no chlorite.
From a porphyritic quartz monzonite; map-unit 5cd, GSC PS Map 16-1958, Fort Enterprise area, District of Mackenzie, Northwest Territories; 64°27'N, 113°17'W. Sample FD-18-58. Collected and interpreted by J.A. Fraser.

This unit carried inclusions of Yellowknife-type rocks and therefore gives a minimum age for the Yellowknife group. (Compare GSC 59-19.)

GSC 59-18 -- Biotite, K 6.55%, Ar^{40}/K^{40} .1987, K-Ar age 1,940 m.y.
Radiogenic argon 97%. Concentrate contained minor chlorite.
From knotted schist; map-unit 3, GSC PS Map 16-1958, Fort Enterprise area, District of Mackenzie, Northwest Territories; 64°00'N, 112°17'W. Sample FD-111A-58. Collected and described by J.A. Fraser.

The sample was from metasediments interlayered with flows of the Yellowknife group. The biotite is of metamorphic origin and its age is presumably a minimum for Yellowknife-group rocks.

GSC 59-19 -- Muscovite, K 7.75%, Ar^{40}/K^{40} .2207, K-Ar age 2,070 m.y.
Radiogenic argon 97%. Concentrate contained no chlorite.
From knotted schist; map-unit 3, GSC PS Map 16-1958, Fort Enterprise area, District of Mackenzie, Northwest Territories; 64°00'N, 112°17'W. Sample FD-111A-58. Collected and interpreted by J.A. Fraser.

The sample was from metasediments interlayered with flows of the Yellowknife group (same sample as GSC 59-18). The muscovite is of metamorphic origin and its age is presumably a minimum for Yellowknife-group rocks.

GSC 59-20 -- Muscovite, K 8.92%, Ar^{40}/K^{40} .1759, K-Ar age 1,800 m.y.
Radiogenic argon 97%. Concentrate contained no chlorite.
From muscovite pegmatite and muscovite granite; map-unit 5a, GSC PS Map 16-1958, Fort Enterprise area, District of Mackenzie, Northwest Territories; 64°26'N, 112°32'W; composite of samples FD 191-57 and FD-194-A-57. Collected and described by J.A. Fraser.

It appears to intrude granite, granite-gneiss, and schist that may be comparable in age to GSC 59-17 (2,115 m.y.) and GSC 59-19 (2,070 m.y.).

GSC 59-21 -- Biotite, K 8.06%, Ar^{40}/K^{40} .2929, K-Ar age 2,445 m.y.
Radiogenic argon 98%. Concentrate was esentially pure; contained no chlorite.
From gabbro; GSC PS Map 16-1958, Fort Enterprise area, District of Mackenzie, Northwest Territories; 64°23'N, 113°42'W. Sample FD27-58. Collected and interpreted by J.A. Fraser.

The body of gabbro was interpreted in the field as an offshoot from a diabase dyke (map-unit 6) that cuts granitic rocks probably comparable in age to GSC 59-17 (2,115 m.y.). However, the K-Ar age of 2,445 m.y. suggests that the gabbro is probably included in the granite and not genetically related to the diabase.

GSC 59-22 -- Muscovite, K 8.05%, Ar^{40}/K^{40} .2972, K-Ar age 2,465 m.y.
Radiogenic argon 98%. Concentrate contained no chlorite.
From medium-grained, equigranular muscovite granite; map-unit 10a, GSC Map 17-1956, Paper 56-10, Eastern District of Mackenzie, Northwest Territories; 63°59'N, 107°56'W. Sample W179-55. Collected and described by G.M. Wright.

The sample is from an area of several square miles underlain by massive, clean, grey to white, heavily jointed granite. This granite (and others of similar type and occurrence) is presumed to be intrusive into the rocks of the Yellowknife group, and is one of a group sampled to establish the general age(s) of the massive, clean, and fresh-looking granites north of Artillery Lake.

GSC 59-23 -- Biotite, K 6.55%, Ar^{40}/K^{40} .2813, K-Ar age 2,390 m.y.
Radiogenic argon 99%.
From massive, coarse-grained, white biotite granite; map-unit 10, GSC Map 17-1956, Paper 56-10, Eastern District of Mackenzie, Northwest Territories; 65°45'N, 107°40'W. Sample H234-55. Submitted and interpreted by G.M. Wright.

The biotite granite intrudes sedimentary schist correlated with the Yellowknife group (Archaean). The biotite is presumed to be the same age as the granite, and younger than the Yellowknife strata; but see GSC 59-25 which indicates metamorphism of Yellowknife strata at about 2,100 m.y. This granite is one of the clean, massive, unfoliated types north of Artillery Lake and west of the Bathurst lineament.

GSC 59-24 -- Muscovite, K 7.13%, Ar^{40}/K^{40} .3164 K-Ar age 2,550 m.y.
Radiogenic argon 85%
From massive, coarse-grained, white, muscovite granite; map-unit 10a, GSC Map 17-1956, Paper 56-10, Eastern District of Mackenzie, Northwest Territories; 65°25'N, 107°33'W. Sample H 247-55. Submitted and interpreted by G.M. Wright.

The muscovite granite intrudes sedimentary schist correlated with the Yellowknife group. The muscovite is presumed to be the same age as the granite and younger than the Yellowknife strata, but is apparently older than the metamorphic biotite in the latter (see GSC 59-25, 2,100 m.y.). This granite is one of the clean, massive, unfoliated types north of Artillery Lake and west of the Bathurst lineament.

GSC 59-25 -- Biotite, K 6.18%, Ar^{40}/K^{40} .2256, K-Ar age 2,100 m.y.
Radiogenic argon 94%. Concentrate contained 3% chlorite.
From fine-grained, quartz-biotite schist with 'knots' of andalusite up to 1/2 inch long; map-unit 3, GSC map 17-1956, Paper 56-10, Eastern District of Mackenzie, Northwest Territories; 65°08'N, 106° 35'W. Sample F290/1-55. Submitted and described by G.M. Wright.

The schist is assumed to belong to the Yellowknife group. Under the microscope this rock is seen to be a nodular schist typical of the group, and to contain about 10% metamorphic biotite, of dark, reddish brown colour. The K-Ar age should be that of the development of biotite (metamorphism) of the schist. The sample was submitted in an effort to relate this metamorphism to the massive granites of the region, with some rather perplexing results, discussed in Part II.

GSC 59-26 -- Biotite, K 2.79%, Ar^{40}/K^{40} .2001, K-Ar age 1,950 m.y.
Radiogenic argon 87%.
From massive, coarse-grained, equigranular, clean, pink-grey granite; map-unit 10b, GSC Map 17-1956, Paper 56-10, Eastern District of Mackenzie, Northwest Territories; 65°06'N, 107°12'W. Sample W366-55. Collected and described by G.M. Wright.

This rock is a true granite with about 10% mica; both biotite (somewhat altered) and muscovite are present in the ratio of about 2 to 1. The rock intrudes sedimentary schist correlated with the Yellowknife group. This remarkably massive and clean granite forms a pluton that is 'wrapped around' by Yellowknife schists. No appreciable mixed zone was seen near the contact. The granite is not gneissic in outcrop, but strain shadows and bent twin lamellae were seen under the microscope. It apparently intrudes Yellowknife strata and is appreciably younger than the metamorphism (biotite) of the latter (GSC 59-25, 2,100 m.y.) and much younger than other massive and clean granites of similar geological occurrence in the area north of Artillery Lake.

GSC 59-27 -- Biotite, K 7.01%, Ar^{40}/K^{40} .2155, K-Ar age 2,040 m.y.
Radiogenic argon 97%. Concentrate showed no chlorite.
From fine- to medium-grained, decidedly gneissic granite with prominent lamellae of black biotite; map-unit 8, GSC Map 17-1956, Paper 56-10, Eastern District of Mackenzie, Northwest Territories; 62°10'N, 105°55'W. Sample E60-55. Submitted and described by G.M. Wright.

The sample was picked as one of several to give age(s) of granitic gneisses of the region, and also of a possible 'host rock' for bands of paragneiss and amphibolite (e.g. GSC 59-28) so commonly found scattered about in granitic-gneiss terrain. No thin section of this rock is available, but it appears to be cataclastic. The age of this rock - about 2,040 m.y. - does not conform to the remarkably uniform age obtained for several other samples from granitic gneisses in the barren grounds (1,690, 1,655, 1,695, and 1,805 m.y.). Nor does this age support the field impression that bands of paragneiss, schist, and meta-volcanic rocks (GSC 59-28 - 1,670 m.y. approximately) are undigested remnants in a 'sea' of granite.

GSC 59-28 -- Biotite, K 6.45%, Ar^{40}/K^{40} .1569, K-Ar age 1,670 m.y.
Radiogenic argon 92%. Concentrate contained no chlorite.
From fine-grained, dark grey biotite amphibolite; map-unit 6, GSC Map 17-1956, Paper 56-10, Eastern District of Mackenzie, Northwest Territories; 62°15'N, 106°15'W. Sample E58/1-55. Submitted and interpreted by G.M. Wright.

This rock comes from an elongated belt of paragneiss and amphibolite, with interbanded granite-gneiss; such belts of steeply dipping gneisses are common within the granitic gneisses of the barren grounds. It was tentatively assumed that the gneisses are remnants within the granite, and that the age of the biotite would be the age of metamorphism (recrystallization) due to engulfment by granitic material. This suggestion is, in general, supported by several age determinations on granitic gneisses of the region (1,690, 1,655, and 1,695 m.y.), but is contradicted by the nearest of these (GSC 59-27, 2,040 m.y.).

GSC 59-29 -- Biotite, K 4.65%, Ar^{40}/K^{40} .3204, K-Ar age 2,070 m.y.
Radiogenic argon 73%.
From massive to slightly gneissic, medium-grained, pink to dull red, fresh, hornblende-biotite quartz monzonite; map-unit 8, GSC Map 17-1956, Paper 56-10, Eastern District of Mackenzie, Northwest Territories; 63°32'N, 104°38'W. Sample H164-55. Submitted and described by G.M. Wright.

This rock is a most uncommon type in this region, and its age is near that of one sample of clean, massive granite (GSC 59-26, 1,950 m.y.) and one of gneissic granite (GSC 59-27, 2,040 m.y.). Nearest outcrops are of Dubawnt sandstone but the relationship is not known.

GSC 59-30 -- Biotite, K 5.50%, Ar^{40}/K^{40} .1482, K-Ar age 1,605 m.y.
Radiogenic argon 81%. Concentrate contained no chlorite.
From massive, pink, coarse-grained granite; map-unit 8, GSC Map 17-1956, Paper 56-10, Eastern District of Mackenzie, Northwest Territories; 64°35'N, 104°35'W. Sample F270-55. Submitted and described by G.M. Wright.

As seen in thin section this rock is a true granite in composition; it shows some granulation along grain boundaries. The biotite is assumed to be the same age as the granite. The sample is chosen to give an age for a more massive phase of granitic rock within generally gneissic granite terrain.

GSC 59-31 -- Biotite, K 5.54%, Ar^{40}/K^{40} .1769, K-Ar age 1,805 m.y.
Radiogenic argon 100%.
From fine- to medium-grained, stratiform, pink granite-gneiss; map-unit 8, GSC Map 17-1956, Paper 56-10, Eastern District of Mackenzie, Northwest Territories; 65°55'N, 105°45'W. Sample W355-55. Collected and interpreted by G.M. Wright.

This sample was picked as possibly representative of a large region of variegated rocks of this general type. Thin section study shows a fine-grained, more or less equigranular aggregate of granitic composition. The rock may be a reconstituted sediment. Both field and microscopic study suggested that the biotite is probably metamorphic (i.e. younger than the original rock).

District of Keewatin, Northwest Territories

GSC 59-32 -- Biotite, K 6.94%, Ar^{40}/K^{40} .1597, K-Ar age 1,690 m.y.
Radiogenic argon 91%. Concentrate contained 4% chlorite.
From medium- to coarse-grained, grey, gneissic biotite granite; map-unit 6, GSC Map 55-17 (West Sheet), Paper 55-17, Central District of Keewatin, Northwest Territories; 65°45'N, 97°10'W. Sample W512-54. Collected and described by G.M. Wright.

This rock is a biotite-bearing, oligoclase granite, with some augen structure. Sample is picked as representative of granite in the area. Most of this granite appears massive from the air, but gneissic and partly impure in the outcrop. The sample was submitted to help to establish the general age(s) of the granitic rocks of this region.

GSC 59-33 -- Biotite, K 7.03%, Ar^{40}/K^{40} .1552 K-Ar age 1,655 m.y.

Radiogenic argon 93%. Concentrate contained no chlorite.
From fine-grained, pinkish grey, gneissic granite; map-unit 6, GSC Map 55-17 (East Sheet), Paper 55-17, Central District of Keewatin, Northwest Territories; 64°40'N, 93°45'W. Sample W83-54, from 100 yards of good outcrop. Collected and described by G.M. Wright.

This sample was submitted with several others to give an indication of the general age(s) of the great expanse of mainly gneissic granitic rocks in the barren grounds.

GSC 59-34 -- Biotite, K 7.06%, Ar^{40}/K^{40} .1605, K-Ar age 1,695 m.y.
Radiogenic argon 92%. Concentrate contained 3% chlorite.
From medium-grained, equigranular, light-grey, clean, slightly gneissic, biotite granite; map-unit 2, GSC Map 53-22 (West Sheet), Paper 53-22, Southern District of Keewatin, Northwest Territories; 60°45'N, 97°20'W. (This map-unit corresponds roughly to map-unit 6 of Paper 55-17 and to map-unit 8 of Paper 56-10). Sample L171-52. Submitted and described by G.M. Wright.

Nearby, this grey granite is believed to contain remnants of meta-volcanic gneisses (map-unit 1, Paper 53-22). The sample was submitted to help to establish general age(s) of granitic terrain.

GSC 59-35 -- Biotite, K 7.56%, Ar^{40}/K^{40} .1555, K-Ar age 1,515 m.y.
Radiogenic argon 98%. Concentrate contained no chlorite.
From massive, dark purple, pyroxene-biotite porphyry (one type of Dubawnt porphyry); map-unit 9, GSC Map 55-17 (West Sheet), Paper 55-17, Central District of Keewatin, Northwest Territories; 62°35'N, 99°35'W. Sample L272-57. Submitted and interpreted by G.M. Wright.

This and similar rocks outcrop as low, isolated 'pancakes' in a large area of grassland south and southeast of Tulemalu Lake in the central barren grounds. Phenocrysts of biotite and clinopyroxene, up to 1/2 inch in size, lie in a groundmass consisting largely of tiny laths of plagioclase(?) feldspar. It is believed, from general and not specific evidence, that the porphyries in this area are flows rather than dykes. The sample is submitted as one of the few in which the biotite is unaltered, in an effort to establish an approximation of the general age of the Dubawnt group (sandstones, porphyries etc., conglomerate). This then, is the first rather than the last word on this problem.

GSC 59-36 -- Biotite, K 7.98%, Ar^{40}/K^{40} .1593 K-Ar age 1,685 m.y.
Radiogenic argon 97%. Concentrate showed no trace of chlorite.
From migmatite gneiss containing abundant biotite; GSC Map 11-1959, 2,500 feet east of Cape Dorset, southwest Baffin Island, Northwest Territories; 64°13'N, 76°31'W. Collected and interpreted by S. H. Kranck.

The mica age should date the regional metamorphism and orogeny in southwest Baffin Island in relation to the rocks of Quebec and Labrador.

GSC 59-37 -- Muscovite, K 6.77%, Ar^{40}/K^{40} .1483, K-Ar age 1,605 m.y.
Radiogenic argon 96%. Concentrate contained no chlorite.
From a muscovite-biotite-bearing gneiss; map-unit 5, GSC Map 1061A, GSC Bull. 61 (in press), Baffin Island, Northwest Territories; 64°50'N, 66°05'W. Sample 202-51. Collected and interpreted by G. C. Riley.

This muscovite age determination suggests a subsequent period of retrogressive metamorphism, also suggested by petrographic evidence. (From same sample as GSC 59-38.)

GSC 59-38 -- Biotite and some muscovite, K 7.77%, Ar^{40}/K^{40} .1611, K-Ar age 1,700 m.y.
Radiogenic argon 98%. Concentrate contained no chlorite.
From a muscovite-biotite-bearing gneiss; map-unit 5, GSC Map 1061A, GSC Bull. 61 (in press), Baffin

Island, Northwest Territories; 64°50'N, 66°05'W. Sample 202-51. Collected and interpreted by G. C. Riley.

The difference in age between the muscovite (see GSC 59-37) and biotite agrees with the petrographic observations, in that the biotite is apparently older than the muscovite.

Saskatchewan

GSC 59-39 -- Biotite, K 3.07%, Ar^{40}/K^{40} .2109 K-Ar age 2,015 m.y.
Radiogenic argon 75%. Biotite only slightly altered to chlorite.
From pegmatite dyke, near Viking Lake in the Beaverlodge region of northern Saskatchewan; 59° 35'N, 108°17'W. Collected by S. C. Robinson. Interpreted by R. J. Traill.

The biotite was undoubtedly formed at the time of original crystallization of the pegmatite and there is no evidence of subsequent recrystallization. Although the outer zone of the pegmatite is considerably fractured and sheared, these effects are minimized in the inner zone and there is no reason to suspect any major loss of argon. The age of the biotite should date the time of pegmatite intrusion.

Uraninite from the same sample was dated in our laboratories by the Pb isotope method. The arithmetical average of the ages obtained from the four ratios Pb^{207}/Pb^{206}, Pb^{207}/U^{235}, Pb^{206}/U^{238}, and Pb^{208}/Th^{232} is 2,000 $\pm$65 m.y. - in close agreement with the age of the co-existing biotite.

Manitoba

GSC 59-40 -- Biotite, K 7.68%, Ar^{40}/K^{40} .1657, K-Ar age 1,730 m.y.
Radiogenic argon 95%. Concentrate showed no trace of chlorite.
From gneissic hornblende-biotite granodiorite; map-unit 2, GSC Map 2-1959, Northern Indian Lake, Manitoba; 57°21'N, 97°26'W. Sample KG-68-58. Collected and interpreted by R. Kretz.

The specified age refers to the last crystallization of the gneissic granodiorite in the Northern Indian Lake area. This was evidently a metamorphic recrystallization. Field evidence indicates that the biotite-garnet gneisses and amphibolites in the area were developed either at the same time as, or earlier than, this crystallization. The formation of large volumes of quartz monzonite and granite in the area evidently occurred at a later date. Some pegmatite-aplite dykes within the granodiorite almost certainly crystallized later.

GSC 59-41 -- Lepidolite, K 7.43%, Ar^{40}/K^{40} .3001, K-Ar age 2,480 m.y.
Radiogenic argon 87%.
From pegmatite dyke, Silver Leaf property; GSC Map 274A, Manitoba; 50°21'N, 95°21'30"W. Collected by R.B. Rowe. Interpretation by R.J. Traill.

In this complex pegmatite dyke the lepidolite occurs as deep lilac-coloured masses composed almost entirely of small flakes less than 1/4 inch in diameter. There is no evidence of alteration or recrystallization of the lepidolite subsequent to its formation.

Ontario

GSC 59-42 -- Biotite, K 6.10%, Ar^{40}/K^{40} .1593, K-Ar age 1,685 m.y.
Radiogenic argon 95%. Concentrate contained no chlorite.
From medium-grained granitic gneiss; map-unit 2b, GSC Map 23-1959, Echo Lake area, Ontario; 46°44'N, 83°50'W. Sample FC-3-58. Collected and interpreted by M.J. Frarey.

This age is of interest in that it is considerably younger than might be expected. The specimen was taken as representative of pre-Huronian basement granite, heretofore assumed to be about 2,500 m.y. old. If true, this date of 1,685 m.y. may indicate a period of tectonic activity previously unrecognized in the district.

GSC 59-43 -- Biotite, K 6.48%, Ar^{40}/K^{40} .1508, K-Ar age 1,625 m.y.
Radiogenic argon 99%.
From biotite schist that has been mapped as sheared basal Huronian (Mississagi) quartzite; south half of lot 1, con. 1, Porter tp., Ontario; 46°22'N, 81° 42'W. Collected and interpreted by R.J. Traill.

The biotite is unaltered and was undoubtedly formed at the time of shearing and metamorphism. The age should date the metamorphic event.

GSC 59-44 -- Muscovite and biotite, K 7.95%, Ar^{40}/K^{40} .0706, K-Ar age 930 m.y.
Radiogenic argon 58%.
From small pegmatite dyke, near Blackstone Lake, Conger tp., Ontario; 45°14'40"N, 77°51'W. Sample TF-56-23. Collected and described by R.J. Traill.

This sample was an intergrowth of approximately equal amounts of muscovite and biotite in flakes up to 1/4 inch in diameter. The sample had been exposed to surface weathering for several decades, and subsequent loss of argon is to be expected.

GSC 59-45 -- Muscovite, K 8.29%, Ar^{40}/K^{40} .0758, K-Ar age 985 m.y.
Radiogenic argon 98%.
From small pegmatite dyke near Blackstone Lake, Conger tp., Ontario; 45°14'40"N, 77°51'W. Collected and described by R.J. Traill.

The pegmatite is one of many small dykes that cut gneisses in the Parry Sound district. These dykes are generally considered to mark the end phase of the Grenville orogeny. The sample was the hand-cobbed central part of a single large muscovite book about 12 inches in diameter and 1 1/2 inches thick. The sample had been exposed to surface weathering for several decades, but the loss of argon should be slight.

Two uraninite samples from an adjacent pegmatite (within 1 mile), which were collected some 30 years ago by H.V. Ellsworth, have been dated in our laboratories by the Pb isotope method. The uraninites gave concordant age patterns; the arithmetical averages of the four isotopic ratios are 1,010 ± 40 m.y. and 1,005 ± 50 m.y. - in good agreement with the 985 m.y. age for the muscovite.

GSC 59-46 -- Biotite, K 3.33%, Ar^{40}/K^{40} .0557 K-Ar age 770 m.y.
Radiogenic argon 70%. Concentrate showed a high degree of chloritization.
From Besner pegmatite dyke, near Byng Inlet, Henvey tp., Ontario; 45°48'30"N, 80°31'30"W. Sample

TF-56-28. Collected and interpreted by R.J. Traill.

Loss of argon from this biotite as the result of weathering and alteration to chlorite could account for this lower biotite age (see GSC 59-47).

GSC 59-47 -- Microcline perthite, K 10.68%, Ar^{40}/K^{40} .0606, K-Ar age 825 m.y.
Radiogenic argon 90%.
From Besner pegmatite dyke, near Byng Inlet, Henvey tp., Ontario; 45°48'30"N, 80°31'30"W. Sample TF-56-29. Collected and interpreted by R.J. Traill.

The pegmatite is one of many small dykes that cut gneisses in the Parry Sound district. The samples (see GSC 59-46) were taken from the mine dump where they had been exposed to surface weathering for about 30 years. The feldspar age of 825 m.y. can only be accepted as a minimum date for the time of pegmatite intrusion.

Two uraninite samples from this pegmatite, collected and analyzed some 30 years ago by H.V. Ellsworth, were dated in our laboratories by the Pb isotope method and found to give discordant age patterns. The arithmetical averages of the ages obtained from the four ratios, Pb^{207}/Pb^{206}, Pb^{207}/U^{235}, Pb^{206}/U^{238}, and Pb^{208}/Th^{232}, are 870 ± 100 m.y. and 890 ± 110 m.y.

GSC 59-48 -- Biotite, K 7.24%, Ar^{40}/K^{40} .0683, K-Ar age 910 m.y.
Radiogenic argon 89%.
From a coarsely pegmatitic segregation in an underground skarn zone; map-unit 7 (in part), Ont. Dept. Mines Map 1957b, vol. 66, pt. 3, 1957, Cardiff tp., Ontario; 45°03'N, 78°10'W. Sample 56-RC-28. Collected and interpreted by S.C. Robinson.

Uraninite crystals were included within single books of mica, but the mica did not seem disrupted by them. The arithmetical average of the uraninite ages obtained from the four ratios, Pb^{207}/Pb^{206}, Pb^{207}/U^{235}, Pb^{206}/U^{238}, and Pb^{208}/Th^{232}, is 950 ± 45 m.y. It seems most probable that the biotite and uraninite are coeval and that the apparent difference in age may be due to loss of argon from the biotite.

GSC 59-49 -- Phlogopite, K 7.90%, Ar^{40}/K^{40} .0834, K-Ar age 1,060 m.y.
Radiogenic argon 96%.
From calcite-fluorite dykes; map-unit 3 (in part), Ont. Dept. Mines Map 1957b, vol. 66, pt. 3, 1957, Cardiff tp., Ontario; 45°01'N, 78°12'W. Sample 56-RC-29. Collected and described by S.C. Robinson.

This phlogopite occurs in large discrete crystals scattered sparsely through the calcite-fluorite dykes. Analogous distribution of uraninite suggests that it is of the same age and, in fact, the dates of the two minerals are essentially the same. The arithmetical average of the uraninite ages calculated from the four ratios, Pb^{207}/Pb^{206}, Pb^{207}/U^{235}, Pb^{206}/U^{238}, and Pb^{208}/Th^{232}, is 1,070 ± 25 m.y.

GSC 59-50 -- Biotite, K 5.60%, Ar^{40}/K^{40} .0658, K-Ar age 880 m.y.
Radiogenic argon 90%. Concentrate contained no chlorite.
From a small lens completely enclosed by massive, unfoliated leucogranite; map-unit 8, Ont. Dept. Mines Map 1957b, (Centre Lake sheet, as mapped by Hewitt), vol. 66, pt. 3, 1957, Cardiff tp., Ontario; 45°00'N, 78°02'W. Sample 58-RC-17. Collected and interpreted by S.C. Robinson.

It seems probable that the biotite crystallized during granitization of an inclusion; it is improbable that it has recrystallized since formation of the granite.

GSC 59-51 -- Biotite, K 7.31%, Ar^{40}/K^{40} .0806, K-Ar age 1,035 m.y.
Radiogenic argon 94%.
From a coarse-grained pegmatite dyke that is not radioactive; map-unit 8, Ont. Dept. Mines Map 1957b, vol. 66, pt. 3, 1957, Faraday tp., Ontario; 45°01'N, 77°53'W. Sample 56-RC-15. Collected and interpreted by S.C. Robinson.

Although this dyke is in contact with a radioactive dyke, the limited exposure underground does not permit evaluation of their relative ages. The mineralogy of the two dykes differs considerably, and as they occur together spatially, some appreciable difference in age is certain. The uraninite age (average of four ratios = 1,045 ± 30 m.y.) from a radioactive dyke is, however, substantially the same.

GSC 59-52 -- Biotite, K 7.20%, Ar^{40}/K^{40} .0979, K-Ar age 1,195 m.y.
Radiogenic argon 95%. Concentrate contained no chlorite.
From fine-grained, massive, granite-gneiss; map-unit 8, Ont. Dept. Mines Map 1957b, vol. 66, pt. 3, 1957. Faraday tp., Ontario; 45°03'N, 77°55'W. Sample 58-RC-12. Collected and interpreted by S.C. Robinson.

This granite-gneiss may well be a granitized sediment. The exceptionally great age is not in keeping with that of the Grenville orogeny which has affected other rocks of the area. Possibly this massive sheet of gneiss was unaffected by the orogeny due to its greater competence.

GSC 59-53 -- Phlogopite, K 7.41%, Ar^{40}/K^{40} .0856, K-Ar age 1,085 m.y.
Radiogenic argon 92%.
From skarn deposit; map-unit 3 (in part), Ont. Dept. Mines Map 1975b, vol. 65, pt. 6, 1956, p. 107, Dungannon tp., Ontario; 45°07'N, 77°47'W. Sample 58-SR-21. Collected and interpreted by S.C. Robinson.

Phlogopite in this skarn is found in small fresh crystals whose distribution is parallel with the small crystals of thorianite, indicating that they are probably of the same age. Thorianite lead-uranium and lead-thorium average age is 1,040 ± 10 m.y.

GSC 59-54 -- Biotite, K 7.58%, Ar^{40}/K^{40} .0697, K-Ar age 925 m.y.
Radiogenic argon 96%.
From pegmatite; map-unit 3 (in part), Ont. Dept. Mines Map 1957b, vol. 65, pt. 6, 1956, p. 136, Monteagle tp., Ontario; 45°10'N, 77°44'W. Sample 56-RC-41. Collected and interpreted by S.C. Robinson.

The biotite from this sharply delineated, unzoned pegmatite is fresh and only a little bent. It is almost certainly coeval with thorianite from the same dyke; the fact that the thorianite age is higher than the biotite age suggests loss of argon from this biotite. Thorianite lead-uranium and lead-thorium average ages are 965 ± 20 m.y. and 975 ± 40 m.y.

GSC 59-55 -- Biotite, K 7.07%, Ar^{40}/K^{40} .0692, K-Ar age 920 m.y.
Radiogenic argon 92%. Concentrate contained no chlorite.
From massive McArthur's Mills granite; map-unit 8, Ont. Dept. Mines Map 1957b, vol. 66, pt. 3, 1957, Mayo tp., Ontario; approx. 45°08'N, 77°33'W. Sample 58-RC-30. Collected by D.F. Hewitt for S.C. Robinson. Interpretation by S.C. Robinson.

Hewitt (Ont. Dept. Mines, vol. 64, pt. 8, 1955, "Geology of Dungannon and Mayo Townships") presented evidence suggesting that the McArthur's Mills granite is younger than the Boulter granite, whereas the K-Ar age of biotite from the McArthur's Mills body (920 m.y.) is greater than that from the Boulter body (865 m.y.). The Boulter granite is gneissic and is formed in the highly metamorphosed Haliburton Highlands terrain; the McArthur's Mills granite is massive and occurs in the Hastings Basin where metamorphism is much less intense. It is possible, therefore, that the biotite of the Boulter granite was recrystallized to a greater degree due to metamorphism, and thus gives a younger age.

GSC 59-56 -- Biotite, K 7.49%, Ar^{40}/K^{40} .0641, K-Ar age 865 m.y.
Radiogenic argon 90%. Concentrate contained less than 1% chlorite.
From foliated Boulter granite (tonalite); map-unit 8, Ont. Dept. Mines Map 1957b, vol. 63, pt. 6, 1954, Carlow tp., Ontario; 45°11'N, 77°37'W. Sample 58-RC-31. Collected by D.F. Hewitt for S.C. Robinson.
For interpretation see note on GSC 59-55.

GSC 59-57 -- Biotite, K 7.60%, Ar^{40}/K^{40} .0673, K-Ar age 900 m.y.
Radiogenic argon 94%. Concentrate contained no chlorite.
From micaceous facies of Blue Mountain nepheline syenite; map-unit 6, Ont. Dept. Mines Map 1957b,

and report on Methuen tp. by D.F. Hewitt (in press), Methuen tp., Ontario; 44°40'N, 77°58'W. Sample 58-RC-34. Collected by D.F. Hewitt for S.C. Robinson. Interpretation by S.C. Robinson.

Hewitt (private communication, July 21, 1958) stated that the Methuen granite intrudes the Blue Mountain syenite. Both rocks are in the little-metamorphosed Hastings Basin. Probably the biotite of the Blue Mountain syenite was recrystallized when intruded by the Methuen granite, thus giving an age younger than would be indicated by field evidence.

Quebec

GSC 59-58 -- Muscovite, K 6.62%, Ar^{40}/K^{40} .3331, K-Ar age 2,625 m.y.

Radiogenic argon 97%. Concentrate contained a trace of chlorite.

From small granite-pegmatite dykes that cut schistose greywacke, iron-formation, and tuff(?) along the western border of a belt of sedimentary and volcanic rocks; map-unit 1, GSC PS Map 23-1957, Sakami Lake, Quebec; 55°05'N, 76°50'W. Sample 58-GF-145. Collected by G.A. Gross.

For interpretation see GSC 59-59.

GSC 59-59 -- Muscovite, K 8.13%, Ar^{40}/K^{40} .3178 K-Ar age 2,555 m.y.

Radiogenic argon 96%. Concentrate contained no detectable impurities.

Medium-grained quartz-mica schist from drill core. The specimen consisted of light greenish grey muscovite schist with minor amounts of mafic minerals, part of a group of schistose rocks interbanded with the iron-formation (see GSC 59-58); map-unit 1, GSC PS Map 23-1957, Sakami Lake, Quebec; 55°05'N, 76°50'W. Sample 58-GF-156. Collected and described by G.A. Gross.

The purpose of these two analyses (GSC 59-58 and 59-59) was to obtain information on the age of a belt of sedimentary and volcanic rocks that is surrounded by granitic gneisses. The belt lies about 40 miles east of the mouth of Great Whale River, Quebec. Iron-formation of economic interest is extensively developed in the belt and although it is similar in lithology and geological setting to other iron-formations of 'Keewatin type', it occurs within 40 miles of iron-formation of 'Proterozoic type' on the east side of Hudson Bay. The question arises as to whether these two types of iron-formation, present in separate geological settings, were deposited contemporaneously but in different sedimentary environments, or whether they are unrelated in age and genesis.

The age of GSC 59-59 (2,555 m.y.) is believed to represent the age of metamorphism of the sedimentary and volcanic rocks of the Great Whale belt. Age determinations on rocks of the nearby Proterozoic belt are not yet available. The pegmatite dykes cutting the schistose greywacke rocks are considered to have formed at about the same time as metamorphism took place in the belt of sedimentary and volcanic rocks (GSC 59-58, 2,625 m.y.).

GSC 59-60 -- Biotite, K 6.84%, Ar^{40}/K^{40} .3073, K-Ar age 2,510 m.y.
Radiogenic argon 98%. Concentrate contained about 18% chlorite.
From paragneiss; map-unit 5, GSC PS Map 23-1958, Quebec; 54°54'N, 72°45'W. Sample HF-737-58. Collected by W. W. Heywood. Interpretation by K. E. Eade.

This is the type gneissic granite of a large area in this region and it is probably safe to assume that approximately the same result would be obtained over a wide region. It agrees with K-Ar ages (GSC 59-58, 2,625 m.y. and GSC 59-59, 2,555 m.y.) obtained in the region to the west.

GSC 59-61 -- Muscovite, K 8.85%, Ar^{40}/K^{40} .3114, K-Ar age 2,530 m.y.
Radiogenic argon 99%. Concentrate contained no chlorite.
From garnetiferous quartz-muscovite-feldspar pegmatite occurring as a concordant body in biotite-quartz-plagioclase paragneiss; map-unit 2, GSC PS Map 23-1958, Quebec; 53°33'N, 72°30'W. Sample HF-336-58. Collected by W. W. Heywood.
Interpretation by K. E. Eade.

The age agrees well with GSC 59-60 (2,510 m.y.) and GSC 59-59 (2,555 m.y.) which are from this general region. It indicates that the pegmatite cutting the paragneiss is of the same general age as the gneiss over a wide area just to the north.

GSC 59-62 -- Biotite, K 6.96%, Ar^{40}/K^{40} .2179, K-Ar age 2,055 m.y.
Radiogenic argon 96%. Concentrate contained only a faint trace of chlorite.
From granite-gneiss; map-unit 3, GSC Map 23-1958, Quebec; 52°11'N, 72°14'W. Sample HF 148/58. Collected by W.W. Heywood and interpreted by K.E. Eade.

Field evidence suggests that this rock is of approximately the same age as GSC 59-60 (2,510 m.y.). However, this specimen is from within 40 miles of the proposed line of the 'Grenville Front' and the effect of later metamorphism from the front has probably extended this far.

GSC 59-63 -- Biotite, K 6.75%, A^{40}/K^{40} .2765, KA age 2,365 m.y.
Radiogenic argon 96%. Concentrate contained a trace of chlorite.
From charnockite gneisses on the west side of the Labrador Trough, map-sheet Wakuach Lake, Quebec; 55°00'N, 67°50'W. Sample BLW 1 and 1a. Collected by S.C.J. Whelan. Interpretation by W.R.A. Baragar.

This gneissic complex to the west of the Labrador Trough is definitely older than rocks of the Trough. The complex includes recognizable paragneisses, amphibolitic gneisses of uncertain origin, granitic gneisses of varying mafic content, and granulites or charnockitic gneisses. The sample, composed chiefly of plagioclase, quartz, garnet, biotite, and pyroxene, belongs to the last group. A body of massive pink granite, apparently younger than the gneissic complex, is found about 15 miles to the north. The age determination dates the metamorphism of the gneissic complex, which probably coincides roughly with emplacement of the pink granite. It should provide a maximum age of the Labrador Trough rocks.

GSC 59-64 -- Biotite, K 6.91%, Ar^{40}/K^{40} .1877, K-Ar age 1,875 m.y.
Radiogenic argon 96%. Concentrate contained no chlorite.
From biotite-quartz-plagioclase gneiss; GSC PS map 17-59, Marion Lake area, Quebec; 54°58'25"N,

65°32'50"W. Sample 58-DF-1A. Collected and interpreted by J. A. Donaldson.

This gneiss outcrops east of the faulted eastern margin of the Labrador Trough. Foliation in the gneiss parallels the fault, suggesting the possibility of metamorphism and faulting during the same period of deformation. Because the fault truncates Trough strata, the biotite age may represent a minimum age for rocks of the Labrador Trough. Possibly, however, the gneiss is upthrust basement rock containing biotite formed during a period of metamorphism pre-dating deposition of Trough strata, in which case the biotite age would represent a maximum age for Trough rocks. Dating of known basement rocks west of the Trough should resolve the problem (see GSC 59-63).

GSC 59-65 -- Biotite, K 5.79%, Ar^{40}/K^{40} .1979, K-Ar age 1,935 m.y.
Radiogenic argon 99%. Concentrate contained a major amount of hornblende and traces of chlorite.
From very coarse-grained, pink, augen gneiss. Biotite layers give the rock a pronounced gneissic banding which is particularly evident on fresh surfaces. Map-unit 14, GSC Prel. Map 55-37, Lac Herodier, Quebec; 57°42'N, 68°41'W. Sample 55-122. Collected and interpreted by W. F. Fahrig.

The sample was collected from an area of regionally metamorphosed and granitized rocks along the eastern part of the Labrador Trough. These are believed to be the metamorphic equivalent of Trough strata of the Kaniapiskau group, and the biotite gives a first approximation of the minimum age of the group. Biotites from the older gneisses west of the Trough are generally several hundred million years older.

GSC 59-66 -- Muscovite, K 8.06%, Ar^{40}/K^{40} .3144, K-Ar age 2,540 m.y.
Radiogenic argon 86%.
From pegmatite; rge. 1, lot 28, Figuery tp., Quebec; map-unit 8, GSC Map 703A, 48°26.2'N, 78°8.5'W. Sample DB-6. Collected by K. R. Dawson. Described by N. J. Snelling.

The muscovite is from a pegmatite dyke that cuts the Preissac-Lacorne batholith; refractive indices: $\gamma = \beta = 1.596 \pm 0.002$.

GSC 59-67 -- Lepidolite, K 6.87%, Ar^{40}/K^{40} .3601, K-Ar age 2,735 m.y.
Radiogenic argon 100%.
From pegmatite; rge. 8, lot 21, Lacorne tp., Quebec; map-unit 8, GSC Map 703A; 48°23.3'N, 77°55.9'W. Sample DB-707. Collected by K.R. Dawson. Described by N.J. Snelling.

The lepidolite is from a pegmatite dyke that cuts the Preissac-Lacorne batholith; refractive indices: $\gamma = \beta = 1.571 \pm 0.002$.

GSC 59-68 -- Muscovite, K 7.30%, Ar^{40}/K^{40} .3605, K-Ar age 2,735 m.y.
Radiogenic argon 96%.
From pegmatite; map-unit 8, GSC Map 703A, Quebec; 48°23.3'N, 77°55.9'W. Sample DB-707. Collected by K.R. Dawson. Described by N.J. Snelling.

The muscovite is from the same pegmatite dyke as the lepidolite of GSC 59-67; refractive indices: $\gamma = \beta = 1.572 \pm 0.002$.

GSC 59-69 -- Biotite, K 5.78%, Ar^{40}/K^{40}
.2512, K-Ar age 2,240 m.y.
.2603, K-Ar age 2,285 m.y. } Average 2,310 m.y.
.2847, K-Ar age 2,405 m.y.
Radiogenic argon 94%. Concentrate contained about 20 to 30% chlorite.
From granodiorite; rge. 7, lot 17, Vassar tp., Quebec; map-unit 8, GSC Map 703A, 48°14.7'N, 77° 56.1' W. Sample DB-425. Collected by K.R. Dawson. Described by N.J. Snelling.

The biotite is from a muscovite-biotite granodiorite of the Preissac-Lacorne batholith; refractive indices of the biotite: $\gamma = \beta = +1.649 \pm 0.002$.

GSC 59-70 -- Muscovite, K 7.87%, Ar^{40}/K^{40}
.3399, K-Ar age 2,650 m.y. } Average 2,630 m.y.
.3305, K-Ar age 2,610 m.y.
Radiogenic argon 95%; 96%.
From granodiorite; map-unit 8, GSC Map 703A, Quebec; 48°14.7'N, 77°56.1'W. Sample DB-425. Collected by K.R. Dawson. Described by N.J. Snelling.

The muscovite is from the same sample as the biotite of GSC 59-69. The two minerals are primary and must have crystallized at virtually the same time. Refractive indices of the muscovite: $\gamma = \beta = 1.596 \pm 0.002$.

GSC 59-71 -- Biotite, K 5.55%, Ar^{40}/K^{40} .2956, K-Ar age 2,455 m.y.
Radiogenic argon 97%. X-ray diffraction analysis of the concentrate revealed no trace of chlorite.
From biotite schist; Lacorne molybdenite mine, rge. 1, lot 1, Lacorne tp., Quebec, map-unit 6, GSC Map 703A; 48°17.3'N, 77°59.5'W. Sample DB-156A. Collected by K.R. Dawson. Described by N.J. Snelling.

The biotite of this rock is believed to be the result of thermal metamorphism, caused by the Preissac-Lacorne batholith, superimposed on low-grade sericite-chlorite schists of the Abitibi group; refractive indices of the biotite: $\gamma = \beta = 1.600 \pm 0.002$.

GSC 59-72 -- Biotite, K 6.78%, Ar^{40}/K^{40} .2775, K-Ar age 2,370 m.y.
Radiogenic argon 86%. X-ray diffraction analyses revealed no chlorite in the concentrate.
From dark-coloured, fine-grained biotite granodiorite; map-unit 8, GSC Map 703 A, Quebec; 48°17.3'N, 77°59.5'W. Sample DB-156. Collected by K.R. Dawson. Described by N.J. Snelling.

The granodiorite is from the Preissac-Lacorne batholith close to the schist of GSC 59-71. A modal analysis, in volume per cent, of the granodiorite showed: quartz, 25.5%; plagioclase (An_{15}), 54.6%; microcline, 3.6%; biotite, 12.4%; epidote, 1.7%; and apatite, 0.3%. Refractive indices of the biotite: $\gamma = \beta = 1.622 \pm 0.002$.

GSC 59-73 -- Biotite, K 6.72%, Ar^{40}/K^{40} .3044, K-Ar age 2,500 m.y.
Radiogenic argon 98%. X-ray diffraction analysis indicated that the biotite was unaltered.
From hornblende-biotite granodiorite; rge. 9, lot 1, Lacorne tp., Quebec, Map-unit 8, GSC Map 703A; 48°25'N, 77°59'W. Sample DB-152, Collected by K.R. Dawson. Described by N.J. Snelling.

The granodiorite is from the Preissac-Lacorne batholith. A modal analysis, in volume per cent, of the granodiorite gave: quartz, 16.4%; microcline, 14.7%; plagioclase, (An_{15}), 47.0%; biotite, 8.9%; hornblende, 8.3%; glaucophane, 1.1%; epidote, 3.0%; sphene, 0.4%; and apatite, 0.3%. Refractive indices of the biotite: $\gamma = \beta = 1.620 \pm 0.002$.

GSC 59-74 -- Biotite, K 6.73%, Ar^{40}/K^{40} .2944, K-Ar age 2,450 m.y.
Radiogenic argon 88%. Biotite is unaltered.
From fine-grained biotite granodiorite; rge. 9, Malartic tp., Quebec, map-unit 8, GSC Map 703A; 48°17.3'N, 78°05'W. Sample DB-263. Collected by K.R. Dawson. Described by N.J. Snelling.

The granodiorite is from the Preissac-Lacorne batholith. A modal analysis, in volume per cent, of the granodiorite gave: quartz, 23.8%; plagioclase (An_{33}), 60.7%; biotite, 7.7%; epidote, 7.4%; iron oxides, 0.4%; and hornblende, 0.3%. Refractive indices of the biotite: $\gamma = \beta = 1.631 \pm 0.002$.

GSC 59-75 -- Biotite, K 7.28%, Ar^{40}/K^{40} .3253, K-Ar age 2,590 m.y.
Radiogenic argon 95%. Biotite is unaltered.
From coarse foliated biotite granodiorite; rge. 1, lot 41, Montgay tp., north of Senneterre, Quebec, map-unit 11b, GSC Map 997A; 48°21.8'N, 77°11'W. Sample DB -11-58. Collected by N.J. Snelling and K.R. Dawson. Described by N.J. Snelling.

The granodiorite is from an extensive and virtually unknown area of foliated gneiss and granitic rock that occurs along the north-eastern margin of the Abitibi group. Refractive indices on the biotite: $\gamma = \beta = 1.640 \pm 0.002$.

GSC 59-76 -- Chloritized biotite, K 1.67%, Ar^{40}/K^{40} .3270, K-Ar age 2,600 m.y.
Radiogenic argon 72%.
From quartz monzonite; Beraud tp., Rapid 7 road, 24 miles south of Cadillac, Quebec, map-unit 2, Quebec Bur. Mines Map 1167, P.R. 340; 47°56.5'N, 78°19.2'W. Sample DB-688. Collected by P.V. Freeman and K.R. Dawson. Described by N.J. Snelling.

The mode of the quartz monzonite, in volume per cent, is as follows: quartz, 28.9%; plagioclase, 28.9%; microcline, 37.9%; chlorite, 4.1%; muscovite, 1.9%; and epidote, 0.1%. The chlorite recorded in the mode occurred as pseudomorphs after biotite. However, the presence of 1.67% K indicated that alteration was not quite complete.

GSC 59-77 -- Biotite, K 7.09%, Ar^{40}/K^{40} .2960, K-Ar age 2,460 m.y.
Radiogenic argon 100%. The biotite is fresh.
From biotite schist; Beraud tp., Rapid 7 road, 23 miles south of Cadillac, Quebec, map-unit 2, Quebec Bur. Mines Map 1167, P.R. 340; 47°57'N, 78°22'W. Sample DB-686. Collected by K.R. Dawson and P.V. Freeman. Described by N.J. Snelling.

From a quartz-biotite-muscovite schist of the Pontiac group; refractive indices of the biotite: $\gamma = \beta = 1.631 \pm 0.002$.

GSC 59-78 -- Biotite, K 7.25%, Ar^{40}/K^{40} .2606, K-Ar age 2,285 m.y., .2611, K-Ar age 2,290 m.y.
Radiogenic argon 94%; 100%. Biotite is unaltered.
From biotite granodiorite; Beraud tp., Rapid 7 road, 23 miles south of Cadillac, Quebec, map-unit 2, Quebec Bur. Mines Map 1167, P.R. 340; 47°57'N, 78°22'W. Sample DB-685. Collected by P.V. Freeman and K.R. Dawson. Described by N.J. Snelling.

The modal analysis of this rock in volume per cent is as follows: quartz, 23.6%; microcline, 10.8%; plagioclase, 58.6%; biotite, 6.3%; hornblende, 0.2%; and epidote, 0.4%. Refractive indices of the biotite: $\gamma = \beta = 1.623 \pm 0.002$.

GSC 59-79 -- Biotite, K 7.19%, Ar^{40}/K^{40} .2457, K-Ar age 2,205 m.y.
Radiogenic argon 92%. Biotite is unaltered.
From biotite-hornblende-quartz syenite; Freville tp., Quebec, on highway 58 about half-way between mile posts 144 and 145, map-unit 8, GSC Map 703A; 47°48.8'N, 77°20.7'W. Sample DB-5-58. Collected by N.J. Snelling and K.R. Dawson. Described by N.J. Snelling.

The syenite is from a stock that intrudes members of the Abitibi group. Refractive indices on the biotite: $\gamma = \beta = 1.628 \pm 0.002$.

GSC 59-80 -- Biotite, K 7.39%, Ar^{40}/K^{40} .1585, K-Ar age 1,680 m.y., .1623, K-Ar age 1,705 m.y.
Radiogenic argon 93%; 97%.
From muscovite-biotite schist; about 100 yards south of mile-post 142 on highway 58, Quebec, map-unit 2a, GSC Map 703A; 47°47.4'N, 77°19'W. Sample DB-6-58. Collected by N.J. Snelling and K.R. Dawson. Described by N.J. Snelling.

This is the only known exposure along highway 58 between the localities of GSC 59-79 and 59-81. The muscovite-biotite schist consists essentially of mica, quartz, and oligoclase. Refractive indices for the biotite: $\gamma = \beta = 1.638 \pm 0.002$.

GSC 59-81 -- Biotite, K 7.59%, Ar^{40}/K^{40} .0723, K-Ar age 950 m.y.
Radiogenic argon 68%.
From garnet-biotite gneiss; mile-post 139 on highway 58, Quebec, map-unit 2a, GSC Map 703A; 47°45.8'N, 77°18.7'W. Sample M-139. Collected by N.J. Snelling.

Refractive indices: $\gamma = \beta = 1.632 \pm 0.002$.

GSC 59-82 -- Biotite, K 7.32%, Ar^{40}/K^{40} .0670, K-Ar age 895 m.y.
Radiogenic argon 80%.
From coarse biotite granite from pod in micaceous gneiss; about 1/2 mile north of mile-post 120 on highway 58, Quebec, Quebec Bur. Mines Map 910; 47°33.8'N, 77°09'W. Sample DB-10-58. Collected by N.J. Snelling and K.R. Dawson. Described by N.J. Snelling.

The granite consists essentially of quartz, perthite, sodic plagioclase, and biotite. Refractive indices on biotite: $\gamma = \beta = 1.650 \pm 0.002$.

GSC 59-83 -- Biotite, K 8.00%, Ar^{40}/K^{40} .0747, K-Ar age 975 m.y.
Radiogenic argon 92%.
From garnet-biotite gneiss; between mile posts 116 and 117 on highway 58, Quebec, Quebec Bur. Mines Map 910; 47°31'N, 77°05'W. Sample DB-9-58. Collected by N. J. Snelling and K. R. Dawson. Described by N. J. Snelling.

The gneiss consists essentially of garnet, biotite, quartz, and sodic plagioclase. Refractive indices for the biotite: $\gamma = \beta = 1.634 \pm 0.002$.

GSC 59-84 -- Biotite, K 7.89%, Ar^{40}/K^{40} .0629, K-Ar age 850 m.y.
Radiogenic argon 73%.
From biotite gneiss; at mile-post 112 on highway 58, Quebec, Quebec Bur. Mines Map 820; 47°25'N, 77°5.8'W. Sample DB-2-58. Collected by N. J. Snelling and K.R. Dawson. Described by N. J. Snelling.

The biotite gneiss consists essentially of garnet, biotite, quartz, and andesine. Refractive indices on the biotite: $\gamma = \beta = 1.638 \pm 0.002$.

GSC 59-85 -- Biotite, K 7.81%, Ar^{40}/K^{40} .0771, K-Ar age 1,000 m.y.
Radiogenic argon 94%.
From granitic biotite granite; at mile-post 107 on highway 58, Quebec, Quebec Bur. Mines Map 820; 47°20'N, 77°00'W. Sample DB-8-58. Collected by N. J. Snelling and K.R. Dawson. Described by N. J. Snelling.

The granitic gneiss occurs as a lens in hornblende gneiss and consists essentially of quartz, sodic plagioclase, and biotite with minor amounts of sillimanite generally replacing biotite. Refractive indices on the biotite: $\gamma = \beta = 1.636 \pm 0.002$.

GSC 59-86 -- Biotite, K 7.38%, Ar^{40}/K^{40} .0707, K-Ar age 935 m.y.
Radiogenic argon 87%.

From pegmatite dyke; Lac Pieds des Monts, Charlevoix County, Quebec; 47°46'N, 70°24'W. Sample TF-56-18. Collected and interpreted by R.J. Traill.

The pegmatite dyke from which the mica was mined is one of many such dykes that cut metasediments and presumably mark the final stage of the Grenville orogeny. Large books of the two types of mica (see GSC 59-87) were collected underwater at the east end of the lake where they are believed to have lain since the mine was operated more than 30 years ago. The hand-cobbed central parts of the books were used for the age determinations. Neither of the samples appeared to be altered.

A sample of uraninite from the same pegmatite has been dated by the Pb isotope method in our laboratories. It was collected in 1894 by J. Obalski and a part was analyzed chemically by H.V. Ellsworth in, or about 1933. Our Pb isotope analysis was made on a $PbSO_4$ residue from Ellsworth's analysis. The uraninite gave a discordant Pb^{208}/Th^{232} age, but close agreement at 990 ± 20 m.y. between the ages calculated from the Pb^{207}/Pb^{206}, Pb^{207}/U^{235}, and Pb^{206}/U^{238} ratios. The uraninite and mica ages are in reasonable agreement considering the histories of the samples.

<u>GSC 59-87</u> -- Muscovite, K 8.30%, Ar^{40}/K^{40} .0696, K-Ar age <u>925 m.y.</u>
Radiogenic argon 85%.
From pegmatite dyke; Lac Pieds des Monts, Charlevoix County, Quebec; 47°46'N, 70°24'W. Sample TF-56-19. Collected by R.J. Traill.
For interpretation see GSC 59-86.

<u>GSC 59-88</u> -- Muscovite, K 8.04%, Ar^{40}/K^{40} .0291, K-Ar age <u>440 m.y.</u>
Radiogenic argon 89%. Concentrate contained no chlorite.
From muscovite schist; GSC PS Map 6-1959, Mt. Wright area, Quebec; 52°33'N, 67°53'W. Sample DE-58-119. Collected and interpreted by S. Duffell.

This muscovite schist is from a pelitic zone in quartzite associated with the iron-formation of the Mt. Wright area. It was anticipated that this muscovite would date the metamorphism that had affected the rocks of the iron-formation sequence, and perhaps the whole region. The very young date is quite surprising as it was expected that the age would prove to be of the order of 900 m.y., that is general for the Grenville province from which this specimen was obtained. This young age may therefore indicate that at least some of the metamorphism in the Grenville is much younger than 900 m.y.

<u>GSC 59-89</u> -- Biotite, K 6.88%, Ar^{40}/K^{40} .0233, K-Ar age <u>362 m.y.</u>
Radiogenic argon 72%. Concentrate contained very minor chlorite.
From coarse-grained massive Ste. Cecile biotite granite that intrudes sedimentary rocks of Ordovician age; map-unit 4, GSC Map 379A, rge. 9, Gayhurst tp., Frontenac County, Eastern Townships, Quebec; 45°45'N, 70°55'05"W. Sample 279-MA-56. Collected and interpreted by A.S. MacLaren.

The age of the biotite from this sample and the ages of those from GSC 59-90 and 59-91 are of the same order of magnitude as ages from Nova Scotia granites (320, 325, and 365 m.y.) which intrude Lower Devonian strata (Harold W. Fairbairn, Dept. Geol. Geophys., Mass. Inst. Technol., U.S. Atomic Energy Comm., Fifth Ann. Prog. Rept., March 1, 1958, p. 16).

<u>GSC 59-90</u> -- Biotite, K 6.99%, Ar^{40}/K^{40} .0245, K-Ar age <u>379 m.y.</u>
Radiogenic argon 79%. Concentrate contained very minor chlorite.
From medium-grained grey biotite granite; map-unit 19, GSC Map 994A, Mem. 257, Weedon mine, Compton County, Quebec; 45°42'N, 71°22'30"W. Sample 1,000-L-56. Collected by A. Larochelle.
For interpretation see GSC 59-89.

<u>GSC 59-91</u> -- Biotite, K 6.62%, Ar^{40}/K^{40} .0204, K-Ar age <u>320 m.y.</u>
Radiogenic argon 79%. Concentrate contained no chlorite.
From coarse-grained, grey granite that intrudes serpentinite in the southeast wall of the Jeffrey mine Shipton tp., Quebec, GSC Map 52A; 45°45'05"N, 71°57'30"W. Sample 592-MA-56. Collected by A.S. MacLaren.
For interpretation see GSC 59-89.

GSC 59-92 -- Biotite, K 6.92%, Ar^{40}/K^{40} .00735, K-Ar age 122 m.y.
Radiogenic argon 63%. Concentrate contained no chlorite.
From medium-grained mottled black and grey-weathering nordmarkite; GSC Map 901, Ann. Rept., 1904, vol. 16, pt. 6, Brome tp., Quebec; 45°17'50"N, 72°37'35"W. Sample A-7. Collected and interpreted by A.S. MacLaren.

The fresh biotite is presumed to be the same age as the nordmarkite. The nordmarkite intrudes sedimentary rocks of Cambrian age, and the K-Ar age indicates that it is probably Lower Cretaceous and one of the youngest intrusive rocks in Eastern Canada.

Nova Scotia

GSC 59-93 -- Biotite, K 7.10%, Ar^{40}/K^{40} .0234, K-Ar age 363 m.y.
Radiogenic argon 74%. Concentrate contained a trace of chlorite.
From coarse-grained porphyritic granodiorite; Nictaux-Torbrook area, Nova Scotia; 44°49'N, 64°49'W. Sample SJ-452B. Collected and interpreted by W.G. Smitheringale.

This sample was taken from a granitic body previously considered to be part of the southern Nova Scotia batholith. Bodies of granitic rock similar in texture and composition to this sample, and within the map-area from which this sample was collected, intrude the fossiliferous Torbrook formation of Lower Devonian age.

Newfoundland

GSC 59-94 -- Biotite, K 4.58%, Ar^{40}/K^{40} .0153, K-Ar age 244 m.y.
Radiogenic argon 56%. Concentrate contained approximately 30% chlorite.
From red, massive, fine-grained granite; map-unit 6, GSC PS Map 3-1957, east of Gander, Newfoundland; 48°51'N, 54°21'6"W. Sample S-55-223. Collected by S.E. Jenness.
For interpretation see GSC 59-95.

GSC 59-95 -- Muscovite, K 8.14%, Ar^{40}/K^{40} .0225, K-Ar age 350 m.y.
Radiogenic argon 75%. Concentrate contained no chlorite.
From red, massive, fine-grained granite; map-unit 6, GSC PS Map 3-1957, east of Gander, Newfoundland; 48°51'N, 54°21'6"W. Sample S-55-223. Collected and interpreted by S.E. Jenness.

The granite metamorphoses nearby arenites of the Gander Lake group of probable Middle Ordovician age. The age determined on the muscovite differs considerably from that on biotite from the same sample (GSC 59-94). As the biotite is partly altered, the muscovite age of 350 m.y. is probably more reliable.

GSC 59-96 -- Biotite, K 6.78%, Ar^{40}/K^{40} .0202, K-Ar age 317 m.y.
Radiogenic argon 10%. Concentrate contained 4% chlorite.
From mica schist forming an inclusion in granite of map-unit 6, GSC PS Map 3-1957, Maccles Pond, Newfoundland; 48°37.2'N, 54°13.5'W. Sample S-55-135A. Collected and interpreted by S.E. Jenness.

The sample is from feldspathized (or granitized) mica schist enclosed and cut by granite. The schist is a metamorphosed member of the Gander Lake group. Seemingly ungranitized xenoliths of quartz-mica schist occur in the associated granite body. The 317 m.y. age is probably good but may reflect post-granite recrystallization.

GSC 59-97 -- Biotite, K 5.54%, Ar^{40}/K^{40} .0242, K-Ar age 374 m.y.
Radiogenic argon 79%. Concentrate contained 40% chlorite.
From white granite; map-unit 6a, GSC PS Map 3-1957, west of Gambo, Newfoundland; 48°39'N, 54°45'W. Sample S-55-228. Collected by S.E. Jenness.
For interpretation see GSC 59-98.

GSC 59-98 -- Muscovite, K 8.10%, Ar^{40}/K^{40} .0211, K-Ar age 330 m.y.
Radiogenic argon 82%. Concentrate contained no chlorite.

From white granite (same sample as GSC 59-97); map-unit 6a, GSC PS Map 3-1957, west of Gambo, Newfoundland; 48°39'N, 54°45'W. Sample S-55-228. Collected and interpreted by S.E. Jenness.

The specimen is from a boulder more than 4 feet in diameter. The source of the boulder is within 4 miles to the west of the above location, from within the white granite mass. This granite contact metamorphoses adjoining middle Ordovician Gander Lake group sediments and volcanic rocks. It is locally pegmatitic and may be a late-crystallization differentiate of the granite of map-unit 6 (see GSC 59-95). The age determined on the muscovite differs somewhat from that on biotite from the same specimen (GSC 59-97). As the biotite is partly altered, the muscovite age of 330 m.y. is probably more reliable.

The ages 350 m.y. (GSC 59-95), 317 m.y. (GSC 59-96), and 330 m.y. (GSC 59-98) are of the same order of magnitude as ages from Nova Scotia granites (320, 325, and 365 m.y.) which intrude Lower Devonian strata. (Harold W. Fairbairn, Dept. Geol., Geophys., Mass. Inst. Technol., U.S. Atomic Energy Comm., Fifth Ann. Prog. Rept., March 1, 1958, p. 16).

-- PART II --

INTERPRETATIONS

Note on the Interpretation of the U-Pb, Th-Pb and K-Ar Ages in the Bancroft, Ontario Region

By S. C. Robinson

This note is to discuss possible mineralogical and geological factors that may have a bearing on the interpretation of the computed ages. In Bancroft, as elsewhere, some of the uraninite and thorianite samples yield discordant results from the Pb^{206}/U^{238}, Pb^{207}/U^{235}, Pb^{207}/Pb^{206}, and Pb^{208}/Th^{232} ratios. The reasons for this discordance will not be reviewed here; only those samples yielding roughly concordant ages from at least three of the ratios are included in Table I.

TABLE I

Age Determinations - Bancroft Region, Ontario

GSC No.	Rock or Deposit	U/Th Ratio	Mineral	Age (m.y.)
59-52	Faraday granite	—	biotite	1,195
59-55	McArthur's Mills granite	—	biotite	920
59-57	Blue Mtn. Nepheline syenite	—	biotite	900
59-50	Centre Lake granite	—	biotite	880
59-56	Boulter tonalite	—	biotite	865
—	Bicroft Mine (pegmatitic granite dyke)	6.79	(a) uraninite	1,065±25*
		3.86	(b) "	1,005±25
		3.86	(c) "	1,000±20
		10.3	(d)	955±30

* The figure reported for the age of the uraniferous minerals is the average of the values calculated from the Pb^{206}/U^{238}, Pb^{207}/U^{235}, Pb^{208}/Th^{232}, and Pb^{207}/Pb^{206} ratios. An indication of the concordance between the individual ages is given by the average error associated with the reported age.

(cont'd)

GSC No.	Rock or Deposit	U/Th Ratio	Mineral	Age (m.y.)
—	Bicroft Mine (pegmatitic granite dyke)	0.23 0.28	uranothorite "	600±50 725±75
59-51	Faraday Mine (pegmatitic granite dyke)	8.25	uraninite biotite	1,045±30 1,035
59-54	Mentor deposit (unzoned pegmatite)	0.86 0.86	(a)thorianite (b) " biotite	965±20 975±40 925
59-48	Nu-Age deposit (unzoned pegmatitic skarn)	5.2 4.7	uraninite uraninite biotite	995±10 950±45 910
59-49	Cardiff U. Mine (calcite-fluoritic 'vein-dyke')	4.44	uraninite phlogopite	1,070±25 1,060
59-53	Normingo deposit (calcite-phlogopite-diopside skarn)	0.83	thorianite phlogopite	1,040±10 1,085
—	Camex deposit (calcite-phlogopite-diopside skarn)	0.835	thorianite	1,000±30

Uraninite - Thorianite Ages

The ages of uraninite and thorianite in Table I are in satisfactory agreement with ages for these deposits reported by other laboratories. Reproducibility indicated by repeated analyses on the same sample of uraninite from Bicroft (1,000, 1,005 m.y.) and of thorianite from Mentor (965, 975 m.y.) is entirely satisfactory. For this reason it is improbable that difference in ages of samples of uraninite taken from different places in the same deposit - Bicroft (1,003, 1,065, 955), Nu-Age (950, 995) - can be attributed to analytical error, and must therefore have some geological significance.

There is insufficient evidence to provide a satisfactory explanation of the divergence in ages of uraninite and thorianite from the different deposits and from different parts of the same deposit in the region. However, the following factors should be considered:

1. Uraninite in most deposits appears to have been formed at the same time as the enclosing rock. In a few deposits there is evidence of later enrichment of uranium minerals, principally uranothorite, in shattered zones in the dykes.

2. There is little evidence of supergene alteration of the uraninite. Extremely minute bright specks may be seen under magnifications of 1,000 diameters in some uraninite crystals. These may be galena, which has been positively identified in only one case. This galena might have been formed as original inclusions in the uraninite. The anomalously high content of Pb^{204} in many uraninites from this district may be due to this galena.

Lead-isotope ratios of galena from the MacDonald mine and from a vug in the Bicroft mine are in the range of modern ore leads. They are not markedly anomalous as they would be if the lead in them had been derived from uraninite or uranothorite.

3. There is wide variation in the ratio of uranium to thorium in samples of the uraninite-thorianite series represented in the table, but there is no indication of systematic variation in age with composition, despite the much greater mobility of U than Th in supergene alteration processes.

4. Concordant uraninite-thorianite ages from the Bancroft region (reported in Table I) vary from 950 to 1,070 m.y. and average 1,010 m.y.

5. There is no clear difference in the age of uraninites or thorianites from different types of deposits in the region.

Uranothorite Ages

Uranothorite ages are generally lower - many much lower - than those obtained on uraninite from the same deposit. Except for the two given in Table I, all are markedly discordant. Studies of the mineral indicate that specimens are nearly all traversed by networks of curving fractures and that all specimens are metamict. X-ray studies reveal traces of galena in many samples. These facts suggest that lead may have been lost to the surrounding rocks. R.W. Boyle (personal communication) reports that he found concentrations of lead in fractures radiating from a crystal of allanite. It seems probable that similar differential loss of lead accounts for the low and discordant ages of uranothorite.

Thorite Ages

Ages from tabular crystals of thorite from two properties are discordant but markedly higher than those of other minerals from the region. Their Pb^{208}/Th^{232} ages are 1,245 and 1,450 m.y., and ages based on Pb^{206}/U^{238} ratios are 1,845 and 1,630 m.y. respectively. These specimens yield an X-ray pattern of thorite and contain little Pb^{204}. Their contents of U are 1.7% and 1.8%, and of Th are 34.7% and 31.5%. Correction for traces of Pb^{204} as ore lead of 1,000 m.y. reduces the Pb^{207}/Pb^{206} ages of these thorites to zero. Although the crystals have rough tetragonal form, internally they are composed of a mixture of thorite and quartz, indicative of pronounced change (pseudomorphism or replacement). Interpretation of their ages must await dating of zircon with which they are associated. It is worth noting however that, geochemically, loss of lead is more likely than loss of thorium, and that most Pb^{208}/Th^{232} ages are low.

Biotite Ages

Biotite concentrates from five major granite masses in the region and from a radioactive skarn, a pegmatitic granite dyke, and an unzoned pegmatite, have been dated. The ages of biotite range from 865 to 1,195 m.y. and average 954 m.y. However two of these dates, 1,035 and 1,195 m.y., depart significantly from the norm. If they are omitted, the range is 865 to 920 and the average is 900 m.y. The older biotite comes from the non-hybrid part of the Faraday granite mass, and the other from a non-radioactive dyke in the Faraday mine, on the south flank of the Faraday granite. The other biotites are from four other granitic bodies in the region and two radioactive deposits.

Phlogopite Ages

Phlogopite from a radioactive skarn and from a calcite-fluorite 'vein-dyke' gives ages of 1,085 and 1,060 m.y. respectively, an average of 1,073 m.y. It is virtually certain that in both cases the phlogopite and uraninite or thorianite are coeval.

Summary

1. It is apparent that most ages for the region are in the range 900-1,050 m.y.

2. Average ages in m.y. for the various minerals, and the ranges in age, are given in Table II.

TABLE II

Age Determinations - Bancroft Region, Ontario

Mineral	Range in Age (m.y.)	No. of Samples	Average Age (m.y.)
Thorite	1,245-1,845	2	1,500 approx.
Phlogopite	1,060-1,085	2	1,073
Uraninite-thorianite	950-1,070	10	1,010
Biotite*	865-920	6	900
Uranothorite	600-725	2	660 approx.

* Biotite from Faraday granite and Faraday mine (non-radioactive dyke) is omitted; these dates are 1,195 and 1,035 m.y. and would bring the biotite average to 954 m.y.

3. It is apparent that the two phlogopite ages are in general agreement with uraninite-thorianite ages from the same deposits. Biotite ages, on the other hand are consistently lower than uraninite-thorianite ages from the same deposits. This conclusion is all the more striking when it is recognized that biotite in the Faraday mine came from a non-radioactive dyke that is probably not coeval with the ore because its mineral composition is entirely different from that of the ore dykes. There is little evidence to suggest that radioactive decay of uraninite or uranothorite had any significant effect on retention of argon in biotites. Crystals of uraninite and uranothorite were contained as inclusions in

the biotite dated from the Nu-Age deposit. Uranothorite ages are all low and variable.

4. The systematic difference in age of biotite and uraninite-thorianite from the same deposit probably indicates loss of argon from the biotite. By contrast, it would appear that little argon is lost from phlogopite in similar conditions. Low ages from uranothorites are probably due to loss of lead as a result of the destruction of crystal bonding, leading to their present metamict state. Variable and discordant ages of uraninite and thorianite are linked with an abnormally high Pb^{204} content of many samples, and possibly the occurrence of galena inclusions in the original uraninite crystals.

5. In some instances the biotite ages conflict with relative ages deduced from field evidence. For example, the biotite from Boulter tonalite gives a younger age than the biotite from McArthur's Mills granite; yet on field evidence, Hewitt (Ont. Dept. Mines, vol. 64, pt. 8, 1955) concludes that Boulter tonalite is older than McArthur's Mills granite. Six of the eight biotite ages fall into the 865-920 m.y. range. These biotites probably formed at approximately the same time; some as constituents of intrusive igneous rocks and others as products of metamorphism accompanying the intrusion. In general, biotites from the less competent and more highly foliated rocks yield lower ages than those from the more competent rocks. It is suggested, therefore, that subsequent minor metamorphism may have had more effect in expelling argon from biotites in incompetent rocks than from biotites protected by structurally stronger, competent, and possibly thermally more resistant masses.

A similar protective effect may be responsible for the greater age of biotite from the massive Faraday granite-gneiss. Where the sample was taken at the south end of Faraday Lake, this rock is a hard fresh granite-gneiss, free from inclusions of other rocks. It seems likely that this rock was sufficiently competent for the biotite in it to be little affected by the main period of metamorphism that characterizes the Grenville sub-province.

Future Work

The Bancroft region provides a particularly wide range of radioactive minerals in a variety of rocks and mineral deposits. We propose to continue a study of the interpretation of the ages of these minerals, and to extend the study to potash feldspar, zircon, titanite, and muscovite, and to the isotopic composition of lead from all minerals from which it can be extracted. We also plan to attempt syntheses of various minerals, followed by studies of recrystallization of minerals in autoclaves. Studies of diffusion and transfer of heat through host rocks are also proposed.

K-Ar Dating in Keewatin and Eastern Mackenzie Districts, Northwest Territories

By G.M. Wright

The samples considered in this section[1] were all collected on helicopter reconnaissance surveys by Lord (1953)[2] and Wright (1955, 1956). They are discussed below as preliminary indicators only. A most interesting phase in geological study based on almost wholesale availability of K-Ar dates is obviously beginning, but much detailed work remains before the many questions already arising will be answered.

Granitic Gneisses and Allied Rocks in the Churchill Province

Samples GSC 59-27 (2,040 m.y.), GSC 59-30 (1,605 m.y.), GSC 59-31 (1,805 m.y.), GSC 59-32 (1,690 m.y.), GSC 59-33 (1,655 m.y.), and GSC 59-34 (1,695 m.y.) are from generally similar geological terrain and cover, albeit thinly, about 200,000 square miles of the barren grounds. All except GSC 59-30 are fairly representative of a widely varying group of gneissic to stratiform biotite granites. GSC 59-30 is from one body of more massive granitic rock found within areas of gneissic granites.

The concentration of ages in the range 1,600 to 1,700 m.y. is impressive. These ages suggest a very large region underlain by granitic gneisses, migmatites etc., of approximately the same age, and this can be tentatively extended to include parts of Baffin Island (GSC 59-36, 37, and 38) and northern Manitoba (GSC 59-40), where similar rocks fall within the range 1,605 to 1,730 m.y.

The micas in many of these rocks may well be metamorphic in origin, but, whether igneous or metamorphic, any geological process affecting such a tremendous area within a limited time-span defies ready explanation. Many more determinations are needed in this region, but it may develop that the ultimate accuracy of K-Ar dating is insufficient to permit detailed breakdown of such granitic terrains.

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[1] GSC 59-22 to 59-35 inclusive; for details see Part I.

[2] Dates in parentheses are those of references listed at the end of this paper.

Massive Granites in the Slave Province

Samples GSC 59-22 (2,465 m.y.), GSC 59-23 (2,390 m.y.), GSC 59-24 (2,550 m.y.), and GSC 59-26 (1,950 m.y.), taken as a group, average some 600 million years older than the gneissic granites to the east. These older granites are clean, non-foliated, and very fresh looking in outcrops. They occur as sharply distinct bodies in schists presumed to be equivalent to Yellowknife-group metasediments. From field evidence they are believed to be intrusive into the Yellowknife rocks, but most of them cannot have any bearing on the development of metamorphic biotite in the latter for which GSC 59-25 gives an age of 2,100 m.y. This does not, of course, say that the granites cannot be intrusive into the schists - but that we must look elsewhere for the cause of one phase of Yellowknife metamorphism, of which there may have been several of different types.

GSC 59-26 (1,950 m.y.) is the nearest in space (20 miles) and in time to the one determination in the Yellowknife schists (2,100 m.y.); the difference in age may be within the range of error in the K-Ar method. The age difference between GSC 59-22, 23, and 24 and GSC 59-26 suggests widely separated intrusive periods within the area of clean and massive granites north of Artillery Lake.

Boundary Between the Churchill and Slave Provinces

Perhaps the most striking situation emerging from recent reconnaissance mapping (Wright, 1956) and receiving support from K-Ar dating is the contrast in geology and ages in granitic rocks occurring on either side of a line running approximately from the northeast end of Artillery Lake to the Bathurst lineament near Western River.

The approximate line separating the eastern area (Churchill province) from the western (Slave province) marks the eastern limit of the Yellowknife group. It is roughly coincidental with the inside of a curving zone of regional gneissosity in granitic gneisses, migmatites, etc., that appears to be 'anchored' on the north and scuth by major faults (Bathurst lineament and Macdonald fault) which both mark the outer edge of large areas of Proterozoic sediments. Finally, this line separates fresh, clean, and massive granites, mostly about 2,400 m.y. in age, from impure and gneissic, stratiform to migmatitic granitic rocks that appear to be mainly about 1,600 to 1,700 m.y. old over vast areas to the east.

This roughly north-south line appears to represent, fairly accurately, the eastern boundary of the Slave province. There is no evidence in the above to support a suggestion by Wilson et al. (1956) that the approximate line from Artillery Lake to Wager Bay represents a boundary between geological provinces (Wilson's Athabasca and Back River provinces). Such a provincial boundary, incidentally, would cut clean through the outcrop regions of the Hurwitz group (Wright, 1955) and the Dubawnt group (Wright, 1955, 1956), which may be of early and late Proterozoic age respectively (but see below).

The contrast in granites outlined above is perplexing; the younger-looking are in the order of 600 million years older than the older-looking. This, perhaps, is due to an igneous age in the former, and a predominantly metamorphic and/or metasomatic age in the latter. In any event, the causes of metamorphism on either side of the boundary are at present unknown.

Age of the Dubawnt Group

GSC 59-35 (1,515 m.y.) is of interest because of the light, that it throws, perhaps dimly, on the age of the Dubawnt group (Wright, 1955, 1956). This group underlies some 35,000 square miles of the central barren grounds. It consists largely of clastic sediments with some volcanic and igneous rocks, and dolomite, and is mainly flat-lying to gently dipping. As the word 'group' implies in this context, it may, in the future, be subject to major subdivision in both stratigraphic content and arrangement, and in age.

The Dubawnt group has been considered by some (Brown and Wright, 1957) as roughly equivalent to the Athabasca, Et-then, and Coppermine River sequences and to be late Proterozoic in age. But GSC 59-35, if supported, is in danger of denying this age, if not the postulated correlation. The sample is a pyroxene-biotite porphyry considered to be a volcanic member of the Dubawnt group. This age of 1,515 m.y., if supported by additional determinations, indicates that the Dubawnt group (or part of it) formed a widespread blanket over the gneissic granites shortly after their formation or reconstitution in their present form (1,600 to 1,700 m.y.), and that, in so far as presently available evidence is concerned, no major geological activity occurred for the next billion years or more!

Conclusions

The available K-Ar age determinations on which these remarks are based seem to have occasioned more questions than answers. This situation will no doubt make for a lively and argumentative future.

More determinations are needed, some of general interest and others to provide answers to specific questions. The area north of Artillery Lake would appear to be most suitable for future detailed mapping in conjunction with K-Ar ages. This might unravel the metamorphic, structural, and intrusive history of the area. To the east, a study of the relationships between the ages of granitic rocks and the Hurwitz sediments and arealy associated greenstones would provide an opportunity to establish a key date in Precambrian time within the District of Keewatin.

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