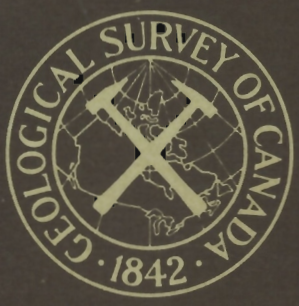

GEOLOGICAL
SURVEY
OF
CANADA

DEPARTMENT OF MINES
AND TECHNICAL SURVEYS

PAPER 64-17 (Part 1)

AGE DETERMINATIONS AND GEOLOGICAL STUDIES

Part 1 - Isotopic Ages, Report 5

(Report and 3 text figures)

R. K. Wanless, R. D. Stevens, G. R. Lachance,
and R. Y. H. Rimsaite

Price, 75 cents

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CONTENTS

Illustrations

ABSTRACT

Potassium-argon age determinations are reported for a total of 184 Canadian mineral and rock samples, listed according to their provincial and territorial distribution. Each sample is described, and a geological interpretation of its determined age is given. The techniques employed are described in outline form, and the analytical precision obtained is discussed.

AGE DETERMINATIONS
BY THE GEOLOGICAL SURVEY OF CANADA

INTRODUCTION

by R.K. Wanless

This is the fifth in the series of annual releases of potassium-argon age measurements carried out in the laboratories of the Geological Survey of Canada. Previous reports included a total of 644 determinations while an additional 184 measurements completed during 1963 are presented here.

Procedure

Samples were examined mineralogically and all mineral concentrates were analyzed by X-ray diffraction to determine the degree of chloritization. X-ray fluorescence techniques were used to determine the potassium content. A high-frequency generator was employed to fuse the sample material in vacuo, and standard isotope dilution techniques were used to determine the radiogenic argon content.

Precision of Age Determinations

A distinction has been drawn between the precision assigned to age measurements based on fresh micaceous mineral concentrates containing from 5 to 9 per cent potassium, and that of determinations based on whole rock samples in which the potassium content ranges from a few tenths of a per cent to 1 or 2 per cent. Considering the factors summarized below, confidence limits at the 95 per cent level have been calculated for all determinations based on micaceous concentrates, and these are given with the individual age results. However, in view of the large uncertainty associated with the potassium determination in the lower concentration range no reasonable limits may be calculated for the measurements based on whole rock samples at this time. At several localities we have found that age measurements based on whole rock samples agree favourably with determinations based on geologically associated micaceous concentrates, indicating that the potassium analyses are reliable; however, comparisons are too few to permit assigning precise limits of accuracy to the ages calculated from the whole rock samples. In the meantime it is suggested that the limits indicated in previous GSC age reports be applied to the whole rock

determinations. The limits to be applied in these cases are ± 8 m.y. at 100 m.y., ± 35 m.y. at 500 m.y., ± 60 m.y. at 1,000 m.y. and ± 125 m.y. at 2,500 m.y. Experiments now being made will permit the comparison of the potassium content determined by both X-ray and isotope dilution techniques, and it is anticipated that in future age reports estimates of confidence for all age measurements will be possible.

The following is a summary of factors to be considered in assigning confidence limits to K/Ar age measurements.

1. Mass Spectrometry — All analyses were carried out on a 6-inch radius, 90-degree mass spectrometer equipped with an electron multiplier. An absolute calibration of this instrument has been achieved by comparing results obtained for atmospheric argon with those determined by Nier (1950)*. Replicate analyses of spectroscopically pure atmospheric argon yielded an Ar^{40}/Ar^{36} ratio that agrees with Nier's accepted value within ± 1 per cent. An error of this magnitude has therefore been adopted.

σ m.s. ..... ± 1%.

2. Argon-38 Spike Calibration — The pressure in a given set (20) of argon-38 spike tubes is determined from the mass spectrometric analysis of a mixture of a known quantity of spectroscopically pure atmospheric argon with the enriched argon-38 in one of the tubes. At least two calibrations were carried out for each set of spikes. The per-cent standard deviation of the average pressure determined for each set of spikes was calculated for the ten most recently calibrated spike sets. The average of the per cent standard deviation was found to be 0.93 per cent. An uncertainty of ± 1.5 per cent has therefore been attributed to the spike calibration.

σ sp ..... ± 1.5%

3. Per cent Radiogenic Argon — The contribution to the overall error to be assigned to the Ar^{40} radiogenic concentration, attributable to the error in the Ar^{36} measurement, is based on the following formula published by Lipson (1958).

---

*Dates and/or names in parentheses refer to publications listed in the References on page 9.

$$E = \frac{ef}{100 - f}$$

E = % error in radiogenic Ar^{40} due to error in Ar^{36}/Ar^{40} ratio
e = % error in Ar^{36}/Ar^{40} ratio
f = % atmospheric argon

The assignment of a value to e is based on the statistics of the individual mass spectrometer analysis. A 5 per cent error in e will result in a 5 per cent error in the radiogenic argon concentration determination for a sample containing equal parts of atmospheric and radiogenic argon.

$\sigma\ Ar^{40}$ ..... 0 to $\pm$ 10%

4. Potassium Determination — The X-ray technique employed for the determination of the K concentration is briefly outlined in a later section. This technique is characterized by excellent reproducibility and it is felt that in the higher potassium concentration range the uncertainty is adequately established at $\pm$ 1.5 per cent. However, for low concentrations the uncertainty increases, as indicated in this table.

% K	% Error (σ K)
5 - 9	$\pm$ 1.5
3	$\pm$ 10
below 1%	error uncertain

The problem posed by the third category is being investigated.

5. Magnification Factor Due to Non-Optimum Selection of Ar^{40}/Ar^{38} Ratio — For any particular set of spike and sample isotope ratios there is an optimum value for the spike-to-sample ratio that will result in the minimum error in determining the ratio. For the spike ratios used in this work the optimum value of the Ar^{40}/Ar^{38} ratio is approximately 4. For obvious reasons it is not practical to attempt to realize this figure for all samples, but fortunately the increase in the error is not rapid in the range with which we are concerned, and the maximum multiplication factor is 1.15 for an Ar^{40}/Ar^{38} ratio of 200.

6. Error in Age Calculated Due to Error in Ar^{40}/K^{40} Ratio — The equation used in the calculation of the age is

$$T = \frac{1}{\lambda} \ln \left(1 + \frac{Ar^{40}}{K^{40}} \frac{1 + R}{R}\right)$$

where R is the branching ratio between the two constants, $\lambda e / \lambda \beta$, in the decay of K^{40}, and is equal to 0.124.

A 1 per cent error in the Ar^{40}/K^{40} ratio produces about the same per cent error in the calculated age at 100 m.y. but the contribution is appreciably less as the age increases. Thus the contribution to the error in the age of a 2,500 m.y. sample will be only 0.55 per cent. The appropriate factor, R, has been applied in calculating errors.

Calculation of Error Limits

It is assumed that there is no correlation between the first four factors considered above, σ m.s., σ sp, σ Ar^{40} and σ K. That is to say, there is no reason to anticipate a large error in determining K to be associated with a large error in determining Ar^{40}. The total error may then be calculated as

$$\sigma t^2 = \sigma \text{ m.s.}^2 + \sigma \text{ sp}^2 + \sigma Ar^{40^2} + \sigma K^2$$

In calculating the final standard deviation to be applied, Factors 5 and 6 must also be considered, σ t being multiplied by the appropriate factors in each case:

$$\sigma t = (\sigma \text{ m.s.}^2 + \sigma \text{ sp}^2 + \sigma Ar^{40^2} + \sigma K^2)^{1/2} \times M_{38}^{40} \times R.$$

Ninety-five per cent confidence limits are considered equivalent to $\pm 1.96 \sigma t$.

Determination of Potassium Content

by G.R. Lachance

Recent modifications in X-ray spectrometric instrumentation permit the determination of the lighter elements (atomic numbers 12-22) by X-ray fluorescence. During 1961 and 1962, methods were developed in the X-ray laboratory of the Geological Survey of Canada to determine the amount of potassium in micas and in rocks.

When a sample is irradiated with X-rays, a part of the energy excites atoms within the sample, resulting in the emission of the characteristic lines of the elements present. Potassium (atomic number 19) when excited by primary X-rays gives off a radiation of 3.742 Å (K alpha line) and 3.454 Å (K beta line). By dispersing the beam of characteristic radiation with a crystal, these potassium

lines can be isolated and their identity established using the well known Bragg equation:

$$n \lambda = 2 d \sin \theta$$

where n = order of reflection,
λ = wavelength of X-radiation (in Angstroms),
d = interplaner spacing of crystal (in Angstroms), and
θ = angle between incident radiation and crystal surface.

For a quantitative determination, the intensity of the strongest potassium line (K alpha) is measured by integrating the detector output at the K alpha peak for a given period of time. Even after subtracting a background, the net intensity is only roughly proportional to potassium concentration, mainly because of absorption effects. For micas this can be shown to be due mostly to the difference in iron content of the two minerals (i.e. $\sim$ 1% Fe_2O_3 in muscovite, $\sim$ 26% in biotites) and a correction, based on the iron content of the mica, can therefore be applied. Figure 1 shows the correlation between chemical (flame photometry) and X-ray fluorescence (iron correction method) analyses for 206 micas. The standard deviation is $\pm$ 0.12 which is $\pm$ 1.5 per cent of the average potassium concentration.

The same principles apply to the determination of potassium in rocks but in this case there is the added problem of providing a homogeneous specimen, due to the difficulty encountered in grinding the material (Volborth, 1964). A direct method is at present being used, based on the standard curve obtained using twelve samples previously analyzed chemically (see Figure 2). Because of insufficient data, greater error limits must be assigned to the potassium values in rocks, especially those below 0.5 per cent. An investigation by both X-ray and isotope dilution methods is being conducted in order to minimize errors in the analysis of non-micaceous samples.

Outline of Methods

Micas —

1. A 1-1 1/2 gram portion of the mineral is ground in a Mixer Mill for 3 minutes.
2. The sample is transferred to a holder and the intensity of the K alpha potassium (1st order), and the K alpha iron (2nd order), and background are measured along with a counting standard. This is repeated at least three times, once for each counting position.

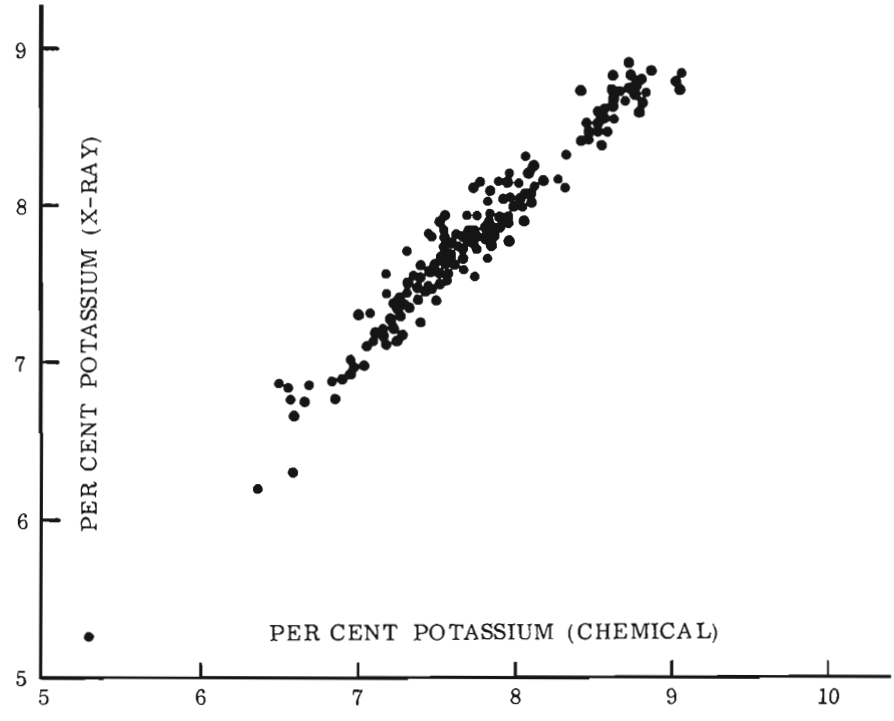

Figure 1. Per cent potassium, X-ray (iron correction method) vs. chemical (flame photometer method).

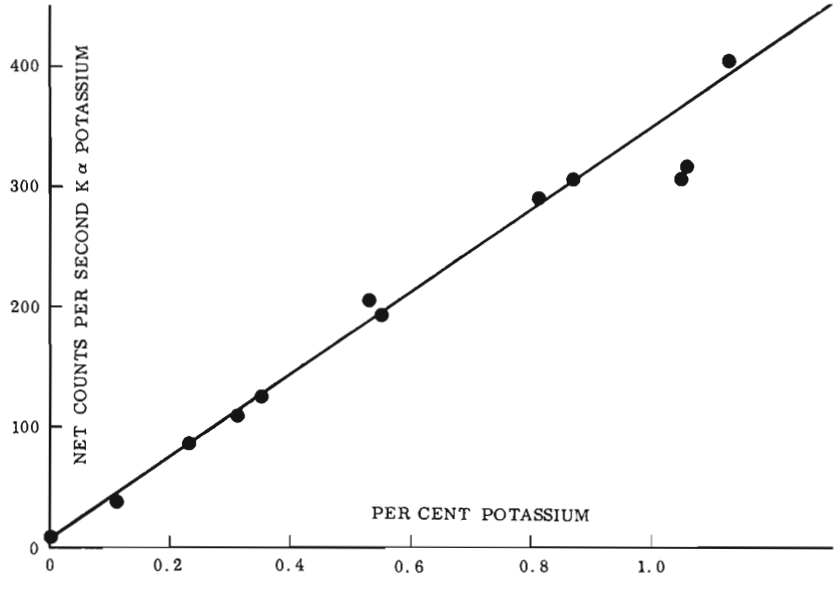

Figure 2. Standard curve used for determining potassium in rock samples.

3. Iron concentration is estimated by direct comparison with the counting standard.
4. Net K alpha potassium intensity is corrected, using counting standard.
5. Corrected K alpha potassium intensity is converted to an "apparent per cent K".
6. "Apparent per cent K" is corrected for absorption, using factor based on the iron content of the mica.

Rocks —

1. A 3-4 gram portion of the rock is ground in a Mixer Mill for 3 minutes.
2. Sample is transferred to a holder and the intensity of the K alpha potassium (1st order) and background are measured along with a counting standard. This is repeated at least twice.
3. Net K alpha potassium intensity is corrected using counting standard.
4. Corrected K alpha potassium intensity is converted to per cent potassium using standard curve (see Figure 2).

Constants Employed in Age Calculations

Age calculations are based on the following potassium-40 decay constants:

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

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

Geological Time-scale

The post-Precambrian time-scales of Kulp (1961) and Holmes (1959) are shown in Figure 3. Details regarding the ages on which the various divisions were established may be found in the original papers.

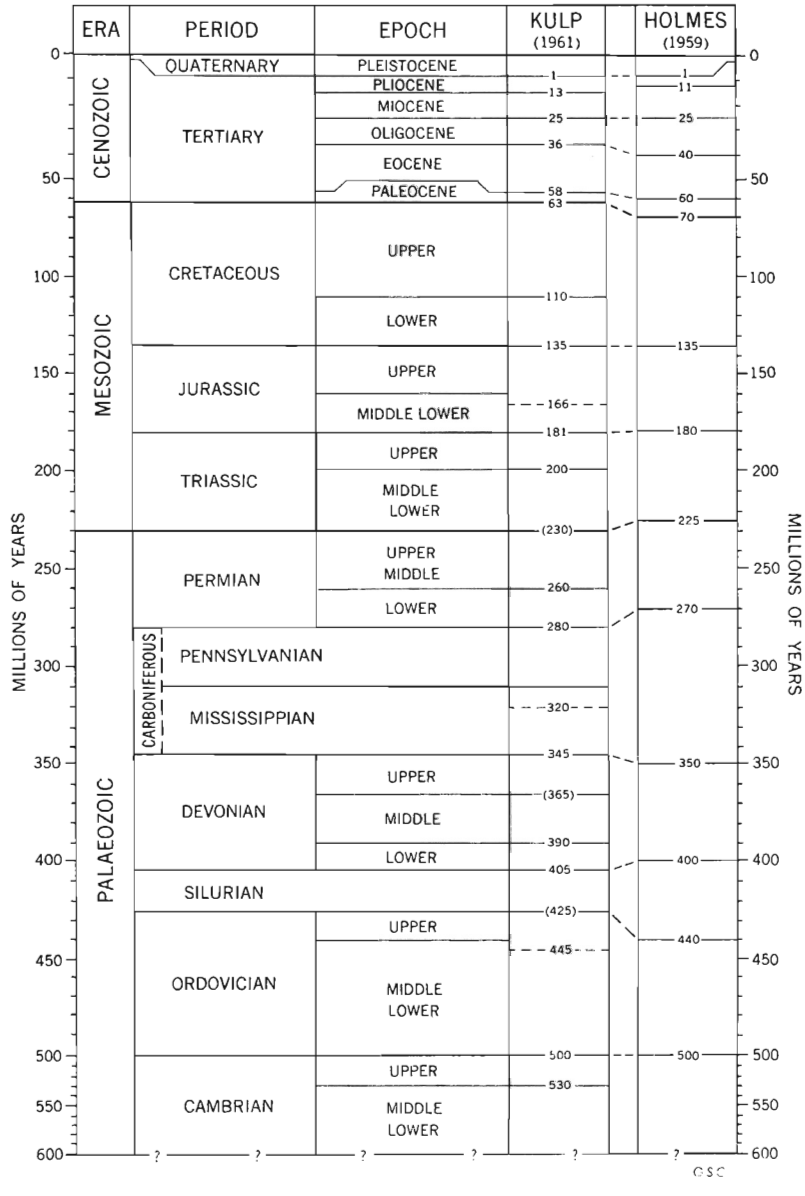

Figure 3. Geological time-scale (after Kulp and Holmes).

References

Holmes, A.
1959: A revised geological time scale; Trans. Edinburgh Geol. Soc., vol. 17, pt. 3, pp. 183-216.

Kulp, J.L.
1961: Geologic time scale; Science, vol. 133, No. 3459, pp. 1105-1114.

Lipson, J.
1958: Potassium-argon dating of sedimentary rocks; Bull. Geol. Soc. Amer., vol. 69, pp. 137-150.

Nier, A.O.
1950: A redetermination of the relative abundances of the isotopes of carbon, nitrogen, oxygen, argon, and potassium; Phys. Rev., vol. 77, p. 789.

Volborth, A.
1964: Biotite mica effect in X-ray spectrographic analysis of pressed rock powders; Am. Mineralogist, vol. 49, Nos. 5, 6.

Errata

GSC Paper 61-17

Determination GSC 60-80:
"southwest" should read "southeast".
Coordinates should read: 56°26'N
95°06'W

GSC Paper 62-17

Determination GSC 61-197:
Coordinates should read: 54°03'N
63°23'W

GSC Paper 63-17

Determination GSC 62-46:
Coordinates should read: 50°49'00"N
118°15'30"W

Determinations GSC 62-51, GSC 62-52:
Sample number should read WB-121-1-61 in each case.

Determination GSC 62-185:
"Snare" should read "Seal".

ISOTOPIC AGES—REPORT 5

Compiled by R. D. Stevens

British Columbia

GSC 63-1 Phlogopite, K-Ar age 41 ± 10 m.y.

$K = 8.45\%$, $Ar^{40}/K^{40} = 0.00245$; radiogenic Ar = 41%. Concentrate; clean concentrate of pale orange to greenish yellow phlogopite. The phlogopite flakes are zoned and contain apatite inclusions. Chlorite not detected.

From porphyritic lamprophyre.

(82 M) 8 miles S 84°W of mouth of Conner Creek, British Columbia, 51°17'N, 118°28'W. Sample WB-63-105-2-7, collected and interpreted by J.O. Wheeler.

The rock is porphyritic with phenocrysts of biotite and clinopyroxene in a matrix of biotite, clinopyroxene, potash feldspar, and minor amphibole, chlorite, and clinozoisite. It is probably a minette.

The lamprophyre dyke is part of a north-trending swarm of almost vertical dykes which cut the granitic gneisses of Frenchman's Cap gneiss dome, part of the Shuswap Metamorphic Complex.

The date of 41 m.y. is slightly younger than dates obtained from volcanic rocks in the Southern Interior of British Columbia[1]. There the ages range from 45 to 53 m.y. - Middle Eocene (Kulp, 1961). The lamprophyre dykes may thus represent a late phase of Mid-Eocene vulcanism.

The date also indicates that the latest metamorphism of the Shuswap rocks ceased some time before 41 m.y. ago and supports the relationships in southern British Columbia where volcanic rocks ranging between 46 and 48 m.y. occur within sequences that unconformably overlie the Shuswap rocks.

Reference

[1]Mathews, W.H.
1963: Thirteen potassium argon dates of Cenozoic volcanic rocks from British Columbia; Univ. Brit. Col., Dept. Geology, Report No. 2, 16 p.

British Columbia

GSC 63-2 Biotite, K-Ar age 242 ± 12 m.y.

$K = 7.02\%$, $Ar^{40}/K^{40} = 0.0151$; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of brown biotite. Impurities consist of minor hornblende (1-2%) and about 5% greenish chlorite with inclusions of epidote. Total chlorite content is 7%.

From granodiorite.
(92 I) Near the bottom of a gully, 500 feet west of Highland Valley Road, 2 miles south of the junction of old and new Highland Valley Roads, British Columbia, 50°36'00"N, 121°14'20"W. Map-unit 1, GSC Map 1010A. Sample 106-CAc-1, collected and interpreted by R.B. Campbell.

The rock is a medium-grained, grey, undeformed biotite-pyroxene granodiorite consisting of 35% plagioclase near An_{30} and moderately to heavily altered, 15% K-feldspar, 30% quartz, 10% biotite, 8% augite, 2% hornblende. The biotite appears to be an original plutonic mineral of primary crystallization.

See discussion following GSC 63-5.

GSC 63-3 Biotite, K-Ar age 265 ± 14 m.y.

$K = 5.29\%$, $Ar^{40}/K^{40} = 0.0166$; radiogenic Ar = 100%. Concentrate; clean concentrate of partly altered brown biotite. About 50% of the biotite flakes are partly altered to chlorite and fine-grained epidote. Total chlorite content is 30%.

From quartz diorite.
(92 I) 300 feet east of Highland Valley Road, 3.5 miles south of the junction of the old and new Highland Valley Roads, British Columbia, 50°34'45"N, 121°13'25"W. Map-unit 1, GSC Map 1010A. Sample 107-CAc-1, collected and interpreted by R.B. Campbell.

The rock is a medium-grained, grey undeformed hornblende-biotite quartz diorite consisting of 30% plagioclase near An_{40} (moderately to highly altered laths with preferred orientation), minor K-feldspar, 25% quartz, 15% hornblende with remnants of augite, 10% biotite, and minor augite. Collected from the northwest part of the Guichon batholith.

British Columbia

See discussion following GSC 63-5.

GSC 63-4 Biotite, K-Ar age 240 ± 12 m.y.

K = 5.29%, Ar^{40}/K^{40} = 0.0150; radiogenic Ar = 100%. Concentrate; consists of partly altered brown biotite. About 40% of the biotite flakes are in part altered to chlorite and some are intergrown with amphibole. Altered flakes contain numerous inclusions of epidote. Impurities consist of hornblende, chlorite, epidote, minor feldspar and apatite. Total chlorite content is 25%. Hornblende content is 15%.

From quartz diorite.
(92 I) North side of road, 0.9 mile west of Witches Brook Bridge, 2 miles west of the junction of Highland Valley and Guichon Creek roads, British Columbia, 50°29'20"N, 120°51'55"W. Map-unit 4, GSC Map 886A. Sample 108-CAc-1, collected and interpreted by R.B. Campbell.

The rock is a medium-grained, grey, undeformed hornblende-biotite quartz diorite nearly identical petrographically with 107-CAc-1. Collected on the east side of the Guichon batholith.

See discussion following GSC 63-5.

GSC 63-5 Biotite, K-Ar age 248 ± 12 m.y.

K = 6.93%, Ar^{40}/K^{40} = 0.0155; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of orange-brown biotite. Impurities consist of amphibole (less than 2%) and pale green chlorite. Total chlorite content is 9%.

From granodiorite.
(92 I) 3,500 feet north of Craigmont open pit, British Columbia, 50°13'10"N, 120°55'00"W. Map-unit 4, GSC Map 886A. Sample 109-CAc-1, collected and interpreted by R.B. Campbell.

British Columbia

The rock is a biotite-pyroxene granodiorite consisting of 50% plagioclase near An35 (mildly to severely altered), 10% K-feldspar, 15% quartz, 15% biotite (somewhat altered to chlorite and epidote), and minor augite and hornblende. Collected at the south end of the Guichon batholith.

Determinations of the age of biotite from six samples from the interior of the Guichon batholith (G.S.C. Mem. 262, Map-unit 1; G.S.C. Mem. 249, Map-unit 4) were reported previously (G.S.C. Paper 63-17, pp. 39-42). These ages ranged from 224 m.y. to 245 m.y. and comprised results on two samples from each of three prominent phases of the batholith; Guichon quartz diorite, Bethlehem quartz diorite, and Bethsaida granodiorite (White et al., 1957). The phases are indistinguishable in terms of biotite age.

The age of the biotites is about Middle Permian whereas the batholith is thought to intrude Upper Triassic rocks of the Nicola Group, though the evidence is circumstantial and inconclusive. The suggestion that the center of the batholith might be older than the marginal phases led to the decision to collect samples from near the margins at widely separated localities. The rocks from these localities are all medium-grained quartz diorite or granodiorite and most contain pyroxene, and amphibole, as well as biotite.

The biotite ages from samples from the western (GSC 63-2 and GSC 63-3), eastern (GSC 63-4), and southern (GSC 63-5) contacts of the batholith range from 240 m.y. to 265 m.y. and are not significantly different from those of the interior. If anything they are slightly older.

The biotite ages clearly indicate that the batholith is older than the Upper Triassic Nicola Group rocks and field evidence suggests that it is younger. No exposures of the contact are known to the writer, but near Craigmont mine silicified Nicola Group rocks are exposed a few feet away from rocks of the batholith. The staff at the mine is confident that an intrusive relationship exists. Near the location of the other samples exposures are so sparse that the relationship of the batholith to the surrounding rocks is most uncertain.

If the biotite ages are accepted as the age of the granitic rocks then it must be assumed that the Nicola Group strata are in fault contact with, or rest unconformably on the batholith, or that the rocks at the contact are not part of the Nicola Group but are older. There is little evidence to support the view that the batholith is a "cold" intrusion of older granitic rocks, though this may be

possible. Detailed field work might solve the problem but stripping and drilling may be necessary to reveal the contact relationships.

Reference

White, W.H., Thompson, R.M., and McTaggart, K.C.
1957: The geology and mineral deposits of Highland Valley, British Columbia; Trans. Can. Inst. Mining Met., vol. 60, pp. 273-289.

GSC 63-6 Biotite, K-Ar age 143 ± 14 m.y.

$K = 8.03\%$, $Ar^{40}/K^{40} = 0.00870$; radiogenic Ar = 78%. Concentrate; clean concentrate of green biotite. Biotite flakes contain a few small inclusions of apatite, epidote, quartz, and zircon. Chlorite not detected.

From granodiorite.

(93 A) Head of main south tributary of East Creek, British Columbia, 52°34'00"N, 120°02'30"W. Map-unit 11a, GSC Map 1-1963. Sample 536-CAc-2(Q), collected and interpreted by R.B. Campbell.

The rock is medium-grained, equigranular, biotite granodiorite consisting of quartz, medium plagioclase, microcline, biotite, hornblende, and minor epidote and zircon. There is little alteration.

The sample was obtained from a small batholith that clearly intrudes the Lower Cambrian Cunningham limestone (map-unit 3), part of the lower Palaeozoic Cariboo Group.

Strata associated with the limestone consist of phyllite and quartzite and are highly deformed. The intrusion is evidently post-orogenic. From this it may be concluded that deformation and metamorphism are older than a minimum age of Upper Jurassic (143 m.y.). Sutherland Brown[1] reported that Carboniferous or Permian Slide Mountain Group rocks rest unconformably upon deformed Cariboo Group strata. He noted, further, that conglomerates of the essentially unmetamorphosed Slide Mountain Group contain fragments of metamorphosed Cariboo Group rocks.

British Columbia

The age of 143 m.y. reported here in no way disagrees with Sutherland Brown's conclusions, rather it lends support to his belief that at least one phase of the deformation and metamorphism of the Cariboo Group may be pre-Carboniferous or Permian and need not be referred to a late Mesozoic tectonic event.

Reference

[1]Sutherland Brown, A.
1957: Geology of the Antler Creek area, Cariboo District, British Columbia; B.C. Dept. Mines, Bull. 38.

GSC 63-7 Biotite, K-Ar age 56 ± 8 m.y.

K = 8.32%, Ar^{40}/K^{40} = 0.00330; radiogenic Ar = 69%. Concentrate; clean concentrate of biotite. Biotite flakes vary in colour from deep brown to pale greenish and contain a few prismatic inclusions of apatite. Total chlorite 2%.

From biotite granite.
(92 O) Southwest of Edmond Creek, British Columbia, 50°00'N, 123°58'W. Sample A3-62TD, collected and interpreted by H.W. Tipper.

The rock is a coarse-grained, equigranular, light grey, very fresh biotite granite intrusive into volcanic rocks overlying late Lower Cretaceous or early Upper Cretaceous sediments. An Upper Cretaceous or Tertiary age is considered probable, and this is in agreement with the K-Ar age.

GSC 63-8 Biotite, K-Ar age 110 ± 6 m.y.

K = 8.25%, Ar^{40}/K^{40} = 0.00666; radiogenic Ar = 100%. Concentrate; clean concentrate of olive-grey biotite. Chlorite not detected.

From granite.
(82 M) 5.98 miles at S 68°E from the boundary station northeast of Revelstoke, British Columbia. Sample WB-34-9-1, collected by J.O. Wheeler, interpreted by J.E. Reesor.

British Columbia

Pink to grey, medium-grained, biotite monzonite, containing about 52% potash feldspar, 30% plagioclase, 7% biotite and 6.6% quartz, 1% muscovite. This rock belongs to the quartz-poor suite intrusive into the general zone between the Shuswap Metamorphic Complex and the lower grade metamorphic rocks along the western limit at the Selkirk Mountains.

This monzonite is intrusive into the Shuswap rocks in the salient northeast of Revelstoke. At 110 m.y. it thus indicates the minimum age for penetrative deformation and metamorphism in the Shuswap, in spite of the many younger ages obtained in the high grade metamorphic rocks of the surrounding terrain.

Reference

Gabrielse, H., and Reesor, J.E.:
Geochronology of Plutonic Rocks in two areas of the Canadian Cordillera; Roy. Soc. Can., in press.

GSC 63-9 Biotite, K-Ar age 42 ± 8 m.y.

$K = 5.69\%$, $Ar^{40}/K^{40} = 0.00246$; radiogenic Ar = 67%. Concentrate; clean concentrate of brown biotite. About 30% of the biotite flakes are partly altered to chlorite and contain very small inclusions of epidote and quartz. Total chlorite 25%.

From quartz monzonite.
(92 O) Headwaters of Beece Creek, 51°12'N, 123°20'W, British Columbia. Sample A1-62TD, collected and interpreted by H.W. Tipper.

The rock is a pinkish grey, medium-grained, equigranular, low-mafic quartz monzonite from an intrusive body that cuts volcanic rocks unconformably overlying sediments with Paleocene or Upper Cretaceous plants. Miocene lavas overlie this body unconformably. An age of early to mid-Tertiary is suggested by the field evidence, and this is in agreement with the K-Ar age.

British Columbia

GSC 63-10 Biotite, K-Ar age 123 ± 20 m.y.

$K = 5.73\%$, $Ar^{40}/K^{40} = 0.007448$; radiogenic Ar = 61%. Concentrate; impure concentrate of biotite. The biotite flakes vary in colour from brown to green and some are altered to chlorite and contain inclusions of quartz, epidote, hematite, and chlorite. Impurities consist of poikilitic hornblende and chlorite. Total chlorite content 25%, hornblende 15%.

From massive biotite-hornblende diorite.
(82 K) 3/4 mile E of saddle at head of Blue Grouse Creek (elevation 6,600 ft., ridge-crest), British Columbia, 50°04'57 1/2"N, 117°43'59"W. Sample HQ-119-8, collected and interpreted by D.W. Hyndman.

The sample is from a medium-grained hypidiomorphic to allotriomorphic granular rock, the mafic and felsic minerals, except for most of the plagioclase, having been reduced in grain size. The mode is as follows: plagioclase An_{34} (55%), hornblende (15%), biotite (9.5%), microcline (10%), quartz (7%), epidote (3%), chlorite (0.5%), apatite, sphene and "magnetite" (< 1%).

This sample was collected from near the southern contact of an east-west elongate (1 mile by 8 miles) stock of quartz monzonite to quartz diorite. The stock intrudes argillaceous and volcanic rocks assigned to the Slocan Group (Triassic). Of the four K-Ar ages determined on granitic stocks in this low-grade metamorphic area between the Shuswap and Valhalla metamorphic complexes (GSC 62-39 at 69 m.y.; GSC 63-12 at 74 m.y.; GSC 63-11 at 107 m.y.; GSC 63-10 at 123 m.y.) this is the oldest date and the most basic stock. A lower Cretaceous age is thus consistent with the geological information. There is no indication that regional metamorphism has affected this stock and, as the time of intrusion should not be younger than the K-Ar age, the time of regional metamorphism is tentatively considered to be prior to 123 m.y. ago. As the regional metamorphism does affect the Slocan Group as well as the Shuswap and Valhalla complexes, it must have occurred during the Jurassic or Lower Cretaceous.

British Columbia

GSC 63-11 Biotite, K-Ar age 107 ± 6 m.y.

$K = 7.34\%$, $Ar^{40}/K^{40} = 0.00641$; radiogenic Ar = 100%. Concentrate; clean concentrate of biotite. Biotite flakes vary from greenish olive to brown. Some flakes are slightly altered and coated with orange-yellow crusts. Minor impurities consist of about 2% hornblende and of a few inclusions of quartz and zircon. Chlorite content is 3%.

From quartz monzonite.

(82 K) 1/4 mile northeast of the main bend in Halifax Creek at elevation 5,500 feet, British Columbia, 50°01'23"N, 117°42'23"W. Sample HQS 28-7, collected and interpreted by D.W. Hyndman.

The sample is from a massive, medium-grained, hypidiomorphic granular rock, the mafic minerals (about 15%) showing a tendency to occur in small groups. Biotite (0.1 to 2 mm), strongly pleochroic (dark brown to pale brownish), is associated with pleochroic (green to pale brown) hornblende grains of the same size. Biotite grains are somewhat bent and quartz shows strong undulose extinction. Potash feldspar shows patchy development of microcline twinning. Plagioclase is but slightly zoned. Accessory minerals include epidote, apatite, sphene, and tourmaline. This rock is from a stock of non-porphyritic quartz monzonite connected gradationally to a larger mass of quartz monzonite to the west containing megacrysts of K-feldspar (see GSC 62-39). Field and petrographic evidence suggests that the megacrysts, at least of this transitional zone, have developed after consolidation of the rock. The K-Ar determination from the phase containing no megacrysts—GSC 63-11 (107 m.y.) and from that containing many megacrysts—GSC 62-39 (69 m.y.) are consistent with two possibilities: (1) both rocks were intruded at about the same time, radiogenic argon being lost at the time of potash remobilization; (2) the non-porphyritic rock was emplaced prior to intrusion of a "porphyritic" rock of similar composition, and where both rock types are in contact, the earlier non-porphyritic rock developed poikiloblasts of K-feldspar in those parts of it adjacent to the later "porphyritic" variety. This age is also in agreement with field relations which indicate that the stock intruded pre-Cretaceous sedimentary and volcanic rocks, probably belonging to the Slocan and/or Kaslo (?) Groups.

British Columbia

GSC 63-12 Biotite, K-Ar age 74 ± 4 m.y.

$K = 8.04\%$, $Ar^{40}/K^{40} = 0.00444$; radiogenic Ar = 100%. Concentrate; clean concentrate of grey-green biotite. A few biotite flakes are altered to bright green chlorite. Total chlorite content is about 1%.

From quartz monzonite.
(82 K) 1/3 mile west of the divide at the westernmost headwaters of Wragge Creek, British Columbia, 50°02'17"N, 117°35'19"W. Sample HQ 119-3, collected and interpreted by D.W. Hyndman.

The rock is a white epidote-biotite quartz monzonite containing about 8% mafic minerals. The biotite is strongly pleochroic from dark brown to pale brownish and occurs as scattered grains (0.2 to 2.0 mm) closely associated with pleochroic epidote. Some of the biotite is slightly bent and quartz shows undulose extinction. Plagioclase is prominently zoned, and microcline occurs (in part) as megacrysts poikilitically enclosing small plagioclase crystals. Other minerals, in small amounts, include hornblende, sphene, apatite, and allanite.

The sample was collected from the west end of a granitic stock which intrudes metasedimentary rocks tentatively assigned to the Slocan Group. The stock is in gradational contact with massive leucogranite stocks with affinities to the border phases of the Kuskanax batholith and may be nearly contemporaneous with them.

An uppermost Cretaceous age is consistent with the known geological data. It is essentially the same age as that of sample GSC 62-39 (69 m.y.) from a porphyritic phase of the same map-unit, 12 miles farther west. The latter is more highly deformed and contains megacrysts, perhaps indicating remobilization of potash feldspar.

GSC 63-13 Biotite, K-Ar age 209 ± 12 m.y.

$K = 6.95\%$, $Ar^{40}/K^{40} = 0.0129$; radiogenic Ar = 100%. Concentrate; impure concentrate of brown, fine-grained biotite. Impurities consist of about 20% chlorite and 10% muscovite.

British Columbia

From argillite.

(82 F) 2 miles west of Alki Creek, British Columbia, 49° 37.4'N, 116°15.85'W. Map-unit 2, GSC Map 15-1957. Sample LDML-7, collected and interpreted by G.B. Leech.

For lithology, petrography, field relations, and interpretation, see paper by Leech in Paper 63-17, Part II "Ages of Regional Metamorphism of the Aldridge Formation near Kimberley, B.C. (Preliminary Report)", p. 132.

This biotite is from an argillite whose muscovite yielded a K-Ar age of 555 m.y. (GSC 62-41), and is interbedded with quartzite whose muscovite yielded a K-Ar age of 398 m.y. (GSC 62-42) and whose biotite yielded a K-Ar age of 221 m.y. (GSC 62-40).

Yukon Territory

GSC 63-14 Biotite, K-Ar age 265 ± 12 m.y.

$K = 6.81\%$, $Ar^{40}/K^{40} = 0.01653$; radiogenic Ar = 88%. Concentrate; clean concentrate of brown biotite. About 40% of the biotite flakes are in part altered to chlorite and contain inclusions of epidote along the edges and fractures. Total chlorite content 30%.

From light grey porphyritic granite.
(107 N) Old Crow Range, Yukon Territory, 67°42'N, 140° 42'W. Sample Ti-103, collected by G.C. Taylor, interpreted by D.K. Norris.

The Old Crow batholith consists of one or more temporally distinct intrusive phases. Generally poor exposure and apparent lack of fossils in sedimentary rocks on the flanks and on top of the batholith make the determination of relative ages difficult. The 265 m.y. biotite age for this specimen and the 220 m.y. biotite age for rocks from the same batholith as determined by Baadsgaard et al[1] would suggest that at least some phases may be younger than the Fitton and Sedgwick stocks (see GSC 63-15 and GSC 63-16). The Old Crow granites probably intrude Tindir Group (Map-unit 2, GSC Map 10-1963) and possibly rocks as young as Carboniferous.

Reference

[1]Baadsgaard, H., Folinsbee, R.E., and Lipson, J. 1961: "Caledonian or Acadian granites of the northern Yukon Territory"; in Geology of the Arctic, vol. 1, G.O. Raasch, Editor, pp. 458-465.

GSC 63-15 Biotite, K-Ar age 370 ± 16 m.y.

$K = 6.82\%$, $Ar^{40}/K^{40} = 0.02382$; radiogenic Ar = 95%. Concentrate; clean concentrate of olive-brown biotite. About 35% of the biotite flakes are partly altered to chlorite and contain fine-grained inclusions of epidote. Total chlorite content 20%.

From coarse porphyritic granite.
(117 A) Mount Fitton, Yukon Territory, 68°28'N, 138°58'W. Sample 48-Ti, collected by G.C. Taylor, interpreted by D.K. Norris.

For description and interpretation see GSC 63-16.

Yukon Territory

GSC 63-16 Hornblende, K-Ar age 355 m.y.

$K = 0.78\%$, $Ar^{40}/K^{40} = 0.02277$; radiogenic Ar = 84%. Concentrate; reasonably clean concentrate of hornblende. Minor impurities consist of sphene, epidote, chlorite and a few flakes of altered biotite.

From coarse porphyritic granite.
(117 A) Mount Sedgwick, Yukon Territory, 68°55'N, 139°07'W. Sample 51-Ti, collected by G.C. Taylor, interpreted by D.K. Norris.

The two similar dates (GSC 63-15 and GSC 63-16) were obtained from biotite and hornblende respectively from small isolated stocks of porphyritic granite. In so far as these are minimum ages it is presumed that the rocks they represent are from coeval stocks intrusive into metasediments of map-unit 2 of GSC Map 10-1963. These intrusions are presumably overlain nonconformably by marine Carboniferous and younger rocks.

Baadsgaard et al.(1961) have reported ages of 353 m.y. for Mount Fitton and 95 m.y. for Mount Sedgwick. While both of these determinations were carried out on biotite, the Mount Sedgwick concentrate was highly chloritized, which may account for the anomalously low age found.

Reference

Baadsgaard, H., Folinsbee, R.E., and Lipson, J.
1961: "Caledonian or Acadian granites of the northern Yukon Territory"; in Geology of the Arctic, vol. 1, G.O. Raasch, Editor, pp. 458-465.

District of Franklin

GSC 63-17 Biotite, K-Ar age 1,635 ± 50 m.y.

K-Ar #832
See Bull. 151 p. 38

K = 7.57%, Ar^{40}/K^{40} = 0.15233; radiogenic Ar = 99%. Concentrate; clean concentrate of orange-brown biotite. Minor impurities consist of olive-green hornblende (3%) and a few grains of pleochroic, pale-green to buff pyroxene. Chlorite not detected.

From mafic gneiss.
(57 G) Boothia Peninsula, District of Franklin, 71°18'N, 95°55'W. Map-unit 1, GSC Map 36-1963. Sample BE-62-92, collected and interpreted by R.G. Blackadar.

The specimen is a dark, medium-grained gneissic rock consisting of biotite (5.2%), hornblende (28.0%), pyroxene (12.9%), quartz (2.7%), plagioclase (48.3%), pyrite (trace), microcline (1.9%), and apatite (0.8%).

It is from a well-banded gneissic complex in northern Boothia Peninsula. At the place where the specimen was collected the gneisses comprise reddish granitic sills, quartz-feldspar granulitic gneiss, biotite-hornblende-pyroxene gneiss (c.f. this specimen), and biotite-quartz-feldspar gneiss. This date gives an age for the metamorphism that resulted in the formation of the gneissic complex.

GSC 63-18 Biotite, K-Ar age 1,670 ± 50 m.y.

K-Ar 833
See Bull. 151 p. 38

K = 7.66%, Ar^{40}/K^{40} = 0.15681; radiogenic Ar = 99%. Concentrate; clean concentrate of orange-red biotite. Some flakes are slightly bleached along the fractures and a few flakes are intergrown with feldspar, quartz and epidote. Total chlorite content 2%.

From foliated gabbroic rock.
(58 B) Somerset Island, District of Franklin, 72°38'N, 94°28'W. Map-unit 1, GSC Map 37-1963. Sample TA 62-T 92, collected and interpreted by R.G. Blackadar.

This specimen is from well-banded mafic gneiss in southern Somerset Island. The date gives an age for the metamorphism that converted apparently sedimentary and volcanic rocks into the present gneissic assemblage. The rock is a biotite-hypersthene-quartz-microcline-plagioclase gneiss.

District of Franklin

GSC 63-19 Whole Rock, K-Ar age 915 m.y.

$K = 0.36\%$, $Ar^{40}/K^{40} = 0.0689$; radiogenic Ar = 100%.

From gabbro.
(48 C) District of Franklin, 73°02'N, 85°05'W. Map-unit 9, GSC Map 55-6. Sample R-31-40-1954, collected by R.G. Blackadar, interpreted by W.F. Fahrig.

The sample is a fine-grained diabase collected from near the contact of a 400' wide dyke. It consists of plagioclase, pyroxene, iron-ores, hornblende, biotite, and olivine. The biotite forms 1-2% of the rock and is orange-brown in colour.

The K content of this rock is rather low for accurate analysis, so the K-Ar age is considered only an approximation to the age of intrusion.

GSC 63-20 Whole Rock, K-Ar age 1,140 m.y.

$K = 0.62\%$, $Ar^{40}/K^{40} = 0.0914$; radiogenic Ar = 85%.

From gabbro.
(48 C) District of Franklin, 73°02'N, 85°05'W. Map-unit 9, GSC Map 55-6. Sample R-31-4-1954, collected by R.G. Blackadar, interpreted by W.F. Fahrig.

The sample is coarse-grained gabbro from the central zone of a diabase dyke. It consists of plagioclase, pyroxene, micrographic quartz-feldspar intergrowth, iron-ores, hornblende, biotite, and chlorite.

The K-Ar analysis gives the approximate age of crystallization of the dyke.

District of Franklin

GSC 63-21 Muscovite, K-Ar age 535 ± 49 m.y.

$K = 4.05\%$, $Ar^{40}/K^{40} = 0.0362$; radiogenic Ar = 100%. Concentrate; impure concentrate of fine-grained muscovite. The muscovite is present mainly in very fine-grained intergrowths with quartz, feldspar, chlorite, and iron oxides. Impurities consist of about 10% opaque grains, a few flakes of yellow altered biotite, a few grains of zircon and a few fragments of carbonate. Total chlorite content is 30%; feldspar 10%; and quartz 15%.

From quartzite.

(560 A) 3 miles southwest of Major River Forks, District of Franklin, 80°54'N, 93°11'W. Sample Tm-62-15e, collected and interpreted by H.P. Trettin.

From a medium-grained, poorly sorted phyllitic sandstone composed of quartz (65%); muscovite (22%); feldspar, mostly albite, some microcline (11%), and minor amounts of chlorite, opaque minerals, tourmaline, and zircon. The muscovite ranges in grain size from approximately 200 to about 10 microns and occurs: 1) with random orientation in the interstices between quartz and feldspar grains; 2) parallel with the boundaries of quartz and feldspar grains; 3) along wavy planes of schistosity that are approximately 2 mm apart. The muscovite of the schistose laminae is comparatively coarse grained and appears to have recrystallized during shearing. The sheath-forming muscovite and some of the relatively coarse-grained interstitial material are similar in appearance and grain size and may also have recrystallized. The state of the silt-sized interstitial muscovite is uncertain but this material has probably not been used for the analysis. The muscovite has partly replaced feldspar and is intergrown with that mineral, quartz, and opaque minerals. The quartz and feldspar have probably not recrystallized as they show a rounding indicative of more than one cycle of sedimentation.

The sample is from map-unit 1b of the Rens Fiord Complex, an unfossiliferous map-unit of pre-Silurian age[1]. Lithology and association suggest that the rocks are correlative with Lower Cambrian or older strata of eastern Ellesmere Island (J.W. Kerr, pers. comm.). The Rens Fiord Complex shows a higher degree of deformation than Silurian and younger strata, suggesting that it has been subjected to a pre-Silurian orogeny.

District of Franklin

The following interpretations are possible: 1) The age obtained is related to a Middle Cambrian or somewhat earlier (Lower Cambrian or Late Proterozoic) orogeny affecting the Rens Fiord area as well as northern Ellesmere Island. The occurrence of such an orogeny in northern Ellesmere Island is proven, and the present age corresponds relatively well with an age of 550 m.y. from northern Ellesmere Island[2]. 2) The muscovite was derived from source rocks metamorphosed in Middle Cambrian or somewhat earlier time. In this case the host rock would have to be a Middle Cambrian or Ordovician post-tectonic deposit which is difficult to reconcile with our present knowledge of the stratigraphic record. 3) The age obtained is the result of an original Precambrian age of the mica combined with Argon-loss during one or more periods of deformation in Palaeozoic and possibly younger time. In this case the coincidence with the age from Ellesmere Island is incidental. At present, the first interpretation seems most likely, provided the very low grade of metamorphism of the sample was sufficient to affect the Argon-contact of the muscovite decisively.

References

[1]Trettin, H.P.
in press: Pre-Mississippian succession of Nansen Sound area, District of Franklin; Geol. Surv. Can., Paper.

[2]Blackadar, R.G.
1960: The age of the Metamorphic Complex of northernmost Ellesmere Island; Arctic, vol. 13, p. 51.

GSC 63-22 Biotite, K-Ar age 325 ± 14 m.y.

$K = 7.56\%$, $Ar^{40}/K^{40} = 0.0206$; radiogenic Ar = 100%. Concentrate; clean concentrate of reddish brown biotite. A few biotite flakes are altered to chlorite and contain inclusions of epidote. Total chlorite content is about 3%.

From schistose granitic rock.
(340 F) 1/4 mile northeast of Creek Delta, District of Franklin, 82°05'N, 85°53'W. Sample Tm-62-55i, collected and interpreted by H.P. Trettin.

District of Franklin

From a metamorphosed granitic stock intruding the Cape Columbia "Group". The rock is composed of quartz, sodic oligoclase, microcline, epidote, chlorite, and opaque minerals. The feldspars are unzoned, mostly untwinned, and relatively free of inclusions. Two S-planes are well developed, and a third is poorly developed. The rock appears to be an original quartz monzonite metamorphosed in the lower subfacies of the almandine-amphibolite facies[3]. Retrogressive metamorphism is not apparent.

Intrusion and metamorphism are believed to have taken place in pre-Middle Cambrian and/or Upper Devonian (possibly Lower Mississippian) time. Allowing for a slight amount of argon loss due to slow cooling or late shearing, the age obtained is in agreement with an Upper Devonian to Lower Mississippian age of metamorphism.

(References - listed under GSC 63-23.)

GSC 63-23 Muscovite, K-Ar age 261 $\pm$ 12 m.y.

$K = 8.69\%$, $Ar^{40}/K^{40} = 0.0164$; radiogenic Ar = 97%. Concentrate; reasonably clean concentrate of muscovite. The muscovite flakes are intergrown along the edges with green biotite, quartz, and feldspar. Chlorite not detected. Total feldspar content is 5%.

From mica-schist.

(560 D) On a peak near the western rim of a glacier, District of Franklin, 81°55'20"N, 88°52'W. Sample Tm-62-24e, collected and interpreted by H.P. Trettin.

From the border phase of a small, metamorphosed granitic pluton there consisting predominantly of quartz, albite, perthite, microcline, muscovite, and biotite. The feldspars have been abraded and partly rotated. Several S-planes are developed. The rock is placed in the intermediate subfacies of the greenschist facies[3].

The pluton intrudes metasediments assigned to the Cape Columbia "Group" representing several subfacies of the greenschist facies. Several thin-sections indicate retrogressive metamorphism, and it is possible that both pluton and metasediments have been subjected to at least two phases of metamorphism.

District of Franklin

Intrusion and original metamorphism probably took place in pre-Middle Cambrian and/or Upper Devonian-Lower Mississippian time[1]. The metamorphic-plutonic complex is in fault contact with Lower Silurian strata and the abrasion, rotation of crystals, and retrogressive metamorphism observed may be related to internal shearing accompanying post-Lower Silurian uplift. Pronounced vertical movements in the region appear to have taken place in Upper Devonian-Lower Mississippian time, in the early Tertiary, and possibly near the Permo-Pennsylvanian boundary[2]. The age obtained is apparently related either to complete recrystallization during Permo-Pennsylvanian movements or, more likely, to partial Argon-loss during Tertiary orogeny.

References

[1]Trettin, H.P.
"Pre-Mississippian Succession of Nansen Sound area, District of Franklin"; Geol. Surv. Can., Paper, in prep.

[2]Thorsteinsson, R., and Tozer, E.T.
1960: "Summary account of structural history of the Canadian Arctic Archipelago since Precambrian time"; Geol. Surv. Can., Paper 60-7.

[3]Fyfe, W.S., Turner, F.J., and Verhoogen, J.
1958: "Metamorphic reactions and metamorphic facies"; Geol. Soc. Amer., Mem. 73.

District of Mackenzie

GSC 63-24 Biotite, K-Ar age 2,570 ± 80 m.y.

$K = 7.68\%$, $Ar^{40}/K^{40} = 0.3207$; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of greyish brown biotite. About 30% of the biotite flakes are partly altered to grey chlorite. Total chlorite content is about 20%.

From granodiorite-gneiss.
(85 I) North tip of a long narrow lake, 1,450 feet east of Upper Ross Lake, just north of the road to Peg Tantalum Mine, District of Mackenzie, 62°43'23"N, 113°08'W. Map-unit 4, GSC Map 47-16A. Sample BLO-29, collected and interpreted by W.R.A. Baragar.

The rock is a medium- to coarse-grained, grey granodiorite-gneiss marked by a knobby appearance due to uneven distribution of feldspar augen. The biotite content ranges widely but is generally less than 25%.

Seen in thin section the rock is dissected by a network of interlacing zones of finely crystalline quartz and feldspar. Between the zones are pods containing a mosaic of interlocking quartz and feldspar crystals or of broken crystals of microcline. Pods are 1 - 3 mm across and crystals within the pods generally less than 1/4 mm. Some microcline crystals are 1 mm across. The finely crystalline network has an average grain size of 1/10 - 1/20 mm. Coarser feldspars are microcline and were possibly originally phenocrysts. A sodic plagioclase is abundant in the groundmass.

Biotite and muscovite form 10 - 15% of the rock, the former being the more abundant. The biotite is pale to moderately brown and locally is associated with and possibly partly altered to chlorite. Most appears unaltered. Mica grains range in size from 1/20 to 1/3 mm with an average length about 1/6 mm.

The granodiorite body (map-unit 4, map 47-16A, Ross Lake map-area, Fortier) from which the specimen was taken is cut in succession by a swarm of basic dykes and a younger granite with its host of satellitic rare-element pegmatites. The contact of the two granitic bodies, about 2 2/3 miles east of the sample locality, is completely gradational but the age relationships are evidenced by the presence of the numerous pegmatites in the granodiorite-gneiss and the disappearance of the basic dyke swarm in the massive

granite. The younger granite a few miles east of the present sample locality and a related pegmatite within the granodiorite only 2,500 feet east of it were dated 2,555 m.y. (muscovite, GSC 61-68; paper 62-17, p. 42) and 2,495 m.y. (muscovite, GSC 61-67, p. 41) respectively. Since the 2,570 m.y. date for the present sample is not significantly different from the other two ages it has probably been effected by metamorphism accompanying the later intrusion.

GSC 63-25 Biotite, K-Ar age 1,920 ± 60 m.y.

K = 7.50%, Ar^{40}/K^{40} = 0.1954; radiogenic Ar = 100%. Concentrate; clean concentrate of greyish brown biotite. A few greenish flakes are slightly altered to chlorite. Chlorite content is 2%.

From gneiss.
(76 G) East of Ellice River, District of Mackenzie, 65°36'N, 106°07'W. Map-unit 8, GSC Map 17-1956. Sample T 94-62, collected and interpreted by L.P. Tremblay.

The rock is a coarse-grained augen feldspar gneiss or schist made up of about 65% well twinned fresh andesine, 10% interstitial quartz, 20% fresh greenish brown biotite, and 2% garnet. Minor amounts of apatite, sphene, zircon, and an opaque substance are present. Chlorite encloses a few opaque grains and occurs as long narrow streaks in biotite and feldspar, but constitutes less than 1% of the rock.

The sample is from an area of schist and gneiss probably representing a granitized metasediment and the rock is traversed by large white pegmatite bodies. This unit was assumed to be in the marginal zone of the Churchill province. Its age suggests, however, that this area is part of the Slave province and that it represents a rock of the Slave province effected by the metamorphism of the Churchill province to a greater degree than GSC 63-26 (2,030 m.y.).

GSC 63-26 Biotite, K-Ar age 2,030 ± 60 m.y.

K = 7.47%, Ar^{40}/K^{40} = 0.2130; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of pale brown biotite. About 30% of the biotite flakes are intergrown with quartz and in part altered to chlorite.

District of Mackenzie

Some flakes contain zircon inclusions surrounded by large, grey pleochroic haloes. Chlorite content is about 15%.

From granodiorite.

(76 G) Southeast of the Western River, west of Bathurst Fault, District of Mackenzie, 65°38'45"N, 106°29'W. Map-unit 10b, GSC Map 17-1956. Sample T5-62, collected and interpreted by L.P. Tremblay.

The rock is a coarse-grained, white to grey granodiorite made up of about 65% well twinned, slightly altered oligoclase, 15% interstitial quartz, and 15% brown biotite. A few grains of hornblende, K-feldspar, and sphene were noted, together with some carbonate. The hornblende is altered to biotite, and biotite and hornblende to chlorite. Chlorite was developed mainly at the edges of the biotite grains and locally has affected whole biotite grains. The rock is slightly brecciated.

The sample is from a discrete granodiorite mass in Yellowknife type sediments of the Slave province. This mass is locally transgressive, and to the north similar rocks are overlain by rocks of the Goulburn Group. The locality is in the marginal zone of the Slave province where the rocks of this province have been effected by the metamorphism of the Churchill province. The age represents a mixture of Slave and Churchill ages.

GSC 63-27 Whole Rock, K-Ar age 1,215 m.y.

$K = 2.64\%$, $Ar^{40}/K^{40} = 0.09988$; radiogenic Ar = 96%. Concentrate; crushed whole rock.

From gabbro.

(76 G) About 1 mile west of Western River, District of Mackenzie, 65°48'N, 106°33'W. Map-unit 18, GSC Map 17-1956. Sample T154-62, collected and interpreted by L.P. Tremblay.

The sample is from a gabbro sill within rocks of the Goulburn Group. The gabbro is massive, medium grained, and black to dark brown. The sill is locally transgressive and encloses blocks of rocks of the Goulburn Group. In thin section the rock is fresh and made up of blocky grains of pyroxene in a mass of feldspar laths. Its texture is ophitic. Feldspar forms about 60% of the rock,

pyroxene 35%, an interstitial quartz-feldspar plumose intergrowth 5%, and minor iron oxides.

The sill is cut by northwesterly trending gabbro dykes, but not by granite. The age is a minimum age for the Goulburn Group and compares with an age of 1,155 m.y. for the Muskox Intrusion (C.H. Smith, GSC Paper 61-25, p. 3) and the age of the base of the Coppermine lava (age not yet published).

GSC 63-28 Biotite, K-Ar age 1,750 ± 60 m.y.

$K = 8.01\%$, $Ar^{40}/K^{40} = 0.1687$; radiogenic Ar = 100%. Concentrate; clean concentrate of reddish brown to brown biotite. Biotite flakes contain numerous inclusions of zircon surrounded by zoned pleochroic haloes. Chlorite not detected.

From granodiorite.

(85 O) East shore of Basler Lake at the mouth of Emile River, District of Mackenzie, 63°58'30"N, 115°59'W. Map-unit 8, GSC Map 18-1962. Sample MC-B-29, collected and interpreted by J.C. McGlynn.

The biotite is from a well foliated, fine-grained, buff weathering granodiorite which is locally porphyritic or porphyroblastic with rectangular phenocrysts of feldspar up to 3/4 inch long. It contains very fresh biotite and muscovite in addition to quartz and pink to flesh coloured plagioclase and microcline. Muscovite GSC 63-29 is from the same specimen.

For interpretation, see GSC 63-29.

GSC 63-29 Muscovite, K-Ar age 1,820 ± 60 m.y.

$K = 9.08\%$, $Ar^{40}/K^{40} = 0.1795$; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of muscovite. Some muscovite flakes contain small adhering fragments of biotite. Minor impurities (1%) consist of a few microcline fragments. Chlorite not detected.

District of Mackenzie

From granodiorite.

(85 O) East shore of Basler Lake at the mouth of Emile River, District of Mackenzie, 63°58'30"N, 115°59'W. Map-unit 8, GSC Map 18-1962. Sample MC-B-29, collected and interpreted by J.C. McGlynn.

For petrographic details of the granodiorite see GSC 63-28.

The dates of the two micas agree with those from micas in granitic rocks that cut the Snare sediments in the general area and confirm the field relations. The young date on the muscovite eliminates the possibility of the granodiorite being a slightly reworked or metamorphosed Archaean intrusion because muscovites from nearby Archaean granitic rocks that have been exposed to some metamorphism retain argon and give Archaean ages. The older date of the muscovite relative to the biotite from the same rock may demonstrate the former's superior argon retention capacity.

GSC 63-30 Biotite, K-Ar age 1,815 ± 60 m.y.

K = 6.78%, Ar^{40}/K^{40} = 0.1787; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of brown biotite. Biotite flakes contain minute inclusions of quartz and epidote, and a few large zoned pleochroic haloes. About 30% of the biotite flakes are partly altered to chlorite. Total chlorite content is about 25%.

From granodiorite.

(86 B) District of Mackenzie, 64°31'N, 115°37'W. Map-unit 5, GSC Map 44-1963. Sample P-61-G-423, collected by P.H. Smith, interpreted by J.C. McGlynn.

The rock is a fine, even grained, light medium grey, slightly gneissic muscovite-biotite granodiorite consisting of plagioclase (60%), K-feldspar (10%), quartz (20%), biotite, and muscovite.

For geological relationships and interpretation of the age, see GSC 63-31.

District of Mackenzie

GSC 63-31 Muscovite, K-Ar age 2,390 ± 70 m.y.

$K = 8.20\%$, $Ar^{40}/K^{40} = 0.2817$; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of muscovite. Impurities, totalling 10%, consist of quartz fragments and sericitized feldspar. Chlorite not detected.

From granodiorite.

(86 B) District of Mackenzie, 64°31'N, 115°37'W. Map-unit 5, GSC Map 44-1963. Sample P-61-G-423, collected by P.H. Smith, interpreted by J.C. McGlynn.

For a description of the rock, see GSC 63-30.

The biotite of GSC 63-30 and the muscovite of GSC 63-31 are from one sample of granodiorite that cuts rocks of the Yellowknife Group and is known from field evidence to be overlain unconformably by rocks of the Snare Group of sediments. In the general area mica from granitic rocks that cut the Yellowknife Group and are older than Snare sediments give dates of about 2,300 m.y. Mica from granitic rocks that cut the Snare Group gives ages of about 1,800 m.y. Therefore, from what is known of the field relations of the granodiorite and regional distribution of dates the muscovite (GSC 63-31) gives the expected age of the granodiorite, but the biotite (GSC 63-30) gives an age equivalent to that of post-Snare granitic rocks. Study of thin sections shows that the muscovite is unaltered, whereas the biotite is partly altered to chlorite. Study of the metamorphism of the sediments of the Yellowknife Group cut by this granodiorite indicates that they were metamorphosed at the time of intrusion of the granodiorite and re-metamorphosed at a later time, possibly when the Snare sediments were altered. The biotite date (GSC 63-30) is thought to be the result of this second metamorphism.

GSC 63-32 Biotite, K-Ar age 1,735 m.y.

$K = 4.47\%$, $Ar^{40}/K^{40} = 0.1664$; radiogenic Ar = 100%. Concentrate; impure concentrate of brown biotite. About 50% of the biotite flakes are altered to chlorite and fine-grained epidote. Also present is about 3% of olive-green hornblende. Total chlorite content 50%.

District of Mackenzie

From granodiorite.

(86 F) Northeast shore of Ellington Lake, District of Mackenzie, 65°01'N, 117°19'W. Map-unit A, GSC Map 1014A. Sample MC-A-21, collected and interpreted by J.C. McGlynn.

The rock is a massive, fine-grained but locally porphyritic granodiorite consisting of plagioclase, quartz, biotite, hornblende, and minor epidote, iron ore, and variable amounts of microcline.

The granodiorite is thought to cut rocks of the Cameron Bay Group and possibly the Echo Bay Group. The biotite data therefore, gives a minimum age for these rocks.

GSC 63-33 Muscovite, K-Ar age 2,420 ± 70 m.y.

$K = 7.24\%$, $Ar^{40}/K^{40} = 0.2882$; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of muscovite. Impurities consist of 5% feldspar and 5% quartz. Chlorite not detected.

From pegmatite.

(86 B) East shore, north end of Basler Lake, District of of Mackenzie, 64°03'N, 115°51'W. Map-unit 3, GSC Map 18-1962. Sample MC-O-61, collected and interpreted by J.C. McGlynn.

The muscovite is from a quartz-feldspar-muscovite pegmatite mass in a granodiorite that cuts rocks of the Yellowknife Group and is overlain unconformably by rocks of the Snare Group of sediments. The pegmatite occurs within a few feet of the unconformity. The muscovite gives the expected age of the granodiorite and has therefore not been affected by the slight metamorphism that altered the overlying younger Snare sediments. In thin section the muscovite is seen to be bent and strained and the feldspar and quartz grains of the pegmatite are crushed around their edges and commonly fractured. This crushing and heat of low-grade metamorphism that affected the nearby Snare sediments and therefore, the underlying granodiorite has had no apparent effect on the argon content of the muscovite.

District of Mackenzie

GSC 63-34 Biotite, K-Ar age 2,200 ± 70 m.y.

$K = 7.82\%$, $Ar^{40}/K^{40} = 0.24410$; radiogenic Ar = 100%. Concentrate; clean concentrate of reddish brown biotite. A few flakes are slightly discoloured. Total chlorite content is 2%.

From schist.
(86 B) District of Mackenzie, 64°15'N, 115°31'W. Map-unit 3b, GSC Map 697A. Sample SR-879-61, collected by P.H. Smith, interpreted by J.C. McGlynn.

For description and interpretation, see GSC 63-35.

GSC 63-35 Muscovite, K-Ar age 2,365 ± 70 m.y.

$K = 7.08\%$, $Ar^{40}/K^{40} = 0.27581$; radiogenic Ar = 95%. Concentrate; reasonably clean concentrate of muscovite. About 30% of the muscovite flakes are coated with pale yellow crusts and contain small adhering flakes of biotite and a few opaque grains. Minor impurities consist of 2% quartz and a trace of feldspar. Total chlorite content is 2%.

From schist.
(86 B) District of Mackenzie, 64°15'N, 115°31'W. Map-unit 3b, GSC Map 697A. Sample SR-879-61, collected by P.H. Smith, interpreted by J.C. McGlynn.

The biotite of GSC 63-34 and muscovite of GSC 63-35 are from one sample of biotite-muscovite schist that represents metamorphosed greywacke slabs of the Yellowknife Group. These rocks are intruded by granitic rocks that, in the general area, date at almost 2,400 m.y. and are overlain unconformably by Snare sediments. The Snare rocks are cut by granitic rocks that contain micas dating at about 1,800 m.y. Therefore, the muscovite from the schist (GSC 63-35) gives the expected age of metamorphism whereas the biotite (GSC 63-34) gives a somewhat younger age. In thin section the biotite is seen to be slightly altered to chlorite. It is thought that these rocks were affected by the heat generated during the intrusion of granites into, and metamorphism of, the Snare sediments to the extent that some argon was driven off from the biotite.

District of Mackenzie

GSC 63-36 Biotite, K-Ar age 1,805 ± 60 m.y.

K = 6.58%, Ar^{40}/K^{40} = 0.17697; radiogenic Ar = 99%. Concentrate; clean concentrate of partly altered biotite. Some of the biotite flakes contain needle-like inclusions of rutile. About 35% of the biotite flakes are partly altered to chlorite and epidote. Total chlorite content 30%.

From biotite-muscovite granodiorite.
(86 B) District of Mackenzie, 64°09'53"N, 115°34'08"W. Map-unit A, GSC Map 697A. Sample SR-HL-1, collected by P.H. Smith, interpreted by J.C. McGlynn.

See GSC 63-37 for description and interpretation.

GSC 63-37 Muscovite, K-Ar age 2,310 ± 70 m.y.

K = 8.98%, Ar^{40}/K^{40} = 0.26533; radiogenic Ar = 99%. Concentrate; clean concentrate of muscovite. Some flakes are stained yellowish buff and contain opaque inclusions. A few grains are rimmed with micrographic intergrowths of muscovite, feldspar, and quartz. Chlorite not detected. Quartz 1%, feldspar trace.

From biotite-muscovite granodiorite.
(86 B) District of Mackenzie, 64°09'53"N, 115°34'08"W. Map-unit A, GSC Map 697A. Sample SR-HL-1, collected by P.H. Smith, interpreted by J.C. McGlynn.

The biotite of GSC 63-36 and muscovite of GSC 63-37 are from one sample of granodiorite that cuts rocks of the Yellowknife Group and is known from field evidence to be overlain unconformably by rocks of the Snare Group of sediments. In the general area mica from granitic rocks that cut only the Yellowknife rocks give dates of about 2,400 m.y., whereas, micas from younger granites that cut the Snare sediments give ages of about 1,800 m.y. Therefore, from what is known of the field relations of the granodiorite and regional distribution of dates, the muscovite GSC 63-37 gives the expected age of the granodiorite but the biotite gives an age equivalent to that of post-Snare granitic rocks. Study of thin sections shows that

biotite is partly altered to chlorite. Study of the sediments of the Yellowknife Group cut by this granodiorite indicates that they were metamorphosed at the time of intrusion of the granodiorite and remetamorphosed at a later time - possibly when the Snare sediments were altered. The biotite date GSC 63-36 is thought to be the result of this second metamorphism.

GSC 63-38 Biotite, K-Ar age 1,995 ± 60 m.y.

K = 7.81%, Ar^{40}/K^{40} = 0.20733; radiogenic Ar = 99%. Concentrate; clean concentrate of brown biotite. Most flakes contain aligned, needle-like inclusions of rutile (sagenite) and some large, dark brown pleochroic haloes. A few flakes are altered along the fractures to chlorite. Total chlorite 3%.

From muscovite-biotite granodiorite.
(86 B) Ingray Lake, District of Mackenzie, 64°15'30"N, 115°35'20"W. Map-unit A, GSC Map 697A. Sample SR-842, collected by P.H. Smith, interpreted by J.C. McGlynn.

For description and interpretation see GSC 63-39.

GSC 63-39 Muscovite, K-Ar age 2,105 ± 60 m.y.

K = 7.15%, Ar^{40}/K^{40} = 0.22686; radiogenic Ar = 98%. Concentrate; impure concentrate of muscovite. Most of the muscovite flakes are intergrown with quartz, epidote, biotite, and altered feldspar. Muscovite flakes contain inclusions of hematite and long needles of rutile. Impurities consist of traces of chlorite and quartz, and 20% feldspar.

From muscovite-biotite granodiorite.
(86 B) Ingray Lake, District of Mackenzie, 64°15'30"N, 115°35'20"W. Map-unit A, GSC Map 697A. Sample SR-842, collected by P.H. Smith, interpreted by J.C. McGlynn.

District of Mackenzie

The biotite of GSC 63-38 and muscovite of GSC 63-39 are from a single sample of granodiorite that cuts rocks of the Yellowknife Group and is known from field evidence to be overlain unconformably by rocks of the Snare Group of sediments. In the general area mica from granitic rocks that cut just the Yellowknife Group give dates of about 2,400 m.y. and mica from younger granitic rocks that cut the Snare Group give ages of about 1,800 m.y. The ages of the two micas (GSC 63-38, 39) therefore, are less than the expected age of the granodiorite. In other samples from this rock (GSC 63-37, 36, this volume) the muscovite gives the expected age whereas the biotites give younger ages. It is thought that the granodiorite has been affected by metamorphism of the Snare sediments to the extent that argon was driven off from both micas. The biotite was more affected and in thin section is seen to be partly altered to chlorite.

GSC 63-40 Biotite, K-Ar age 1,865 ± 60 m.y.

$K = 7.57\%$, $Ar^{40}/K^{40} = 0.18621$; radiogenic Ar = 99%. Concentrate; brown biotite, some flakes with long needle-like inclusions. About 40% of the biotite flakes are partly bleached and slightly altered to chlorite and epidote. Total chlorite 8%.

From muscovite-biotite granodiorite.

(86 B) Ingray Lake, District of Mackenzie, 64°09'53"N, 115°34'08"W. Map-unit A, GSC Map 697A. Sample SR-Ma-62, collected by P.H. Smith, interpreted by J.C. McGlynn.

The biotite is from a granodiorite that cuts metasediments of the Yellowknife Group and is overlain unconformably by sediments of the Snare Group. These latter rocks are cut by granites that in the general area date at about 1,800 m.y. In the region, granitic rocks that are older than Snare sediments date at about 2,400 m.y. The biotite, therefore, does not give the expected age of the intrusion. It probably gives the age of metamorphism of the Snare sediments, which, it is suggested, affected this pre-Snare granodiorite. In thin section the biotite is seen to be slightly altered to chlorite.

District of Mackenzie

GSC 63-41 Muscovite, K-Ar age 2,250 ± 60 m.y.

$K = 8.19\%$, $Ar^{40}/K^{40} = 0.25381$; radiogenic Ar = 99%. Concentrate; reasonably clean concentrate of muscovite. Some flakes are stained pinkish buff and contain attached specks of altered biotite and inclusions of quartz, epidote, and opaque grains. Minor impurities consist of quartz and sericitized feldspar. Total chlorite content 5%.

(86 B) From porphyritic biotite-muscovite granodiorite. Ingray Lake, District of Mackenzie, 64°11'48"N, 115°47'17"W. Map-unit A, GSC Map 697A. Sample SR-Rap-62, collected by P.H. Smith, interpreted by J.C. McGlynn.

The muscovite GSC 63-41 is from a granodiorite that cuts metasediments of the Yellowknife Group and is overlain unconformably by sediments of the Snare Group. Such granitic rocks in the region contain micas that date at about 2,400 m.y. This muscovite therefore, gives an age slightly less than expected. This sample was collected close to the Snare unconformity and the mica may have been affected by metamorphism of the nearby Snare sediments.

GSC 63-42 Biotite, K-Ar age 1,835 ± 70 m.y.

$K = 7.08\%$, $Ar^{40}/K^{40} = 0.18170$; radiogenic Ar = 100%. Concentrate; clean concentrate of dull brown biotite. Biotite flakes are partly bleached and contain large dark pleochroic haloes. Some flakes are altered to chlorite and contain acicular inclusions. Total chlorite content 25%.

(86 B) From coarse, locally porphyritic granodiorite. Ingray Lake area, District of Mackenzie, 64°09'N, 115°47'W. Map-unit A, GSC Map 697A. Sample SR-869, collected by P.H. Smith, interpreted by J.C. McGlynn.

The biotite is from a sample of granodiorite that cuts rocks of the Yellowknife Group and is overlain unconformably by sediments of the Snare Group. In the general area such granitic rocks date at about 2,400 m.y. This biotite, which is from a

sample close to the Snare unconformity, is not dating the time of intrusion of the granodiorite. It is thought to be dating the time of metamorphism and intrusion in Snare sediments. Granitic rocks cutting the Snare sediments in the region contain biotite with ages of about 1,800 m.y. The biotite in this sample is partly altered to chlorite.

GSC 63-43 Biotite, K-Ar age 1,245 m.y.

K = 2.15%, Ar^{40}/K^{40} = 0.1034; radiogenic Ar = 100%. Concentrate; impure concentrate of biotite composed of the following minerals: about 30% biotite, 20% chlorite, 40% hornblende, 10% pyroxene, and some opaque grains.

From gabbro.
(75 M) District of Mackenzie, 63°08'N, 110°14'W. Map-unit 6, GSC Map 738A. Sample FA-201-62, collected and interpreted by W.F. Fahrig.

The rock is a coarse-grained gabbro consisting of intensely altered plagioclase, pyroxene, iron ores, yellow-brown to greenish biotite, hornblende, fine-grained graphic quartz-feldspar intergrowths, and apatite.

The biotite is concentrated around the iron ores. The hornblende, which is present in minor amounts, is pseudomorphic after pyroxene. These minerals are thought to be late magmatic and the K-Ar date gives the age of crystallization of the intrusion.

GSC 63-44 Biotite, K-Ar age 1,360 ± 50 m.y.

K = 5.74%, Ar^{40}/K^{40} = 0.1166; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of brown biotite. About 20% of the biotite flakes are partly altered to chlorite. Impurities consist of about 5% amphibole and 10% green chlorite flakes.

From granophyre.
(66 D) District of Mackenzie, 64°30'N, 102°45'W. Map-unit 18b, GSC Map 17-1956. Sample FA-203-62, collected and interpreted by W.F. Fahrig.

District of Mackenzie

The rock is a coarse-grained biotite granophyre which grades laterally into normal ophitic gabbro. It consists of plagioclase, hornblende, iron ores, biotite, apatite, and micrographic quartz-feldspar intergrowths. The biotite is red-brown and only locally chloritized.

The K-Ar date probably gives the age of crystallization of the intrusion.

GSC 63-45 Biotite, K-Ar age 1,885 ± 60 m.y.

$K = 5.73\%$, $Ar^{40}/K^{40} = 0.1892$; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of brown biotite. About 10% of the biotite flakes are in part altered to chlorite. Impurities consist of amphibole (5%) with opaque inclusions, and about 5% chlorite flakes. Total chlorite content is 11%.

From gabbro.
(75 E) District of Mackenzie, 61°17'N, 111°48'W. Map-unit 9, GSC Map 55-9. Sample FA-204-62, collected and interpreted by W.F. Fahrig.

The biotite was extracted from a sample of ophitic gabbro that contains a large number of wall-rock inclusions. The inclusions are chiefly granitic and have been partly digested. Within the zone of inclusions amygdules have developed, and biotite occurs within and around the periphery of the amygdules. The analyzed biotite is from the amygdaloidal zone.

The rock consists of relatively unaltered plagioclase, intensely altered pyroxene, iron-ores, fine-grained micrographic quartz-feldspar intergrowths, biotite, hornblende, and extensive patches of fine-grained chlorite. The amygdules are occupied by carbonate and quartz.

The K-Ar age of 1,885 m.y. appears anomalously great as ages of biotite in the surrounding rocks are generally less than this and dykes of similar trend have a K-Ar age of about 1,300 m.y. (see GSC 63-43, 44, 48). Possibly the digestion of country rock by the gabbro released volatiles, including argon, that were incorporated in the biotite of the gabbro.

District of Mackenzie

GSC 63-46 Whole Rock, K-Ar age 2,105 m.y.

$K = 0.53\%$, $Ar^{40}/K^{40} = 0.2265$; radiogenic Ar = 100%.

From gabbro.
(76 P) District of Mackenzie, 67°34'N, 105°30'W. Not mapped. Sample FA-217-62, collected and interpreted by W.F. Fahrig.

Fine-grained very dark grey gabbro from the chilled contact of a diabase dyke. The whole rock K-Ar analysis gives the approximate age of intrusion.

GSC 63-47 Whole Rock, K-Ar age 630 m.y.

$K = 0.56\%$, $Ar^{40}/K^{40} = 0.0436$; radiogenic Ar = 100%.

From gabbro.
(86 M) District of Mackenzie, 67°07'N, 119°00'W. Map-unit 18, GSC Map 18-1960. Sample FA-218-62, collected and interpreted by W.F. Fahrig.

The rock is dark grey fine-grained diabase collected 2 feet from the wall of a diabase dyke. It is typical ophitic gabbro composed of pyroxene, plagioclase, iron-ores and less then one per cent yellow-brown biotite. The cores of the plagioclase crystals are replaced by fine-grained secondary minerals but apart from this the rock is fresh.

The K-Ar analysis probably gives the age of intrusion of the dyke.

GSC 63-48 Whole Rock, K-Ar age 1,335 m.y.

$K = 1.04\%$, $Ar^{40}/K^{40} = 0.1139$; radiogenic Ar = 100%.

From gabbro.
(86 H) District of Mackenzie, 65°20'N, 112°02'W. Map-unit 18, GSC Map 18-1960. Sample FA-219-62, collected and interpreted by W.F. Fahrig.

District of Mackenzie

The sample is from the dark grey chilled contact of a gabbro dyke. It consists of 1/16 inch subparallel needles of plagioclase in an extremely fine-grained semi-opaque matrix. The matrix appears to contain several per cent yellow-brown biotite.

The K-Ar analysis probably provides a close approximation to the age of crystallization of the dyke.

GSC 63-49 Whole Rock, K-Ar age 920 m.y.

$K = 0.73\%$, $Ar^{40}/K^{40} = 0.0692$; radiogenic Ar = 100%.

From gabbro.
(86 P) District of Mackenzie, 67°08'N, 112°30'W. Map-unit 18, GSC Map 18-1960. Sample FA-220-62, collected and interpreted by W.F. Fahrig.

The rock is dark grey fine-grained gabbro a few inches from the edge of a diabase dyke. It consists of blocky, 1 mm pyroxene and plagioclase crystals in a finer grained matrix of hornblende, plagioclase, iron-ore, and orange-brown biotite. Biotite forms 2-3% of the rock.

The K-Ar analysis probably gives a good approximation to the age of crystallization of the intrusion.

GSC 63-50 Whole Rock, K-Ar age 830 m.y.

$K = 0.90\%$, $Ar^{40}/K^{40} = 0.0612$; radiogenic Ar = 100%.

From gabbro.
(86 F) District of Mackenzie, 65°31'N, 117°56'W. Map-unit 9, GSC Map 333A. Sample FA-221-62, collected and interpreted by W.F. Fahrig.

The sample is from the chilled margin of a diabase dyke. It consists of sub-parallel, 1 mm plagioclase laths and elongate pyroxene crystals in a sub-opaque to opaque matrix. The opaque matrix occurs immediately adjacent to the dyke contact and gives way at about 1 centimeter to extremely fine-grained rock whose only microscopically identifiable phase consists of minute plagioclase needles.

District of Mackenzie

The K-Ar analysis provides the approximate age of crystallization.

GSC 63-51 Whole Rock, K-Ar age 2,180 m.y.

$K = 1.12\%$, $Ar^{40}/K^{40} = 0.2403$; radiogenic Ar = 94%.

From gabbro.
(86 B) District of Mackenzie, 64°06'N, 114°23'W. Map-unit 8, GSC Map 1022A. Sample FA-222-62, collected and interpreted by W.F. Fahrig.

The sample is dark grey chilled gabbro and consists of 1 mm phenocrysts of plagioclase and smaller phenocrysts of pyroxene and ilmenite in a fine-grained matrix of hornblende, plagioclase, and iron ores. Yellow brown mica is abundant, particularly around the ilmenite grains.

The K-Ar analysis gives the approximate age of crystallization of the gabbro.

GSC 63-52 Whole Rock, K-Ar age 2,090 m.y.

$K = 0.29\%$, $Ar^{40}/K^{40} = 0.2235$; radiogenic Ar = 100%.

From gabbro.
(85 O) District of Mackenzie, 63°52'N, 115°24'W. Map-unit 10, GSC Map 1021A. Sample FA-223-62, collected and interpreted by W.F. Fahrig.

The sample is dark grey-green gabbro from the contact zone of a 30' wide diabase dyke. The rock is a mass of fine-grained hornblende, altered plagioclase and iron ores surrounding sparsely distributed, largely altered pyroxene phenocrysts.

The whole rock K-Ar analysis give the minimum age of intrusion.

GSC 63-53 Whole Rock, K-Ar age 2,105 m.y.

$K = 0.42\%$, $Ar^{40}/K^{40} = 0.2268$; radiogenic Ar = 100%.

District of Mackenzie

From gabbro.
(76 D) District of Mackenzie, 64°07'N, 110°05'W. Map-unit 7, GSC Map 977A. Sample FA-224-62, collected and interpreted by W.F. Fahrig.

The sample is fine-grained, dark grey gabbro collected a few inches from the edge of a diabase dyke. The rock consists of plagioclase and pyroxene, in a somewhat finer matrix of plagioclase, pyroxene, hornblende and iron ores.

The K-Ar analysis is a first approximation to the age of crystallization of the intrusion.

GSC 63-54 Whole Rock, K-Ar age 2,185 m.y.

$K = 0.28\%$, $Ar^{40}/K^{40} = 0.2410$; radiogenic Ar = 100%.

From gabbro.
(85 J) District of Mackenzie, 62°42'N, 114°13'W. Map-unit 10, GSC Map 868A. Sample FA-225-62, collected and interpreted by W.F. Fahrig.

The rock is dark grey aphanitic gabbro from the chilled contact zone of a diabase dyke. The rock consists of aligned 1 mm needles of plagioclase in a semi-opaque, fuzzy, finely crystalline groundmass. A few olivine phenocrysts are present and the plagioclase is locally replaced by white mica.

The K-Ar analysis gives the approximate age of crystallization of the gabbro.

GSC 63-55 Whole Rock, K-Ar age 1,985 m.y.

$K = 0.46\%$, $Ar^{40}/K^{40} = 0.2057$; radiogenic Ar = 100%.

From gabbro.
(85 J) District of Mackenzie, 62°53'N, 114°22'W. Map-unit 5, GSC PS Map 14-40. Sample FA-226-62, collected and interpreted by W.F. Fahrig.

The sample is dark grey aphanitic gabbro from the chilled contact of a diabase dyke. It consists of 1 mm laths of plagioclase and equant olivine phenocrysts in a matrix of minute plagioclase needles and a semi-opaque groundmass. Both the

plagioclase phenocrysts and groundmass plagioclase are well aligned. The plagioclase crystals are virtually unaltered, but in parts of the thin section the olivine has been replaced by fine-grained secondary minerals.

The K-Ar analysis gives the approximate age of crystallization of the gabbro.

GSC 63-56 Whole Rock, K-Ar age 770 m.y.

$K = 0.80\%$, $Ar^{40}/K^{40} = 0.0557$; radiogenic Ar = 100%.

From gabbro.
(97 A) District of Mackenzie, 68°45'N, 121°42'W. Map-unit 18, GSC Map 18-1960. Sample HF-79-1959, collected by W.W. Heywood, interpreted by W.F. Fahrig.

The rock is mottled pink and light green, coarse-grained gabbro. It consists of slightly altered subhedral plagioclase, clinopyroxene and orthopyroxene, iron ore, quartz-feldspar micrographic intergrowth, and minor biotite. The pyroxenes are partly replaced by yellow antigorite and hornblende.

The K-Ar analysis provides first approximation to the age of crystallization of the intrusion.

GSC 63-57 Whole Rock, K-Ar age 705 m.y.

$K = 1.33\%$, $Ar^{40}/K^{40} = 0.0499$; radiogenic Ar = 100%.

From gabbro.
(97 D) District of Mackenzie, 69°33'N, 123°00'W. Map-unit 18, GSC Map 18-1960. Sample C.D. 31/59, collected by B.G. Craig, interpreted by W.F. Fahrig.

The rock is dark green gabbro with conspicuous pink feldspar crystals visible on the fresh surface. It was collected from the central part of a diabase dyke and the K-Ar analysis gives the approximate age of crystallization.

District of Mackenzie

GSC 63-58 Biotite, K-Ar age 2,210 m.y.

$K = 1.78\%$, $Ar^{40}/K^{40} = 0.2456$; radiogenic Ar = 100%. Concentrate; consists of partly altered biotite and is composed of the following minerals: about 10% reasonably clean, brown and unaltered biotite flakes; about 50% partly chloritized biotite with epidote inclusions; and about 40% chlorite with epidote and long needle-like inclusions. Total chlorite content is 80%.

From granite.
(75 N) District of Mackenzie, 63°54'N, 108°29'W. Map-unit 6b, GSC Map 1013A. Sample FA-227-62, collected and interpreted by W.F. Fahrig.

The biotite was extracted from a sample of granite that lies 16 feet from the contact of a 150-foot wide diabase dyke. The biotite of the granite has been noticeably chloritized adjacent to, and presumably as a result of, the dyke intrusion. Biotite in samples closer than 16 feet to the diabase appears to have been completely chloritized and biotite in samples farther away appears megascopically to be unaltered. It was thought that the biotite at a distance of 16 feet from the dyke would surely have lost all of its earlier developed argon as a result of the dyke intrusion and would give an accurate K-Ar age for the intrusion.

The granite from which the biotite was analyzed consists of quartz, plagioclase, microcline and yellow-brown biotite crystals of which are slightly to completely chloritized.

The K-Ar age agrees well with a whole rock analysis (GSC 63-54) from the same dyke swarm and is believed to give the age of crystallization of the intrusion.

GSC 63-59 Biotite, K-Ar age 1,315 m.y.

$K = 4.04\%$, $Ar^{40}/K^{40} = 0.1113$; radiogenic Ar = 100%. Concentrate; impure concentrate of biotite. Biotite flakes vary from brown to olive-green. Some flakes are zoned. About 50% of the biotite flakes are intergrown and partly altered to chlorite. Impurities consist of 35% chlorite and 5% hornblende.

District of Mackenzie

From gabbro.
(75 N) District of Mackenzie, 63°15'N, 108°14'W. Map-unit 6A, GSC Map 1013A. Sample FA-229-62, collected and interpreted by W.F. Fahrig.

The rock is coarse-grained gabbro consisting of plagioclase, pyroxene, iron-ores, hornblende, biotite, and micrographic quartz-feldspar intergrowth. The feldspar and pyroxene are extensively altered to very fine-grained secondary minerals. The biotite is chiefly yellow-brown to dark red-brown but locally has a greenish colour as a result of chloritization.

The K-Ar age is the approximate age of crystallization of the gabbro.

GSC 63-60 Biotite, K-Ar age 1,330 ± 50 m.y.

$K = 5.14\%$, $Ar^{40}/K^{40} = 0.1131$; radiogenic Ar = 100%. Concentrate; consists of partly altered brown biotite. About 40% of the biotite flakes are in part altered to chlorite and some are intergrown with amphibole. Some of the chlorite flakes are zoned. Total chlorite content is 20%, amphibole content is 3%.

From gabbro.
(76 N) District of Mackenzie, 67°17'N, 109°32'W. Sample FA-230-62, collected and interpreted by W.F. Fahrig.

The rock is coarse-grained ophitic gabbro consisting of plagioclase, pyroxene, hornblende, iron-ores, biotite and extensive patches of quartz-feldspar intergrowth. The pyroxene is cloudy as a result of submicroscopic alteration and some of the plagioclase is replaced by fine-grained secondary minerals. The biotite varies in colour from yellow brown to green as a result of chloritization.

The K-Ar age of the biotite is the approximate age of crystallization of the gabbro.

District of Mackenzie

GSC 63-61 Biotite, K-Ar age 2,270 ± 70 m.y.

$K = 8.12\%$, $Ar^{40}/K^{40} = 0.2576$; radiogenic Ar = 100%. Concentrate; clean concentrate of olive-brown biotite. Biotite flakes contain small inclusions of epidote along the fractures and a few zircon inclusions surrounded by pleochroic haloes. About 2% of the biotite flakes are altered to chlorite. Total chlorite content is about 2%.

From quartz monzonite.
(76 O) 16 miles northeast of the north point on Kanuyak Island, District of Mackenzie, 67°39'30"N, 107° 29'W. Sample BK-306-62, collected by H.H. Bostock, interpreted by J.A. Fraser.

The rock is fine-grained, massive and pinkish grey in colour. It consists mainly of quartz, microcline, and oligoclase, and a few per cent of slightly ragged brown biotite. Traces of epidote, muscovite, apatite and magnetite are present.

Granitic rocks of similar character outcrop across a large area northeast of Bathurst Inlet. These have been invaded, in many places, by a grey muscovite leucogranite. The age of the biotite is considered to represent the age of the older granite and is comparable to Slave ages obtained from rocks west of Bathurst Inlet.

GSC 63-62 Biotite, K-Ar age 1,760 ± 60 m.y.

$K = 7.81\%$, $Ar^{40}/K^{40} = 0.1700$; radiogenic Ar = 100%. Concentrate; clean concentrate of rusty brown biotite. A few flakes are altered to chlorite and contain inclusions of epidote, quartz, and opaque grains. Total chlorite content is about 2%.

From charnockite or hypersthene-quartz monzonite.
(76 I) 56 miles east of Lower Western River, District of Mackenzie, 66°03'N, 104°50'W. Sample PB-131-62, collected by W.H. Poole, interpreted by J.A. Fraser.

The monzonite is dark pinkish grey, medium to fine grained, and slightly foliated. It contains mainly quartz, perthite, oligoclase, and a few per cent of myrmekite, reddish brown biotite, and orthopyroxene that is partly altered to chlorite and biotite.

District of Mackenzie

The sample is from one of several bodies of pyroxene-bearing granitic rocks that occur in the MacAlpine Lake region in association with pyroxene-bearing gneisses.

The age of the biotite, which is consistent with other ages in the Churchill province, may represent either the time of intrusion of the monzonite, or the latest period of metamorphism at this locality.

GSC 63-63 Biotite, K-Ar age 1,960 ± 65 m.y.

$K = 7.74\%$, $Ar^{40}/K^{40} = 0.2013$; radiogenic Ar = 100%. Concentrate; clean concentrate of red-brown biotite. Biotite flakes contain long needle-like inclusions. A few flakes are altered to chlorite and fine-grained epidote. Total chlorite content is 1%.

From granodiorite.
(76 L) 3 miles west of Cree River, 8 miles southeast of Burnside River, District of Mackenzie, 66°08'30"N, 110°08'30"W. Sample DF-65-62, collected by J.A. Donaldson, interpreted by J.A. Fraser.

The granodiorite is buff to white, medium to coarse grained, and massive, with allotriomorphic texture. It is composed of oligoclase, quartz, perthite, and about 15% deep reddish brown biotite. Apatite is an accessory.

The granodiorite and gneiss of granodioritic composition are well exposed in the valley of Burnside River. These rocks are probably derived mainly from sedimentary and volcanic strata of the Yellowknife Group. The sample locality lies within the Slave province, but the age evidently indicates the influence of a younger metamorphism.

GSC 63-64 Muscovite, K-Ar age 2,530 ± 80 m.y.

$K = 8.71\%$, $Ar^{40}/K^{40} = 0.3118$; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of muscovite. About 15% of the muscovite flakes are stained yellow and contain small adhering fragments of altered biotite. Minor impurities (less than 5%) consist of feldspar, quartz, myrmekite and tourmaline. Chlorite not detected.

District of Mackenzie

From pegmatite.

(76 E) 8 miles southeast of Peacock Hills, District of Mackenzie, 65°55'N, 110°44'30"W. Sample PB-48-62, collected by W.H. Poole, interpreted by J.A. Fraser.

The muscovite is from a white, medium- to coarse-grained, massive pegmatite and pegmatitic granite that also contains oligoclase, perthitic microcline, quartz, and small amounts of biotite, chlorite and tourmaline.

Masses of granite and pegmatitic granite of this kind are common in the granitic terrain adjacent to Contwoyto Lake, where they intrude and metamorphose sediments of the Yellowknife Group. The age, which is comparable to some of the older ages in the Slave province, is a minimum for this group.

GSC 63-65 Biotite, K-Ar age 1,800 ± 60 m.y.

$K = 7.55\%$, $Ar^{40}/K^{40} = 0.1761$; radiogenic Ar = 100%. Concentrate; clean concentrate of orange-brown biotite. Some biotite flakes contain fine-grained prismatic inclusions of rutile and opaque grains along the fractures. Minor impurities consist of pyroxene and hornblende. Chlorite content is less than 1%. Hornblende content is 2%.

From diorite.

(66 L) Southeast end of MacAlpine Lake, District of Mackenzie, 66°23'30"N, 102°14'30"W. Sample PB-78A-62, collected by W.H. Poole, interpreted by J.A. Fraser.

The sample was taken from a pyroxene-hornblende diorite which forms a mafic inclusion in a grey leucogranite. The diorite is dark grey, medium grained, foliated, and comprises zoned andesine, hornblende, clinopyroxene, fairly fresh reddish brown biotite, and minor black opaque minerals.

The age represents a possible minimum for mafic rocks in this region.

District of Mackenzie

GSC 63-66 Biotite, K-Ar age 1,810 ± 60 m.y.

$K = 7.92\%$, $Ar^{40}/K^{40} = 0.1781$; radiogenic Ar = 100%. Concentrate; clean concentrate of greenish grey biotite. Some flakes are slightly altered and contain fine-grained epidote inclusions along the fractures. Total chlorite content is 2%.

From quartz diorite.

(76 N) 3 miles southwest of Daniel Moore Bay, District of Mackenzie, 67°43'N, 109°46'W. Sample BK-377-62, collected by H.H. Bostock, interpreted by J.A. Fraser.

The rock is a pink, medium-grained, massive quartz diorite with hypidiomorphic texture. It consists chiefly of andesine and quartz, and about 5% clean biotite. Accessory minerals include epidote, sphene, apatite, and magnetite.

The sample was collected immediately west of the Bathurst fault and is considered to be representative of a large area of massive granitic rocks that presumably lies within the Slave province. The age of the biotite is, however, more typical of those from the Churchill province, and possibly reflects the influence of the Hudsonian orogeny. Alternatively, the age may be related to metamorphism associated with movement along the Bathurst fault.

GSC 63-67 Muscovite, K-Ar age 2,000 ± 70 m.y.

$K = 7.48\%$, $Ar^{40}/K^{40} = 0.2082$; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of muscovite. About 30% of the muscovite flakes are intergrown with quartz, feldspar and minor chlorite, and contain a few small plates of orange-red iron oxide. Feldspar content is 5%, quartz 5%. Chlorite not detected by X-ray.

From slate.

(76 M) 3 miles northeast of the mouth of Tree River, District of Mackenzie, 67°41'30"N, 111°49'W. Sample PB-357-62, collected by W.H. Poole, interpreted by J.A. Fraser.

District of Mackenzie

The sample is from dark grey slate that contains silt-sized grains of detrital quartz and secondary muscovite. The muscovite is fairly uniform in size and is distributed evenly through the rock in thin plates parallel with the bedding or parallel with fractures inclined about 50 degrees to bedding. The slate is from a section of Epworth strata exposed east of Tree River and separated by a fault from granite to the east. Farther south along Tree River, Epworth rocks overlie granite unconformably.

The age of the muscovite is considered to date the latest metamorphism of Epworth rocks at this locality. If so, the age should represent a minimum for the Epworth. If, however, the muscovite has inherited some of its argon from the original detrital components of the slate, the age would be a maximum for the metamorphism, and might even pre-date Epworth sedimentation.

GSC 63-68 Biotite, K-Ar age 2,110 ± 70 m.y.

$K = 6.09\%$, $Ar^{40}/K^{40} = 0.2275$; radiogenic Ar = 100%. Concentrate; impure concentrate of brown biotite. About 30% of the biotite flakes are in part altered to chlorite. Some flakes are intergrown with quartz. Total chlorite content is 25%, quartz 10%.

From rhyolite.

(76 M) 2 miles south of Grays Bay, District of Mackenzie, 67°44'15"N, 111°01'W. Sample PB-342A-62, collected by W.H. Poole, interpreted by J.A. Fraser.

The rhyolite from which the samples were taken is light grey, very fine grained, and schistose. It consists principally of quartz and feldspar with small amounts of epidote, apatite, and pyrrhotite. Biotite and muscovite each constitute about 15 per cent.

The rhyolite is from a belt of volcanic flows, mainly of andesitic composition, that extends more than 80 miles southward from Coronation Gulf. The flows are intruded by granite and are assumed to belong to the Yellowknife Group. The age dates the most recent metamorphism at this locality and represents a minimum for the Yellowknife Group.

District of Mackenzie

GSC 63-69 Biotite, K-Ar age 1,895 ± 70 m.y.

$K = 7.27\%$, $Ar^{40}/K^{40} = 0.1910$; radiogenic Ar = 100%. Concentrate; clean concentrate of partly altered brown biotite. About 50% of the biotite flakes are partly altered to chlorite and contain inclusions of epidote in bleached areas. Total chlorite content is 20%.

From gneiss.
(76 M) 2.5 miles southeast of the mouth of Tree River, District of Mackenzie, 67°39'30"N, 111°46'30"W. Sample PB-337C-62, collected by W.H. Poole, interpreted by J.A. Fraser.

The sample is a greyish, fine-grained schist, composed of quartz, feldspar, and biotite, and accessory apatite and zircon. The quartz is strained and the feldspar is altered to masses of sericite and epidote. The biotite crystals are bent and intergrown with minor chlorite and muscovite.

The schist has probably been derived from sediments of the Yellowknife Group. The age, however, is low compared with most other ages in the Slave province, and is possibly related to metamorphism associated with fault movement.

GSC 63-70 Biotite, K-Ar age 1,890 ± 70 m.y.

$K = 7.62\%$, $Ar^{40}/K^{40} = 0.18985$; radiogenic Ar = 100%. Concentrate; clean concentrate of brown biotite. Biotite flakes contain minute specks of quartz along the fractures. Some flakes are altered to dull-green chlorite. Total chlorite 10%.

From biotite quartz monzonite.
(76 E) 10 miles NW of Yamba Lake, District of Mackenzie, 65°08 1/2'N, 111°47 1/2'W. Map-unit 5, GSC Map 45-1963. Sample PB-8-62, collected by W.H. Poole, interpreted by J.A. Fraser.

The sample is grey to pink, medium to coarse grained, and composed of sodic oligoclase, quartz, perthitic microcline in subhedra 2 cm long, minor myrmekite, and accessory minerals. Clean brown biotite containing scattered zircon inclusions constitutes about 6 per cent of the quartz monzonite.

District of Mackenzie

The quartz monzonite is exposed over a wide area and is, in part, intrusive into gneisses that have probably been derived from sediments and volcanic rocks of the Yellowknife Group. Although the sample locality is within the Slave province, the age is characteristic of the Hudsonian orogeny. Similar ages have been obtained from granitic rocks exposed in the area between Yamba and Mohawk Lakes, a few tens of miles to the south.

GSC 63-71 Biotite, K-Ar age 1,810 ± 70 m.y.

K = 7.65%, Ar^{40}/K^{40} = 0.17742; radiogenic Ar = 91%. Concentrate; clean concentrate of brown biotite. Most flakes contain aligned needle-like inclusions of rutile. Some biotite flakes are slightly altered along the edges to greenish chlorite and contain inclusions of epidote. Total chlorite 4%.

From granodiorite.

(76 O) 37 miles NE of Bathurst Post, District of Mackenzie, 67°09'N, 106°55'W. Map-unit 5, GSC Map 45-1963. Sample BK-235-62, collected by H.H. Bostock, interpreted by J.A. Fraser.

Light grey, massive, granodiorite is widely exposed in the area east of Bathurst Inlet. Field relations indicate it to be younger than strata of the Yellowknife Group. The sample consists largely of oligoclase and quartz, with traces of microcline. Biotite and associated muscovite constitute about 7 per cent. Accessory minerals are chlorite and magnetite.

Although the sample locality is considered to be within the Slave province, the age suggests that the biotite was affected by the Hudsonian orogeny. Note that muscovite (GSC 63-72) from the same sample gives an older age.

GSC 63-72 Muscovite, K-Ar age 1,990 ± 70 m.y.

K = 8.72%, Ar^{40}/K^{40} = 0.20679; radiogenic Ar = 99%. Concentrate; reasonably clean concentrate of muscovite. Some muscovite flakes are intergrown with feldspar, biotite and quartz. A few flakes are coated with yellow crusts. Total chlorite 1%, trace of feldspar.

District of Mackenzie

From granodiorite.

(76 O) 37 miles NE of Bathurst Post, District of Mackenzie, 67°09'N, 106°55'W. Map-unit 5, GSC Map 45-1963. Sample BK-235-62, collected by H.H. Bostock, interpreted by J.A. Fraser.

The age is that of muscovite from the granodiorite described under GSC 63-71 and may be considered to be characteristic of the Slave province from which the sample was collected.

GSC 63-73 Muscovite, K-Ar age 2,470 ± 80 m.y.

K = 8.95%, Ar^{40}/K^{40} = 0.29840; radiogenic Ar = 100%. Concentrate; clean concentrate of muscovite. Some flakes are blistered and contain small inclusions of quartz and epidote along the fractures. A few flakes contain small adhering fragments of altered biotite. Total chlorite 1%.

From granodiorite.

(76 F) 12 miles north of Thistle Lake, District of Mackenzie, 65°08'N, 108°44'W. Map-unit 5, GSC Map 45-1963. Sample DF-10-62, collected by J.A. Donaldson, interpreted by J.A. Fraser.

The granodiorite is representative of massive, medium-grained, equigranular, granitic rocks that outcrop south of Mara Lake. The sample contains quartz, albite, microcline, and about 15 per cent mica consisting of fresh blades of muscovite intergrown with biotite. Tourmaline is present in trace amounts.

The age of the muscovite is consistent with other ages from the Slave province in which the sample locality occurs.

GSC 63-74 Biotite, K-Ar age 1,815 ± 70 m.y.

K = 7.64%, Ar^{40}/K^{40} = 0.17889; radiogenic Ar = 99%. Concentrate; clean concentrate of olive-brownish biotite. About 30% of the biotite flakes are partly altered to greenish chlorite and contain inclusions of epidote in chloritized areas. Zircon inclusions are surrounded by dark pleochroic haloes. Total chlorite content 20%.

District of Mackenzie

From biotite-muscovite schist.
(76 I) 40 miles NE of mouth of Western River, District of Mackenzie, 66°38 1/4'N, 105°53 1/2'W. Map-unit 4, GSC Map 45-1963. Sample PB-158-A-62, collected by W.H. Poole, interpreted by J.A. Fraser.

The sample is a dark greyish green, fine-grained schist that shows flakes of mica on cleavage surfaces and consists mainly of quartz with minor potash feldspar and augen of plagioclase. Clean muscovite, intergrown with biotite, constitutes about 12 per cent of the rock.

The schist was probably derived from Yellowknife Group sediments. It is interlayered with red, medium-grained chloritic granite of cataclastic texture, a rock characteristic of the migmatite-gneiss terrain east of Bathurst Inlet. The sample locality lies in the vicinity of the Slave-Churchill boundary and, on the basis of the biotite age, within the Churchill province.

GSC 63-75 Muscovite, K-Ar age 1,765 ± 70 m.y.

$K = 8.23\%$, $Ar^{40}/K^{40} = 0.17062$; radiogenic Ar = 100%. Concentrate; clean concentrate of muscovite. Most of the muscovite flakes are intergrown with fine-grained quartz, feldspar, and epidote. They also contain adhering fragments of greenish biotite.

From biotite-muscovite schist.
(76 I) 40 miles NE of mouth of Western River, District of Mackenzie, 66°38 1/4'N, 105°53 1/2'W. Map-unit 4, GSC Map 45-1963. Sample PB-158-A-62, collected by W.H. Poole, interpreted by J.A. Fraser.

The muscovite was obtained from sample GSC 63-74 described previously. The age is in agreement with that of the biotite and with ages of other granitic rocks from the Churchill province.

GSC 63-76 Biotite, K-Ar age 1,765 ± 70 m.y.

$K = 7.93\%$, $Ar^{40}/K^{40} = 0.17088$; radiogenic Ar = 100%. Concentrate; clean concentrate of olive-greenish biotite. Some biotite flakes contain fine-grained

aggregates of epidote and sphene on cleavage planes. Other impurities consist of small rutile needles and inclusions of zircon surrounded by pleochroic haloes. Chlorite not detected.

From quartz monzonite.

(76 L) 19 Miles south of James River, District of Mackenzie, 66°58 1/2'N, 111°25'W. Map-unit 5, GSC Map 45-1963. Sample DF-323-62, collected by J.A. Donaldson, interpreted by J.A. Fraser.

Massive granitic rocks are extensively exposed in the area south of James River where they are younger than strata of the Yellowknife Group. The sample is a light pink and grey, medium-grained, equigranular quartz monzonite composed of albite and quartz and 10 per cent greenish brown biotite flakes that have slightly ragged margins. Traces of epidote, sphene, apatite, chlorite, magnetite, and pale green amphibole are also present.

The age is similar to that of another biotite (GSC 61-75) collected from the same general area. Muscovite associated with this biotite, however, gives a Kenoran age.

GSC 63-77 Whole Rock, K-Ar age $\left.\begin{matrix}730\text{ m.y.}\\ \underline{740\text{ m.y.}}\end{matrix}\right\}$ Average, $\underline{735\text{ m.y.}}$

$K = \begin{matrix}1.40\%\\ 1.50\%\end{matrix}$, $Ar^{40}/K^{40} = \begin{matrix}0.05208\\ 0.05310\end{matrix}$; radiogenic $Ar = \begin{matrix}91\%\\ 96\%\end{matrix}$.

Concentrate; crushed whole rock.

From Coppermine River basalt.

(86 N) 16 miles NW of Dismal Lakes, District of Mackenzie, 67°44'N, 117°50'W. Map-unit 12, GSC Map 18-1960. Sample FD-105-59, collected and interpreted by J.A. Fraser.

The basalt is aphanitic, dark grey to purplish grey, weathering dull brown. Chlorite is present in thin discontinuous, parallel seams and in amygdules. Other constituents include labradorite, clinopyroxene, magnetite, and in small amygdules, quartz, zeolites, and carbonate. Plagioclase and pyroxene occur both in matrix and as insets. The texture is subophitic.

The sample was collected from one of the upper flows of the Coppermine River sequence. The age represents, then, a minimum for the underlying Hornby Bay sediments and a maximum for the overlying Coppermine River sediments.

District of Mackenzie

GSC 63-78 Whole Rock, K-Ar age $\left.\begin{matrix}920\text{ m.y.}\\915\text{ m.y.}\end{matrix}\right\}$ Average, 918 m.y.

$K = \begin{matrix}0.31\%\\0.32\%,\end{matrix}$ $Ar^{40}/K^{40} = \begin{matrix}0.06934\\0.06890;\end{matrix}$ radiogenic Ar = $\begin{matrix}87\%.\\88\%.\end{matrix}$
Concentrate; crushed whole rock.

From Coppermine River basalt.
(76 N) West end of Lewes Island, Chapman Islands Group, District of Mackenzie, 67°58'N, 109°09'W. Map-unit 18, GSC Map 45-1963. Sample FD-286-62, collected and interpreted by J.A. Fraser.

The basalt is dark greenish grey, weathering brownish. It is massive and fine grained with subdiabasic texture. Minerals identified are labradorite, clinopyroxene, serpentine, magnetite, and traces of native copper.

The flows sampled are exposed at the mouth of Bathurst Inlet and are tentatively considered to be correlative with those found in the Coppermine River region. The age falls within the range of ages reported for Coppermine River samples and represents a minimum for the underlying Kanuyak and Parry Bay Formations.

GSC 63-79 Biotite, K-Ar age 1,750 ± 70 m.y.

K = 7.66%, Ar^{40}/K^{40} = 0.16863; radiogenic Ar = 99%.
Concentrate; reasonably clean concentrate of olive-greenish biotite. About 15% of the biotite flakes are partly altered to chlorite and contain small specks of quartz, hematite, and a few acicular inclusions. Minor impurities consist of a few flakes of muscovite and chlorite. Total chlorite content 20%.

From quartz monzonite.
(76 P) 63 miles E of S tip of Kanuyak Island, District of Mackenzie, 67°19 3/4'N, 105°32'W. Map-unit 5, GSC Map 45-1963. Sample PB-140-62, collected by W.H. Poole, interpreted by J.A. Fraser.

The sample is a pink, massive, medium-grained quartz monzonite composed of oligoclase, microcline, quartz, and dark brown fine-grained biotite which occurs in widely scattered clusters intergrown with traces of muscovite. Accessory minerals include apatite and opaque material.

District of Mackenzie

The sample locality lies in the region east of Bathurst Inlet traversed by the Slave-Churchill boundary. The age reflects the effect of the Hudsonian orogeny and is comparable with other ages determined for rocks exposed farther east. The locality is, therefore, considered to be within the Churchill province.

GSC 63-80 Biotite, K-Ar age 1,835 ± 60 m.y.

$K = 7.98\%$, $Ar^{40}/K^{40} = 0.1816$; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of brown biotite. Biotite flakes contain a few inclusions of quartz, zircon, and apatite. About 10% of the biotite flakes are slightly discoloured to olive-brown and are partly altered to chlorite and epidote along the edges. Chlorite content is about 3%.

From granitic gneiss.

(75 K) Island in the north arm of Dion Lake, District of Mackenzie, 62°29'00"N, 109°25'00"W. Map-unit 26, GSC Map 51-26A. Sample SH-65-59, collected and described by C.H. Stockwell.

The sample is a medium-grained granitic gneiss composed of grains of quartz, microcline, and andesine which have been crushed around their edges to fine-grained material composed of the same minerals together with a later development of undeformed, randomly oriented biotite crystals. The material was collected from terrane of gneiss and mylonite four miles south of the McDonald fault, which marks the southern boundary of Lower Proterozoic sedimentary rocks of Great Slave Lake. The biotite age represents a period of post-mylonite metamorphism and may be a minimum for a time of movement along the McDonald fault.

GSC 63-81 Biotite, K-Ar age 2,555 ± 70 m.y.

$K = 7.03\%$, $Ar^{40}/K^{40} = 0.3169$; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of partly altered biotite. Biotite flakes vary from brown to greenish. About 35% of the biotite flakes are in part altered to chlorite and epidote and contain long needle-like inclusions. Total chlorite content is 25%.

District of Mackenzie

From granodiorite.

(75 K) East end of Charlton Bay, Great Slave Lake, District of Mackenzie, 62°45'50"N, 108°56'40"W. Map-unit 4, GSC Map 51-26A. Sample SH-79-59, collected and interpreted by C.H. Stockwell.

The granodiorite is a massive, pinkish grey, medium-grained rock composed of quartz, oligoclase, microcline, biotite, and a little muscovite. The muscovite is fresh but the biotite is considerably altered to chlorite.

The sample is from the Slave province and the age is typical of the Kenoran orogeny. The granodiorite is overlain unconformably by the Great Slave Group and the muscovite gives a maximum age for this group. The sample locality is 6 miles northwest of the McDonald fault which here marks the boundary with the Churchill province but at that distance the biotite was unaffected by the Hudsonian orogeny.

GSC 63-82 Biotite, K-Ar age 1,850 ± 60 m.y.

$K = 6.53\%$, $Ar^{40}/K^{40} = 0.1837$; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of orange-reddish biotite. Biotite flakes contain aligned inclusions of rutile (sagenite) and a few grains of quartz and epidote. Impurities consist of about 10% pale green chlorite.

From granitic gneiss.

(75 I) East shore of Small Lake 8 miles south of the inlet to Tyrrell Lake, District of Mackenzie, 62°57'00"N, 105°49'00"W. Map-unit 8, GSC Map 17-1956. Sample SH-77-59, collected and interpreted by C.H. Stockwell.

The sample is a light grey granitic gneiss consisting of quartz, oligoclase, and biotite with a little apatite and carbonate. Some of the biotite is altered to chlorite but most is fresh. In this part of the Churchill province a few much older ages have been obtained (2,000 to 2,460 m.y.) suggesting that the rocks may be Archaean variously modified by the Hudsonian orogeny but the present sample (at 1,850 m.y.) approaches the average Hudsonian age of about 1,700 m.y.

District of Mackenzie

GSC 63-83 Pyroxene, K-Ar age 750 m.y.

K = 0.28%, Ar^{40}/K^{40} = 0.0536; radiogenic Ar = 100%. Concentrate; clean concentrate of pyroxene. About 40% of the pyroxene grains contain small inclusions along the cleavage planes and fractures, including traces of epidote, hornblende, and biotite.

From diabase.

(75 L) Island in Great Slave Lake, District of Mackenzie, 62°39'45"N, 110°29'00"W. Map-unit 14, GSC Map 51-25A. Sample SH-80-59, collected and interpreted by C.H. Stockwell.

The pyroxene is from a sill of medium-grained, massive diabase composed of labradorite, pyroxene, and myrmekite with minor hornblende and biotite and plentiful magnetite. Most of the pyroxene is fresh but parts are clouded with alteration products.

The sill cuts rocks of the Great Slave Group and is also no doubt younger than the Et-Then Group which unconformably overlies the Great Slave.

Due to lack of experience with potassium argon dating of pyroxene it is uncertain whether the determined age is reasonably close to the true age of the diabase. However, it may serve to give the approximate minimum age for the Et-Then Group whose maximum age is given at 1,845 m.y. (GSC 61-78). Accordingly, the Et-Then may tentatively be classified as Middle Proterozoic.

GSC 63-84 Biotite, K-Ar age 2,525 ± 80 m.y.

K = 7.84%, Ar^{40}/K^{40} = 0.3103; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of biotite. Biotite flakes vary from greenish to brown and contain rare inclusions of quartz, epidote, and a few grains of zircon surrounded by zoned pleochroic haloes. Impurities consist of chlorite and altered biotite. Total chlorite content is 10%.

From granodiorite.

(75 M) District of Mackenzie, 63°05'30"N, 110°33'30"W. Sample HF 609-1962, collected by W.W. Heywood.

District of Mackenzie

GSC 63-85 Muscovite, K-Ar age 2,625 ± 80 m.y.

$K = 8.79\%$, $Ar^{40}/K^{40} = 0.3333$; radiogenic Ar = 100%. Concentrate; clean concentrate of muscovite. Minor impurities make up about 2% and consist of a few grains of quartz and altered feldspar. Chlorite not detected.

From pegmatite.
(75 M) District of Mackenzie, 63°13'20"N, 110°33'W. Sample HF 120c-1962, collected by W.W. Heywood.

GSC 63-86 Biotite, K-Ar age 2,455 ± 80 m.y.

$K = 7.07\%$, $Ar^{40}/K^{40} = 0.2956$; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of dark brown biotite. About 15% of the biotite flakes are altered to green chlorite and contain dendritic inclusions of epidote. Total chlorite content is about 12%.

From quartz monzonite.
(75 M) Indian Mountain Lake, District of Mackenzie, 63°09'N, 110°59'W. Sample HF 473-1962, collected by W.W. Heywood.

GSC 63-87 Biotite, K-Ar age 2,525 ± 80 m.y.

$K = 7.68\%$, $Ar^{40}/K^{40} = 0.3110$; radiogenic Ar = 100%. Concentrate; clean concentrate of brown biotite. Biotite flakes contain minute inclusions of quartz and a few prisms of apatite. Minor impurities consist of about 3% green chlorite.

From granite.
(75 M) District of Mackenzie, 63°02'25"N, 110°35'W. Sample HF 415-1962, collected by W.W. Heywood.

GSC 63-88 Whole Rock, K-Ar age 1,110 m.y.

$K = 1.34\%$, $Ar^{40}/K^{40} = 0.08808$; radiogenic Ar = 90%. Concentrate; crushed whole rock.

District of Mackenzie

(86 O) From granophyre-bearing diabasic gabbro. Muskox area, District of Mackenzie, 67°07'30"N, 115°16'00"W. Map-unit 29, GSC Map 36, 1961, Sheet 1. Sample SDC-60-227-A, collected and interpreted by C.H. Smith.

The rock is a medium-grained diabasic gabbro composed of saussuritized plagioclase (60%) pyrobole (35%) and iron oxides (5%). Some chlorite is also present. It occurs as a diabase dyke cutting dolomite of the Hornby Bay Group, an extension of younger diabases cutting the Muskox Intrusion.

Although field evidence indicates this is one of many dykes cutting the Muskox Intrusion, this date is not significantly different from those obtained from rocks in the intrusion. The date indicates the general contemporaneity of dykes and intrusion.

GSC 63-89 Whole Rock, K-Ar age 975 m.y.

K = 1.43%, Ar^{40}/K^{40} = 0.07449; radiogenic Ar = 91%. Concentrate; crushed whole rock.

(86 J) From granophyre-bearing gabbro. District of Mackenzie, 66°35'N, 115°03'W. Map-unit 29, GSC Map 36-1961, Sheet 5. Sample SDC-59-231-S, collected by D.C. Findlay, interpreted by C.H. Smith.

The rock is medium- to coarse-grained granophyric gabbro dyke composed of augite, amphibole after augite, plagioclase, skeletal iron oxides, and interstitial quartz-potassium feldspar aggregates. There is a moderate amount of amphibole-chlorite alteration. The dyke outcrops alongside the Muskox feeder.

General field relations had suggested that this dyke was older than the Muskox Intrusion, i.e. greater than 1,100-1,200 m.y. However, no chilled contacts were observed and other similar dykes in the area do cut the Muskox Intrusion. The date is significantly younger than the spread of dates obtained from the intrusion. Although the possibility of argon loss cannot be denied in view of the grain size and alteration of the rock, it appears reasonable to assume this dyke is part of the younger dyke swarm cutting the intrusion.

District of Mackenzie

GSC 63-90 Whole Rock, K-Ar age 1,095 m.y.

$K = 0.91\%$, $Ar^{40}/K^{40} = 0.08679$; radiogenic Ar = 84%. Concentrate; crushed whole rock.

From gabbro.
(86 J) District of Mackenzie, 66°30'N, 115°00'W. Map-unit 22, GSC Map 36-1961, Sheet 5. Sample SDC-62-3087-G, collected by D.C. Findlay, interpreted by C.H. Smith.

The rock is a bluish grey, fine-grained, equigranular gabbro composed of plagioclase (40%), orthopyroxene (26%), clinopyroxene (23%), biotite (2%), potassium feldspar (1%), quartz (3-5%), and opaque minerals. There is no secondary alteration. The sample was taken from the chilled margin of the feeder part of the Muskox Intrusion.

The date of 1,095 m.y. represents the age of emplacement of the Muskox Intrusion and compares well with a 1,155 m.y. date reported earlier (GSC 60-38, GSC Paper 61-17).

GSC 63-91 Whole Rock, K-Ar age 1,200 m.y.

$K = 1.22\%$, $Ar^{40}/K^{40} = 0.09841$; radiogenic Ar = 87%. Concentrate; crushed whole rock.

From basalt.
(86 O) District of Mackenzie, 67°17.5'N, 115°11'W. Map-unit 10, GSC Map 36-1961, Sheet 1. Sample SDC-62-3062, collected by D.C. Findlay, interpreted by C.H. Smith.

The rock is a fine-grained, dark brown basalt composed of plagioclase (45%), augite (45%), chlorite (6%), opaque minerals (3%), and carbonate. It occurs within 100 feet of the base of the Coppermine River basalt.

The 1,200 m.y. date represents the age of the beginning of volcanism in the Coppermine River area. The date is older than most obtained on the Muskox Intrusion, which conforms to structural interpretations of the geology of the area. However, the date is not significantly older than the intrusion.

District of Keewatin

GSC 63-92 Biotite, K-Ar age 1,660 ± 60 m.y.

$K = 7.50\%$, $Ar^{40}/K^{40} = 0.15528$; radiogenic Ar = 97%. Concentrate; clean concentrate of brown biotite. About 15% of the biotite flakes are partly altered to dull-green chlorite and contain inclusions of rutile, epidote, and sphene. Some flakes contain small zircon inclusions surrounded by dark pleochroic haloes. Total chlorite content 10%.

From porphyritic granite.

(57 C) Boothia Peninsula, District of Keewatin, 69°31'N, 94°01'W. Map-unit 3, GSC Map 36-1963. Sample TA-62-T68, collected by F.C. Taylor, interpreted by R.G. Blackadar.

The rock is a coarse-grained granite with pinkish phenocrysts of microcline and visible biotite. The matrix is dark coloured, with smoky quartz predominating. A micrometric analysis indicates the following mineral constitution: quartz (36.0%), biotite (12.4%), plagioclase (4.6%), microcline (45.0%), chlorite (0.8%), magnetite (trace), apatite (1.2%), and zircon (trace).

This specimen is located near the southern end of Boothia Peninsula, N.W.T. The date gives an age for the metamorphism responsible for the gneissic terrane characteristic of almost all Middle Proterozoic exposures in this area. The rock is granitic in texture but has been metamorphosed at least to the extent of potash metasomatism.

GSC 63-93 Whole Rock, K-Ar age 1,620 m.y.

$K = 1.03\%$, $Ar^{40}/K^{40} = 0.1505$; radiogenic Ar = 100%. Concentrate; crushed whole rock.

From diabase.

(34 D) North end of Churchill Sound, Belcher Islands, District of Keewatin, 56°29'30"N, 79°28'30"W. Map-unit 14, GSC Map 60-20. Sample JD-298G-59, collected and described by G.D. Jackson.

District of Keewatin

The sample was taken from the central part of a diabase sill about 35 feet thick and intruding Map-unit 4. The sill is fine grained, inequigranular, has a subophitic texture, and contains a few scattered phenocrysts of augite. A volumetric modal analysis of one thin section gave: augite 22%, plagioclase 19%, chlorite 19%, actinolite 18%, talc 14%, magnetite 6%, biotite 1%, epidote 1%, and traces of pyrrhotite, pyrite and carbonate.

No major unconformities were observed between Map-units 1-13, 15, and 16. Also, diabase and other basic intrusions have been identified in all map-units except 15 and 16. It seems likely that most of these basic intrusions, especially those intruding Map-units 3-13, are related to the volcanic activity recorded in Map-unit 13. It is suggested that the determined age may be an approximate age for Map-unit 13 and most of Map-unit 14, a maximum age for Map-units 15 and 16, and a minimum age for Map-units 1-12 and part of 14. It is noted, however, that the diabase sill has undergone a large amount of deuteric and/or secondary alteration.

Alberta

GSC 63-94 Biotite, K-Ar age 1,810 ± 60 m.y.

$K = 7.21\%$, $Ar^{40}/K^{40} = 0.17795$; radiogenic Ar = 99%. Concentrate; clean concentrate of deep brown biotite. Some flakes are almost opaque and some are partly altered to chlorite. The biotite flakes contain small specks of zircon surrounded by zoned pleochroic haloes. Total chlorite content 9%.

From biotite schist.
(74 M) Southwest of Andrew Lake, Alberta, 59°49'N, 110°18'W. GSC Map 12-1960, Research Council of Alberta Map 58-4A. Sample JG-58-44-1, collected and interpreted by J.D. Godfrey (Research Council of Alberta).

The sample is from a biotite schist layer within a metasedimentary band consisting of phyllitic quartzite, biotite schist, and pegmatite. Abundant molybdenite accompanies uraninite. Biotite is fresh, reddish brown, with no sign of chloritization. Minor minerals include iron oxide, uraninite, epidote, and molybdenite.

The metasedimentary rock band from which the sample is taken forms part of the 'basement complex' which consists predominantly of biotite and hornblende granite-gneisses. Together these rocks constitute part of the Churchill province of the Canadian Precambrian Shield. Both the biotite and uraninite ages are within the accepted range of the Hudsonian orogeny and probably also indicate the time of the molybdenite and uraninite mineralization.

GSC 63-95 Whole Rock, K-Ar age 61 ± 4 m.y.

$K = 6.2\%$, $Ar^{40}/K^{40} = 0.00363$; radiogenic Ar = 75%. Concentrate; crushed whole rock.

From porphyritic trachyte.
(82 G) 100 feet below top of Crowsnest Mountain, Alberta, 49°42'N, 114°34'W. GSC Map 35-1961. Sample N-479, collected and interpreted by D.K. Norris.

Alberta

The rock is a porphyritic, greenish grey trachyte with flow oriented, euhedral sanidine (up to 5 mm long) and clinopyroxene phenocrysts in a microcrystalline matrix of feldspar and mafic minerals. The sanidine phenocrysts are zoned and partly kaolinized in the rims. The microcrystalline matrix of sanidine(?) shows obvious flow texture, and is both kaolinized and chloritized. Clinopyroxene constitutes about 5% of the rock, and zoned melanite garnet about 2%.

The sample is from a dyke in Mississippian Livingstone Formation in a klippe of the Lewis thrust plate. The dyke does not appear to continue downwards below the thrust fault, and on structural grounds would therefore appear to be older than the beginning of the Laramide deformation. The age of 61 m.y., being a minimum value, is compatible with the field relations.

Saskatchewan

GSC 63-96 Biotite, K-Ar age 1,930 m.y.

K = 3.75%, Ar^{40}/K^{40} = 0.1970; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of partly altered, light-brown biotite. Impurities consist of fibrous amphibole and pale green chlorite flakes. Total chlorite content is about 50%; amphibole content is about 5%.

From skarn.

(63 K) Coronation Mine, 1,050 level, Saskatchewan, 54°35'N, 102°00'W. Sample WH 61.817.9, collected and interpreted by D.R.E. Whitmore.

The rock is an anthophyllite-garnet-biotite skarn, fine- to medium-grained and gneissic. It consists of biotite (40%+), anthophyllite and/or tremolite (30%+), quartz (10%), chlorite (5%), sulphides (10%), spinel and magnetite (5%). The biotite is intergrown with amphibole and locally altered to chlorite.

The specimen was collected from the 1,050 level of the Coronation Mine at section 66+00S. It represents metamorphosed and fragmental volcanic rocks found principally at the south end of the orebody in the lower levels of the mine. Granites in the area and the Kisseynew gneisses to the north have all shown consistently younger dates of 1,740 ± m.y. Whether this date is significantly older than these is uncertain, although the original accretion of the ore sulphides is thought to be pre-metamorphism in age.

GSC 63-97 Whole Rock, K-Ar age 1,490 m.y.

K = 2.27%, Ar^{40}/K^{40} = 0.13302; radiogenic Ar = 96%. Concentrate; crushed whole rock.

From gabbro.

(74 N) West shore of a large island in Fredette Lake, Saskatchewan, 59°36'45"N, 108°32'W. Map-unit 11, GSC Map 25-1957. Sample T691-60, collected and interpreted by L.P. Tremblay.

The sample is from a gabbro dyke cutting the basal conglomerate and some siltstone and arkose above it, all of the Martin Formation. The dyke is believed to be related to the gabbroic sills and volcanic flows of the Martin Formation, and is part of the late gabbro dykes of the Beaverlodge area.

Saskatchewan

The gabbro is massive, fine- to medium-grained, and dark brown to dark green. In thin section it is lightly altered and made up of about 50% plagioclase, 35% alteration products of pyroxene, 8% iron oxides, and 5% quartz or quartz-feldspar intergrowths. The alteration products are amphibole, chlorite, and some biotite.

The age is a minimum for the rocks of the Martin Formation below the volcanic unit. It compares fairly well with the age of the gabbroic sill represented by sample GSC 63-98 (S4-52).

GSC 63-98 Whole Rock, K-Ar age 1,410 m.y.

$K = 2.06\%$, $Ar^{40}/K^{40} = 0.12264$; radiogenic Ar = 97%. Concentrate; crushed whole rock.

From gabbro.

(74 N) South of a small bay at the south end of Martin Lake, Saskatchewan, 59°30'35"N, 108°36'25"W. Map-unit 12, GSC Map 54-15. Sample S4-52, collected and interpreted by L.P. Tremblay.

The sample is from a gabbro sill in the Martin Formation. The sill is regarded as related to the volcanic flows of the Martin Formation, and also to the gabbro and basalt dykes that cut parts of the Martin Formation below the volcanic unit.

The gabbro is massive, dark brown to dark green, and medium- to coarse-grained. It intrudes the arkose in which it is found. In thin-section it is made up of large labradorite laths in a mass of alteration products (serpentine, chlorite, and light brown to light grey, almost isotropic substance), probably representing original augite. Magnetite constitutes about 8% of the rock, and other minerals present include sphene, apatite, carbonate, and some interstitial felsic minerals.

The age is a minimum for the parts of the Martin Formation below the volcanic rocks, and is possibly close to a maximum age for the rocks of the Martin Formation above the volcanic unit. This age compares well with GSC 63-97, which is from a gabbro dyke cutting the lower parts of the Martin Formation and which is part of the late dykes in the Beaverlodge area.

If this age is compared to the Pb/U ages on pitchblende veins in volcanic rocks at the Martin Mine, it is seen to be much lower. These Pb/U ages average 1,620 m.y. and are probably anomalous due to loss of lead or gain of uranium.

Manitoba

GSC 63-99 Muscovite, K-Ar age 1,790 ± 60 m.y.

$K = 8.66\%$, $Ar^{40}/K^{40} = 0.1749$; radiogenic Ar = 100%. Concentrate; clean concentrate of muscovite. Some muscovite flakes are stained buff and are partly coated with orange-brown crust of iron oxide. Chlorite not detected.

From pegmatite.
(63 J) West shore of south arm of Crowduck Bay (Wekusko Lake), Manitoba, 54°51'48"N, 99°43'00"W. From a point on the mainland 3,000 feet southeast of sample GSC 63-100. Map-unit 3B, GSC Map 987A. Sample BA-F-83, collected and described by C.K. Bell.

For description and interpretation see sample GSC 63-100. Sample is from part of an extensive pegmatite sill that is on strike and appears to be an extension of the described pegmatite.

GSC 63-100 Biotite, K-Ar age 1,610 ± 50 m.y.

$K = 7.11\%$, $Ar^{40}/K^{40} = 0.1487$; radiogenic Ar = 100%. Concentrate; clean concentrate of bright green biotite. About 20% of the biotite flakes are discoloured and partly coated with orange-yellow crusts of iron oxide. Chlorite not detected.

From pegmatite.
(63 J) Island 4,500 feet southwest of Survey Monument M-15, west shore of south arm of Crowduck Bay (Wekusko Lake), Manitoba, 54°52'03"N, 99°42'00"W. Map-unit 3B, GSC Map 987A. Sample BA-F-84, collected and interpreted by C.K. Bell.

The biotite is from a post-Missi quartz-microcline-mica pegmatite (14) sill that intrudes Missi garnetiferous-staurolite schist (3B). These pegmatites are undeformed, postdate the last orogeny, and are end phases of the granite (12) stocks in the area.

This date approximates that of the last granitic activity in this part of the Churchill province. Compare with GSC 63-104 (1,960 m.y. on biotite) from a late granite stock; and with GSC 61-119 (1,770 m.y. on biotite) and GSC 61-120 (1,620 m.y. on muscovite) from Missi impure quartzite.

Manitoba

GSC 63-101 Biotite, K-Ar age 2,100 ± 70 m.y.

$K = 8.25\%$, $Ar^{40}/K^{40} = 0.2260$; radiogenic Ar = 100%. Concentrate; clean concentrate of olive-brown biotite. Chlorite not detected.

From quartz monzonite porphyry.
(63 J) South shore of the extreme western end of Cross Lake at the mouth of the Minago River, Manitoba, 54°32'N, 98°09'W. Sample BA-F-14, collected and interpreted by C.K. Bell.

The rock is a medium-grained, pink, quartz monzonite porphyry with orthoclase phenocrysts up to 2 inches across. It occurs as a mile-wide band around a stock of anorthosite. Field relationships between this rock and the Cross Lake Group of metasediments are unknown.

The following ages have been determined on rocks of the Cross Lake Group: 2,068 m.y. (biotite GSC 60-84); 2,135 m.y. (biotite GSC 61-124); 1,680 m.y. (muscovite GSC 61-125); 1,945 m.y. (biotite GSC 63-103); and 1,755 m.y. (muscovite GSC 63-102).

The muscovite ages are younger than expected from the Superior province and may be explained by a late metamorphism that accompanied the younger granitic intrusions in the area. This observation is corroborated by a biotite age of 1,840 m.y. found by Burwash, et al. for a post-Cross Lake Group granodiorite (Burwash, et al., Jour. Geophys. Research, vol. 67, No. 4, p. 1620).

GSC 63-102 Muscovite, K-Ar age 1,755 ± 60 m.y.

$K = 6.24\%$, $Ar^{40}/K^{40} = 0.1697$; radiogenic Ar = 100%. Concentrate; impure concentrate of muscovite. About 40% of the muscovite flakes are intergrown with altered, greenish brown biotite. Impurities (about 25%) consist of quartz, feldspar, carbonate, and sillimanite. Total chlorite content is about 15%.

From paragneiss.
(63 J) Island at the west end of Cross Lake, 4 miles east of the mouth of the Minago River, Manitoba, 54°36'N, 98°01'W. Map-unit 6b, GSC Map 32-1961. Sample BA-F-54, collected and interpreted by C.K. Bell.

Manitoba

The muscovite taken from the same sample as GSC 63-103. Refer to discussion under that heading.

GSC 63-103 Biotite, K-Ar age 1,945 ± 70 m.y.

$K = 8.05\%$, $Ar^{40}/K^{40} = 0.1990$; radiogenic Ar = 100%. Concentrate; clean concentrate of brown biotite. Some flakes are slightly bleached and contain inclusions of quartz and thin coatings of silica on (001) faces. Also present are a few muscovite flakes. Chlorite content is 2%.

From paragneiss.

(63 J) Island at the west end of Cross Lake, 4 miles east of the mouth of the Minago River, Manitoba, 54°36'N, 98°01'W. Map-unit 6b, GSC Map 32-1961. Sample BA-F-54, collected and interpreted by C.K. Bell.

The rock is an oligoclase-microcline-quartz-biotite-muscovite paragneiss.

The age of these recrystallized sediments indicates a late phase of metamorphism within the Superior province which is associated with the intrusion of granite stocks. It suggests that intrusions associated with the Hudsonian orogeny occur on both sides of the Churchill-Superior boundary. Muscovite from the same sample GSC 63-102 is 1,755 m.y. A similar age ratio is found elsewhere in Cross Lake Group paragneiss; GSC 61-124, biotite, 2,100 m.y.; GSC 61-125, muscovite, 1,680 m.y. The muscovite is thought to be more indicative of the true age of orogeny.

GSC 63-104 Biotite, K-Ar age 1,960 ± 60 m.y.

$K = 7.09\%$, $Ar^{40}/K^{40} = 0.2013$; radiogenic Ar = 99%. Concentrate; reasonably clean concentrate of olive-brown biotite. Some biotite flakes contain zircon inclusions surrounded by pleochroic haloes. About 10% of the biotite flakes are altered, greenish brown, and contain inclusions of quartz and rutile. Chlorite content is 7%.

Manitoba

From quartz monzonite.
(63 J) 1.5 miles northwest of the head of Goose Bay, Wekusko Lake, on the Snow Lake road, Manitoba, 54°43'N, 99°59'W. Map-unit 14, GSC Map 665a. Sample BA-F-218a, collected and interpreted by C.K. Bell.

The rock is a massive, non-foliated, tan biotite quartz monzonite (14). This stock varies in composition from granite through granodiorite to quartz-diorite. It is probably co-magmatic with similar stocks in the area and parent to the local pegmatite-aplite intrusions.

Compare with determinations GSC 63-99 and GSC 63-100. The intruded Missi sediments give a younger age (GSC 61-119, 120; 1,770 m.y., 1,620 m.y.) so that the intrusion of these granites is probably associated with the late stages of metamorphism in the Churchill province.

GSC 63-105 Biotite, K-Ar age 1,785 ± 60 m.y.

$K = 7.75\%$, $Ar^{40}/K^{40} = 0.1740$; radiogenic Ar = 100%. Concentrate; clean concentrate of orange-brown biotite. Biotite flakes contain minute inclusions of quartz and some zircons surrounded by zoned pleochroic haloes. About 10% of the biotite flakes are in part altered to grey-green chlorite. Total chlorite content is 3%.

From quartz monzonite.
(63 J) Island in Setting Lake, 4 miles northwest of Wabowden, Manitoba, 54°57'N, 98°39'W. Sample BA-F-106a, collected and interpreted by C.K. Bell.

This oligoclase-microcline quartz monzonite stock forms one body in a chain that parallels the approximate Churchill - Superior boundary. These granites are omnipresent with, and post-date, the nickel-bearing peridotites that extend from Wabowden north-east to Thompson. They are products of the end phases of Hudsonian orogeny and are unique in that they appear (i.e. granitic rocks of the same relative age) on both sides of what is considered to be the boundary between the two structural provinces.

Manitoba

GSC 63-106 Muscovite, K-Ar age 1,620 m.y.

K = 3.41%, Ar^{40}/K^{40} = 0.1505; radiogenic Ar = 100%. Concentrate; impure concentrate of muscovite consisting of: about 30% clean muscovite flakes; about 40% of fine-grained intergrowths of muscovite with quartz, feldspar, chlorite, epidote, and opaque grains; and free impurities consisting mainly of feldspar, quartz, and a trace of tourmaline. Total chlorite content is 30%, feldspar 20% and quartz 10%.

From granitic rock.

(63 K) 1,000 feet east of Cliff Lake, Manitoba, 54°48'10"N, 101°50'03"W. Map-unit 9, GSC Map 1078A. Sample SH-136-59, collected and interpreted by C.H. Stockwell.

The sample is a medium-grained, greenish grey, altered granitic rock with eyes of quartz and containing also albite, chlorite, sericite, and a considerable amount of secondary carbonate. The sericite occurs in flakes mostly parallel with one another and is secondary. The rock shows considerable evidence of crushing.

This is a sample of the Cliff Lake Granite mapped as post-Amisk Group and pre-Missi Group in age. It is probably Archaean, reworked by the Hudsonian orogeny. The age of 1,620 m.y. is younger than the typical Hudsonian age of about 1,700 m.y. but this may be due to the fine-grained sericite which, apparently, loses argon more readily than coarse material.

A number of samples from this granite were collected with the purpose of running a whole rock Rb/Sr isochron but the material was found to be unsuitable.

GSC 63-107 Muscovite, K-Ar age 1,440 ± 50 m.y.

K = 7.77%, Ar^{40}/K^{40} = 0.12621; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of muscovite. Some muscovite flakes contain quartz inclusions along the edges. Impurities consist of microcline and altered feldspar (less than 10%), quartz (1%) and chlorite (4%).

Manitoba

From quartz monzonite.

(64 C) North end of Beatty Lake, Manitoba, 56°32'05"N, 100°32'05"W. Map-unit 17, Man. Dept. Mines Map 57-1, No. 6. Sample SH-29-59, collected and interpreted by C.H. Stockwell.

The quartz monzonite is a medium-grained, pink, slightly gneissic rock consisting of quartz, clouded oligoclase, fresh microcline, muscovite, and biotite. The biotite is almost completely altered to chlorite and the muscovite flakes are slightly bent as a result of post-crystallization deformation. The rock is mapped as being younger than the Sickle Group. The potassium-argon age gives a minimum for the Sickle and is somewhat younger than the Hudsonian orogeny which prevails in this region, the discrepancy being due to the post-crystallization deformation.

GSC 63-108 Biotite, K-Ar age 1,865 ± 65 m.y.

K = 8.17%, Ar^{40}/K^{40} = 0.18648; radiogenic Ar = 99%. Concentrate; clean concentrate of olive-brown and greenish biotite. Biotite flakes contain apatite prisms and a few acicular inclusions. A few flakes are partly altered to chlorite. Total chlorite content 2%.

From porphyritic granodiorite.

(63 K) W shore of Phantom Lake, Manitoba, 54°42'20"N, 101°52'10"W. Map-unit 16, GSC Map 1078A. Sample SH-135-59, collected and interpreted by C.H. Stockwell.

The granodiorite is a medium-grained, massive, pink rock with phenocrysts of feldspar. As seen in thin section the rock is composed of quartz, albite, orthoclase, biotite and minor hornblende with accessory magnetite, apatite, and titanite. The albite is somewhat saussuritized and the biotite is associated with plentiful epidote.

The sample represents the Kaminis Granite which is the youngest granitic rock in the Flin Flon area. A dyke of granite that cuts the Flin Flon orebody may be correlated with the Kaminis Granite and, if so, the 1,865 m.y. date is a minimum for the time of deposition of the ore.

Manitoba

GSC 63-109 Muscovite, K-Ar age 1,790 ± 60 m.y.

$K = 8.51\%$, $Ar^{40}/K^{40} = 0.17445$; radiogenic Ar = 98%. Concentrate; clean concentrate of muscovite. Some flakes contain opaque inclusions and yellow stain along (001) fractures.

From pegmatite.

(64 I) S shore of Shethanei Lake, Manitoba, 58°46'10"N, 97°49'30"W. Map-unit 3, GSC Map 15-1958. Sample SH-118-59, collected and interpreted by C.H. Stockwell.

The sample is from a white pegmatite with feldspar crystals up to 3 inches across. The rock is associated with paragneiss and is composed of quartz, albite, microcline, muscovite, and lesser amounts of biotite and tourmaline. The micas are fresh. The determined age no doubt indicates the time of emplacement of the pegmatite.

Ontario

GSC 63-110 Biotite, K-Ar age 2,655 ± 80 m.y.

K = 7.33%, Ar^{40}/K^{40} = 0.3410; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of brown biotite. Biotite flakes contain inclusions of quartz. Some flakes are discoloured, brown-grey, and in part altered to chlorite. Minor impurities consist of quartz and green chlorite. Total chlorite content is 7%.

From granodiorite.
(53 B) North of Eyapamikama Lake, near the east end of the lake, Ontario, 52°57'34"N, 90°41'05"W. Map-unit 2, GSC Map 18-1961. Sample JD-218/21-62, collected and interpreted by G.D. Jackson.

The sample is from a granodiorite boulder in a conglomerate zone at least 48 feet thick, overlying a sequence of basic volcanic rocks. The boulder is slightly deformed, and nearly two feet in diameter. The granodiorite is light grey, fine grained, inequigranular, has a granoblastic texture, and is poorly foliated. It contains about 44% oligoclase, 39% quartz, 12% biotite, 4% muscovite and traces of chlorite, kaolinite, zircon, sphene, potash feldspar, pyrite, pyrrhotite, magnetite, and hematite.

It was thought originally that the mineral assemblage in the granodiorite might be significantly older than the Kenoran orogeny. The age obtained is a metamorphic one and is greater than most ages obtained for micas from the Superior province. It does, however, lie within the time-span attributed to the Kenoran orogeny.

GSC 63-111 Biotite, K-Ar age 920 ± 40 m.y.

K = 8.29%, Ar^{40}/K^{40} = 0.06940; radiogenic Ar = 98%. Concentrate; clean concentrate of olive-brown biotite. Some flakes are bleached and contain fine-grained inclusions along the fractures. Total chlorite content 2%.

From granitic gneiss.
(40 G) From Imperial Oil Ltd., well No. 816, at a depth of 2,900 feet, Lot 22, Concession 1, Burford tp., Brant county, Ontario, 43°08'48"N, 80°35'00"W. GSC Map 1062A, B.V. Sanford. Sample 1-G-24-1. Collected and interpreted by B.V. Sanford.

Ontario

A dark grey granitic gneiss consisting of quartz, orthoclase, oligoclase, hornblende, biotite, and minor carbonate, apatite, and zircon. The biotite is unaltered.

The age on this sample indicates that the basement rocks beneath the Palaeozoic of southern Ontario were involved in the Grenville orogeny.

GSC 63-112 Biotite, K-Ar age 895 ± 40 m.y.

K = 8.19%, Ar^{40}/K^{40} = 0.06686; radiogenic Ar = 99%. Concentrate; clean concentrate of pale brown biotite. A few flakes are altered to very pale blue-greenish chlorite and contain fine-grained inclusions of epidote and quartz along the cleavage planes. Total chlorite content 3%.

From migmatite.

(40 G) Imperial Oil Ltd., well No. 646, at a depth of 3,650 feet, Lot A, Concession Gore, Romney tp., Kent county, Ontario, 42°10'52"N, 82°18'28"W. GSC Map 1062A, B.V. Sanford. Sample 3-TA-Gore, collected and interpreted by B.V. Sanford.

The migmatite is a dark grey paragneiss permeated with pink granitic material. The sample is composed of quartz, oligoclase, orthoclase, biotite, and minor magnetite, pyrite, and zircon.

The age on this sample indicates that the basement rocks beneath the Palaeozoic of southern Ontario were involved in the Grenville orogeny.

GSC 63-113 Biotite, K-Ar age 2,450 m.y.

K = 4.29%, Ar^{40}/K^{40} = 0.2941; radiogenic Ar = 100%. Concentrate; consists of partly altered biotite. Biotite varies from brown to olive-green. About 20% of the biotite flakes are altered to chlorite alone, and about 10% are altered to chlorite and iron oxides and appear almost opaque. Impurities consist of dark green chlorite, a few muscovite flakes and a few grains of garnet. Total chlorite content is 60%.

Ontario

From pegmatite.
(42 G) Quarry on the south side of the railway just south of Highway 11, 5 miles west of the Opazatika River, Ontario, 49°32'20"N, 82°56'50"W. Map-unit 3, GSC Map 411A. Sample SH-25-60, collected and interpreted by C.H. Stockwell.

The pegmatite is dominantly white but contains some crystals of pink feldspar up to 1 foot across. It is composed of quartz, microcline, albite, biotite, and muscovite. The micas are fresh. It occurs within an easterly trending belt of predominantly paragneiss and granitic rocks. The biotite age obtained is that of the time of intrusion and crystallization of the pegmatite. At a point about 10 feet from the sample locality the pegmatite is cut by small dykes of diabase and the heat from them may have driven off a little of the argon from the biotite giving it a somewhat younger apparent age (2,450 m.y.) than the associated muscovite described below (2,585 m.y., GSC 63-114).

GSC 63-114 Muscovite, K-Ar age 2,585 ± 80 m.y.

$K = 9.02\%$, $Ar^{40}/K^{40} = 0.3243$; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of muscovite. Muscovite flakes contain small inclusions of feldspar and a few specks of iron oxides. K-feldspar content is 10%. Chlorite not detected.

From pegmatite.
(42 G) Quarry on the south side of the railway just south of Highway 11, 5 miles west of the Opazatika River, Ontario, 49°32'20"N, 82°56'50"W. Map-unit 3, GSC Map 411A. Sample SH-25-60, collected and interpreted by C.H. Stockwell.

The muscovite was separated from the same sample as GSC 63-113. The muscovite age agrees reasonably well with that obtained on the biotite but is probably unaffected by the diabase and gives the true age of the pegmatite; the age agrees with that of the Kenoran orogeny generally.

Ontario

GSC 63-115 Amphibole, K-Ar age 875 m.y.

$K = 0.44\%$, $Ar^{40}/K^{40} = 0.06515$; radiogenic Ar = 95%. Concentrate; clean concentrate of amphibole. Most fragments appear opaque and have only slightly transparent blue edges. About 10% of the fragments are transparent and pleochroic from brown to buff. Less than 1% chlorite, biotite not detected.

From granite.

(31 C) Highway No. 7, 6 miles east of Marmora, Ontario, 44°29'40"N, 77°34'00"W. Map-unit 8a, GSC Map 560A. Sample SH-5-63, collected and interpreted by C.H. Stockwell.

This is a medium-grained, massive, red granite composed of perthite, quartz, and amphibole with minor biotite, fluorite, and zircon. The amphibole is essentially orthorhombic with very strong pleochroism from pale brown to indigo blue.

The sample is from the Doloro stock which invades rocks of the Grenville and Hastings Series and is overlain unconformably by rocks of Ordovician age. The stock occurs in a region of lower grade metamorphism than prevalent elsewhere in the Grenville province and, if old, might have escaped the strong effects of the Grenville orogeny. However, the amphibole gave the usual Grenville age which suggests that the stock was intruded during the Grenville orogeny. This sample is one of a number from the same stock that are being tested by the whole rock Rb/Sr isochron method.

GSC 63-116 Hornblende, K-Ar age 2,475 m.y.

$K = 0.52\%$, $Ar^{40}/K^{40} = 0.29918$; radiogenic Ar = 98%. Concentrate; reasonably clean concentrate of green hornblende. Minor impurities consist mainly of biotite and a trace of chlorite.

From granodiorite.

(52 B) Island in Saganaga Lake, Ontario, 48°14'30"N, 90°52'30"W. Map-unit 8a, GSC Map 432A. Sample SH-55-63, collected by W.F. Fahrig, interpreted by C.H. Stockwell.

Ontario

The granodiorite is a medium-grained, massive, grey rock composed of quartz, oligoclase, orthoclase, hornblende, and a little biotite, apatite, and magnetite. The oligoclase is somewhat clouded and the biotite is considerably altered to chlorite but the hornblende is fresh.

This is from the Saganaga Granite which invades Keewatin rocks and, according to some authorities, is overlain unconformably by the Knife Lake Group which is Archaean. On the basis of geological evidence the granite, therefore, is probably Laurentian (pre-Kenoran) but the hornblende gave the usual Kenoran age; this could be a metamorphic age. A number of samples were collected for testing by the Rb/Sr whole rock isochron method but were found to be unsuitable.

GSC 63-117 Biotite, K-Ar age 1,330 ± 50 m.y.

$K = 6.60\%$, $Ar^{40}/K^{40} = 0.1131$; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of orange-red biotite. Some flakes are slightly altered to chlorite. About 10% of impurities are composed of amphibole, pyroxene and chlorite. Total chlorite content is 2%. Amphibole content is 3%.

From gabbro.

(41 I) Ontario, 46°18'N, 81°47'W. Map-unit 7, Ontario Dept. Mines Map 1952-1. Sample FA-202-62, collected and interpreted by W.F. Fahrig.

The rock is a coarse-grained, dark grey, ophitic gabbro consisting of plagioclase, pyroxene, olivine, iron-ores, and minor biotite. Minor amounts of alteration product, notably chlorite, are also present. The biotite is present as small orange-red flakes closely associated with the iron-ores.

The biotite appears to be a primary magmatic mineral, and the K-Ar date indicates the age of crystallization.

GSC 63-118 Biotite, K-Ar age 1,240 ± 50 m.y.

$K = 7.33\%$, $Ar^{40}/K^{40} = 0.1026$; radiogenic Ar = 100%. Concentrate; clean concentrate of orange-red biotite. About 10% of the biotite flakes are slightly altered to chlorite and contain a few opaque inclusions. Chlorite content is 3%.

Ontario

From gabbro.
(42 A) Ontario, 48°36'N, 80°21'W. Map-unit 7, Ontario Dept. Mines Map 1947-2. Sample FA-205-62, collected and interpreted by W.F. Fahrig.

The rock is a coarse-grained gabbro consisting of an ophitic intergrowth of plagioclase and pyroxene, along with iron-ores, olivine, and biotite. The biotite appears orange-red in thin section and rims the iron-ore minerals.

The K-Ar age gives the age of crystallization of the intrusion.

GSC 63-119 Whole rock, K-Ar age 2,485 m.y.

$K = 0.25\%$, $Ar^{40}/K^{40} = 0.3014$; radiogenic Ar = 100%.

From gabbro.
(42 A) Ontario, 48°32'N, 81°35'W. Map-unit Dm, Ontario Dept. Mines Map 118. Sample FA-208-62, collected and interpreted by W.F. Fahrig.

Porphyritic gabbro consisting of light green-weathering clots of coarse-grained feldspar in a dark green matrix. The analyzed sample is a chilled contact.

In thin section the large plagioclase crystals appear to be almost completely altered. They are set in a matrix consisting of a second generation of smaller lath-shaped plagioclase and pyroxene phenocrysts which in turn are in a matrix of very fine-grained ophitic gabbro. No biotite is visible in thin section. The rock appears moderately fresh.

This is a sample of Matachewan diabase and the whole rock age is in agreement with the generally accepted idea that these intrusions are pre-Huronian.

GSC 63-120 Whole Rock, K-Ar age 1,170 m.y.

$K = 0.23\%$, $Ar^{40}/K^{40} = 0.0951$; radiogenic Ar = 100%.

Ontario

From diabase.

(42 M) Outlet of Makokibatan Lake, Ontario, 51°19'N, 87°07'W. Map-unit 7c, GSC Map 6-1962. Sample JD-417/4, collected by G.D. Jackson, interpreted by W.F. Fahrig.

The analyzed material is coarse-grained ophitic gabbro from the central part of a diabase dyke. It consists of plagioclase, pyroxene, iron-ores and hornblende.

The K content is rather low for accurate determination so that the age should be considered a first approximation to the age of intrusion.

GSC 63-121 Whole Rock, K-Ar age 2,005 m.y.

$K = 0.79\%$, $Ar^{40}/K^{40} = 0.2087$; radiogenic Ar = 100%.

From diabase.

(42 M) Martin Falls on the Albany River, Ontario, 51°32'30"N, 86°30'W. Map-unit 7c, GSC Map 6-1962. Sample JD-300/6-2, collected by G.D. Jackson, interpreted by W.F. Fahrig.

The rock is very dark green ophitic gabbro taken from the border zone of a 100-foot wide diabase dyke.

It consists of plagioclase, pyroxene, iron-ores, hornblende, and biotite.

This K-Ar age is greater than that obtained on dykes of similar trend, for example GSC 63-120. Further work will be necessary to establish whether this is the age of dyke intrusion.

GSC 63-122 Whole Rock, K-Ar age 1,450 m.y.

$K = 0.37\%$, $Ar^{40}/K^{40} = 0.1277$; radiogenic Ar = 100%.

From gabbro.

(41 N) Ontario, 47°14'N, 84°39'W. Map-unit 3, Ontario Dept. Mines Map 1955-I. Sample FA-209-62, collected and interpreted by W.F. Fahrig.

Ontario

Chilled gabbro consisting of 1/16 inch needles of plagioclase in a semi-opaque very finely crystalline matrix. The analyzed rock has a trachytic texture.

The whole rock K-Ar age is a first approximation to the age of crystallization of the gabbro.

GSC 63-123 Whole Rock, K-Ar age 1,810 m.y.

$K = 0.70\%$, $Ar^{40}/K^{40} = 0.1779$; radiogenic Ar = 100%.

From gabbro.
(42 D) Ontario, 48°51'N, 86°57'W. Map-unit "diabase", Ontario Dept. Mines Map Circular Number 4. Sample FA-210-62, collected and interpreted by W.F. Fahrig.

The rock is dark grey gabbro from the chill zone of a diabase dyke. It consists of blocky plagioclase and pyroxene crystals 1/16 inch long in a microcrystalline to cryptocrystalline matrix. The matrix is completely opaque in thin section immediately adjacent to the contact with the country rock. Plagioclase phenocrysts are extensively altered.

The whole rock date is considered to be a first approximation to the age of crystallization of the gabbro.

GSC 63-124 Whole Rock, K-Ar age 2,320 m.y.

$K = 0.48\%$, $Ar^{40}/K^{40} = 0.2677$; radiogenic Ar = 100%.

From gabbro.
(42 C) Ontario, 48°41'N, 85°48'W. Unmapped area. Sample FA-211-62, collected and interpreted by W.F. Fahrig.

The rock is dark grey gabbro from the chill zone of a diabase dyke. It consists of 1/16 inch phenocrysts of blocky pyroxene and lath-shaped, randomly oriented plagioclase crystals in a very fine-grained dark matrix. The matrix is chiefly dark green hornblende, iron ores, and plagioclase. The rock is essentially unaltered.

Ontario

In outcrops the dyke contains clots of coarse-grained feldspar and is megascopically similar to Matachewan diabase of similar age (GSC 63-119).

GSC 63-125 Whole Rock, K-Ar age 2,505 m.y.

$K = 0.47\%$, $Ar^{40}/K^{40} = 0.3065$; radiogenic Ar = 100%.

From gabbro.
(42 C) Ontario, 48°08'N, 84°49'W. Unmapped area.
Sample FA-212-62, collected and interpreted by W.F. Fahrig.

The rock is fine-grained dark grey gabbro from near the contact with country rock. It contains sparsely distributed blotches of coarse-grained plagioclase. In thin section the rock appears quite fresh and consists of pyroxene, iron ores, hornblende, and yellow-brown biotite.

The K-Ar date provides a first approximation to the age of crystallization.

GSC 63-126 Whole Rock, K-Ar age 2,225 m.y.

$K = 0.70\%$, $Ar^{40}/K^{40} = 0.2483$; radiogenic Ar = 100%.

From gabbro.
(42 C) Ontario, 48°13'N, 84°51'W. Unmapped area.
Sample FA-213-62, collected and interpreted by W.F. Fahrig.

The rock is fine-grained dark grey gabbro from the contact zone of a diabase dyke. The analyzed material consists of 1 mm phenocrysts of plagioclase and olivine in a fine-grained matrix of hornblende, plagioclase, iron ores, and biotite. Biotite forms about 3% of the rock.

The determination gives the approximate age of crystallization of the rock.

Ontario

GSC 63-127 Whole Rock, K-Ar age 1,265 m.y.

K = 1.64%, Ar^{40}/K^{40} = 0.1055; radiogenic Ar = 100%.

From gabbro.

(42 C) Ontario, 48°12'N, 84°53'W. Map-unit 3, GSC Map 1972. Sample FA-214-62, collected and interpreted by W.F. Fahrig.

The sample is fine-grained gabbro from the chilled border of a diabase dyke. The dyke contains a large amount (up to 7%) of unaltered red-brown biotite. Biotite from this dyke has previously been analyzed (GSC 62-110) and yielded a K-Ar age of 1,120 m.y.

The present whole rock analysis was made in order to check the results of whole rock analysis of basaltic rock against results of analysis of biotite from these rocks. In the present case the results check moderately well.

GSC 63-128 Whole Rock, K-Ar age 1,465 m.y.

K = 0.81%, Ar^{40}/K^{40} = 0.1296; radiogenic Ar = 88%.

From gabbro.

(41 J) Ontario, 46°14'N, 82°35'W. Map-unit "diabase", Ontario Dept. Mines Map P131. Sample FA-215-62, collected and interpreted by W.F. Fahrig.

The sample is from a dark green aphanitic margin of a diabase dyke. It consists of irregular patchy hornblende pseudomorphic after pyroxene, areas of fine-grained white mica and zoisite pseudomorphic after plagioclase, iron-ores, and fine-grained chlorite.

The dyke appears to have undergone low grade regional metamorphism after consolidation. The K-Ar analysis probably gives only a minimum age for the intrusion.

GSC 63-129 Whole Rock, K-Ar age 1,660 m.y.

K = 0.67%, Ar^{40}/K^{40} = 0.1559; radiogenic Ar = 93%.

Ontario

From gabbro.

(41 J) Ontario, 46°26'N, 82°40'W. Not mapped. Sample FA-216-62, collected and interpreted by W.F. Fahrig.

The rock is a grey, fine-grained gabbro from a diabase dyke. The sample was taken at a distance of 3 feet from the dyke wall and is a hornblende-quartz diabase.

The dyke cuts early Proterozoic rocks north of Lake Huron, so that the whole-rock age is quite reasonable in terms of the geological setting.

GSC 63-130 Biotite, K-Ar age 1,220 ± 40 m.y.

$K = 7.25\%$, $Ar^{40}/K^{40} = 0.1002$; radiogenic Ar = 100%. Concentrate; clean concentrate of orange-reddish biotite. About 5% of the biotite flakes are altered to chlorite and a few flakes are partly chloritized. Minor impurities consist of amphibole and quartz. Total chlorite content is 7%.

From gabbro.

(42 A) Ontario, 48°32'N, 81°35'W. Ontario Dept. Mines Map P118. Sample FA-228-62, collected and interpreted by W.F. Fahrig.

The sample is a mottled pink and green, coarse-grained gabbro from the central zone of a diabase dyke. It consists of plagioclase, pyroxene, iron-ores, hornblende, and extensive patches of fine-grained chlorite that may be pseudomorphic after olivine or a second pyroxene. The plagioclase is extensively replaced by secondary fine-grained minerals. The biotite is very locally altered to chlorite.

The K-Ar age is believed to give the approximate age of crystallization of the intrusion.

GSC 63-131 Pyroxene, K-Ar age 800 m.y.

Ontario

$K = 0.26\%$, $Ar^{40}/K^{40} = 0.0582$; radiogenic Ar = 98%. Concentrate; clean concentrate and pleochroic pale violet to buff pyroxene. Pyroxene crystals are altered along cleavage planes to reddish-brown biotite and to chlorite. Only a trace of biotite and chlorite is present.

From gabbro.

(42 C) Road cut on Highway 17, just south of a small stream 8 1/2 miles north of Catfish Lake, Ontario, 48°12'N, 84°53'W. Map-unit 3, GSC Map 1972. Sample SH-87-60, collected by C.H. Stockwell, interpreted by W.F. Fahrig.

The pyroxene was extracted from a sample of olivine diabase from which biotite was extracted and analyzed in 1962. The purpose of the present analysis was to investigate the feasibility of determining K-Ar ages from pyroxenes of basic rock. The K-Ar age here reported (800 m.y.) is significantly smaller than the K-Ar age of 1,120 reported for coexisting biotite (GSC 62-110).

As it is thought that the biotite analysis has given more nearly the correct age of intrusion, the lower K-Ar age of the pyroxene is ascribed either to an error in K determination or to a loss of argon from the pyroxene structure.

Quebec

GSC 63-132 Muscovite, K-Ar age 1,915 ± 60 m.y.

K = 7.99%, Ar^{40}/K^{40} = 0.1943; radiogenic Ar = 100%. Concentrate; clean concentrate of muscovite. Chlorite not detected.

From pegmatite.
(24 K) On the western outskirts of Fort Chimo, Quebec, 58°06'30"N, 68°25'00"W. Sample SH-8-62, collected and described by C.H. Stockwell.

The pegmatite dyke is about 20 feet wide and consists mainly of quartz, pink feldspar up to 2 feet across, and a little beryl and garnet. It cuts lit-par-lit gneiss. The sample was collected from a pocket in the dyke and contains undeformed books of muscovite mostly about 1/4 inch in diameter. The age indicates the time of intrusion and crystallization of the pegmatite. The sample is from the Churchill province east of the Labrador trough and the age is somewhat older than the prevalent age of the Hudsonian orogeny.

GSC 63-133 Perthite, K-Ar age 540 ± 24 m.y.

K = 7.63%, Ar^{40}/K^{40} = 0.0367; radiogenic Ar = 100%. Concentrate; clean concentrate of perthite. Perthite fragments contain minute inclusions and red crusts of hematite along cleavage planes.

From granite.
(31 G) Quarry, 3 1/2 miles northwest of Brownsburg, Quebec, 45°42'20"N, 74°27'40"W. Quebec Dept. Mines Map 408. Sample SH-44-62, collected and described by C.H. Stockwell.

The sample from which the perthite was separated is a medium-grained, massive, purplish grey granite composed chiefly of quartz and perthite with a little albite and amphibole. It is from the Chatham-Grenville stock of granite and syenite which is younger than diabase dykes that cut older granitic rocks and metasediments of the Grenville series at its type locality. The Grenville orogeny is here dated at 850 m.y. (GSC 60-112) and one of the diabase dykes gave 790 m.y. (GSC 63-151). The perthite at 540 m.y. therefore agrees with the relative ages as determined by geological evidence.

This age, however, being on a feldspar, is probably somewhat younger than the true age, which is probably Upper Proterozoic (Hadrynian). The stock is a post-orogenic intrusion.

GSC 63-134 Biotite, K-Ar age 1,810 ± 60 m.y.

$K = 5.68\%$, $Ar^{40}/K^{40} = 0.1775$; radiogenic Ar = 100%. Concentrate; impure concentrate of orange-brown biotite. Impurities consist of 15% hornblende, 5% plagioclase, and a little quartz. Chlorite not detected.

From mafic gneiss.
(24 B) Island in Lac Secondon, Quebec, 56°38'15"N, 67°01'00"W. Sample SH-3-62, collected and described by C.H. Stockwell.

This is a medium-grained, well foliated, mafic gneiss composed of quartz, andesine, hornblende, garnet, and a little biotite and magnetite. The gneiss is cut and interleaved by stringers of granitic material some of which are included in the sample. The rock lies within the Churchill province east of the Labrador trough and biotite age is that of the Hudsonian orogeny.

GSC 63-135 Hornblende, K-Ar age 1,730 m.y.

$K = 0.94\%$, $Ar^{40}/K^{40} = 0.1660$; radiogenic Ar = 100%. Concentrate; clean concentrate of pleochroic, green-olive hornblende. Minor impurities consist of a few fragments of pink garnet.

From mafic gneiss.
(24 B) Island in Lac Secondon, Quebec, 56°38'15"N, 67°01'00"W. Sample SH-3-62, collected and described by C.H. Stockwell.

The hornblende is from the same sample as GSC 63-134 and the age agrees well with that obtained on the biotite.

Quebec

GSC 63-136 Muscovite, K-Ar age 2,295 ± 80 m.y.

$K = 6.39\%$, $Ar^{40}/K^{40} = 0.26188$; radiogenic Ar = 99%. Concentrate; impure concentrate of muscovite. Most of the muscovite flakes are intergrown with feldspar, quartz, biotite, and epidote. Some flakes are stained buff. Impurities consist of traces of quartz, K-feldspar and plagioclase.

From granodiorite.
(32 G) On island in Lac Le Royer, Quebec, 49°36'15"N, 74°26'40"W. Map-unit 6, Que. Dept. Mines Map 1236. Sample SH-54-62, collected and interpreted by C.H. Stockwell.

This is a medium-grained, massive, grey, granodiorite consisting of quartz, oligoclase, biotite, muscovite, and accessory apatite, titanite, and zircon. The feldspar is considerably altered to epidote and sericite but the micas are fresh. The muscovite is euhedral against biotite.

The sample is from the Dauversiere stock in the Superior province and was collected from a point 8 miles northwest of the Grenville front. The muscovite age of 2,295 m.y. probably approaches the true age of the granodiorite although it is possible that some argon may have been driven off by heat from the Grenville orogen (Compare with GSC 63-137). For discussion see Paper 64-17, Part II.

GSC 63-137 Biotite, K-Ar age 2,085 ± 70 m.y.

$K = 8.07\%$, $Ar^{40}/K^{40} = 0.22284$; radiogenic Ar = 100%. Concentrate; clean concentrate of brown biotite. Biotite flakes contain a few inclusions of zircon and quartz. Chlorite content less than 1%.

From granodiorite.
(32 G) On island in Lac Le Royer, Quebec, 49°36'15"N, 74°26'40"W. Map-unit 6, Que. Dept. Mines Map 1236. Sample SH-54-62, collected and interpreted by C.H. Stockwell.

Quebec

The biotite is from the same sample as the muscovite of the previous determination (GSC 63-136, 2,295 m.y.). The biotite age of 2,085 m.y. is thought to be anomalously too young due to loss of argon as a result of heat derived from the Grenville orogen. For discussion see Paper 64-17, Part II.

GSC 63-138 Biotite, K-Ar age 1,070 ± 40 m.y.

$K = 8.50\%$, $Ar^{40}/K^{40} = 0.08417$; radiogenic Ar = 98%. Concentrate; clean concentrate of olive-brown biotite. Biotite flakes contain small crystals of rutile and sphene along the cleavage planes and fractures. Chlorite not detected.

From migmatite.
(23 D) Quebec, 52°03'N; 70°05'W. Map-unit 5, GSC Map 56-1959. Sample KS-53-59, collected by S.H. Kranck, interpreted by C.H. Stockwell.

The migmatite is composed of white granite mixed with biotite-rich gneiss. The sample was run to help to determine the position of the Grenville front in a little known area. The biotite date of 1,070 m.y. is somewhat older than the typical Grenville age which probably means that the rock is close to the Grenville front but in the Grenville province.

GSC 63-139 Biotite, K-Ar age 955 ± 40 m.y.

$K = 7.67\%$, $Ar^{40}/K^{40} = 0.07270$; radiogenic Ar = 98%. Concentrate; clean concentrate of brown biotite. Minor impurities consist of a few altered pyroxene and hornblende fragments. Chlorite not detected.

From anorthosite.
(31 J) Highway No. 11, 1/2 mile SE of branch road to Ivy, Quebec, 46°05'00"N, 74°19'25"W. Quebec Dept. of Mines Map No. 343. Sample SH-38-62, collected and interpreted by C.H. Stockwell.

The anorthosite is a coarse-grained, dark grey, massive rock composed of labradorite, hypersthene, quartz, biotite, and a little hornblende and magnetite. The quartz and biotite are interstitial to the feldspar and hypersthene and are probably primary. The biotite crystals are up to 1/2 inch across and are fresh.

Quebec

As the biotite is probably primary this sample was run in an effort to obtain the true age of intrusion of anorthosites in the Grenville province, it being reasonable to suppose that their age is about the same as anorthosite in the Nain province (1,400 m.y., GSC 63-164). The 955 m.y. date obtained probably resulted from loss of argon during a moderate metamorphic effect during the Grenville orogeny.

GSC 63-140 Whole Rock, K-Ar age 805 m.y.

$K = 0.90\%$, $Ar^{40}/K^{40} = 0.05873$; radiogenic Ar = 100%.
Sample: Crushed whole rock.

From anorthosite.
(31 J) Highway 11, 1/2 mile east of St. Faustin, Quebec, 46°07'00"N, 74°28'00"W. Quebec Dept. of Mines Map 343. Sample SH-41-62, collected and interpreted by C.H. Stockwell.

This anorthosite is medium-grained, light grey, and massive and is composed of andesine and a little quartz, pyroxene, hornblende, biotite, and muscovite. The muscovite occurs as scattered small crystals that appear to be primary.

An effort was made to separate the muscovite but this was unsuccessful and the whole rock was run instead. The age of 805 m.y. is probably a metamorphic age (See GSC 63-139 which is from the same anorthosite body).

GSC 63-141 Biotite, K-Ar age 1,425 ± 50 m.y.

$K = 7.82\%$, $Ar^{40}/K^{40} = 0.12458$; radiogenic Ar = 99%.
Concentrate; reasonably clean concentrate of dark olive-greenish biotite. Some flakes are almost opaque. About 15% of the biotite flakes are in part altered to chlorite and contain small inclusions of epidote. Total chlorite content 8%.

From granitic gneiss.
(32 G) Railway cut just west of Chibougamau Highway, Quebec, 49°32'50"N, 74°11'30"W. Map-unit 7a, Quebec Dept. Mines Map 1235. Sample SH-58-62, collected and interpreted by C.H. Stockwell.

Quebec

The granitic gneiss is a medium-grained rock in which grey and pink layers alternate. It consists of quartz, oligoclase, biotite, muscovite, epidote, and accessory apatite, titanite, and zircon. Most of the biotite is fresh but a few crystals are interleaved with chlorite and dark opaque material. The muscovite crystals are euhedral against biotite.

The sample was collected from the Grenville province at a point 4 1/2 miles southeast of the Grenville front. The biotite age of 1,425 m.y. is thought to be anomalous, probably due to the addition of argon (see discussion in Part II). Compare with the muscovite age of 985 m.y. from the same sample, GSC 63-142.

GSC 63-142 Muscovite, K-Ar age 985 ± 30 m.y.

$K = 8.58\%$, $Ar^{40}/K^{40} = 0.07568$; radiogenic Ar = 98%. Concentrate; reasonably clean concentrate of muscovite. Some muscovite flakes are intergrown with green biotite and contain inclusions of quartz and red crusts of hematite. Total chlorite content 4%.

From granitic gneiss.
(32 G) Railway cut just west of Chibougamau Highway, Quebec, 49°32'50"N, 74°11'30"W. Map-unit 7a, Quebec Dept. Mines Map 1235. Sample SH-58-62, collected and interpreted by C.H. Stockwell.

The muscovite is from the same sample as the biotite GSC 63-141, which gave an anomalous age of 1,425 m.y. The muscovite at 985 m.y. is a more reliable indication of the time of Grenville metamorphism (see discussion in Part II).

GSC 63-143 Biotite, K-Ar age 2,485 ± 70 m.y.

$K = 7.51\%$, $Ar^{40}/K^{40} = 0.30215$; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of olive-brownish biotite. About 40% of the biotite flakes are partly bleached and locally altered to pale green chlorite and epidote. Total chlorite content 20%.

Quebec

From granite.
(32 G) East shore of Lac La Dauversiere, Quebec, 49°34'50"N, 74°19'25"W. Map-unit 6, Quebec Dept. Mines Map 1236. Sample SH-18-63, collected by G. Duquette, interpreted by C.H. Stockwell.

This is a medium-grained, grey, gneissic granite composed of quartz, feldspar, biotite, muscovite, and accessory titanite. The feldspar is considerably altered to sericite and epidote and the biotite to chlorite but the muscovite is fresh. Both micas are slightly bent.

The sample is from the Dauversiere stock, in the Superior province, at a point about 2 1/2 miles northwest of the Grenville front.

For discussion see GSC 63-147.

GSC 63-144 Muscovite, K-Ar age 2,025 ± 60 m.y.

K = 8.58%, Ar^{40}/K^{40} = 0.21270; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of muscovite. Most of the muscovite flakes contain small inclusions of quartz and feldspar, while some flakes have attached specks of partly altered biotite and are stained yellow. Total chlorite content 2%.

From granite.
(32 G) East shore of Lac La Dauversiere, Quebec, 49°34'50"N, 74°19'25"W. Map-unit 6, Quebec Dept. Mines Map 1236. Sample SH-18-63, collected by G. Duquette, interpreted by C.H. Stockwell.

This muscovite (2,025 m.y.) was separated from the same sample as the biotite of GSC 63-143 (2,485 m.y.).

For discussion see GSC 63-147.

GSC 63-145 Muscovite, K-Ar age 1,630 ± 50 m.y.

Quebec

$K = 8.62\%$, $Ar^{40}/K^{40} = 0.15130$; radiogenic Ar = 99%. Concentrate; reasonably clean concentrate of muscovite. Some muscovite flakes have attached specks of biotite, quartz, feldspar and epidote.

From granite.
(G 1) Southeast shore of Lac La Dauversiere, Quebec, 49°32'40"N, 74°20'25"W. Map-unit 6, Quebec Dept. Mines Map 1236. Sample SH-17-63, collected by G. Duquette, interpreted by C.H. Stockwell.

This muscovite (1,630 m.y.) was separated from the same sample as the biotite of GSC 63-146 (3,300 m.y.).

For discussion see GSC 63-147.

GSC 63-146 Biotite, K-Ar age 3,300 ± 90 m.y.

$K = 7.37\%$, $Ar^{40}/K^{40} = 0.52410$; radiogenic Ar = 100%. Concentrate; clean concentrate of brown biotite. Biotite flakes contain a few zircon inclusions surrounded by dark brown pleochroic haloes. Some flakes are slightly bleached and contain inclusions of quartz.

From gneissic granite.
(G 1) Southeast shore of Lac La Dauversiere, Quebec, 49°32'40"N, 74°20'25"W. Map-unit 6, Quebec Dept. Mines Map 1236. Sample SH-17-63, collected by G. Duquette, interpreted by C.H. Stockwell.

This is a light grey, medium-grained, gneissic granite composed of quartz, orthoclase, plagioclase, biotite, muscovite, and accessory titanite and zircon. The feldspars are considerably altered to sericite and epidote. The feldspars and quartz show a recrystallized cataclastic structure but the micas are fresh and undeformed.

The sample is from the Dauversiere stock, in the Superior province, at a point about 2 miles northwest of the Grenville front and 2.6 miles southwesterly from the locality where GSC 63-143 was collected.

For discussion see GSC 63-147.

Quebec

GSC 63-147 Whole Rock, K-Ar age 1,675 m.y.

K = 1.30%, Ar^{40}/K^{40} = 0.15821; radiogenic Ar = 98%. Concentrate; crushed whole rock.

From granite.

(32 G) Southeast shore of Lac La Dauversiere, Quebec, 49°32'40"N, 74°20'25"W. Map-unit 6, Quebec Dept. Mines Map 1236. Sample SH-17-63, collected by G. Duquette, interpreted by C.H. Stockwell.

This whole rock age of 1,675 m.y. was obtained on the same sample from which biotite gave an age of 3,300 m.y. (GSC 63-146) and muscovite an age of 1,630 m.y. (GSC 63-145).

Age determinations (GSC 63-143, 144, 145, 146, 147) were made in a further study of discrepant ages across the Grenville front at the Chibougamau highway locality where the Grenville orogen of about 900 m.y. is in geologically sharp contact with the Kenoran orogen of about 2,500 m.y. Previous studies of the problem were summarized in last year's report (Stockwell, 1963b) where it was concluded that muscovite retained its argon quite well on both sides of the front. This conclusion has to be modified somewhat for it is now known that this mineral gives discrepantly young dates close to the front on the Kenoran side. This is shown by an age of 1,630 m.y. (GSC 63-145) at 2 miles from the front and of 2,025 m.y. (GSC 63-144) at 2 1/2 miles, which contrast with the more nearly normal muscovite age of 2,340 m.y. (GSC 62-154) at 5 miles out.

Discrepant ages obtained on biotite are more difficult to interpret. In last year's report it was suggested that argon driven off from biotites on the Kenoran side of the front was added to biotites on the Grenville side to give them discrepantly old dates. The new data indicate that the problem is more complex for unexpectedly old biotite dates are now found on the Kenoran side as well. This is illustrated by an age determination of 3,300 m.y. (GSC 63-146) at 2 miles from the front and of 2,485 m.y. (GSC 63-143) at 2 1/2 miles out. The 3,300 m.y. date, at least, is unrealistic and is difficult to explain but most probably results from the addition of argon released from other minerals in the zone affected by the Grenville orogeny. The problem of argon migration is further compounded by the whole rock age of 1,675 m.y. (GSC 63-147) obtained on the same sample which gave biotite at 3,300 m.y. and muscovite at 1,630 m.y.

Quebec

Additional age determinations are being made and when the results are known further consideration will be given to the interpretation of the highly anomalous ages of this locality.

GSC 63-148 Biotite, K-Ar age 1,455 ± 50 m.y.

$K = 7.85\%$, $Ar^{40}/K^{40} = 0.12844$; radiogenic Ar = 100%. Concentrate; clean concentrate of brown biotite. About 30% of the biotite flakes are partly bleached and locally altered to chlorite and fine-grained epidote. Total chlorite content 13%.

From paragneiss.
(13 L) Island near N.W. end of Prong Lake, Quebec, 54°47'30"N, 63°50'30"W. Sample SH-32-62, collected and interpreted by C.H. Stockwell.

The paragneiss is a medium-grained, grey rock with augen of pink feldspar. Constituent minerals include quartz, oligoclase, biotite, apatite, magnetite, pyrite, and rounded zircons. Most of the biotite is fresh but some crystals are interleaved with chlorite or contain streaks of opaque material along cleavage planes.

The sample is from the western part of the Nain province and was collected from a point 4 miles north of an intrusion of anorthosite. The potassium-argon age is about the age of the last period of metamorphism.

GSC 63-149 Whole Rock, K-Ar age 1,825 m.y.

$K = 0.56\%$, $Ar^{40}/K^{40} = 0.1804$; radiogenic Ar = 100%.

From gabbro.
(32 D) Quebec, 48°25'N, 78°21'W. Map-unit "diabase", Quebec Dept. Mines Map 1388. Sample FA-206-62, collected and interpreted by W.F. Fahrig.

The rock is aphanitic, dark grey gabbro consisting of pyroxene, plagioclase, iron-ores, and biotite. Biotite forms approximately 2% of the rock.

As the accuracy of whole rock K-Ar determinations of basaltic rocks is not well established, the whole rock age is considered a first approximation to the age of crystallization of the gabbro.

Quebec

GSC 63-150 Whole Rock, K-Ar age 1,655 m.y.

$K = 0.36\%$, $Ar^{40}/K^{40} = 0.1551$; radiogenic Ar = 100%.

From gabbro.
(32 D) Quebec, 48°14'N, 79°00'W. Map-unit "diabase", Quebec Dept. Mines Map 1388. Sample FA-207-62, collected and interpreted by W.F. Fahrig.

Dark-grey aphanitic gabbro consisting of pyroxene, plagioclase, and iron-ores. Biotite is not visible in thin section. Ovoid patches of chlorite and epidote suggest minute amygdules. Very fine-grained chlorite is widely visible in thin sections of this rock.

This is a first approximation of the age crystallization of the gabbro.

GSC 63-151 Whole Rock, K-Ar age 790 m.y.

$K = 0.28\%$, $Ar^{40}/K^{40} = 0.0574$; radiogenic Ar = 100%.

From gabbro.
(31 G) 2 miles north of a bridge over the Rouge River, Quebec, 45°44'05"N, 74°41'20"W. Map-unit "Quartz diabase dykes", Quebec Dept. Mines Map 408. Sample SH-45-62, collected by C.H. Stockwell, interpreted by W.F. Fahrig.

The rock is dark grey, fine-grained gabbro from near the edge of a diabase dyke intrusion. It consists of 1-2 mm phenocrysts of plagioclase and pyroxene (augite) in a matrix of plagioclase, pyroxene, iron-ores, and minor hornblende and biotite. The rock as a whole is fresh but 1/2 mm irregular clots of fine-grained chlorite make up about 3% of the slide.

The K-Ar analysis gives the approximate age of crystallization of the dyke.

GSC 63-152 Whole Rock, K-Ar age 1,465 m.y.

$K = 0.68\%$, $Ar^{40}/K^{40} = 0.12957$; radiogenic Ar = 90%.
Concentrate; crushed whole rock.

Quebec

From gabbro.

(23 D) East shore of Lac Conflans, Quebec, 52°23'30"N, 70°47'W. Map-unit 11, GSC Map 56-1959. Sample EA-900A-61, collected by W.F. Fahrig, interpreted by K.E. Eade.

Gabbro from a sill intruding the Otish Group. It is a medium-grained greenish black gabbro composed of labradorite feldspar and augite pyroxene, with minor hornblende, magnetite, and chlorite.

It is believed that this age is approximately the age of the gabbro intrusion. It is a minimum age for the sedimentary rocks of the Otish Group. These rocks occur just to the north of the Grenville front.

GSC 63-153 Whole Rock, K-Ar age 300 m.y.

$K = 2.70\%$, $Ar^{40}/K^{40} = 0.01896$; radiogenic Ar = 96%. Concentrate; crushed whole rock.

From dacite.

(34 B) South side of large island in north sector of Clearwater Lake, overlooking bay dividing east and central sections of island, Quebec, 56°16'10"N, 74°26'20"W. Map-unit 9, GSC Map 36-1962. Sample BKA-63-57, collected and interpreted by H.H. Bostock.

This is a massive fine-grained equigranular light red dacite containing zoned labradorite-andesine, augite, alkali feldspar, quartz, magnetite, and apatite. Plagioclase subhedra are antiperthitic and commonly rimmed by alkali feldspar. Grains of quartz and alkali feldspar in interstitial patches are interlaced by apatite needles. Some alteration of mafic minerals to hematite is evident.

Massive dacite at Clearwater Lake overlies a complex of diabase dykes and friable to coherent breccias that intrude the Precambrian basement. The breccias are also known to be younger than limestone remnants that are sparingly preserved on the island ring in the western part of Clearwater Lake. This limestone is considered, on the basis of fossils found in similar but slightly less altered drift, to be middle or upper Ordovician (Kranck and

Sinclair, 1963). The K-Ar whole rock age (Pennsylvanian) determined on the dacite is therefore consistent with the field data. The age of a glass from the Clearwater Lake area dated by the fission track method is dated at 34 m.y. (Fleischer and Price, 1963).

References

Kranck, S.H., and Sinclair, G.W.
1963: Clearwater Lake, New Quebec; Geol. Surv. Can., Bulletin 100.

Fleischer, R.L., and Price, P.B.
1963: Chunks of the Moon; Time Magazine, vol. 8, No. 22, p. 44 (Canadian Edition).

GSC 63-154 Whole Rock, K-Ar age 285 m.y.

$K = 2.70\%$, $Ar^{40}/K^{40} = 0.01790$; radiogenic Ar = 93%. Concentrate; crushed whole rock.

From dacite.

(34 B) Bluffs at east end of west part of large island in south part of Clearwater Lake, Quebec, 56°08'30"N, 74°31'50"W. Map-unit 9, GSC Map 36-1962. Sample BKA-63-192, collected and interpreted by H.H. Bostock.

The description of sample GSC 63-154 is the same as that for GSC 63-153, except that alteration of mafic minerals to hematite is not evident.

New Brunswick

GSC 63-155 Biotite, K-Ar age 462 ± 20 m.y.

$K = 7.22\%$, $Ar^{40}/K^{40} = 0.0307$; radiogenic Ar = 100%. Concentrate; clean concentrate of orange-brown biotite. A few flakes are altered to colourless chlorite. Total chlorite content is 2%.

From gabbro.

(21 G) Dump of the St. Stephen Nickel property, shaft at Rodger Farm, New Brunswick, 45°13'N, 67°18'W. Map-unit 6, GSC Map 1096A. Sample MB-STS-62. Collected and interpreted by W.D. McCartney.

The quartz-biotite gabbro sample is dark greyish green and equigranular, and was selected in preference to the associated and more abundant gabbro and norite because of the visible abundance of biotite grains. As seen in thin section grains approach 0.25 cm in diameter and comprise about 50% plagioclase (An_{90}), 10% biotite, 10% quartz, 15% pyroxene and alteration product (hornblende), and minor chlorite, magnetite, apatite, and carbonate.

The gabbro intrudes sediments of the Charlotte Group of Ordovician or earlier age. The gabbro and related rocks (including peridotite) were considered to be Middle Devonian in age (Map 1096A, G.S.C.). The nickel mineralization within the gabbro suggested to the writer that an Ordovician age would be compatible with one metallogenic hypothesis outlined by McCartney and Potter (1962), whereas the accepted Middle Devonian age clashed with the hypothesis. The absolute age indicated in this report supports both an Ordovician age and the metallogenic working hypothesis.

Reference

McCartney, W.D., and Potter, R.R.
1962: "Mineralization as related to structural deformation, igneous activity and sedimentation in folded geosynclines"; Canadian Mining Journal, vol. 83, No. 4.

GSC 63-156 Muscovite, K-Ar age 463 ± 20 m.y.

New Brunswick

$K = 8.73\%$, $Ar^{40}/K^{40} = 0.0307$; radiogenic Ar = 100%. Concentrate; clean concentrate of muscovite. Some flakes contain quartz inclusions and yellow stained patches. Chlorite not detected.

From pegmatite.
(21 J) Napadogan - Juniper Highway, 1.05 miles east of the mouth of Biggar Brook near the picnic site, New Brunswick, 46°30'39"N, 67°05'49"W. Map-unit 13, GSC Map 910A. Sample 5-60-23B/PB. Collected by R.R. Potter, interpreted by W.H. Poole.

For description and interpretation see GSC 63-159.

GSC 63-157 Biotite, K-Ar age 399 ± 18 m.y.

$K = 7.46\%$, $Ar^{40}/K^{40} = 0.0260$; radiogenic Ar = 100%. Concentrate; clean concentrate of brown biotite. About 8% of the biotite flakes are partly altered to chlorite and epidote. Total chlorite content is 6%.

From gneiss.
(21 J) 13,600 feet N 85°E from the east end of Beaver Brook Lake, New Brunswick, 46°44'09"N, 66°50'00"W. Sample 5-28-5/PB. Collected and interpreted by W.H. Poole.

For description and interpretation see GSC 63-159.

GSC 63-158 Biotite, K-Ar age 385 ± 18 m.y.

$K = 8.10\%$, $Ar^{40}/K^{40} = 0.02516$; radiogenic Ar = 96%. Concentrate; clean concentrate of olive-brown biotite. Some flakes are discoloured along the fractures and contain small inclusions of epidote. Total chlorite content 3%.

From gneiss.
(21 J) Irving P & P road, Juniper to Deadman Brook, 3 1/2 miles ENE of bridge over North Branch of S.W. Miramichi River, New Brunswick, 46°34'44"N, 67°05'49"W. Map-unit 13, GSC Map 910A. Sample 5-60-25/PB, collected by R.R. Potter, interpreted by W.H. Poole.

New Brunswick

For description and interpretation see GSC 63-159.

GSC 63-159 Muscovite, K-Ar age 400 ± 18 m.y.

$K = 7.09\%$, $Ar^{40}/K^{40} = 0.02591$; radiogenic Ar = 97%. Concentrate; impure concentrate of muscovite. About 20% of the muscovite flakes are stained greenish and yellow. Impurities consist of chlorite, quartz, feldspar, biotite and opaque grains, mainly in intergrowths with the muscovite. Total chlorite 3%, quartz 3%, trace of biotite, trace of feldspar.

From gneiss.

(21 J) Irving P & P road, Juniper to Deadman Brook, 3 1/2 miles ENE of bridge over North Branch of SW Miramichi River, New Brunswick, 46°34'44"N, 67°05'49"W. Map-unit 13, GSC Map 910A. Sample 5-60-25/PB. Collected by R.R. Potter, interpreted by W.H. Poole.

Biotite augen gneiss (GSC 63-157) is medium grey and medium grained with large, round, pink, sodic oligoclase augen. In thin section, aggregates of a polycrystalline mosaic of microscopic quartz and warped brown biotite are seen to sweep around the feldspar augen. Apparently the rock was once strongly cataclastic and is now partly recrystallized.

Pegmatite (GSC 63-156) is light grey to pink and massive. About one-third of the rock is unstrained quartz. From 10% to 20% consists of books of bladed planar muscovite. The remainder is light pink feldspar, some of which is graphically intergrown with quartz. In thin section, about half the feldspar is turbid perthitic microcline and half turbid sodic oligoclase. The pegmatite is associated with fine-grained muscovite-biotite granite, both of which cut a fine-grained biotite gneiss.

Biotite gneiss (GSC 63-158 and 159) is medium grey, fine to medium grained, equigranular, and thinly but poorly banded with varying proportions of biotite and quartz-feldspar. In thin section, the rock has about 30% unstrained quartz; 50% albite-oligoclase; 15% brown biotite slightly chloritized and containing a few zircons with pleochroic haloes; 5% muscovite which cuts across the biotite; and accessory black iron ore and apatite.

New Brunswick

All three samples are representative of an "old" granitic terrane of probable late Ordovician to early Silurian age which has been intruded along its southeast side by younger, Devonian, late tectonic granites (Map 6-1963). These samples were chosen in an attempt to confirm the field evidence indicating a pre-Devonian age of the "old" granites. Ages of 425 to 450 m.y. were anticipated, although mica ages on the same rocks in the general area show the strong overprint of the Devonian activity (Report 3, pp. 109-113; Report 4, pp. 99-102).

The biotite augen gneiss (GSC 63-157) returned a 399 m.y. age characteristic of the Devonian-type massive granites of central New Brunswick. Evidently, metamorphism of the gneiss by the nearby massive granite completely (or nearly so) dissipated old radiogenic argon from the biotite. The age is like the mica ages from related rocks several miles to the southwest (Map 6-1963).

The samples of pegmatite (GSC 63-156) and of biotite gneiss (GSC 63-158, 159) were chosen from an area northwest of the zone of Devonian granites, in an attempt to find old crystalline rocks that have been but little affected by the younger intrusion and metamorphism. Conceivably, more pre-Devonian radiogenic argon retained would return a pre-Devonian age.

Muscovite in the pegmatite (GSC 63-156) returned an age of 463 m.y. and apparently retained much or nearly all of the old argon. Barring undetected absorption of foreign argon, the age is a minimum for the emplacement of the pegmatite, i.e., Middle Ordovician on Kulp's (1961) time scale, the same age as, or slightly older than, the Middle Ordovician greywackes and volcanic rocks of central New Brunswick (Map 6-1963; Map 1-1957).

Biotite (GSC 63-158) and muscovite (GSC 63-159) of the biotite gneiss returned disappointingly low ages, 385 and 400 m.y. respectively. If the gneiss is indeed part of the old terrane, then the pre-Devonian radiogenic argon must have been driven out of micas by Devonian activity. The ages are remarkably like those found near the Devonian granites (Map 6-1963).

Newfoundland

GSC 63-160 Biotite, K-Ar age 400 ± 20 m.y.

$K = 5.21\%$, $Ar^{40}/K^{40} = 0.0261$; radiogenic Ar = 100%. Concentrate; reasonably clean concentrate of brown biotite. About 30% of the biotite flakes are partly altered to chlorite and contain inclusions of epidote. Impurities consist mainly of about 10% olive-green hornblende. Total chlorite content is 17%.

From granite.
(1 M) 5.5 miles west of Belleoram, Newfoundland, 47°32'N, 55°32'W. Map-unit 4C, GSC Map 1043A. Sample AA-11-236-12, collected and interpreted by F.D. Anderson.

The rock is an equigranular, medium to fine-grained granodiorite composed of quartz, orthoclase, microcline, albite, biotite, hornblende, magnetite, chlorite, and minor accessories. The granodiorite intrudes the Great Bay de l'Eau conglomerate which has been dated as late Upper Devonian from faunal remains in contained sandstone lenses.

The apparently anomalous age could be due either to the sample having been erroneously taken from an infaulted block or xenolith of older granodiorite, or to the granodiorite from which the sample was taken having been intruded in several stages, starting in early Devonian and ending in late Devonian or Carboniferous. Field evidence does not support either hypothesis, and additional age determinations may resolve the problem.

GSC 63-161 Whole Rock, K-Ar age 375 m.y.

$K = 1.1\%$, $Ar^{40}/K^{40} = 0.02428$; radiogenic Ar = 89%. Concentrate; crushed whole rock.

From basalt.
(3 D) 1 mile west of Table Head, Newfoundland (Labrador), 52°05'20"N, 55°43'00"W. Map-unit 12, GSC Map 22-1962, K.E. Eade. Sample EA-397-61, collected by P.L. Reynolds, interpreted by K.E. Eade.

Newfoundland

The sample is a dense, dark grey to black, fine-grained to very fine-grained basalt. The basalt flows overlie reddish arkose and conglomerate. Christie (1951) suggests that the arkose and conglomerate are Lower Cambrian in age. The determination on this basalt indicates a Middle Devonian age. K-Ar determinations are not available on similar basalt remnants in the Great Northern Peninsula of Newfoundland or the northern coast of Labrador.

Whether this basalt represents a remnant of a large basalt province of Middle Devonian age will be determined by further work in these other areas.

Reference

Christie, A.M.
1951: Geology of the southern coast of Labrador from Forteau Bay to Cape Porcupine, Newfoundland; Geol. Surv. Can., Paper 51-13.

GSC 63-162 Muscovite, K-Ar age 400 ± 20 m.y.

$K = 8.67\%$, $Ar^{40}/K^{40} = 0.02595$; radiogenic Ar = 89%. Concentrate; clean concentrate of muscovite. Some flakes contain a few specks of iron oxide on the surface. Chlorite not detected.

From muscovite pegmatite.
(11 O) 0.3 miles ENE of mouth of Rose Blanche Brook, Newfoundland, 47°37'05"N, 58°41'50"W. Sample GJ-133-63, collected and interpreted by J.W. Gillis.

The pegmatite is light grey and massive. Perthite constitutes about 60% of the rock, quartz 25%, and muscovite 15%. The muscovite varies from undeformed to slightly crenulated.

The pegmatite is interbanded with schists and gneisses that may pass into rocks of the Lower to Middle Devonian Bay du Nord Group (Cooper, 1954) about 30 miles northeastward along strike. This 400 m.y. date is similar to a 415 m.y. date (GSC 61-202) on muscovite from a pegmatitic layer in schistose quartzite and amphibolite at Port aux Basques 20 miles to the west. According to Kulp's recent time scale the 400 m.y. and 415 m.y. dates

indicate an Upper Silurian or Lower Devonian age and suggest that these rocks were affected by the Acadian orogeny.

Reference

Cooper, J.R.
1954: La Poile-Cinq Cerf Map-area, Newfoundland; Geol. Surv. Can., Mem. 276.

GSC 63-163 Biotite, K-Ar age 1,520 ± 50 m.y.

$K = 7.10\%$, $Ar^{40}/K^{40} = 0.13640$; radiogenic Ar = 99%. Concentrate; clean concentrate of reddish brown biotite. Biotite flakes contain a few zircon inclusions surrounded by pleochroic haloes. Minor impurities consist mainly of quartz. Chlorite not detected.

From quartz-biotite-garnet paraschist.
(13 L) Island in west-central part of Kasheshibaw Lake, Newfoundland (Labrador), 54°13'N, 63°47'W. Sample EC-63-341, collected and interpreted by R.F. Emslie.

The rock is from a sequence of paraschists and paragneisses in contact with the Michikamau anorthositic intrusion. The specimen was taken one half mile from the contact. There is a recognizable increase in grade of metamorphism from approximately the position of the specimen inward toward the intrusion. The rock is fine grained, light to medium grey, with fine schistosity. The chief minerals are quartz and biotite with small amounts of garnet and plagioclase.

The specimen was thought to be within the thermal aureole of the intrusion and thus would give a date approximately equal to the age of the intrusion. If outside the thermal aureole, it should still provide a maximum age for the Michikamau intrusion. See also specimens EC-62-24 (GSC 63-164) and EC-62-CT249A (GSC 63-165).

GSC 63-164 Biotite, K-Ar age 1,400 ± 50 m.y.

Newfoundland

K = 7.91%, Ar^{40}/K^{40} = 0.12147; radiogenic Ar = 98%. Concentrate; clean concentrate of orange-reddish biotite. A few flakes are partly altered to bright green chlorite. Minor impurities consist of a few altered plagioclase fragments. Total chlorite 1%.

From olivine anorthosite.

(23 I) About 300 ft. north of lake shore, Newfoundland (Labrador), 54°17.5'N, 64°17.5'W. Map-unit 5b, GSC Map 31-1963. Sample EC-62-24, collected and interpreted by R.F. Emslie.

The specimen is from a marginal facies of the Michikamau intrusion. The rock is medium-grained, dark grey, troctolitic anorthosite, and has for essential minerals labradorite and olivine, plus small quantities of biotite, magnetite, serpentine, and carbonate. The serpentine-carbonate alteration occurs along fractures that clearly post-date the biotite crystallization.

The biotite is believed to be a primary crystallization product and as such, provides an age for the crystallization of the Michikamau intrusion. The age of 1,400 m.y. is in excellent agreement with the minimum age of 1,360 m.y. given by specimen EC-62-CT-249-A (GSC 63-165), and the maximum age of 1,520 m.y. provided by specimen EC-63-341 (GSC 63-163).

GSC 63-165 Biotite, K-Ar age 1,360 m.y.

K = 3.73%, Ar^{40}/K^{40} = 0.11674; radiogenic Ar = 100%. Concentrate; concentrate of partly altered greenish brown biotite. More than 50% of the biotite flakes are almost entirely altered to chlorite and epidote. Some flakes contain red platy inclusions of hematite. Chlorite content 60%.

From granite.

(23 I) Newfoundland (Labrador), 54°37'N, 64°21'W. Map-unit 7b, GSC Map 31-1963. Sample EC-62-CT-249-A. Collected by P.R. Coté, interpreted by R.F. Emslie.

The rock is a pale pink, coarse-grained microperthite granite from a large mass northwest of the Michikamau intrusion. The minerals present are microperthite, plagioclase, quartz, biotite, chlorite, hornblende, and zircon.

Newfoundland

Small pink granite dykes were found at several localities in the northwest part of the anorthosite mass. A specimen of the granite from the main body was selected to provide a minimum age for the Michikamau intrusion. The age of 1,360 m.y. for the granite is in excellent agreement with the 1,400 m.y. age found for the anorthositic intrusion.

GSC 63-166 Biotite, K-Ar age 452 ± 20 m.y.

$K = 7.38\%$, $Ar^{40}/K^{40} = 0.0299$; radiogenic Ar = 100%. Concentrate; clean concentrate of brown biotite. Some flakes are altered to chlorite and contain inclusions of epidote and small red plates of hematite. Chlorite content is 7%.

From biotite-granite augen gneiss.
(12 B) South shore of Grand Lake, 0.72 miles from Wend, Newfoundland, 48°39'40"N, 58°02'30"W. Map-unit 17c, GSC Map 117A. Sample NA-3879, collected and interpreted by E.R.W. Neale.

See GSC 63-167 for interpretation.

GSC 63-167 Biotite, K-Ar age 420 ± 20 m.y.

$K = 7.74\%$, $Ar^{40}/K^{40} = 0.02741$; radiogenic Ar = 95%. Concentrate; clean concentrate of olive-green biotite. About 10% of the biotite flakes are altered to bright green chlorite and contain inclusions of hematite, epidote and sphene. Total chlorite 10%.

From biotite granite.
(12 B) North shore of Grand Lake, 1.15 miles from SW tip of lake, Newfoundland, 48°40'00"N, 58°00'30"W. Map-unit 17c, GSC Map 1117A. Sample NA-3878, collected and interpreted by E.R.W. Neale.

These specimens are part of a granite-gneiss-schist-marble complex mapped near Grand Lake (Riley, 1962). The granite-gneiss (represented by NA-3879, GSC 63-166) of this complex is presumed to be related to the folding and metamorphism of Cambrian and Ordovician strata that lie immediately to the west. Appropriately, the 452 m.y. date on biotite from this gneiss is

older than biotite from granitic dyke rock (specimen NA-3878, GSC 63-167) which probably represents the youngest element of the complex. The 420 m.y. biotite from the dyke can, within the limits of error, be interpreted as Devonian and associated with climactic Acadian orogeny of the Appalachian region. The 452 m.y. biotite from the gneiss can be interpreted as a relic of Lower Palaeozoic country rock within the gneiss that may have been somewhat 'updated' by Devonian metamorphism.

However, an increasing number of isotopic ages in the 415-484 m.y. range have been obtained on samples in a broad belt that extends across Newfoundland from Cape Ray northeastward to Notre Dame Bay. Together with some geological evidence, it points to a period or periods of pre-Devonian, Palaeozoic intrusion.

GSC 63-168 Biotite, K-Ar age 450 ± 20 m.y.

$K = 7.86\%$, $Ar^{40}/K^{40} = 0.0297$; radiogenic Ar = 100%. Concentrate; clean concentrate of orange-brown biotite. About 5% of the biotite flakes are partly altered to pale green chlorite and epidote. A few flakes contain long prismatic inclusions of apatite. Total chlorite content is about 3%.

From granodiorite.

(2 E) Southeast end of Coal All Island, Notre Dame Bay, Newfoundland, 49°23'N, 54°46'W. Map-unit 8a, GSC Map 55-31. Sample WF-301-62, collected and interpreted by H. Williams.

The rock is a medium- to coarse-grained, massive, pink to grey weathering, hornblende-biotite granodiorite.

The intrusion has been interpreted by Patrick (1956) to cut Silurian strata. Similar early intrusions, dated radioactively at approximately the same age, have been interpreted by Williams (1962) to cut the Silurian Boxwood Group. These intrusive rocks were previously regarded as Devonian on field relationships, but radioactive dates generally indicate Upper Ordovician or Lower Silurian according to recent time scales. In view of the conflicting field evidence and isotopic dates, it would seem most reasonable to interpret the intrusions as Silurian and only slightly younger than the Silurian strata they intrude.

Newfoundland

References

Patrick, T.O.H.
1956: Comfort Cove, Newfoundland, Geol. Surv. Can., Paper 55-31.

Williams, H.
1962: Boxwood (West-Half) Newfoundland, Geol. Surv. Can., Paper 62-9.

GSC 63-169 Biotite, K-Ar age 380 ± 16 m.y.

$K = 7.61\%$, $Ar^{40}/K^{40} = 0.02454$; radiogenic Ar = 97%. Concentrate; clean concentrate of dark olive-brown biotite. A few flakes are altered to dark green chlorite. Total chlorite content is 2%.

From granite.

(2 E) 1.8 miles northwest of Tilting, along the road to Joe Batts Arm, Fogo Island, Newfoundland, 49°42'48"N, 54°06'18"W. Map-unit 9a, GSC Map 1065A. Sample WF-727-62, collected by M. Ryan, interpreted by H. Williams.

The rock is a medium-grained, equigranular, grey biotite granite consisting of 30% quartz, 30% microcline, 25% oligoclase-andesine, 10% biotite, and accessory apatite, chlorite, pyrite, sericite and epidote. This rock is part of the Fogo batholith.

The granite intrudes unfossiliferous rocks of the Fogo Group which have been recently interpreted by Williams to be of Silurian age. The isotopic date of 380 million years suggests the intrusion is of Devonian age and probably related to Acadian orogeny recognized throughout most of the Canadian Appalachians.

GSC 63-170 Biotite, K-Ar age 415 ± 20 m.y.

$K = 7.43\%$, $Ar^{40}/K^{40} = 0.02705$; radiogenic Ar = 99%. Concentrate; clean concentrate of brown biotite. About 10% of the biotite flakes are partly altered to pale green chlorite and contain epidote inclusions. Minor impurities consist of amphibole fragments. Amphibole content is 2%. Total chlorite content is 8%.

Newfoundland

From granodiorite.

(2 E) 3/4 mile southwest from the southwest end of North Twin Lake, Newfoundland, 49°12'30"N, 55°59'30"W. Map-unit 16, GSC Map 19-1962. Sample 6-413-62, collected by B.A. Greene, interpreted by H. Williams.

Sample collected from outcrop of medium-grained, massive, grey, hornblende-biotite granodiorite. The granodiorite intrudes Ordovician rocks of the Exploits Group, and lithologically similar nearby intrusions to the west have been interpreted to cut the tentatively Silurian Springdale Group. If the intrusive relationships between the granodiorite and Springdale Group are conclusive, then the Springdale Group is no younger than Silurian. The isotopic date of 415 million years suggests that the intrusion is Upper Silurian.

GSC 63-171 Biotite, K-Ar age 144 ± 12 m.y.

$K = 6.24\%$, $Ar^{40}/K^{40} = 0.00876$; radiogenic Ar = 64%. Concentrate; heterogeneous concentrate of zoned biotite. Mica flakes vary in colour from pale buff (Mg-rich) to reddish brown (Fe, Ti-rich), and contain inclusions of apatite and red hematite. Impurities consist of aggregates composed mainly of epidote, carbonate and opaque grains. Chlorite not detected.

From lamprophyre dyke.

(2 E) North end of Beach Island, Northwest Arm, New Bay, Newfoundland, 49°27'25"N, 55°22'55"W. Sample WF - 70 - 62, collected and interpreted by H. Williams.

Sample was collected from a grey-brown weathering porphyritic melanocratic dyke with phenocrysts of biotite set in a matrix of plagioclase, amphibole, and magnetite. Similar dykes are common throughout Botwood map-area, particularly around Exploits Bay, and have been described as lamprophyres (Heyl, 1936). The dykes are small, generally less than 6 feet wide, and are undeformed except for jointing perpendicular to the walls. Commonly the dykes have chilled border zones and a coarse-grained or porphyritic-textured interior zone. The dykes cut Ordovician and Middle Silurian strata as well as post-Middle Silurian granite

intrusions, and they are considered to be the youngest intrusive rocks in the map-area. The isotopic age of 144 million years suggests intrusion during the Jurassic period. No similar young ages have been determined on dyke rocks of Newfoundland, but Triassic basalt flows and probable dykes are known in Nova Scotia and Jurassic or younger Monteregian plugs in Southern Quebec.

Reference

Heyl, G.R.
1936: Geology and mineral deposits of the Bay of Exploits area, Newfoundland; Nfld. Dept. Nat. Resources, Geol. Sec., Bull. 3.

GSC 63-172 Hornblende, K-Ar age 2,665 m.y.

$K = 0.89\%$, $Ar^{40}/K^{40} = 0.3424$; radiogenic Ar = 100%. Concentrate; clean concentrate of hornblende. No impurities detected.

From mafic gneiss.
(13 N) North shore of unnamed lake, 37 miles west of Hopedale, Newfoundland (Labrador), 55°24'30"N, 61°09'30"W. Sample SH-31a-62, collected and described by C.H. Stockwell.

The mafic gneiss is a medium-grained rock composed chiefly of hornblende, pyroxene, and labradorite. The feldspar is considerably altered to sericite but the ferromagnesian minerals are fresh. The outcrop is cut in all directions by dykes of pink granite.

The rock is from the eastern part of the Nain province and is correlated with the Hopedale gneiss as mapped on the Coast of Labrador. The hornblende age indicates that the rock is Archaean and was involved in the Kenoran orogeny (for further discussion see Paper 64-17, Part II).

GSC 63-173 Hornblende, K-Ar age 2,545 m.y.

$K = 1.42\%$, $Ar^{40}/K^{40} = 0.31545$; radiogenic Ar = 99%. Concentrate; clean concentrate of hornblende. Minor impurities consist of a few altered plagioclase and pyroxene fragments, with a trace of biotite.

Newfoundland

From mafic gneiss.

(14 L) North shore of Reddick Bight, Newfoundland (Labrador), 58°56'45"N, 63°11'00"W. Map-unit 4, GSC Map 52-22A. Sample SH-14-62, collected and interpreted by C.H. Stockwell.

The mafic gneiss is a dark green rock composed of hornblende, pyroxene, and andesine with accessory magnetite and apatite. The pyroxene is peripherally altered to fine-grained material but the hornblende is fresh.

The mafic gneiss forms inclusions and layers in white granite and the whole is unconformably overlain by gently dipping sediments of the Ramah Series. The hornblende age gives the time of metamorphism and is a maximum for the Ramah. The sample is from the eastern part of the Nain province.

GSC 63-174 Biotite, K-Ar age 1,340 ± 50 m.y.

$K = 7.06\%$, $Ar^{40}/K^{40} = 0.11443$; radiogenic Ar = 99%. Concentrate; clean concentrate of brown biotite. Biotite flakes contain zircon inclusions surrounded by dark pleochroic haloes. Some of the biotite flakes are in part altered to olive-green chlorite and a few are intergrown with green hornblende. Chlorite content 4%.

From adamellite.

(13 M) Unnamed lake 9 miles south of Mistastin Lake, Newfoundland (Labrador), 55°42'00"N, 63°17'30"W. Sample SH-30-62, collected and interpreted by C.H. Stockwell.

This is a coarse-grained, grey adamellite in which feldspar crystals are 1 inch to 2 inches across and are closely spaced in a fine-grained groundmass containing ferromagnesium minerals. As seen in thin section the rock consists of microcline, oligoclase, biotite, hornblende, minor quartz, and accessory magnetite, zircon, and apatite. Most of the biotite is fresh but some crystals are partly altered to chlorite. The potassium-argon date no doubt is a close approximation to the true age of the intrusion. (Compare with GSC 63-175.)

Newfoundland

GSC 63-175 Hornblende, K-Ar age 1,325 m.y.

$K = 1.10\%$, $Ar^{40}/K^{40} = 0.11243$; radiogenic Ar = 95%. Concentrate; reasonably clean concentrate of olive-green hornblende. Minor impurities consist of altered pale green pyroxene. Trace of biotite; no chlorite detected.

From adamellite.
(14 D) Island in Hawk Lake, Newfoundland (Labrador), 56°02'30"N, 63°34'00"W. Sample SH-29-62, collected and interpreted by C.H. Stockwell.

The adamellite is a coarse-grained, massive, brown rock with feldspar crystals up to 1 inch across. It consists of perthite, plagioclase, quartz, pyroxene, hornblende, a little biotite, and accessory magnetite, apatite, and zircon. All the minerals are fresh.

The rock is unmetamorphosed and the hornblende age of 1,325 m.y. is thought to give a reliable indication of the age of the intrusion. (Compare with the biotite age of 1,340 m.y. (GSC 63-174), from the same batholith at a point 26 miles farther south.) The batholith lies within the western part of the Nain province.

GSC 63-176 Biotite, K-Ar age 1,300 ± 45 m.y.

$K = 8.50\%$, $Ar^{40}/K^{40} = 0.10932$; radiogenic Ar = 99%. Concentrate; clean concentrate of brown biotite. A few flakes are coated with opaque crusts and contain inclusions of quartz. Chlorite not detected.

From migmatite.
(14 L) 9 miles SW of end of Saglek Fiord, Newfoundland (Labrador), 58°13'15"N, 63°48'00"W. Sample SH-15-62, collected and interpreted by C.H. Stockwell.

The migmatite is a medium-grained, buff-coloured rock consisting of biotite-rich layers interleaved with granitic material. Constituent minerals include orthoclase and lesser amounts of andesine, myrmekite, quartz, orthopyroxene, and accessory magnetite, apatite, and zircon. The biotite is unaltered. The biotite age is that of the period of last metamorphism. The sample is from the western part of the Nain province.

Newfoundland

GSC 63-177 Hornblende, K-Ar age 1,350 m.y.

$K = 1.1\%$, $Ar^{40}/K^{40} = 0.11540$; radiogenic Ar = 98%. Concentrate; clean concentrate of pleochroic blue-green to olive-brown hornblende. Hornblende fragments contain fine-grained inclusions of quartz, feldspar, hematite, epidote, and biotite.

From hornblende gneiss.
(13 L) 1/2 mile north of Shipiskan Lake, Newfoundland (Labrador), 54°39'45"N, 62°18'00"W. Map-unit A3, GSC Map 53-14. Sample SH-24a-62. Collected and interpreted by C.H. Stockwell.

This is a black hornblende gneiss consisting of hornblende, pyroxene, andesine, quartz, and a little epidote and titanite. It forms an inclusion in pink granite-gneiss from the same outcrop as the paragneiss of GSC 62-177 which gave a biotite age of 1,430 m.y. The hornblende of the present sample was run as a check and its age at 1,350 m.y. agrees with that on the biotite. The gneiss lies within the western part of the Nain province and is overlain unconformably by the Seal Group; the pair of ages gives a maximum for the Seal.

GSC 63-178 Whole Rock, K-Ar age 865 m.y.

$K = 0.84\%$, $Ar^{40}/K^{40} = 0.06413$; radiogenic Ar = 93%. Concentrate; crushed whole rock.

From diabase.
(13 K) North shore of Seal Lake, Newfoundland (Labrador), 54°21'20"N, 61°00'40"W. Map-unit 12, GSC Map 1079A. Sample SH-18-61, collected by K.E. Eade, interpreted by C.H. Stockwell.

This is a medium-grained, dark green diabase crossed by many slickensided surfaces. The rock is composed of fresh pyroxene, saussuritized plagioclase, chlorite, and magnetite. It forms a sill intruding rocks of the Seal Group. The whole rock potassium argon age is approximately the age of intrusion and gives a minimum for the Seal Group, another minimum is given by GSC 62-185 (975 m.y.). The maximum is given by GSC 62-177 (1,430 m.y.) and by GSC 63-177 (1,350 m.y.). The Seal Group is placed in the Grenville structural province; although it has been only slightly metamorphosed it was folded, apparently, during the Grenville orogeny.

Newfoundland

GSC 63-179 Whole Rock, K-Ar age 1,260 m.y.

$K = 0.46\%$, $Ar^{40}/K^{40} = 0.10495$; radiogenic Ar = 91%. Concentrate; crushed whole rock.

From bluish grey anorthosite.
(13 K) Island in unnamed lake, Newfoundland (Labrador), 54°48'00"N, 61°53'00"W. Map-unit 2, GSC Map 1079A. Sample SH-25-62, collected and interpreted by C.H. Stockwell.

The sample is a coarse-grained, massive, bluish grey anorthosite composed almost entirely of labradorite but containing a little pyroxene and minor myrmekite. The pyroxene is much altered to chlorite. The sample was collected from a large body of anorthosite which lies within the western part of the Nain province and is unconformably overlain by the Seal Group.

The whole rock age was determined as an experiment and the result (at 1,260 m.y.) appears to be somewhat too young, because it is reasonable to suppose that this body is the same age as the anorthosite at Michikamau Lake which gave a biotite age of 1,400 m.y. (GSC 63-164).

GSC 63-180 Hornblende, K-Ar age 2,045 m.y.

$K = 0.33\%$, $Ar^{40}/K^{40} = 0.21593$; radiogenic Ar = 93%. Concentrate; clean concentrate of bright-green hornblende containing fine-grained inclusions along the fractures.

From amphibolite.
(14 F) SE end of Mugford Harbour (Kraaken Inlet), Newfoundland (Labrador), 57°46'30"N, 61°43'00"W. Map-unit 4, GSC Map 52-22A. Sample SH-18-B-62, collected and interpreted by C.H. Stockwell.

This is a dark green, coarse-grained, gneissic amphibolite composed of hornblende and lesser amounts of somewhat chloritized biotite. The amphibolite forms a layer within the lit-par-lit gneiss of GSC 62-171 which gave a biotite age of 2,225 m.y. The hornblende of the amphibolite was metamorphosed at the same time but gave the somewhat younger age of 2,045 m.y. The sample is from the eastern part of the Nain province. It seems

probable that the main period of orogeny was Kenoran (about 2,500 m.y.) and that the younger ages obtained are due to subsequent events of a more moderate nature. The ages are a maximum for the period of deposition of the unconformably overlying Mugford Group.

GSC 63-181 Biotite, K-Ar age 1,635 ± 55 m.y.

K = 8.05%, Ar^{40}/K^{40} = 0.15234; radiogenic Ar = 99%. Concentrate; clean concentrate of brown biotite. Biotite flakes contain a few opaque inclusions and fine-grained quartz along the edges. Chlorite not detected.

From paragneiss.
(14 E) West end of small lake, Newfoundland (Labrador), 57°55'00"N, 62°51'30"W. Sample SH-17-62, collected and interpreted by C.H. Stockwell.

The sample is a light grey, medium-grained, well banded paragneiss composed of quartz, andesine, microcline, biotite, garnet, and accessory apatite and rounded grains of zircon. The biotite is fresh but some of the crystals are bent. The determined age represents the period of last metamorphism. The sample is from the eastern part of the Nain province.

GSC 63-182 Biotite, K-Ar age 410 ± 21 m.y.

K = 5.90%, Ar^{40}/K^{40} = 0.02689; radiogenic Ar = 86%. Concentrate; clean concentrate of partly altered, orange-reddish biotite. About 50% of the biotite flakes are altered to green chlorite along fractures and contain inclusions of epidote. Total chlorite content 3%.

From quartz-biotite diorite.
(2 D) Island at north end of Burnt Lake, Newfoundland, 48°54'N, 55°25'W. Map-unit 5, GSC Preliminary Map 50-17. Sample WF-621-63, collected and interpreted by H. Williams.

Newfoundland

The sample was collected from an outcrop of hornblende-biotite quartz diorite which is medium-grained and massive. The rock type represents part of an intermediate to basic northwestern border phase of a pluton that includes large amounts of granite in its inner and southeastern parts. The intrusion definitely cuts Middle Silurian strata of the Botwood Group and on geological ground must therefore be either late Silurian or younger. A similar isotopic age of 423 million years was obtained on biotite from thermally metamorphosed rocks of the Botwood Group, which form a thin aureole surrounding this same intrusion.

GSC 63-183 Muscovite, K-Ar age 360 ± 14 m.y.

$K = 8.50\%$, $Ar^{40}/K^{40} = 0.02330$; radiogenic Ar = 88%. Concentrate; clean concentrate of muscovite. Some flakes are intergrown with quartz along the edges and contain aligned inclusions of sillimanite.

From garnetiferous muscovite granite and pegmatite.
(2 E) Ladle Cove, Notre Dame Bay, Newfoundland, 49°28'12"N, 54°02'12"W. Sample WF-591-63, collected and interpreted by H. Williams.

The sample was taken from an outcrop of medium- to coarse-grained, garnet-muscovite granite that is massive in most exposures and has associated pegmatitic phases. The granite is surrounded by an extensive aureole of high grade metamorphic rocks that are absent or but sparingly developed around other varieties of granite in northeastern Newfoundland. The garnetiferous granite truncates Middle Ordovician rocks of the Gander Lake Group and its isotopic age of 360 million years suggests a Devonian age for the intrusion. A devonian age is supported by isotopic determinations on lithologically similar rocks to the south (Jenness, 1963)[1].

Reference

[1]Jenness, S.E.
1963: Terra Nova and Bonavista map-areas, Newfoundland; Geol. Surv. Can., Mem. 327.

Newfoundland

GSC 63-184 Biotite, K-Ar age 335 ± 14 m.y.

$K = 6.70\%$, $Ar^{40}/K^{40} = 0.02159$; radiogenic Ar = 93%. Concentrate; reasonably clean concentrate of brown biotite. About 40% of the biotite flakes are partly altered to chlorite and contain fine-grained inclusions. Total chlorite content 35%.

From porphyritic biotite granite.

(2 E) At the end of Bowater Road which circles Indian Bay, Ten Mile Pond, Newfoundland, 49°13'20"N, 54°03'25"W. Sample WF-298-63, collected and interpreted by H. Williams.

The sample was taken from an outcrop of massive, coarse-grained, porphyritic pink granite with phenocrysts of potash feldspar in places exceeding 2 inches in length. The rock is lithologically similar to granite that has been referred to as the Ackley batholith by Bradley (1962)[1] and Jenness (1963)[2] in southeast and east-central Newfoundland, respectively. In the vicinity of Ten Mile Pond the granite intrudes sedimentary rocks of the Gander Lake Group - lower unit, which apparently underlies conformably Middle Ordovician rocks of the middle unit of the same group. The isotopic age of 335 million years suggests an early Carboniferous age for the intrusion according to recent time scales, but as the Carboniferous rocks of Newfoundland are nowhere intruded by granite, the date is suspect (note the high chlorite content), and the rock is not considered younger than late Devonian. Isotopic dates reported from the Ackley batholith to the south show a wide time spread but have been interpreted as indicating a general Devonian age for the intrusion (Jenness, 1963[2]; Anderson, 1963, in Leech et al., 1963[3]).

References

[1]Bradley, D.A.
1962: Gisborne Lake and Terrenceville map-areas, Newfoundland; Geol. Surv. Can., Mem. 321.

[2]Jenness, S.E.
1963: Terra Nova and Bonavista map-areas, Newfoundland; Geol. Surv. Can., Mem. 327.

[3]Leech, G.B., Lowdon, J.A., Stockwell, C.H., and Wanless, R.K.
1963: Age determinations and geological studies; Geol. Surv. Can., Paper 63-17.