Isotopic age dating in Liverpool Land, East Greenland

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Abstract

In Liverpool Land in the eastern part of the Scoresby Sund region gneisses and migmatites were intruded by a number of intermediate plutonites and by younger granites. A number of K-Ar, Rb-Sr and U-Pb isotope age determinations indicate that:

1) the gneisses have a pre-Caledonian as well as a Caledonian history,

2) the migmatites were thoroughly reworked during the late part of the Caledonian orogeny, while

3) the plutonic rocks all seem to have been intruded during the Caledonian orogeny.

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During the summers of 1969 and 1971 detailed geological investigations were carried out in Liverpool Land in the course of systematic mapping of the Scoresby Sund region by the Geological Survey of Greenland (Coe & Cheeney, 1972; Henriksen & Higgins, 1976). The subsequent laboratory work included a programme of Rb-Sr isotope age dating studies, which led to ambiguous results (O. van Breemen, personal communication). This led to increasing emphasis on alternative methods of dating. A limited number of large samples had been collected from suitable rocks for the purpose of U-Pb age determinations on zircons, and this paper reports on the results obtained from the zircons and on some other geochronological studies of the Liverpool Land rocks.

Geological setting

In the Scoresby Sund region the crystalline core of the Caledonian fold belt crops out below younger sediments. Most of the fjord region exposes crystalline rocks influenced to a varying degree by the Caledonian orogeny. A large part of the eastern half of the region is, however, occupied by a major post-Caledonian sedimentary basin (the Jameson Land basin) containing Devonian to Lower Cretaceous non-metamorphosed rocks. Liverpool Land (and Canning Land to its north) represents a horst-like uplift of the crystalline basement at the east side of the Jameson Land basin; various lithological comparisons and correlations with the crystalline areas to the west have been proposed (Coe & Cheeney, 1972; Henriksen & Higgins, 1976; Bengaard, 1985; Henriksen, 1985). The present geochronological work is an attempt to clarify the lithological correlations.

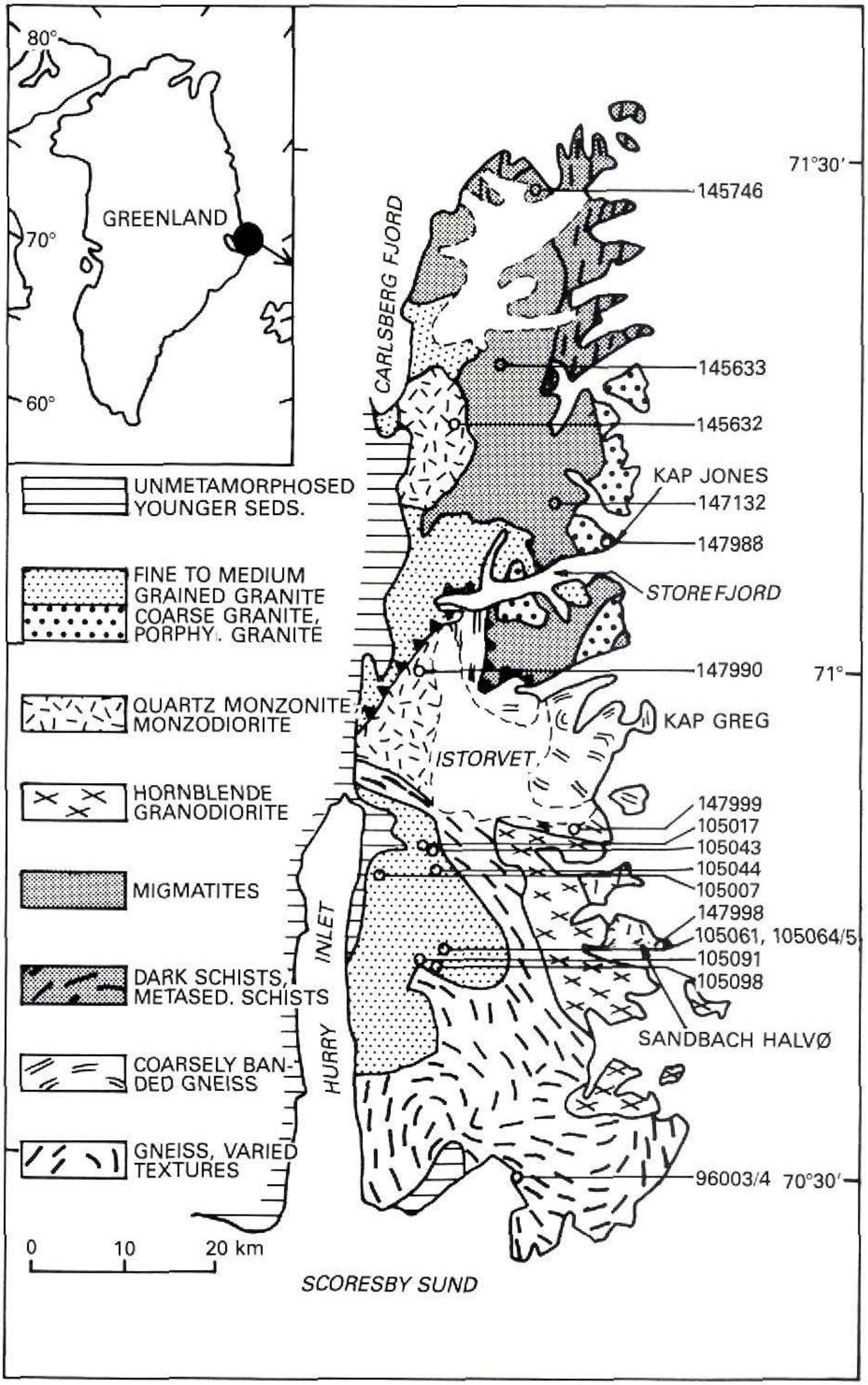

Fig. 1. Geological map of Liverpool Land showing the principal lithological units. Collection sites are indicated by sample numbers.

Analytical procedures

All the laboratory work (apart from the K-Ar determinations) was carried out at the Zentrallaboratorium für Geochronologie (ZLG) at the University of Münster, according to the methods described by Persson *et al.* (1983) for the U-Pb analyses, and Persson & Hansen (1982) for the Rb-Sr analyses. All ages quoted in this paper have been recalculated using the constants recommended by the IUGS subcommission on geochronology (Steiger & Jäger, 1977). Errors based on replicate analyses are 0.7% for $^{207}Pb/^{235}U$, and 0.4% for $^{206}Pb/^{238}U$ and $^{207}Pb/^{206}Pb$; for $^{87}Sr/^{86}Sr$ and $^{87}Rb/^{86}Sr$, errors of 0.05% and 1.5% respectively were assigned. Regression lines were calculated according to the least squares method of York (1969). Errors quoted in this paper are 2 σ of the means.

Liverpool Land gneiss complexes

The gneisses which occur in the southern two thirds of Liverpool Land are the oldest rock units exposed, and are intersected by abundant bodies of younger plutonic rocks. Two separate gneiss complexes are distinguished.

Southern complex of gneisses with variable textures

This gneiss complex has been described by Cheeney (1985) and is composed of a series of quartzofeldspathic gneisses (fig. 1). They include strongly sheared basic gneisses of presumed Lower Proterozoic age and an underlying inhomogeneous series of light-coloured gneisses with scattered inclusions of mafic and ultramafic rocks.

Samples 96003/4 (fig. 1, Table 1) were collected from a garnet amphibolite lens in the lower part of the gneiss series. The K-Ar age of 1134 ± 40 Ma was obtained on hornblende, and is interpreted as the time of the last major recrystallisation.

Sample 105043 (fig. 1, Table 1) represents the hornblende-biotite gneiss forming the country rock to the Hurry Inlet granite (described below); it has been described by Coe & Cheeney (1972) as a veined garnet-hornblende-biotite gneiss. The K-Ar age of 1193 ± 40 Ma is interpreted as the minimum age for the event forming this gneiss.

Table 1. K-Ar analytical data for hornblende from gneiss in Liverpool Land

GGU Sample No	Potassium Wt %	Radiogenic ^{40}Ar in 10^{-8} cc/g (STP)	Radiogenic ^{40}Ar / Total ^{40}Ar	Age in Ma
96003/4	0.268	1643	0.830	1134 ± 40
105043	0.1657	1088	0.857	1193 ± 40

Potassium analyses by atomic absorbtion (R. Heusser, ETH Zürich).
Argon analyses (U. Frick, ETH Zürich).

The northern complex of coarsely banded gneiss

This complex in central Liverpool Land has been described by Coe (1975) as having a general domal shape. The complex has tectonic contacts with the surrounding rocks; a Caledonian thrust cuts off the gneissic banding to the north, while to the south a thin, mylonitic garnet-quartz rich gneiss forms the boundary. Coe (1975) made a threefold division of the complex, of which the upper division is the mylonitic gneiss; the middle division comprises concordant amphibolites and paragneiss, heavily injected by granitic veins; the lower division is structurally complex, but of a more homogeneous composition than the middle division. The mylonitisation of the upper division is thought to be Middle Proterozoic (Bengaard, 1985).

Sample 147999 from the coarsely banded gneiss (fig. 1) is a typical representative of the middle division of the complex. The U-Pb data points for four of the zircon fractions (Table 2) define a discordia with a lower intercept at 446 $^{+42}_{-48}$ Ma (fig. 2). This age seems to reflect metamorphic overprinting during early Caledonian time, and is possibly related to the heavy injection of granitic veins. The data points all indicate the presence of older, inherited components in the zircons.

The upper intercept age of 1880 Ma is somewhat uncertain due to the long extrapolation, but the $^{207}Pb/^{206}Pb$ ages of all fractions are in the range of 1110 to 1170 Ma, which is interpreted as a minimum age for the gneiss formation.

Rb-Sr analyses were carried out on the same samples. The whole rock/biotite tie line (Table 3) corresponds to a Rb-Sr age as young as 372 ± 6 Ma, which may be related to late Caledonian veining.

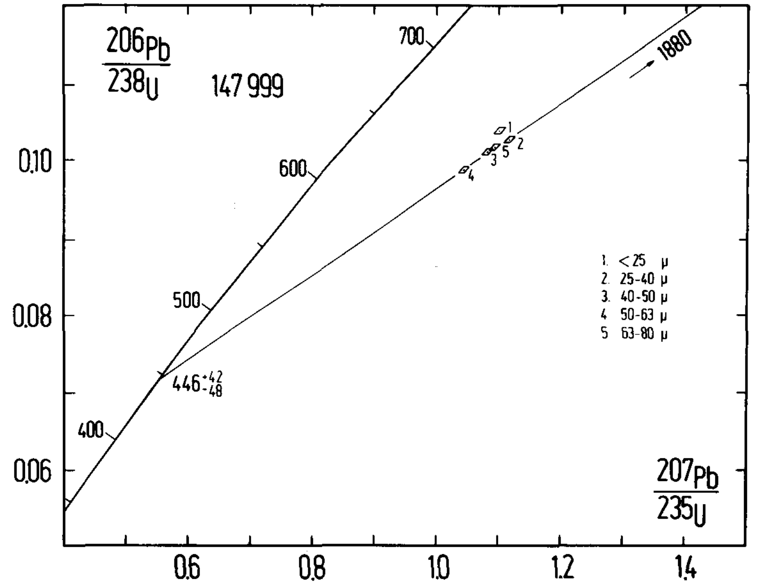

Fig. 2. Concordia plot of the analysed zircon fractions from sample 147999, the coarsely banded gneiss.

Table 2. U-Pb analytical data for crystalline rocks in Liverpool Land

GGU sample No & sieve fraction in μm*	g sample analysed	Observed atomic ratios			U ppm	Pb_{rad} ppm	$^{206}Pb_{rad}$ n mol/g	Atomic ratios corrected for blank† and common Pb		
		$\frac{^{208}Pb}{^{206}Pb}$	$\frac{^{207}Pb}{^{206}Pb}$	$\frac{^{206}Pb}{^{204}Pb}$				$\frac{^{206}Pb}{^{238}U}$	$\frac{^{207}Pb}{^{235}U}$	$\frac{^{207}Pb}{^{206}Pb}$
GGU 145632										
< 40 T	0.0115	0.198673	0.060592	2568	546	36.2	141.4	0.06215	0.47039	0.05490
63 – 80 Cl	0.0039	0.196351	0.063982	1654	392	27.1	106.6	0.06524	0.49604	0.05514
80 – 100 Cl	0.0070	0.192074	0.060876	2733	333	26.1	102.4	0.07379	0.57025	0.05605
> 100 Cl	0.0103	0.232008	0.062281	2163	387	26.9	102.5	0.06353	0.48864	0.05578
GGU 145633										
< 355 Cl	0.00015	0.347072	0.166025	131	478	26.7	116.1	0.05831	0.43291	0.05385
GGU 145746										
< 40 T	0.0013	0.174456	0.066660	1472	518	39.3	157.8	0.07280	0.56908	0.05669
40 – 63 Cl	0.0007	0.196473	0.075910	766	606	46.3	178.6	0.07353	0.57594	0.05681
63 – 80 Cl	0.0013	0.181036	0.071236	963	453	34.0	137.2	0.07261	0.56083	0.05602
80 – 100 Cl	0.0004	0.257728	0.107500	286	436	32.2	131.2	0.07213	0.56019	0.05632
100 – 125 Cl	0.0006	0.191757	0.081767	579	482	35.7	146.1	0.07265	0.56544	0.05645
GGU 147132										
< 40 T	0.0221	0.086161	0.071911	6092	738	65.5	277.9	0.08977	0.86097	0.06956
40 – 63 T	0.0101	0.081830	0.075750	7703	661	66.5	280.3	0.10164	1.0355	0.07389
63 – 100 T	0.0053	0.080104	0.078553	6553	812	88.0	370.8	0.10957	1.1539	0.07638
< 100 T	0.0121	0.074775	0.076139	5667	722	73.7	312.9	0.10393	1.0548	0.07362
GGU 147998										
< 25 T	0.0107	0.308220	0.065754	1661	266	20.8	75.0	0.06758	0.53083	0.05697
40 – 50 T	0.0154	0.302385	0.065975	1264	231	17.9	64.9	0.06726	0.51039	0.05504
63 – 80 T	0.0164	0.291505	0.065796	1299	242	18.7	68.5	0.06776	0.51004	0.05459
80 – 100 T	0.0257	0.288386	0.065591	1387	234	18.1	66.3	0.06796	0.51581	0.05505
125 – 200 T	0.0103	0.285344	0.067820	1279	226	17.3	63.6	0.06756	0.52538	0.05640
GGU 147999										
< 25 T	0.0095	0.115197	0.081101	3401	940	99.2	407.0	0.10380	1.1012	0.07695
25 – 40 T	0.0115	0.145118	0.094268	920	1012	105.9	433.3	0.10267	1.1155	0.07879
40 – 50 T	0.0114	0.114552	0.082399	2857	1036	106.3	436.6	0.10108	1.0796	0.07746
50 – 63 T	0.0109	0.120401	0.084040	1387	1043	104.4	429.4	0.09870	1.0420	0.07657
63 – 80 T	0.0039	0.141585	0.090779	1093	1016	105.6	430.9	0.10169	1.0917	0.07786
GGU 147988										
< 25 T	0.0071	0.143255	0.060881	2597	1255	80.6	329.8	0.06298	0.47980	0.05525
25 – 40 T	0.0142	0.142636	0.060583	2778	1321	84.9	347.1	0.06302	0.48073	0.05533
40 – 50 T	0.0089	0.147701	0.063120	1942	1325	81.6	334.0	0.06046	0.46346	0.05560
50 – 63 T	0.0113	0.149229	0.061764	2304	1319	84.6	345.4	0.06271	0.47926	0.05543
63 – 80 T	0.0038	0.166568	0.066251	1563	1235	79.8	322.1	0.06255	0.49089	0.05692
GGU 147990										
< 25 T	0.0065	0.319052	0.063724	1789	344	26.9	96.1	0.06705	0.51350	0.05555
40 – 50 T	0.0269	0.299130	0.060323	2890	329	25.6	92.5	0.06732	0.51306	0.05527
80 – 100 T	0.0057	0.304409	0.070390	939	289	22.1	80.7	0.06697	0.50656	0.05486

* T = Total fraction, Cl = Clear idiomorphic fraction.

† Composition of lead used for blank correction $^{206}Pb/^{204}Pb$ = 18.7, $^{207}Pb/^{204}Pb$ = 15.63, $^{208}Pb/^{204}Pb$ = 38.63.

The composition of common lead used for correction accords to the model of Stacey & Kramers (1975).

Migmatites and schists

The northern part of Liverpool Land is dominated by metasedimentary rocks in the north and extensive areas of migmatites in the central part (fig. 1).

Sample 145746 comes from the northern area of metasedimentary rocks, but represents a body of metamorphosed and foliated granodiorite. The sample has been dated by the U-Pb method on zircons. For the fractions coarser than 40 μ only clear idiomorphic grains were analysed, in order to date the last time of growth of new zircon grains, whereas the fraction finer than 40 μ is a total fraction (Table 2). All five data points plot nearly concordantly and indicate an age of 445 $^{+12}_{-18}$ Ma (fig. 3) for the last important metamorphic recrystallisation.

Due to the long extrapolation the upper intercept age of some 1200 Ma is poorly defined.

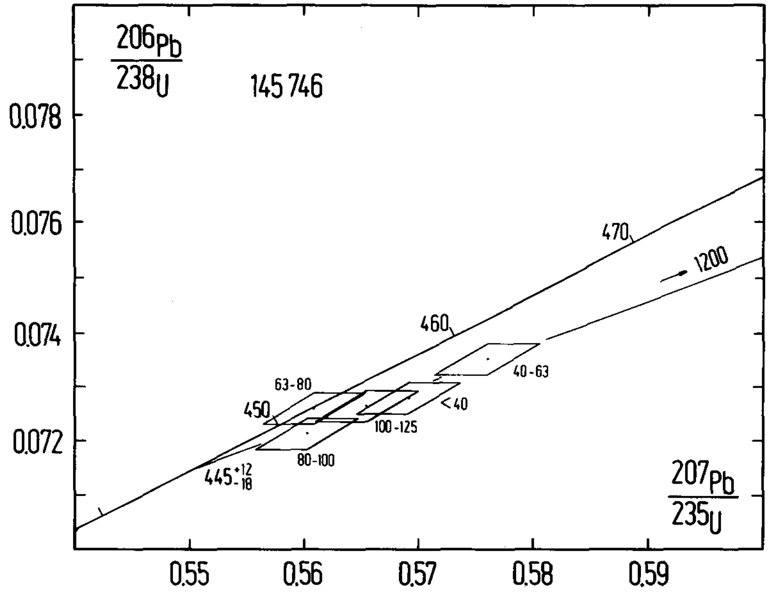

Fig. 3. Concordia plot of the analysed zircon fractions from sample 145746, a metagranodiorite from the migmatite area.

Sample 147132 is from an acid vein in the southern part of the extensive migmatite area (fig. 1). Five size fractions of zircons were analysed from this sample (fig. 4, Table 2). The data indicate that a considerable amount of inherited material is present with a minimum age of 1100 Ma. The inherited material is probably also responsible for the scatter of the data points around the best fit line. The lower intercept age of 396 $^{+16}_{-18}$ Ma is regarded as the time of formation of the vein.

Sample 145633 also comes from an acid vein in the migmatite area (fig. 1). One analysis of idiomorphic zircons was undertaken, and the data point (fig. 5, Table 2) shows a concordant age of only 365 ± 3 Ma.

Both samples from veins in the migmatite area give surprisingly young ages, but similar ages

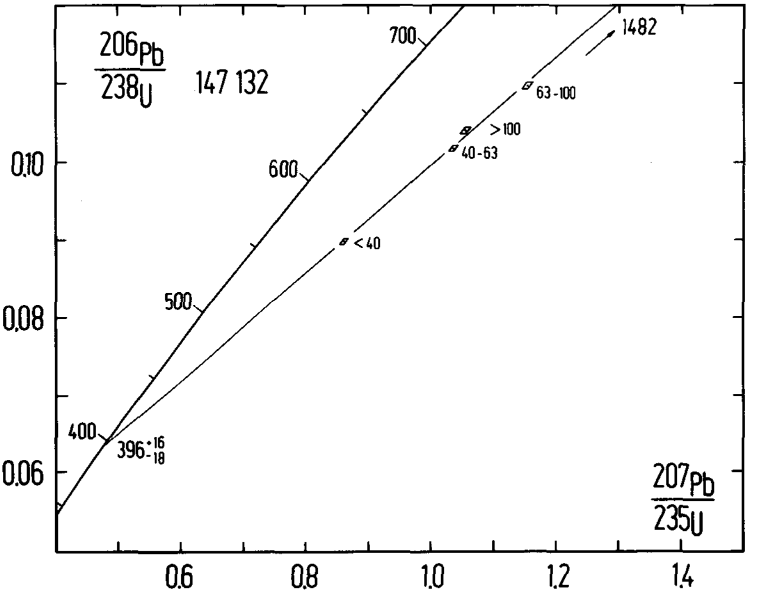

Fig. 4. Concordia plot of the analysed zircon fractions from sample 147132, an acid vein from the migmatite area.

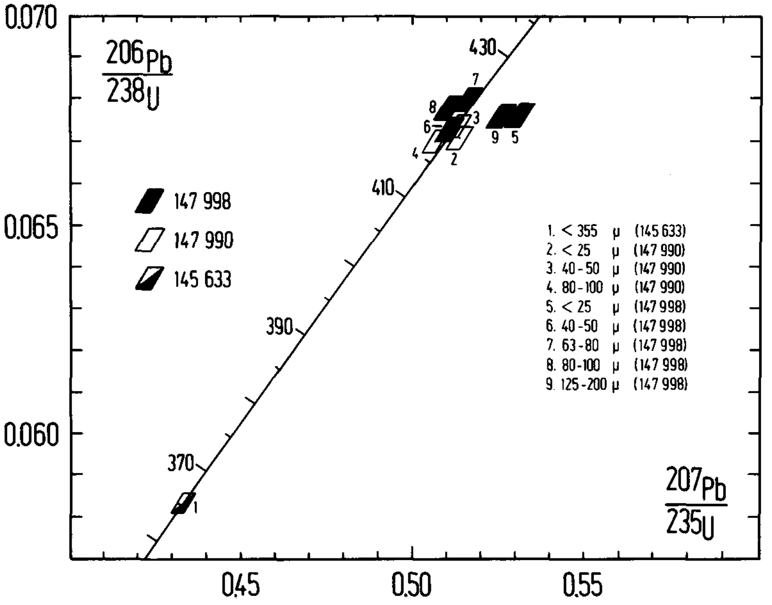

Fig. 5. Concordia plot of the analysed zircon fractions from sample 147998, the Sandbach Halvø hornblende-quartz monzonite; sample 147990, the Istorvet hornblende-quartz monzonite and sample 145633, an acid vein from the migmatite area.

have been reported from immediately west of the post-Caledonian sedimentary basin, namely from the youngest plutonic rocks and from veins in the migmatite (Hansen & Tembusch, 1979; Hansen *et al.*, 1987).

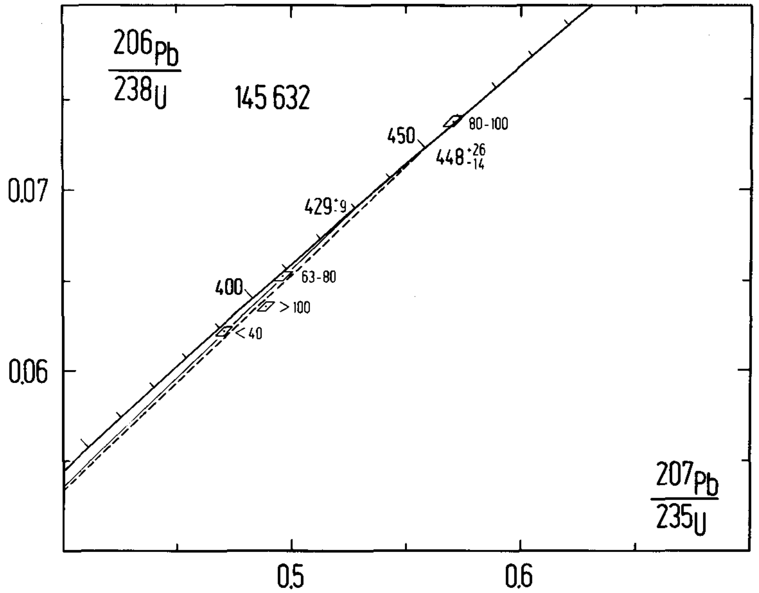

Fig. 6. Concordia plot of the analysed zircon fractions from sample 145632, the hornblende-biotite-quartz monzonite at Carlsberg Fjord.

Plutonic rocks in Liverpool Land

A suite of intrusions post-date the metamorphic rocks. Among the intrusive rocks quartz monzonites are thought to be older than a series of granites.

Quartz monzonites

Sample 147998 represents a massive hornblende-quartz monzonite body on Sandbach Halvø (fig. 1). It has a slight foliation parallel to the margin, and contains a few dioritic inclusions. Five fractions of zircons yielded a concordant Caledonian age of close to 420 Ma (fig. 5, Table 2). Rb-Sr analyses have been carried out on the same sample (Table 3), and a whole rock-biotite tie line age of 398 ± 9 Ma was obtained.

Sample 147990 is also derived from a massive hornblende-quartz monzonite situated just west of Istorvet. This slightly foliated rock cuts across the mylonitic gneiss to the south, but is cut by a Caledonian thrust to the north. Three fractions of zircon were analysed and gave a concordant U-Pb age close to 420 Ma, the same as sample 147998 (fig. 5, Table 2). Rb-Sr analyses were also undertaken on this sample, but the biotite from the sample is slightly chloritised, and some associated loss of radiogenic ^{87}Sr seems to have decreased the age to 357 ± 13 Ma (Table 3).

Sample 145632 comes from a hornblende-biotite-quartz monzonite east of the head of Carlsberg Fjord. The monzonite displays irregular contacts with the surrounding rocks. U-Pb isotope determinations were made on four zircon fractions, and these have a complicated plot pattern (fig. 6, Table 2). The points define a chord with an upper intercept of 448 $^{+26}_{-14}$ Ma, while the lower intercept lies close to zero, indicating a recent loss of lead and disturbance of the U-Pb system. Such patterns have previously been observed in plutonic rocks from Liverpool Land (Hansen & Friderichsen, unpublished). The presence of inherited material may be neglected in the two fine fractions, where an age of 429 ± 9 Ma is observed.

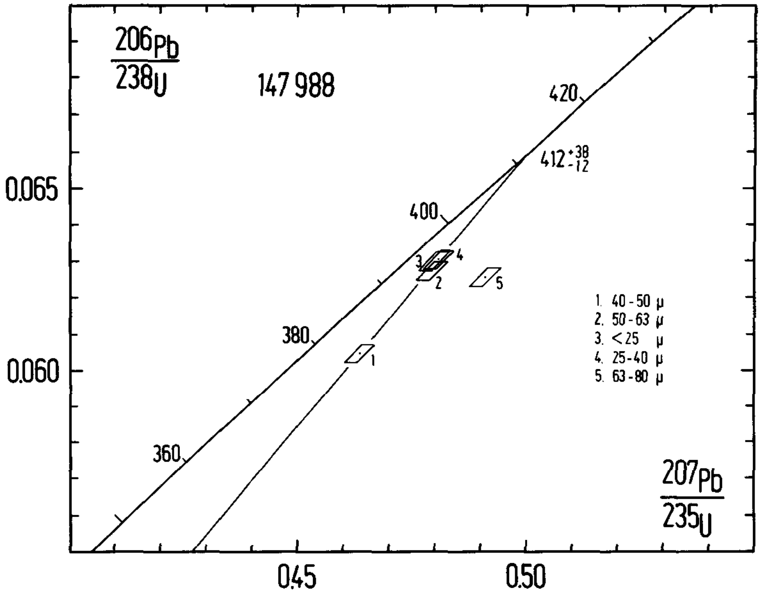

Fig. 7. Concordia plot of the analysed zircon fractions from sample 147988, the Kap Jones granite.

Granites

The intrusion of a suite of granite bodies marked the end of the plutonic regime in Liverpool Land. Field relationships indicate that they originated within a single plutonic episode.

The Kap Jones granite

Sample 147988 was collected at Kap Jones from the medium to coarse grained hornblende granite which contains numerous migmatite host rock inclusions. Feldspar phenocrysts are up to 10 cm long. U-Pb isotope analyses were carried out on five zircon fractions, of which four define a discordia with an upper intercept at 412 $^{+38}_{-12}$ Ma (fig. 7, Table 2). This age is interpreted as the time of intrusion. The fifth and coarsest fraction (63 to 80 μm) clearly reflects the presence of older inherited material. The slight discordance of all the data points can be referred to recent loss of lead. A Rb-Sr whole rock/biotite age determination gave 402 ± 5 Ma (Table 3).

Table 3. Rb-Sr analytical data from intrusive rocks in Liverpool Land

GGU Sample No	Type of sample*	Rb ppm	Sr ppm	^{86}Sr µmol/g	$\frac{^{87}Rb}{^{86}Sr}$	$\frac{^{87}Sr†}{^{86}Sr}$	Age Ma	$\frac{^{87}Sr}{^{86}Sr_0}$
105007	WR	93.6	1679	1.889	0.161	0.71084		
105017	WR	68.7	1360	1.531	0.146	0.71066		
105061	WR	114.4	453	0.5101	0.730	0.71407	438 ± 42	0.7096 ± 0.0003
105065	WR	125.2	489	0.5505	0.741	0.71470		
105098	WR	113.4	783	0.8811	0.419	0.71183		
105064	WR	102.3	594	0.6685	0.499	0.71248	425 ± 7	0.7095 ± 0.0005
105064	Bi	518.8	17.5	0.0186	90.49	1.2567		
105044	WR	101.7	434	0.4878	0.679	0.71248		
105091	WR	108.7	526	0.5917	0.598	0.71432		
147988	WR	135.3	715	0.8050	0.547	0.71036	402 ± 5	0.7072 ± 0.0005
147988	Bi	805.5	29.5	0.0317	82.7	1.1788		
147990	WR	51.0	1743	1.962	0.085	0.70790	357 ± 13	0.7075 ± 0.0004
147990	Bi	247.5	94.0	0.1055	7.64	0.74635		
147998	Wr	68.0	1605	1.807	0.122	0.70823	398 ± 9	0.7075 ± 0.0004
147998	Bi	290.0	44.3	0.0494	19.1	0.81585		
147999	WR	179.9	158.6	0.1773	3.31	0.78025	372 ± 6	0.7627 ± 0.0009
147999	Bi	1110.0	7.03	0.0060	601.0	3.9448		

* Bi = biotite, WR = whole rock

† $^{87}Sr/^{86}Sr$ normalized to $^{86}Sr/^{88}Sr$ of 0.1194

The Hurry Inlet granite

This is the largest intrusive rock body in Liverpool Land. The granite has been described by Kranck (1935) and Coe (1975) as a uniform, pink and medium grained biotite granite.

Sample 105064 (fig. 1) was subjected to Rb-Sr analyses on biotite reported by Hansen & Steiger (1971). They record a Rb-Sr biotite age of 434 Ma, for which the analytical data (previously unpublished) are presented in Table 3 in this paper.

Samples 105007, 105017, 105044, 105061, 105064, 105065, 105091 and 105098 (fig. 1) were employed in the present study for a number of additional Rb-Sr whole rock age determinations on different facies of the Hurry Inlet granite (fig. 8, Table 3). Of the eight samples analysed, two (samples 105044 and 105091) were omitted in the calculation of the best fit line. The isochron obtained (with MSWD: 0.99) gives an age of 438 ± 42 Ma for the intrusion of the Hurry Inlet granite. For the same granite Gleadow & Brooks (1979) obtained a fission track uplift age on sphene of 410 ± 10 Ma.

The omission of the two samples can be justified on geological reasons. Sample 105044 was taken from close to a thick unit of siliceous garnet-biotite gneiss, a major Proterozoic shear zone, regenerated in Caledonian time, which may have caused loss of radiogenic ^{87}Sr. Sample 105091 was taken from the boundary with the country rock, and the granite here contains thick sheets of a dark and relatively quartz-poor variety of hybrid granite. The position of the data point above the isochron (fig. 8) may therefore be related to contamination with the

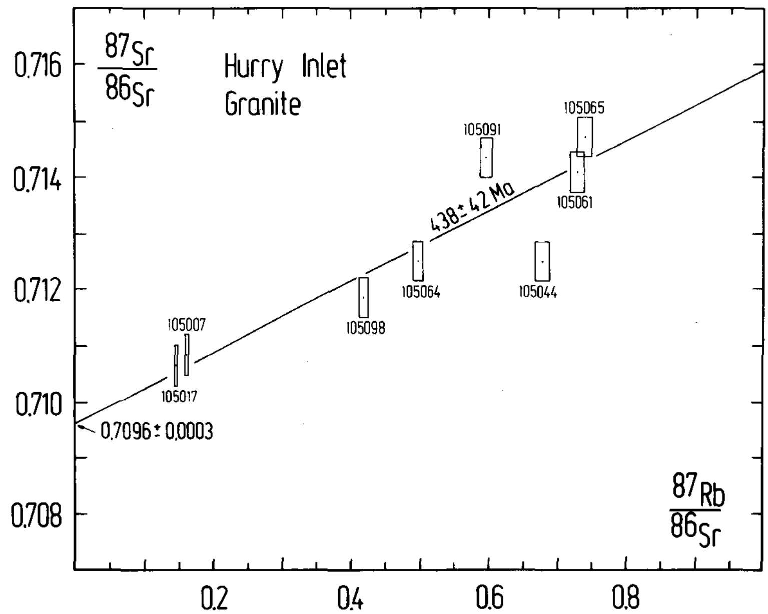

Fig. 8. Rb-Sr isochron diagram for the whole rock samples from the Hurry Inlet granite.

country rock. A whole rock – biotite tieline uplift age of 425 ± 7 Ma has been calculated for sample 105064 (Table 3).

Conclusions

This isotopic study demonstrates a distinct difference in the rocks of Liverpool Land, between a southern part dominated by gneissic host rocks and a northern part dominated by migmatites and schists; the two areas are separated by a Caledonian thrust. In the southern part there is K-Ar as well as U-Pb isotope evidence for Middle Proterozoic recrystallisation, whereas in the northern area ages are mainly Caledonian, and only inherited material in zircons of sample 147132 indicates the presence of pre-Caledonian rocks.

Adjacent to the western side of the post-Caledonian sedimentary basin there are extensive areas of migmatite which have suffered an intense Caledonian metamorphic overprint (Chadwick, 1975). The paragenesis sillimanite – K-feldspar with (Caledonian) cordierite in that area is also recorded in the northern area of migmatites in Liverpool Land. Caledonian low pressure granulite facies regional metamorphism seems to have affected the crystalline rocks on both sides of the Jameson Land basin in the Upper Ordovician.

The intrusive rocks all give Caledonian ages. The intrusive rocks occur on both sides of the thrust in Liverpool Land and are older than the thrusting. The monzonitic plutonites were emplaced as sheet like bodies and had a marginal foliation produced during their crystallisation; the granites were intruded slightly later, but both types of plutonites were formed within Silurian time (440 to 410 Ma).

The young ages obtained from veins from both sides of the thrust in Liverpool Land have their counterparts in the region immediately west of the Jameson Land basin; here Hansen *et* *al.* (1987) report similar ages from late veins. The thrusting in Liverpool Land may have occurred in the Lower Devonian about 400 Ma ago.

The uplift and cooling history of Liverpool Land seems to reflect generation of the granites relatively deep in the crust, such that cooling temperatures of some 350° C for the Rb-Sr system in biotites were reached some 10 to 20 Ma after their crystallisation. Cooling of the crystalline rocks to below 100° C took place as late as the Lower Jurassic, i.e. more than 200 Ma later (Gleadow & Brooks, 1979). New fission track dating by Hansen (1985) has confirmed the slow uplift of Liverpool Land; this may be compared to that of the crystalline rocks on the west side of the Jameson Land basin, where plutonic activity has been recorded as late as 370 Ma ago (Hansen & Tembusch, 1979; Hansen *et al.*, 1987).

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References

Bengaard, H.-J. 1985: Beskrivelse til et geologisk, et metamorft og et strukturelt kort i målestokken 1:1.000.000 over Østgrønland 70° – 82°N. Unpublished thesis, Copenhagen University, Denmark. 150 pp.

Chadwick, B. 1975: The structure of south Renland, Scoresby Sund – with special reference to the tectono-metamorphic evolution of a southern internal part of the Caledonides of East Greenland. *Bull. Grønlands geol. Unders.* **112,** 67 pp.

Cheeney, R. F. 1985: The plutonic igneous and high-grade metamorphic rocks of southern Liverpool Land, central East Greenland, part of a supposed Caledonian and Precambrian complex. *Rapp. Grønlands geol. Unders.* **123,** 39 pp.

Coe, K. 1975: The Hurry Inlet granite and related rocks of Liverpool Land. *Bull. Grønlands geol. Unders.* **115,** 34 pp.

Coe, K. & Cheeney, R. F. 1972: Preliminary results of mapping in Liverpool Land, East Greenland. *Rapp. Grønlands geol. Unders.* **48,** 7 – 20.

Gleadow, A. J. W. & Brooks, C. K. 1979: Fission track dating, thermal histories and tectonics of igneous intrusions in East Greenland. *Contr. Miner. Petrol.* **71,** 45 – 60.

Hansen, B. T. & Friderichsen, J. D. (unpublished): The influence of recent lead loss on the interpretation of disturbed U-Pb systems in zircons. Part I: Igneous rocks.

Hansen, B. T. & Steiger, R. H. 1971: The geochronology of the Scoresby Sund area. Progress report I: Rb/Sr mineral ages. *Rapp. Grønlands geol. Unders.* **37,** 55 – 57.

Hansen, B. T. & Tembusch, H. 1979: Rb-Sr isochron ages from east Milne Land, Scoresby Sund, East Greenland. *Rapp. Grønlands geol. Unders.* **95,** 96 – 101.

Hansen, B. T., Steiger, R. H., Henriksen, N. & Borchardt, B. 1987: U-Pb and Rb-Sr age determinations on Caledonian plutonic rocks in the central part of the Scoresby Sund region, East Greenland. *Rapp. Grønlands geol. Unders.* **134,** 5 – 18.

Hansen, K. 1985: Fission track age determinations of vertical movements in the crust caused by continental rifting: a fission track study of the Scoresby Sund area; method and results. Unpublished thesis, Copenhagen University, 119 pp.

Henriksen, N. 1985: The Caledonides of central East Greenland 70° – 76°N. *In* Gee, D. G. &

Sturt, B. A. (edit.) The Caledonide orogen - Scandinavia and related areas, 1095 – 1113. John Wiley & Sons.

Henriksen, N. & Higgins, A. K. 1976: East Greenland Caledonian fold belt. *In* Escher, A. & Watt, W. S. (edit.) *Geology of Greenland.* The Geological *Survey of Greenland,* 183 – 246.

Kranck, E. H. 1935: On the crystalline complex of Liverpool Land. *Meddr Grønland* **95**(7), 122 pp.

Persson, P. O. & Hansen, B. T. 1982: The Rb-Sr age of the Sundsta granite in the Western Pregothian tectonic mega-unit, south-western Sweden. *Geol. Fören. Stockh. Förh.* **104**, 17 – 21.

Persson, P. O., Wahlgren, C. H. & Hansen, B. T. 1983: U-Pb ages of Proterozoic metaplutonics in the gneiss complex of southern Wärmland, south-western Sweden. *Geol. Fören. Stockh. Förh.* **105**, 1 – 8.

Stacey, J. S. & Kramers, J. D. 1975: Approximation of terrestrial lead isotope evolution by a two-stage model. *Earth Planet. Sci. Lett.* **26**, 207 – 221.

Steiger, R. H. & Jäger, E. 1977: Subcommission on Geochronology. Convention on use of decay constants in geo- and cosmo-chronology. *Earth planet. Sci. Lett.* **36**, 359 – 362.

York, D. 1969: Least square fitting of a straight line with correlated errors. *Earth Planet. Sci. Lett.* **5**, 320 – 324.