POTASSIUM-ARGON AND URANIUM-LEAD AGES FROM TWO LOCALITIES

SHEILA M. A. BOUTCHER,[1] G. L. DAVIS,[2] AND W. W. MOORHOUSE[1]

Abstract

Detrital zircon from a Timiskaming conglomerate near Kirkland Lake, Ontario, gives a uranium-lead age of 2700 m.y. ± 3 per cent and muscovite from the same rock gives a potassium-argon (metamorphic) age of 2410 ± 50 m.y. In Hastings conglomerate near Madoc, Ontario, detrital zircon age of crystallization is 1140 m.y. ± 3 per cent and the potassium-argon ratio of muscovite indicates metamorphism at 898 ± 20 m.y. These results may be interpreted as suggesting that the conglomerates have been derived from source rocks which formed in the same geological cycle, without the intervention of a major orogeny prior to sedimentation and final folding and metamorphism of the conglomerates.

Introduction

Conglomerates in Precambrian sedimentary successions were commonly assigned considerable significance in the interpretation of orogenic events by pioneer investigators on the Canadian Shield. Timiskaming conglomerates have been regarded as the result of erosion of previously folded Keewatin volcanics, and the Hastings conglomerate in the Grenville of Southeastern Ontario has been thought by some to have been derived from previously folded and intruded Grenville rocks. The purpose of this study was to attempt to determine, by comparing ages obtained from uranium-lead ratios of zircons, and potassium-argon ages from metamorphic micas, whether there is a time interval of the order of one or more tectonic cycles between the time of crystallization of the detrital zircons, and the main period of folding and metamorphism of the conglomerates in which they occur. Although some difference in the two dates is apparent from the results presented here, for a conglomerate of each type, it does not exceed the length of a tectonic cycle, in the broadest sense. The results for the Timiskaming conglomerate are somewhat vitiated by the uncertainty as to what proportion of the zircons might have been supplied from underlying Timiskaming trachytic volcanics.

Timiskaming Conglomerate

A large sample of conglomerate and greywacke (in about equal proportions) was collected on the power line south of Highway 66, about 6 miles

[1]Department of Geological Sciences, University of Toronto.
[2]Geophysical Laboratory, Carnegie Institute of Washington, Washington, D.C.

east of the town of Kirkland Lake (Fig. 1). The greywacke is rather coarse-grained, approaching a lithic sandstone in texture; the sand grains include quartz, feldspar, and fine-grained acid volcanics. The conglomerate is gravelly in character, little deformed, and contains pebbles of a variety of volcanic rocks, chiefly felsitic, and cherty sediments in a matrix very similar to the greywacke. It is possible that much of the clastic material came from trachytes interbedded with the sediments. The conglomerate also contains elongated lenticles and wisps of fine-grained bluish-green mica which gave a typical muscovite pattern on x-ray analysis. Considerable alteration is indicated by the presence of white mica, carbonate, chlorite, and pyrite.

Approximately 150 mg. of zircon were concentrated from the sample of conglomerate and greywacke, using flotation to remove sulphides, a super-panner to concentrate the heavy minerals, a Frantz separator to remove magnetic particles, heavy liquids for further concentration, and, finally, hand-picking. About $2\frac{1}{2}$ grams of green mica were picked from streaks and pockets in the conglomerate.

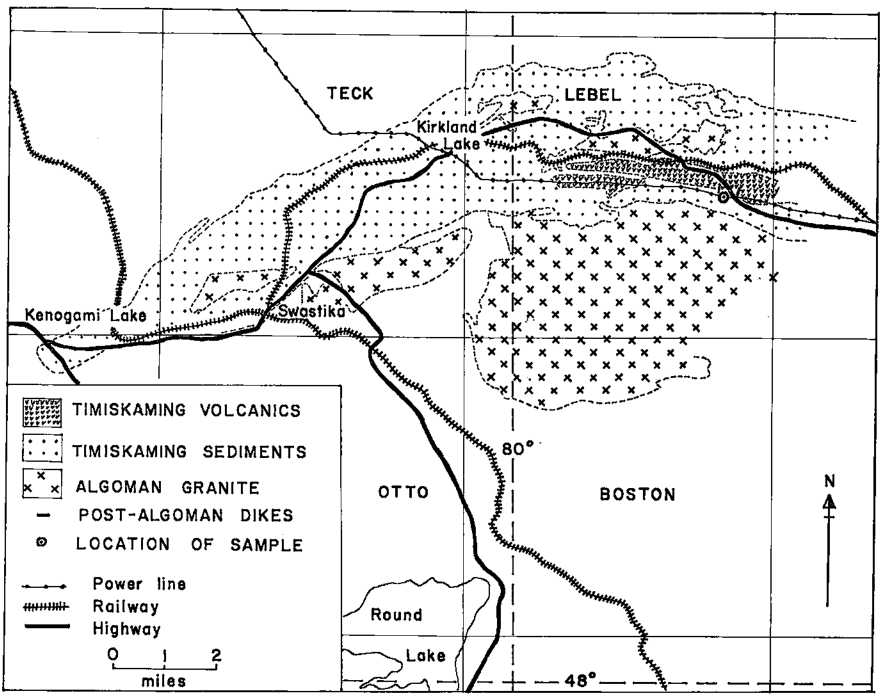

FIG. 1. Map showing location of Timiskaming conglomerate sample.

Isotopic analysis of the zircon sample is reported in Table 1. The zircons appear to occur as normal clastic grains; some small crystals and fragments may have come from pebbles in the conglomerate. The age determined from the zircons may therefore be presumed to indicate the time of crystallization of the zircons and of the rocks (chiefly volcanics) in which they occur. Thus the sediments must have accumulated less than 2700 million years ago.

The mica concentrated from this sample was sent to Geochron Laboratories for potassium-argon analyses, and gave the results shown in Table 2.

The potassium-argon age is consistent with values obtained for the Algoman (Kenoran) metamorphism and orogeny by other workers (Lowdon, 1961; Aldrich & Wetherill, 1960). It dates the last major metamorphic event to affect the Timiskaming sediments in the Kirkland Lake area. Thus a period of about 300 million years encompasses vulcanism, sedimentation, and mountain-building (including metamorphism and plutonic activity). This may be compared with the 420 million year span of orogenic cycles inferred by Gastil (1960) from the frequency distribution of "mineral dates". If his conclusion is valid, the Timiskaming sediments, derived predominantly from Keewatin and Timiskaming acid to intermediate volcanics (Hewitt, 1963), may be regarded as a part of a single orogenic cycle, beginning with the Keewatin vulcanism, and culminating in Algoman intrusion and metamorphism. Consequently, the unconformity separating the Timiskaming and Keewatin in the Kirkland Lake area (Thomson, 1946) would in this view represent not a major pre-Timiskaming period of folding, but an incidental structural disturbance, probably local in character, and perhaps a precursor of the main mountain-building which followed the deposition of the sediments.

The restriction of the Archean history in Ontario to a single orogenic cycle is consistent with the views expressed by several writers, most recently by Bass (1961) and Goodwin (1962). It is our intention to continue the search for still older zircons in the Kirkland Lake–Lake Timiskaming area, but the present results make unlikely the prospects of finding evidence of much older orogeny and plutonism in this area.

Hastings Conglomerate

Although the Grenville was long regarded as Archean, and still is by some authorities (Wilson, 1958; Osborne & Morin, 1962), uranium-lead and potassium-argon ages have consistently been in the range 800 to 1100 million years (Lowdon, 1961; Cumming *et al.*, 1955; Shillibeer & Cumming, 1956). This has led Wilson *et al.*, (1956) to advocate the view

TABLE 1.

Sample	Analysis U ppm.	Analysis Pb ppm.	Isotopic Composition of Pb $\frac{204}{206}:100:\frac{207}{206}:\frac{208}{206}$	AGE 206–238	AGE 207–235	AGE 207–206
Timiskaming	217.1	131.4	.267:100:21.32:29.55	2410 m.y.	2570 m.y.	2700 m.y.
Grenville	522.9	100.2	.108:100:9.252:14.35	1060 m.y.	1090 m.y.	1140 m.y.

Decay constants: U^{238}:1.54 $\times$ 10^{-10}/year U^{235}:.972 $\times$ 10^{-9}/year
All ages have been rounded to the nearest 10 m.y. Ages are ±3 per cent.

TABLE 2.

Sample	Ar^{40*} ppm.	$\frac{Ar^{40*}}{\text{Total } Ar^{40}}$	Average Ar^{40*} ppm.	% K	Average % K	K^{40} ppm.	$\frac{Ar^{40*}}{K^{40}}$	Age
Timiskaming	2.73 2.76	0.983 0.935	2.745	7.80 7.95	7.88	9.60	0.286	2410 ± 50 m.y.
Grenville	0.710 0.710	0.797 0.615	0.710	8.66 8.65	8.655	10.58	0.0672	898 ± 20 m.y.

Constants: $b = 4.72 \times 10^{-10}$/year
$e = 0.585 \times 10^{-10}$/year
$K^{40}/K = 1.22 \times 10^{-4}$g/g.
Ar^{40*} refers to radiogenic Ar^{40}.

that Grenville rocks, from initial sedimentation and vulcanism to final metamorphism and pegmatite development, represent the last main episode in the building of the Canadian shield. The determination of zircon ages from sediments in the Grenville is a logical step in seeking to decide between a late Precambrian and Archean age.

To make this test, an outcrop of quartz conglomerate located just south of Highway 7, six miles east of the town of Madoc (Fig. 2), was sampled. This conglomerate, one of the Hastings conglomerates, is considered by some to be a phase of the Grenville (Adams & Barlow, 1910) and by others to be a younger series (Wilson, 1956; Miller & Knight, 1914). The conglomerate and associated gneissic quartzite possess a groundmass composed of muscovite, biotite, quartz, and minor feldspar, with a little chlorite, calcite, and epidote, and accessory apatite, magnetite, tourmaline, and zircon. The zircon is turbid, damaged by radiation effects, and frequently zoned, in marked contrast to the clear, unzoned, fresh zircon of the Timiskaming sample described above. A concentrate of about 130 mg. of zircon was obtained, using essentially the same procedure as for the previous sample. A sample of muscovite was picked from the crushed rock. The results of analyses of these samples are reported in Tables 1 and 2. These indicate that as in the Timiskaming example, the interval between 1140 and 898 m.y. is of the order of magnitude of a geological cycle, in the broad sense here advocated.

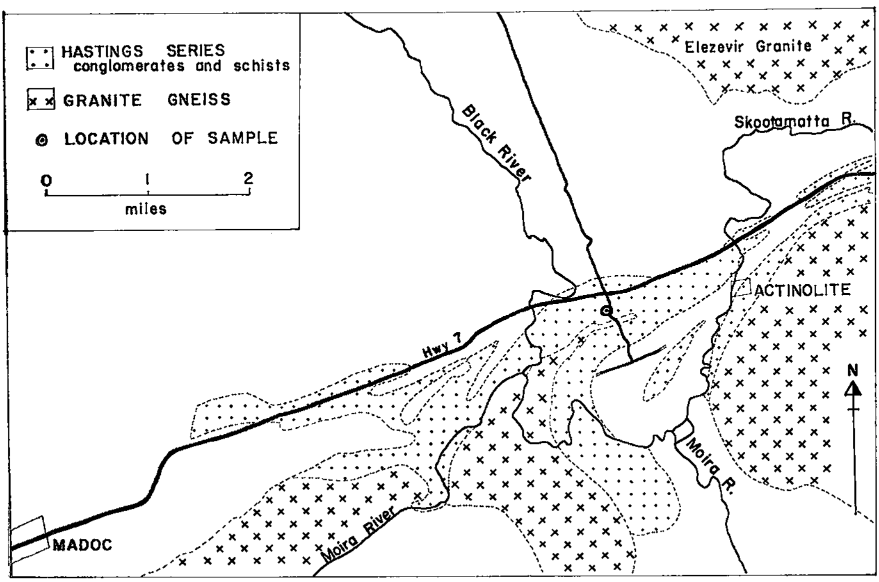

Fig. 2. Map showing location of Hastings conglomerate sample.

It must therefore be concluded that this preliminary attempt to look behind the veil of metamorphism has failed to produce evidence of much older rocks in this part of the Grenville. As far as this conglomerate is concerned, it does not appear to have been formed in the Archean (Miller & Knight, 1914) or Huronian (Quirke & Collins, 1930), but at a much later time, which can be regarded as truly Grenville.

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References

Adams, F. D. & Barlow, A. E. (1910): Geology of the Haliburton and Bancroft areas, *Geol. Surv., Canada, Memoir* **6**.

Aldrich, L. T. & Wetherill, G. W. (1960): Rubidium-strontium and potassium-argon ages of rocks in Ontario and northern Minnesota, *J. Geophys. Res.*, **65**, 337–340.

Bass, M. N. (1961): Regional tectonics of part of the southern Canadian Shield, *J. Geol.*, **69**, 668–702.

Cumming, G. L., Wilson, J. T., Farquhar, R. M., & Russell, R. D. (1955): Some dates and subdivisions of the Canadian Shield, *Proc. Geol. Assoc. Canada*, **7**, part 2, 27–79.

Gastil, G. (1960): The distribution of mineral dates in time and space, *Am. J. Sci.*, **258**, 1–35.

Goodwin, A. M. (1962): Structure, stratigraphy and origin of iron formations, Michipicoten area, Algoma District, Ontario, Canada, *Geol. Soc. Am., Bull.* **73**, 561–585.

Hewitt, D. F. (1963): The Timiskaming Series of the Kirkland Lake area, *Can. Mineral.*, **7**, 497–523.

Lowdon, J. A. *et al.* (1961): Age determinations by the Geological Survey of Canada, *Geol. Surv., Canada, Paper* **61-17**.

Miller, W. G. & Knight, C. R. (1914): The Pre-Cambrian geology of southeastern Ontario, *Ont. Dept. Mines, Ann. Rept.* **22**, pt. II.

Osborne, F. F. & Morin, M. (1962): Tectonics of part of the Grenville subprovince in Quebec, in *The Tectonics of the Canadian Shield, Roy. Soc. Canada, sp. pub.* **4**, 118.

Quirke, T. T. & Collins, W. H. (1930): The disappearance of the Huronian, *Geol. Surv., Canada, Memoir* **160**.

Shillibeer, H. A. & Cumming, G. L. (1956): The bearing of age determinations on the relation between the Keewatin and Grenville Provinces, in *The Grenville Problem, Roy. Soc. Canada, sp. pub.* **1**, 54.

Thomson, E. (1946): The Keewatin-Timiskaming unconformity in the Kirkland Lake district, *Roy. Soc. Canada*, **40**, series III, section IV, 113.

Wilson, J. T., Russell, R. D. & Farquhar, R. M. (1956): Economic significance of basement subdivion and structures in Canada, *Can. Inst. Min. Met., Bull.*, no. **532**, 550–558.

Wilson, M. E. (1956): Discussion, in *The Grenville Problem, Roy. Soc. Canada, sp. pub.* **1**, 53.

——— (1958): Precambrian classification and correlation in the Canadian Shield, *Geol. Soc. Am., Bull.* **69**, 757–773.

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