N86-28557

Pb ISOTOPIC EVIDENCE FOR EARLY ARCHAEAN CRUST IN SOUTH GREENLAND.

Paul N. Taylor(*) & Feiko Kalsbeek(+).
* Department of Earth Sciences, University of Oxford, U.K.
+ The Geological Survey of Greenland (GGU), Øster Voldgade 10, Copenhagen, Denmark.

Early Archaean crust has been positively identified in the Godthaab district of West Greenland - the Amîtsoq gneisses, the Isua supracrustals, and the Akilia association - and on the other side of the Davis Straits in the Saglek area of Labrador - the Uivak gneisses etc.. These rock-units have all been directly sampled and dated by a variety of methods.

An indirect method of detecting unexposed ancient crust using Pb isotopic analyses of younger igneous rocks exposed at surface was pioneered by Moorbath & Welke (1) in their study of Tertiary basalts on Skye, N.W.Scotland. Ancient U-depleted Lewisian basement is recognizable as the source of very distinctive unradiogenic contaminant Pb in the basalts. The early Archaean Amîtsoq gneisses have a still more distinctive, less radiogenic Pb, and that characteristic has been employed in studies of the late Archaean gneisses of West Greenland - the Nûk gneisses of the Godthaab district, and their temporal equivalents in areas to the north and south of Godthaab - to test for the presence of Amîtsoq gneiss at depth (2). Contamination of late Archaean rocks with Amîtsoq-derived Pb has been detected as far south as Sermilik. The Nordland-Sukkertoppen granulites show no evidence of contamination with Amîtsoq-type Pb; nor do the quartzo-feldspathic gneisses at Majorqap Qava in the Fiskenaesset area - the southern limit of that study. Thus Sermilik was identified as the southern limit of inferred early Archaean crust in West Greenland, and the mouth of Godthaabsfjord as the north-western limit.

Over the last few years we have carried out a substantial programme of Pb isotope geochemistry on late Archaean and early Proterozoic rock-units in the southern part of the Archaean craton and the Ketilidian (Proterozoic) mobile belt belt. Table 1 presents age data and model μ_1 values for each of the rock-units studied. By comparison with the model μ_1 values for most other late Archaean - early Proterozoic rock -units, the model μ_1 values reported in table 1 are ubiquitously low, a characteristic feature of rock-units derived from, or contaminated by, ancient U-depleted crust in which Pb isotopic evolution has been severely retarded. Fig. 1 illustrates the variations in model μ_1 value with time predicted by Zartman & Doe 'Plumbotectonics' (3) for rock-units derived from their model lower crust, upper crust, mantle, and orogene sources. Note the very low [illegible] values for derivation of Pb from the lower crust d[illegible] late Archaean and early Proterozoic times. The low mo[illegible] values for even the oldest of the analysed rock-units [illegible] South Greenland - the gneisses around Ivigtut - imply t[illegible] this area has been the site for several episodes of reworking of older, U-depleted continental crust.

Table 1.

Locality	Rock-unit	Age (Ma.)	Model μ_1 value	
Ivigtut	Gneisses	3110±65	7.19	(6)
Kungmiut	Grey banded gn.	2985±115	7.47	(6)
Kungmiut	White orthogn.	2769±110	7.25	(6)
Vesterland	Gneisses	2784±53	7.21	([illegible])
Iviangiussat	Gneisses	2734±130	7.14	([illegible])
Tornarssuk	Gneisses	2791±70	6.90	(6)
Torssut	MD3 dolerite	ca. 2150 (*)	6.57 - 6.87	(4)
Ketilidian BZ	Kaerne granite	1775±25 (*)	7.19	(5)

(*) Age determined by Rb-Sr whole-rock isochron method.

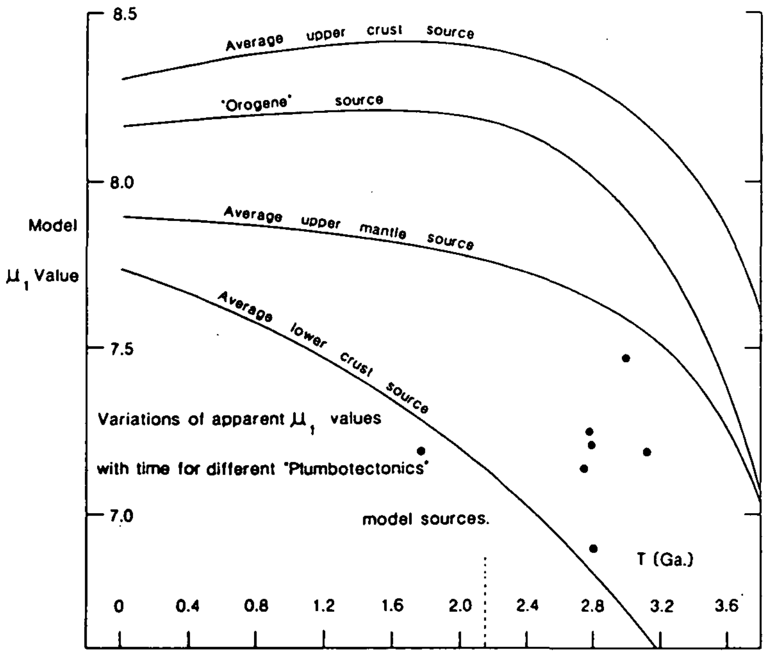

Fig.1. Plot of age & model μ_1 values for the South Greenland rock-units (Table 1.). Plumbotectonics sources (3) would give magmas with age & apparent μ characteristics specified by the four curves in the diagram.

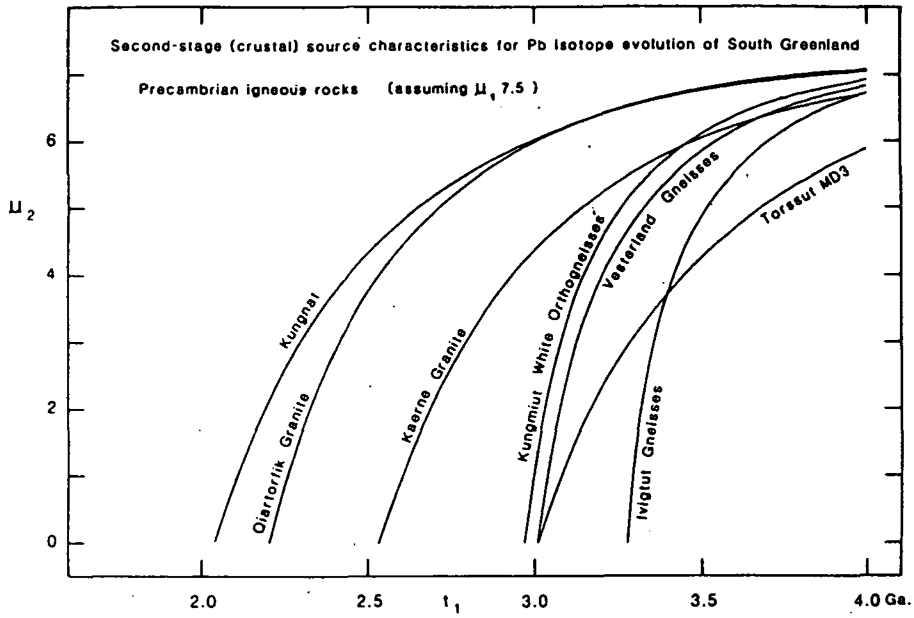

Fig.2. Possible age & μ characteristics of the source materials for South Greenland rock-units with low model μ_1 values.

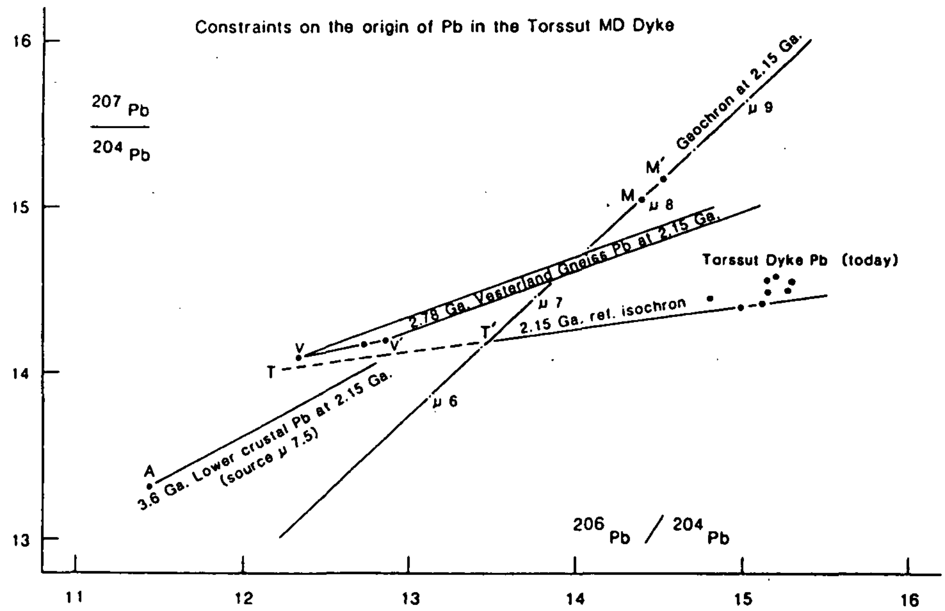

Fig.3. Pb isotope evolution diagram for the Torssut MD3 dolerite dyke, and its country rocks - Vesterland gneisses.

Fig. 2 illustrates possible two-stage model solutions for the isotopic evolution of the initial Pb of some of the South Greenland rock-units, assuming that the lowest viable first stage μ value would be ~7.5. This assumption yields minimum estimates for the age of the source of crustal Pb in the rock-units concerned. Thus the ~3110 Ma. Ivigtut gneisses must have a source of crustal Pb at least as old as ~3300 Ma., and the ~2150 Ma. Torssut MD3 dolerite dyke must have acquired its Pb from crust at least ~3000 Ma. old. In fact the source of crustal Pb in the Torssut dyke is likely to be significantly older than that minimum of ~3000 Ma. for two reasons:
(i) No continental crust suffers total U-depletion to give μ_2 values of 0 : finite μ_2 values require older source ages.
(ii) Since Torssut is a dolerite dyke, it inevitably has a juvenile (~2150 mA.) mantle-derived component of Pb : this requires that its source of crustal contaminant Pb must have $t_1 - \mu_2$ characteristics plotting below / to the right of the curve for Torssut in fig. 2. (4)
The country rock gneisses to the Torssut dyke had Pb already too radiogenic at ~2780 Ma. to provide the contaminant Pb required to account for the Torssut dyke compositions. This point is illustrated in fig. 3, in which it is also shown that Pb of a similar character to that of the Amîtsoq gneisses is a very plausible contaminant (4).
Despite extensive studies of gneisses from the southern part of the West Greenland craton, we have yet to discover any direct evidence for the presence of early Archaean rocks at the present surface. However, we consider that the Pb isotopic data discussed above is strong indirect evidence indicating the occurrence of early Archaean U-depleted crust at depth beneath southern West Greenland.

References.

(1) Moorbath,S. & Welke,H. (1969) Earth Planet. Sci. Lett. 5, 217-230.

(2) Taylor,P.N., Moorbath,S., Goodwin,R. & Petrykowski,A.C. (1980) Geochim. Cosmochim. Acta 44, 1437-1453.

(3) Zartman,R.E. & Doe,B.R. (1981) Tectonophys. 75, 135-162

(4) Kalsbeek,F. & Taylor,P.N. (1985) Contrib. Mineral. Petrol. 89, in press.

(5) Kalsbeek,F. & Taylor,P.N. (1985) Earth Planet. Sci. Lett. 73, in press.

(6) Taylor,P.N. & Kalsbeek,F. unpublished data.

This abstract is published with the kind permission of the Director of the Geological Survey of Greenland.