Short Communications

Zircon fission track ages from the Coldwell Complex Ontario

Canada. Sohan L. KOUL, Lewis T. CHADDERTON, R. Garth PLATT* and

C.B. DOUTHITT[†], *CSIRO, Division of Chemical Physics P.O. Box 160, Clayton, Victoria, Australia-3168*, **Department of Geology, Lakehead University Thunder Bay, Ontario, Canada-P7B5E1* and [†]*Department of Earth Sciences, Monash University, Clayton, Victoria, Australia-3168*.

Abstract

Fission track ages are reported for the mineral zircon from the Coldwell Complex, Ontario, Canada using both the external detector and the population methods. Results for zircon yield a spread of fission track ages from 956.7 ± 40 to 978.6 ± 41 Ma. The geological history of the area is discussed in the light of fission track ages uncovered.

The Coldwell Complex, a large and complex alkaline intrusion, has been the focus of field, petrologic, radiometric, and geophysical studies by one of us (RGP) for a number of years (Platt and Mitchell, 1982; Mitchell and Platt, 1978, 1982). This study reports the results of fission track ages obtained for a zircon separated from the Coldwell Complex. Fission track ages from minerals in plutonic rocks can be used to constrain the passage of the rock through characteristic blocking temperature (the value of which is mineral dependent) thus aiding in a reconstruction of the cooling and/or uplift history. The new zircon data in conjunction with recalculated K–Ar data yield two points on a time-temperature diagram.

The syenite pegmatite, from which the zircon was collected, is situated in the western contact region of the Complex on the shore line of Lake Superior. Mineralogically it consists essentially of perthitic alkali feldspars with variable amounts of amphibole, pyroxene and opaque grains. Carbonate, quartz and zircon from accessory phases. The 'large' size of the zircon collected is unusual, as, within the pegmatite suite in general, the zircons range in size from 0.2 mm – 2 mm. In this section, these crystals show extensive development of growth zones. The large zircon crystal was crushed in a steel mortar and the fragments mounted in Teflon by embedding at a temperature of 190 – 200°C; the fragment mounts were then polished, with the final polish being administered with 6 – 1 μ grade diamond paste. The samples were etched in a eutectic melt of potassium hydroxide and sodium-hydroxide at 180°C for 7 hours.

Irradiations were performed in the HIFAR reactor and the induced tracks counted

by both the external detector method (EDM) and the population method. For EDM, the mounted mineral separates were covered with pieces of clean, low-uranium muscovite prior to neutron irradiation; the spontaneous tracks were counted on the planar zircon surface in contact with the mica detector, while the induced tracks were counted on the detector after etching in 48% HF for one hour at room temperature. For the population method, spontaneous track density was measured in one sample while induced track density was measured in a separate sample which was annealed prior to irradiation. The integrated thermal neutron dose was determined by counting induced tracks in muscovite detectors irradiated in contact with NBS standard glasses SRM 962 and 963. The constants used in the age calculations are listed in Table 1; errors ($\pm 1\sigma$) are calculated according to the methods of Koul and Singh (1985).

TABLE 1. Zircon fission track analytical data, Coldwell Complex, Ontario

Sample No.	Spontaneous track density $\times 10^6 \text{ cm}^{-2}$	Tracks counted	Induced track density $\times 10^6 \text{ cm}^{-2}$	Tracks counted	Fluence neutrons $\times 10^{15}$ (n cm^{-2})	Age $\pm 1\sigma$ (Ma)
EXTERNAL DETECTOR METHOD						
Coldwell Complex zircon						
SKZ/107	7.45	889	2.85	935	6.32	948.1 $\pm$ 40
SKZ/119	7.63	936	2.85	1238	—	969.4 $\pm$ 41
SKZ/106	8.65	776	3.22	814	—	972.5 $\pm$ 39
SKZ/105	7.83	659	3.01	594	—	943.8 $\pm$ 41
SKZ/111	6.73	460	2.57	534	—	949.7 $\pm$ 39
					Mean	956.7 $\pm$ 40
POPULATION METHOD						
Coldwell Complex zircon						
RGZ/114	6.55	785	2.41	654	6.32	983.1 $\pm$ 41
RGZ/115	8.39	650	3.12	530	—	973.4 $\pm$ 42
RGZ/116	6.72	870	2.48	962	—	980.3 $\pm$ 41
					Mean	978.6 $\pm$ 41

λ_f (spontaneous fission decay constant of ^{238}U) = $6.80 \times 10^{-17} \text{ a}^{-1}$

λ_d (total decay constant of uranium) = $1.55 \times 10^{-10} \text{ a}^{-1}$

I (isotopic abundance of ^{235}U w.r.t ^{238}U) = 7.25×10^{-3}

σ_f (cross section for thermal neutron induced fission of ^{235}U) = $5.902 \times 10^{-22} \text{ cm}^2$

Standards: SRM 962 & SRM 963 = $6.32 \times 10^{15} \pm 0.05 \text{ n cm}^{-2}$

While there is some debate about the precise age of the Coldwell Complex (Blenkinsop and Bell, 1983; Platt and Mitchell, 1984), we will take the 17-point Rb–Sr isochron age of 1045 ± 6 Ma (Platt and Mitchell, 1982) as the age of crystallization of the Complex; temperatures of crystallization are estimated as being between 900°C and 500°C , while depth of intrusion is about 6 kilometers ($p = 1$ to 2 kb: Currie, 1980; Mitchell and Platt, 1982).

The EDM/population zircon fission track age is $956.7 \pm 40 - 978.6 \pm 41$ Ma (Table 1). Previously reported data relevant to constraining the cooling history of the Complex includes k–Ar dates on biotite from an early gabbro (1005 ± 36 Ma, Currie, 1980), fenitized granodiorite (1015 ± 36 Ma, Currie, 1980 – fenitization is related to intrusion of the Complex), and a nepheline syenite (1055 Ma, data from Fairbairn et al., 1959 recalculated with the constants of Steiger and Jager, 1977). In order to interpret fission track data, the stability of fission tracks in zircon was investigated in terms of what might be called a “closing temperature” Koul et al., 1983. The effective closing temperature for fission tracks in zircon has been determined as 180°C , while the closure temperature for argon in biotite is taken to be 260°C (Harrison et al., 1979). A time-temperature plot was constructed using these available data (omitting the datum of Fairbairn et al., 1959) (Figure 1).

The cooling rate for the pluton is classified as “intermediate” (Harrison et al., 1979) since the temperature drop from magmatic temperature ($800 - 900^{\circ}\text{C}$; Mitchell and Platt, 1982) to zircon fission track closure temperature (180°C) took place 67 –

FIG. 1.

89 Ma. If the Rb–Sr age of Blenkinsop and Bell (1983) is correct, the cooling took place over 92 – 114 Ma. Can't choose between cooling below 180°C isobarically (loss of heat to wall rock-note extensive 1 – 2 km. wide zone of contact metamorphism) and cooling due to removal of cover by erosion during uplift.

Acknowledgements—One of us (SLK) wishes to thank Dr. M. J. Kenny for his help during reactor irradiations.

References

- BLINKINSOP, J. & BELL, K. (1983) *Can. Journ. Earth Sci.*, **20**, 1499-1500.
 CURRIE, K. L. (1980) *Geol. Survey Canada, Bull.*, **287**, 1-43.
 FAIRBAIRN, H. W., BULLWINKEL, J. H., PINSON, W. H. & HURLEY, P. M. (1959) *Proc. Geol. Assoc. Canada*, **11**, 141-144.
 HARRISON, T. M., ARMSTRONG, R. L., NAESER, C. W. & HAKAL, J. E. (1979) *Can. Journ. Earth Sci.*, **16**, 390-410.
 KOUL, S. L., CHADDERTON, L. T. & BROOKS, C. K. (1983) *Mat. Fys. Medd. Vid. Selsk.*, **40**:13, 1-37.
 KOUL, S. L. & SINGH, N. (1985) *Statistics Research Report*, **116**, 1-13.
 MITCHELL, R. H. & PLATT, R. G. (1978) *Journ. Petrol.*, **19**, 627-651.
 MITCHELL, R. H. & PLATT, R. G. (1982) *Journ. Petrol.*, **23**, 186-214.
 PLATT, R. G. & MITCHELL, R. H. (1982) *Can. Journ. Earth Sci.*, **19**, 1796-1801.
 PLATT, R. G. & MITCHELL, R. H. (1984) *Can. Journ. Earth Sci.*, **21**, 128.
 STEIGER, R. H. & JAGER, E. (1977) *Earth Planet. Sci. Letters*, **36**, 359-362.

Received October 3, 1985; revised November 20, 1985.