and 3555 Hz and transmitter receiver distances of 25, 50 and 100 m; and (5) susceptibility measurements using the Scintrex SM5 susceptibility meter.

The profile lines were laid out with a theodolite to obtain very accurate chaining data for the topographic correction of the horizontal loop EM measurements. The total length of these profile lines was approximately 4 km. Geophysical data were collected along practically all lines. An additional 1 to 2 km of magnetic and VLF data were acquired along reconnaissance profiles in the area.

The data were compiled in the field (diurnal correction of magnetic data, filtering of VLF data, Fraser, 1969). The horizontal loop EM measurements did not add to the results obtained with the VLF profiling, except to indicate that no massive sulphides were present at low to moderate depths. Consequently, the combination of VLF, EM and magnetics can be recommended for the mapping of these norite/sulphide occurrences with associated faulting. The multifrequency horizontal loop EM cannot be recommended for mapping work, but may of course still be valuable for detailed work on more massive sulphides of which there are some in the area (Secher this report).

Good results were obtained and it was possible to interpret the data in relation to the geologic features. Data and results will be presented later.

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Anatectic origin of mid-Proterozoic granite dyke in the Isukasia area, West Greenland
Pb-Pb and Rb-Sr isotope evidence

F. Kalsbeek and P. N. Taylor

It was found some time ago on the evidence of mineral-isotope relations that the early Archaean gneisses of the Godthåbsfjord region in West Greenland were mildly reheated during the mid-Proterozoic at *c.* 1600–1700 Ma (Pankhurst *et al.,* 1973; Baadsgaard *et al.,* 1976). A Rb-Sr whole-rock isotope study of a fine-grained granitic dyke from the Isukasia area indicated that this dyke was formed 1610 ± 130 Ma ago by anatexis of early Archaean rocks (Kalsbeek *et al.,* 1980). This suggested that temperatures not less than *c.* 650°C were reached at depth, at least locally, within the Archaean craton during the Proterozoic. We have made a Pb-Pb isotope study of this dyke to check and amplify this conclusion. The field relations, petrology and chemistry of the dyke have been described in the earlier paper.

Table 2. Pb-isotope ratios in samples of acid dyke, Isukasia area

Sample No.	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$
248108 A	19.375	14.756	50.080
248108 B	20.120	14.844	51.465
248108 C	17.326	14.530	44.117
248108 E	20.055	14.848	51.905
248108 F	20.589	14.854	53.973
248108 G	19.275	14.740	50.079

The data have been corrected for mass fractionation during the measurement. Accuracies are in the order of 0.1 per cent.

Lead was extracted from the samples by the double electrodeposition method of Arden & Gale (1974), and measured on the fully automated VG Isomass 54E mass spectrometer at Oxford. The isochron fit has been calculated by the method of York (1969). The decay constants listed by Steiger & Jäger (1977) have been used in the age calculations, and ages from older publications have been recalculated using these new constants. All errors are quoted at the 2σ (95%) level of confidence. The results of the Pb-isotope measurements are given in Table 2 and plotted on the $^{207}Pb/^{204}Pb$ against $^{206}Pb/^{204}Pb$ diagram of figure 11A. For comparison the Rb-Sr isochron diagram is shown in figure 11B.

In the isochron diagram (fig. 11A) the Pb-isotope data define an isochron (MSWD 2.0) and give an age of 1740 ± 180 Ma. This is in agreement with the Rb-Sr whole-rock age of 1610 ± 130 Ma obtained earlier (Kalsbeek *et al.*, 1980).

It has been established (see Taylor *et al.*, 1980, and Moorbath *et al.*, 1981 for details) that the early Archaean gneisses from the Godthåbsfjord region and the late Archaean gneisses from a large part of the Archaean craton of West Greenland were formed from mantle-like sources with μ_1 ($^{238}U/^{204}Pb$) values of *c.* 7.5. If the granite dyke studied here had also been formed directly from such a source at *c.* 1750 Ma, the Pb-isotope data would plot along the line BC in figure 11A. In fact, the isochron is displaced towards considerably lower $^{207}Pb/^{204}Pb$ ratios, requiring either that the dyke was formed from a mantle-like source with very low μ_1 (6.3 ± 0.1), which we regard as highly unlikely, or that it incorporated less radiogenic ('retarded') lead from older rocks, in the same way as, for example, the late Archaean Qôrqut Granite (Moorbath *et al.*, 1981).

Pb-isotope data for a collection of early Archaean gneisses from the Isukasia area (Moorbath *et al.*, 1975) have also been plotted on figure 11A. The data points scatter along a 3740 Ma reference isochron (not shown in the diagram). The lead-isotope composition of these samples at the time of formation of the granite dyke, *c.* 1740 Ma ago, can be found by projecting the data points onto an isochron line for *c.* 3700 Ma rocks at 1740 Ma (line AB in fig. 11A) along lines with a slope corresponding to an age of 1740 Ma, and plot near the line segment DE in figure 11A. The isochron line for the dyke samples projects onto the line AB

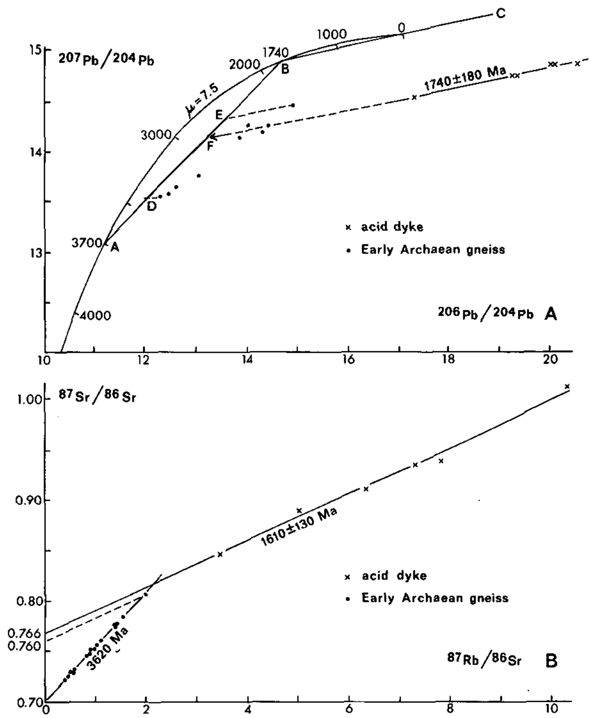

Fig. 11. Pb-Pb (A) and Rb-Sr (B) isochron diagrams for samples of the acid dyke (crosses) and gneisses (dots) from the Isukasia area. For further explanation see the text.

at point F, and lies well within the interval DE defining the Pb-isotope composition of the gneisses in the area at 1740 Ma. Therefore, the origin of the dyke by anatexis of early Archaean gneisses, with Pb-isotope ratios as those studied by Moorbath *et al.* (1975) is consistent with our data for the dyke samples.

The chemistry of the dyke, especially the high K_2O content (*c.* 5%; Kalsbeek *et al,* 1980) which is much higher than that of the early Archaean gneisses, indicates that the dyke is a product of partial melting. The high $^{206}Pb/^{204}Pb$ ratios of the dyke samples imply high U/Pb ratios for the dyke relative to the gneisses. This is consistent with an origin of the dyke by partial melting because part of the Pb would be retained in a plagioclase-rich residue whereas nearly all U would be taken up in the melt.

With regard to the Rb-Sr data (fig. 11B), the intital $^{87}Sr/^{86}Sr$ ratio (at 1610 ± 130 Ma) for the dyke samples is 0.766 ± 0.012, whereas none of the early Archaean gneiss samples from the Isukasia area on which Rb-Sr measurements have been done (Moorbath *et al.,* 1972, 1975) at that time had $^{87}Sr/^{86}Sr$ ratios higher than *c.* 0.76 (fig. 11B). The isochrons for the early Archaean gneisses and the dyke intersect at $^{87}Rb/^{86}Sr = 2.1$, requiring that, if the dyke was formed by anatexis of early Archaean gneisses, these had on average $^{87}Rb/^{86}Sr$ ratios of about 2.1, which is twice as high as the mean of published $^{87}Rb/^{86}Sr$ ratios. However, early Archaean white granite gneisses are now known to be abundant in the Isukasia area (Nutman, 1982) and many of these have significantly higher Rb/Sr ratios than those used in published isotopic studies (A. P. Nutman, personal communication, 1981). The granite dyke may thus have formed by anatexis of gneisses with higher Rb/Sr ratios than those studied by

Moorbath *et al.* (1972, 1975). Alternatively, more Rb-rich early Archaean supracrustals from the Isukasia area may have been involved in the formation of the granite dyke, but too little is known of the Rb-Sr and Pb-Pb systematics of these rocks to test this alternative quantitatively.

The cause of the Proterozoic thermal activity at *c.* 1600–1700 Ma in the Godthåbsfjord region is not clear. It seems that the dyke did not originate very deep in the crust because both the lead and the strontium incorporated during its formation had relatively radiogenic compositions. Early Archaean granulite facies gneisses, probably representing a deeper crustal level than the gneisses in the Isukasia area, have much lower $^{207}Pb/^{204}Pb$ and $^{87}Sr/^{86}Sr$ ratios than the gneiss material incorporated in the granite dyke (Griffin *et al.*, 1980). The only evidence of Proterozoic magmatic activity in this part of the Archaean craton is the presence of numerous basic dykes (MD's, see Bridgwater *et al.*, 1976, p. 68–71). Most of these dykes, however, are probably older than the acid dyke from the Isukasia area. Comparable dykes from the southern part of the craton have been dated at *c.* 2100 Ma (unpublished Rb-Sr data of the authors) and two dykes in the northern part of the craton have given Rb-Sr whole-rock isochron ages of 1950 ± 60 Ma (Kalsbeek *et al.*, 1978).

The occurrence of the acid dyke in the Isukasia area shows that Proterozoic thermal activity in Greenland was not restricted to the mobile belts north and south of the Archaean craton but that also in the centre of the craton such high temperatures were locally reached that anatexis could occur.

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Continuation of the mapping of Archaean rocks in the southern part of the Ivisârtoq map sheet

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Field work was resumed in the southern part of the Ivisârtoq map sheet in the 1982 field season. S.R. completed an area in Kangiussap nunâ and undertook special investigations including detailed sampling for isotope studies in selected areas in more northern parts. K.C. was joined by M.B. for mapping in Nunatarssuaq so that by the end of the field season more than three quarters of the southern part had been mapped and the work is well up to schedule (fig. 12).

The ground covered in 1982 presented problems similar to those of 1981, the main difficulty being that of assigning quartzo-feldspathic gneisses to one of the established groups. The well tried criteria have again proved to be fallible and our conviction that a large scale isotope programme is essential is strengthened. This programme is already in hand.

Amîtsoq gneisses

Gneisses believed to be of Amîtsoq affinity were reported from Kangiussap nunâ (Coe & Robertson 1982). Their extent to the north-east of the area is now known. In good coastal