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Rb/Sr WHOLE ROCK ISOCHRON AGE DETERMINATIONS ON METAMORPHOSED ACID VOLCANIC ROCKS AND GRANITIC GNEISSES FROM THE KETILIDIAN MOBILE BELT, SOUTH-EAST GREENLAND

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The metamorphosed supracrustal rocks and paragneisses studied were collected during a reconnaissance traverse across the trend of the Ketilidian mobile belt in South-East Greenland (Andrews *et al.,* 1971, 1973). All the samples are taken from gneisses regarded as derived from supracrustal material which was originally composed of acid volcanic material deposited as lavas, ignimbrites or sediments with a large volcanic component. Sample localities are shown in fig. 2. All the rocks have been affected by at least one metamorphic episode during the formation of the Ketilidian mobile belt. All are regarded as deposited after the end of regional high grade metamorphism in the Archaean block to the north (which has yielded a U/Pb zircon diffusion age of 2808 m.y.) and are intruded by a variety of syn- to late tectonic granites within the Ketilidian mobile belt which have yielded U/Pb diffusion and concordia ages between 1850 and 1770 m.y. in this area (Gulson & Krogh, 1972).

The rocks in the border zone of the Ketilidian mobile belt show field evidence of a complex metamorphic history. Early deposition of supracrustal rocks, deformation and granite injection is separated from later metamorphic and granitic activity by a period of basic dyking (Watterson, 1965; Bridgwater *et al.,* 1973). South of the border zones regional metamorphic and granitic activity, major phases of which have been dated between 1830 and 1900 m.y. (Gulson & Krogh, 1972; Van Breemen *et al.,* 1974), largely destroyed evidence of earlier events, and correlation within the fold belt is a matter of speculation.

The objects of the present study were to establish the age of the early events in

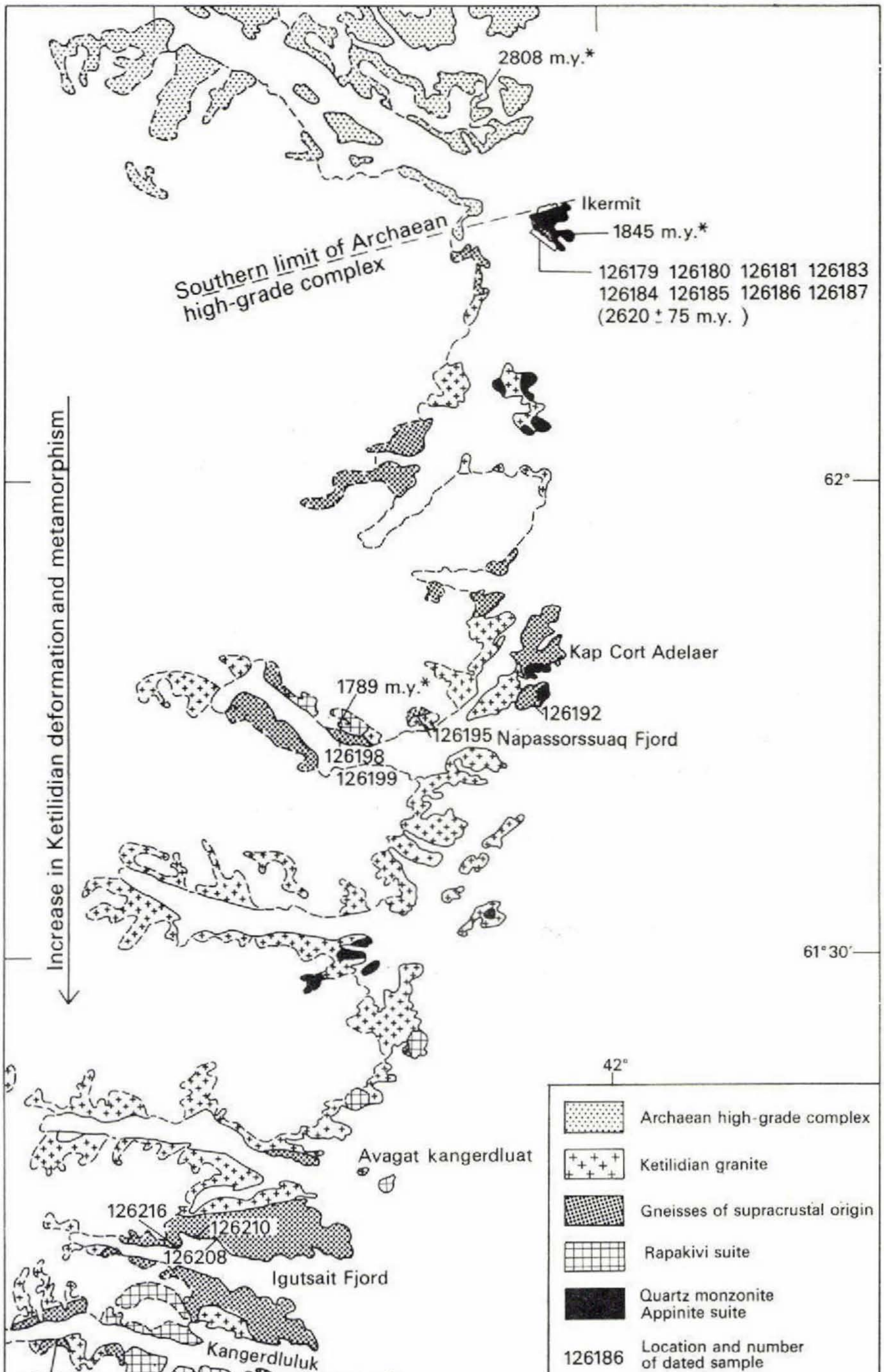

Fig. 2. Geological sketch map of part of the Ketilidian mobile belt in South-East Greenland showing the locations of the dated samples described by Pedersen *et al.*

the border zone of the mobile belt and to make an isotopic reconnaissance of the supracrustal rocks across the regional trend of the mobile belt to see if these could be correlated.

Description of localities

Ikermît (8 samples 2620 ± 75 m.y.)

Ikermît island lies on the border between the Ketilidian mobile belt and the Archaean block to the north. The south-west part of the island consists largely of a group of flat-lying quartzo-feldspathic rocks in which layers of medium to fine grained intermediate and acid gneiss with well preserved original volcanic structures alternate and grade into foliated granitic gneisses with little or no direct evidence of their supracrustal origin. Subconcordant sheets of later intrusive granite occur within the layered sequence on the adjacent mainland. The flat-lying gneiss complex was intruded by scattered basic dykes which have been subsequently metamorphosed under greenschist facies conditions and is cut by a suite of late to post-tectonic intermediate and acid intrusions (including appinitic rocks) one of which has yielded a U/Pb zircon diffusion age of 1845 m.y. (Gulson & Krogh, 1972). All the samples were taken from the layered supracrustal sequence, four from rocks with clear original volcanic textures, three from the granitic rocks interlayered with them, and one sample from a layer showing textures which are transitional between the metavolcanics and the granitic gneisses.

Kap Cort Adelaer - Napassorssuaq fjord (4 samples)

This area marks the southernmost part of the border zone of the Ketilidian mobile belt. It is separated from the higher grade parts of the mobile belt by the eastern extension of the Julianehåb granite which outcrops between Napassorssuaq and Avarqat kangerdluat. The sampled units were mapped as the southern more highly metamorphosed equivalents of the Ikermît sequences although the outcrop of supracrustal rocks is discontinuous. They are cut by scattered metabasic dykes. Appinitic intrusions regarded as the equivalent of the body dated at 1845 m.y. from Ikermît are affected by later deformation in the Kap Cort Adelaer region. A post-tectonic intrusion on the north coast of Napassorssuaq has yielded a U/Pb diffusion age of 1789 m.y. comparable to the ages obtained from members of the rapakivi granite suite further south (Gulson & Krogh, 1972).

Most of the rocks interpreted as derived from supracrustal acid volcanic suites from this area have been strongly recrystallised and now form layers of grey granitic gneiss stratigraphically intercalated with more basic horizons and some calc-silicate layers. All the samples used in the isotope studies show clear field evidence of a metavolcanic origin.

Igutsait – Kangerdluluk (5 samples)

The supracrustal gneisses collected from the Igutsait - Kangerdluluk area are regarded as the continuation of the same suite of cover rocks south of the major mass of granite which extends from Napassorssuaq to Avarqat kangerdluat. They consist of a layered complex of amphibolite facies gneisses with some units of recognisable metasedimentary or clear metavolcanic origin alternating with grey gneiss. They are intruded by several generations of granite including syntectonic and late tectonic bodies and a large post-tectonic rapakivi complex yielding a 1784 m.y. U/Pb zircon diffusion age (Gulson & Krogh, 1972).

Methods

The Rb/Sr ratios were obtained by XRF by Dr. J. Bailey (Institute of Petrology, University of Copenhagen) using GSP-1 and G-2 as standards. Rb/Sr ratios of 1.093 and 0.355 respectively were assigned to these standards.

The isotopic composition of strontium was measured on unspiked samples using a Varian TH-5 mass spectrometer. The isotopic ratios were evaluated from chart recordings and are assumed to be accurate to within $\pm$ 1 ‰.

The isochrons were calculated using a modified version of the computer program introduced by McIntyre *et al.* (1966). Following the suggestion of Brooks *et al.* (1972) the 'Student's T' correction factor has been omitted from the error calculations. Lacking sufficient statistical basis for the assessment of an overall error factor for the Rb/Sr-ratio measurements, we have attempted temporarely to introduce an assessed 'error' for each Rb/Sr ratio.

Results and interpretation

The samples dated fall into two distinct isotopic groups: those from Ikermît island and those from further south. Locality and analytical details of the two groups are given in tables 3 and 4 with evolution diagrams plotted as figs 3 and 4.

The Ikermît rocks give a well-defined isochron at 2620 ± 75 m.y. with an initial ratio of 0.7019 ± 0.0008. No significant difference has been detected between samples showing clear pre-metamorphic textures and those which have completely recrystallised as granite gneisses.

The age of 2620 m.y. is interpreted as either the age of the original extrusion of the acid volcanic sequence or the age of their first metamorphism. The initial ratio is close to the average strontium isotopic ratio predicted for the mantle at about 2600 m.y. (Faure & Powell, 1972). In the absence of signs of high-grade metamorphism it seems unlikely that these rocks could have had a history in the upper crust much earlier than the date obtained. Whichever interpretation is preferred the

Table 3. Analytical details of samples from the Ikermît area (62°16'N, 42°06'W), South-East Greenland

GGU Sample No.	Rock type	$^{87}Rb/^{86}Sr$*	$^{87}Sr/^{86}Sr$
126187	granite gneiss	0.137±0.027	0.7060±1 ‰
126181	metavolcanic	0.211±0.006	0.7097
126179	metavolcanic	0.226±0.009	0.7110
126180	metavolcanic	0.352±0.011	0.7143
126183	metavolcanic	0.359±0.012	0.7153
126184	'transitional'	0.461±0.014	0.7194
126186	granite gneiss	1.240±0.024	0.7477
126185	granite gneiss	1.335±0.026	0.7515

Initial ratio: 0.7019±0.0008 } Errors given at the
Age : 2620±75m.y. } 1σ confidence level

Decay constant: $1.39 \times 10^{-11}\ y^{-1}$

* Rb/Sr ratios determined by XRF using the following Rb/Sr ratios for USGS standards: GSP–1 : 1.093, G–2 : 0.355

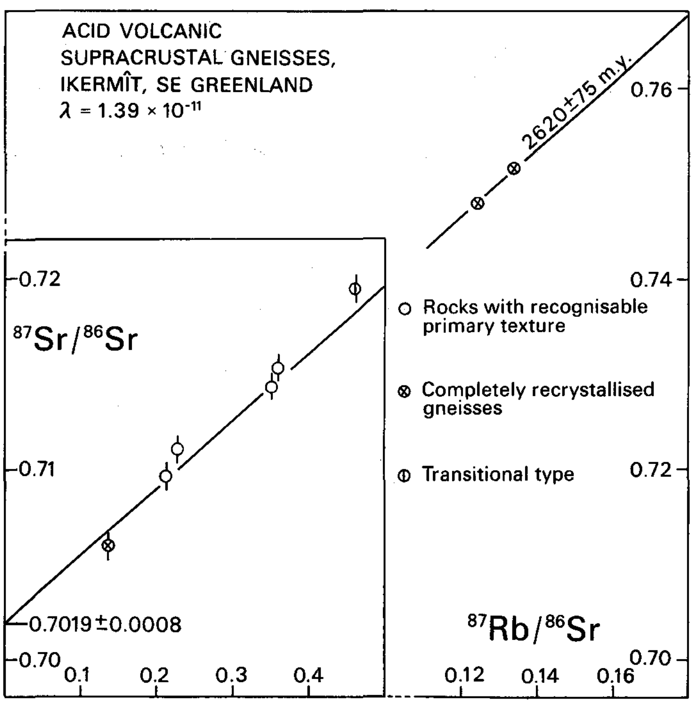

Fig. 3. Rb/Sr evolution diagram for whole-rock samples from Ikermît, South-East Greenland, listed in table 3 (Pedersen *et al.*).

Table 4. Location and analytical details of supracrustal rocks from the area south of Ikermît, South-East Greenland

GGU Sample No.	Locality		$^{87}Rb/^{86}Sr$*	$^{87}Sr/^{86}Sr$
126192	Kap Cort Adelaer-Napassorssuaq Fjord	61°46′N 42°08′W	0.098±0.029	0.7043±1 ‰
126198	Napassorssuaq Fjord	64°44′N 42°37′W	0.147±0.006	0.7053
126199	Kap Cort Adelaer-Napassorssuaq Fjord	64°44′N 42°47′W	0.182±0.027	0.7079
126208	Igutsait Fjord	61°13′N 42°54′W	0.249±0.012	0.7086
126210	Igutsait Fjord	61°13′N 42°55′W	0.269±0.027	0.7105
126195	Napassorssuaq Fjord	61°46′N 42°20′W	0.590±0.012	0.7171
126216	Igutsait Fjord	61°13′N 43°02′W	0.907±0.027	0.7263
126223	Kangerdluluk	61°05′N 43°12′W	3.26 ±0.07	0.7859
126225	Kangerdluluk	61°05′N 43°12′W	3.73 ±0.08	0.8010

Initial ratio: 0.7017±0.0005 } Errors given at the
Age : 1850±35 m.y. } 1σ confidence level

Decay constant: 1.39 ± 10^{-11} y^{-1}

* Rb/Sr ratios determined by XRF using the following Rb/Sr ratios for USGS standards: GSP–1 : 1.093, G–2 : 0.355

results support the suggestion that the border zone of the Ketilidian mobile belt was affected by more than one period of thermal activity.

The results from the second group of rocks, collected from supracrustal gneisses south of Ikermît, plot close to an 'isochron' with an initial ratio of 0.7022 ± 0.0005 and giving an age of 1850 ± 35 m.y. We do not have sufficient statistical data on the instrumental errors to fully justify the age as an isochron age (Model 1 according to McIntyre et al., 1966). However, considering that the samples were collected from three different localities separated by major intrusive masses of granite and the rather inhomogeneous nature of the supracrustal rocks sampled, the results do lie surprisingly close to an ideal isochron. The age of 1850 m.y. together with the low initial ratio of the strontium isotopes obtained from these rocks strongly suggests that they were formed considerably later than the Ikermît supra-

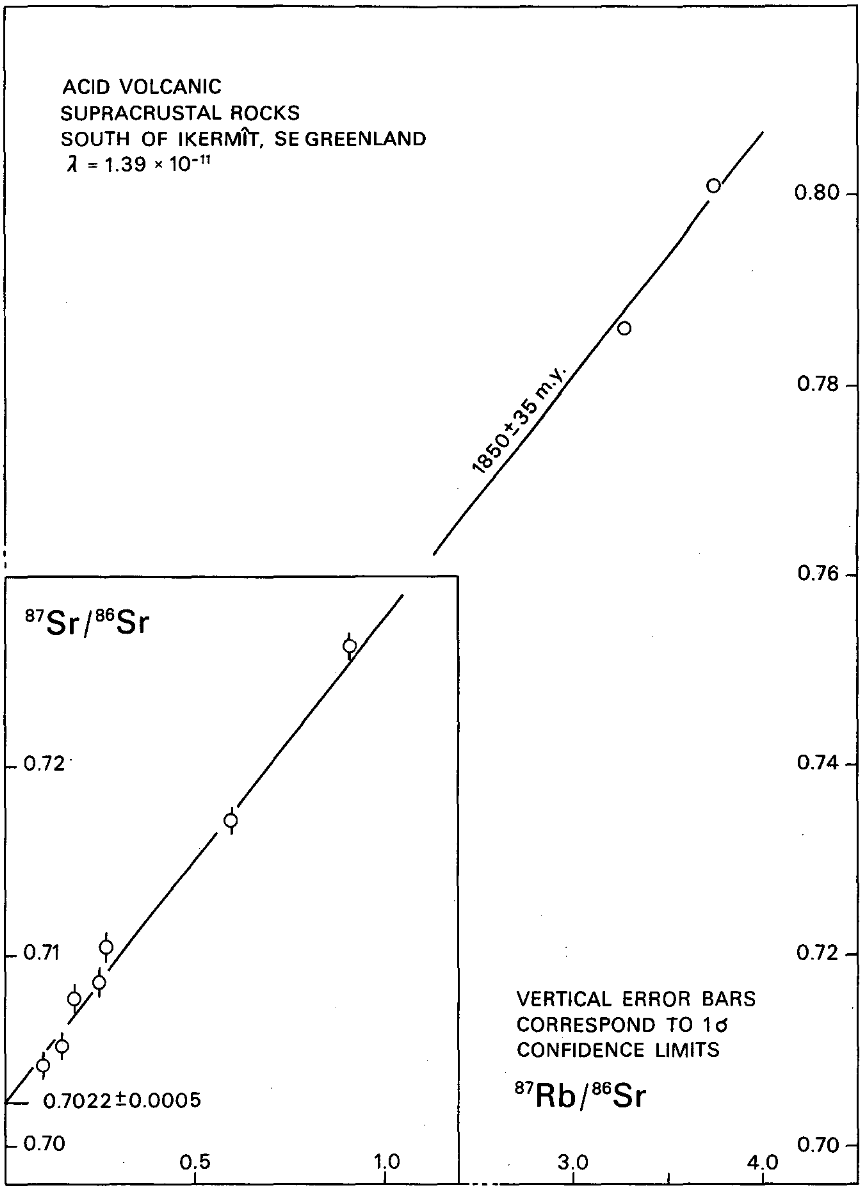

Fig. 4. Rb/Sr evolution diagram from whole-rock samples from the area south of Ikermît, South-East Greenland listed in table 4 (Pedersen *et al.*).

crustals. The age may indicate the time of volcanic extrusion or may alternatively represent the age of Ketilidian metamophism. If the latter is the case, the generally accepted interpretation of low initial strontium ratios implies that the rocks must have had a comparatively short history in the upper crust before the onset of metamorphism. The field geology has demonstrated a complex sequence of events which separate the deposition of the supracrustal rocks from the emplacement of Ketilidian granites which yield U/Pb and Rb/Sr whole rock isochron ages close to 1850 m.y. (van Breemen *et al.*, 1974). The volcanism, the intermediate events and the plutonism are probably all associated with the main thermal event within the Ketilidian mobile belt. The close fit to the isochron demonstrates that the rocks have not been disturbed by metamorphic effects following the time of isotopic equilibrium, so the isochron age sets a minimum for the age of Ketilidian metamorphism in this region.

Conclusions

The age obtained from the Ikermît rocks confirms the field evidence of an early thermal event in the border zone of the Ketilidian mobile belt separated by at least 700 m.y. from thermal events dated within the higher grade areas of the belt. The low initial strontium ratios obtained strongly suggest that the supracrustal rocks within the belt were formed later than those at the margin. The field evidence is not good enough to dispute this as geological mapping in the area is restricted to reconnaissance work. We can think of no geochemical reason why the supracrustal rocks within the belt should have been depleted in rubidium at an early stage in their history or why they should have lost radiogenic strontium at a later period. However, in view of the work for example by Gittins *et al.* (1969) who suggest that a cogenetic suite of supracrustal carbonate rocks traced across the Grenville front show a marked change in initial ratio as they pass into higher grade areas some of us have slight reservations about accepting low initial ratios as necessarily demonstrating a short crustal history for rocks in high-grade metamorphic terrains. We consider the border zone of the Ketilidian mobile belt between Ikermît and Kap Cort Adelaer as a key area both from the point of view of controlling the sequence of events within the Ketilidian and in observing what occurs isotopically when a varied suite of rocks is traced into an area of increasing metamorphism.

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