Isotopic Mineral Ages of a Diorite from the Eisenkappel Intrusion, Austria

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$^{40}K-^{40}Ar$ ages on biotite (227 ± 7 m.y.) and hornblende (244 ± 8 m.y.) and a $^{238}U-^{206}Pb$ age on sphene (230 ± 5 m.y.) were determined for a diorite from the Eisenkappel intrusion from Southern Carinthia in Austria. The intrusion is stratigraphically dated at younger than Lower Carboniferous. The isotopic results suggest the diorite was emplaced between the Upper Permian and the Lower Triassic.

Introduction

The greenschist and crystalline rocks of Eisenkappel form low hills between two branches of the Karawanken mountains. The crystalline rocks consist of flaser tonalite, surrounded by schist, hornblende gabbro, massive granite with granitic dykes and different porphyries [1]. The Greenschist zone contains diabase and strongly schistose metasediments with tuffaceous characteristics. It is thought that the dioritic nature of some of the intrusive rocks adjacent to the greenschist zone is due to mixing of diabase and granite material. The presence of so many different rock types and the complicated tectonic relationships have attracted much geological attention [1–7].

Graber [1] has proposed the following age scheme for the region:

– Greenschist and gabbro – post-Kulm, schists surrounding tonalite – Upper Carboniferous, Tonalite – Permo-Carboniferous, granite – post Permian.

The younger age limits for the intrusive rocks are uncertain though these events certainly pre-date the Miocene.

The contact aureole of the granite with Carboniferous metasediments near Schwarzenbach (at first thought to represent Werfern beds) provides evidence that the older age limit of the granite intrusion is Lower Carboniferous [5]. Post Palaeozoic igneous activity is also suggested by acid veins in Triassic limestone in the area. Graber [5] believes that the tonalite is older than the granite.

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In this study we report K – Ar and U – Pb ages for the granite from Eisenkappel. Our object in this is to assist in clarifying the complex age relationships of the crystalline rocks and metasediments in this zone.

This study parallels a study on the fission track dating of sphene, being made at the Heidelberg laboratory in which is included an investigation of the sphene from the granite of Eisenkappel (noted for its remarkably high sphene content [8]).

The present publication reports only the K – Ar and U – Pb results. The fission track investigation is to be reported at a later date.

Experimental Techniques and Results

The granite sample (C. 5 Kgms) was collected in the Leppenbach Valley from approximately 150 metres above the road from Eisenkappel to Bad Vellach, on the south side of the creek.

The rock is a diorite. It consists of 45 per cent plagioclase (An 30) and 35 per cent green hornblende with ten per cent of microcline — perthite and pyroxene and one per cent of idiomorphic sphene [9]. Accessories are biotite and chlorite. The biotite appears secondary after hornblende.

K – Ar analyses were made in Heidelberg on separated hornblende and biotite. A U – Pb analysis of the sphene was made in East Kilbride.

The K – Ar procedure was analogous to that described by Horn, Lippolt and Todt [10]. Argon analysis of the biotite was performed on a MAT GD 150 mass-spectrometer. The Ar measurements of the hornblende was made on a triple collector mass-spectrometer [11]. The measured K – Ar age of the hornblende of 244 ± 8 Ma is higher than the measured K – Ar biotite age of 227 ± 7 Ma. The analytical results and the constants used for the age calculations are given in Table 1.

Table 1. K – Ar-ages of Hornblende and Biotite from a Diorite of the Eisenkappel intrusion.

Sample	Potassium %	Ar-Run	Ar (rad) 10^{-6} cc/g	Ar (atm) %	Age 10^6 a
LK 5 Hornblende	0,408	III-55	4,24	18,4	244 ± 8
		III-69	4,25	7,9	
LK 5 Biotite	3,87	1484	36,8	14,1	227 ± 7

$\lambda = 5{,}32 \cdot 10^{-10}\ a^{-1}$; $R = 0{,}123$; $^{40}K/K = 0{,}0118$.

The uranium and lead analytical methods followed those of Krogh [12]. The sphene sample was purified to greater than 99 percent by hand picking. It was then warmed in 1:1 nitric acid and then in distilled water, dried, and then dissolved in sub-boiling-distilled hydrofluoric acid in a teflon pressure vessel. After aliquoting and spiking, with enriched lead 208 and uranium 235, the lead and uranium was isolated by ion exchange techniques. Lead and uranium were mounted on single rhenium filaments as phosphate in silica gel (Pb) and as phosphate with tantalum oxide (U). Isotopic analysis was performed on the A.E.I.G.E.C. MS 12, 12 inch radius, 90° sector mass spectrometer at the Scottish Universities Research and Reactor Centre.

Table 2. U – Pb isotopic analysis of sphene from the Eissenkappel intrusion.

	Pb ppm	U ppm	$^{206}Pb/^{204}Pb$ (measured)	Atom percent radiogenic lead ^{206}Pb	^{207}Pb	^{208}Pb	Atomic ratios $^{207}Pb/^{206}Pb$	$^{207}Pb/^{235}U$	$^{206}Pb/^{238}U$	Apparent Ages * in million years (Ma) $^{207}Pb/^{206}Pb$	$^{207}Pb/^{235}U$	$^{206}Pb/^{238}U$
Correction 1	12.26	165.1	152.8	41.77	2.154	56.07	.05157	.2553	.3590	275	234	230
Correction 2	12.17	165.1	152.8	42.01	2.085	55.90	.04964	.2452	.03582	186	225	229

Common lead correction 1 (blank lead) $^{206}Pb/^{204}Pb = 18.1$, $^{207}Pb/^{204}Pb = 15.5$, $^{208}Pb/^{204}Pb = 36.8$.
Common lead correction 2 (230 Ma old lead) $^{206}Pb/^{204}Pb = 18.3$, $^{207}Pb/^{204}Pb = 15.8$, $^{208}Pb/^{204}Pb = 38.6$.
* Apparent ages calculated with the following constants
$^{238}U/^{235}U = 137.8$, $\lambda\,(^{238}U) = 1.537 \cdot 10^{-10}\,a^{-1}$, $\lambda\,(^{235}U) = 9.72 \cdot 10^{-10}\,a^{-1}$.

The percentage standard error of the mass spectrometric runs was within 0.2 percent for this sample, except for the $^{206}Pb/^{204}Pb$ ratio which was approximately five percent. The uncertainty in the atomic ratios of $^{207}Pb/^{206}Pb$ and lead to uranium is strongly dependent on the uncertainty in the common lead correction. This is shown on Table 2, where the ratios have been calculated using two estimates for the composition of the common lead. The first correction is based on the composition of the laboratory blank lead and assumes all contaminating lead is from the blank. The second correction is made assuming that all the contaminating lead is from 230 Ma old lead initially incorporated in the sphene.

The apparent ages, corresponding to the calculated atomic ratios, are presented in Table 2 (column 10–13). The $^{207}Pb/^{206}Pb$ and $^{207}Pb/^{235}U$ apparent ages are seen to be strongly dependent on the choice of common lead correction. The $^{206}Pb/^{238}U$ apparent age is seen to be relatively insensitive to the uncertainty in the common lead correction and as a consequence 230 ± 5 Ma (the error is an approximation) is adopted as the best estimate of the age of the sphene from Eisenkappel intrusion. If the recently determined decay constants for uranium are used [13] the $^{206}Pb/^{238}U$ age becomes 227 Ma. This is within the limits of 230 ± 5 Ma and we retain this value as the age of the sphene.

Discussion

The three age determinations of the granite (K – Ar hornblende 244 ± 8 Ma, biotite 227 ± 7 Ma and U – Pb sphene 230 ± 5 Ma) are almost identical within the uncertainties. Certainly there is no difference between the biotite K – Ar age and the $^{238}U/^{206}Pb$ sphene age of the granite.

Taking the K – Ar age results separately it is possible that the difference between the hornblende age and the biotite age is in excess of experimental error. Such relative apparent ages are in accord with the known stability of hornblende and biotite K – Ar systems and could be explained in terms of argon loss during cooling. The blocking temperature for argon loss from the hornblende is higher than that of biotite so each mineral would record a slightly different apparent age in response to the cooling rate. If the K – Ar ages are the result of cooling the granite could well have been intruded slightly before 244 ± 8 Ma.

Tilton and Grünenfelder [14] found that sphene U – Pb ages were generally concordant and did not as a rule show evidence of partial isotopic discordance as is commonly observed in the U – Pb isotopic systems of zircons. Pasteels and Michot [15] on the other hand suggest that the sphene age could be a cooling age. The present authors are doubtful whether the sphenes could have lost all radiogenic lead (or intermediate daughters) during a period of cooling after crystallization. It would seem, taking into account all the uncertainties between the methods, that the similar age result are recording the emplacement of the granite into relatively cold rock (indicated by the aureole) and that the measured age of 227 – 244 Ma essentially is that of granite emplacement.

This age determination shows without doubt that the granite intrusion was pre-Alpine and possible occured during the Permian or Lower Triassic.

This age result can be compared with generally pre-Jurassic age measurements from other intrusive rocks from the chain of intrusives extending from Adamello (over Riesenferner) to Eisenkappel. The mineral ages of the Monte-Sabion granodiorite, the Brixen granite and the Cima d'Asta granite can be considered as Upper Carboniferous [16–18]. Similar age-values to that of the granite from Eisenkappel have been reported for the Ankogel leucogranite from the Tauern window and for the Predazzo-Monzoni complex [19, 20].

The exact correlation of the intrusion age with the stratigraphic column can not be made with certainty at the present time. The Permo-Triassic boundary of 225 ± 5 Ma was adopted at the 1964 Symposium on the Phanaerozoic time scale (Holmes Symposium). If this value is taken it follows that the intrusion took place within the interval which marks the uncertainty of the Permo-Triassic boundary. It has been suggested that the Permo-Triassic boundary should be older but this remains to be conclusively demonstrated [21, 22].

We conclude that the granite was intruded in the Upper Permian to Lower Triassic.

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