$^{40}Ar/^{39}Ar$ mineral age constraints on the timing of deformation and metamorphism, North-East Greenland Caledonides

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$^{40}Ar/^{39}Ar$ mineral ages have been determined from basement gneisses and cover sequences exposed in the Caledonides of North-East Greenland. These range between *c.* 438 Ma and *c.* 370 Ma (Early Silurian – Middle Devonian). They are interpreted as dating cooling following polyphase Caledonian metamorphism which completely rejuvenated intracrystalline argon systems within the (early Proterozoic) basement gneisses. The $^{40}Ar/^{39}Ar$ results indicate that thrust-related regional deformation and metamorphism in North-East Greenland continued into the Early Devonian.

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Isotopic mineral ages from regional metamorphic rocks and syn- to post-kinematic igneous suites record ages of cooling through closure temperatures and provide valuable constraints on orogenic evolution (e.g. Purdy & Jäger, 1976; Jäger, 1979; Dempster, 1985; Dallmeyer *et al.*, 1992). Amphibole and muscovite from various lithologic units within the North-East Greenland Caledonides have been analysed using $^{40}Ar/^{39}Ar$ incremental-release dating techniques to provide constraints on the timing of tectonothermal events, and in particular to establish an upper limit for regional deformation and metamorphism. The $^{40}Ar/^{39}Ar$ dating technique is a refinement of the K-Ar method (Dalrymple & Lanphere, 1971). The reliability of K-Ar mineral ages obtained by conventional methods is difficult to assess, because such ages may result from partial isotopic disturbance or excess argon. The advantage of the $^{40}Ar/^{39}Ar$ technique is that progressive heating of a single sample evolves separate aliquots of argon which are dated independently. Assessment of the resultant age spectrum allows identification of contamination, partial isotopic rejuvenation and excess argon so that greater confidence may be placed on the interpretation of the data. This contribution is a shortened version of a paper published by the Geological Society of London (Dallmeyer *et al.*, 1994).

$^{40}Ar/^{39}Ar$ analytical methods

Mineral concentrates were wrapped in aluminium-foil packets, encapsulated in sealed quartz vials, and irradiated for 40 hours at the TRIGA Reactor at the U.S. Geological Survey, Denver. Variations in the flux of neutrons along the length of the irradiation assembly were monitored with several mineral standards, including MMhb-1 (Samson & Alexander, 1987). The samples were incrementally heated until fusion in a double-vacuum, resistance heated furnace following methods described by Dallmeyer & Gil Ibarguchi (1990). Measured isotopic ratios were corrected for total system blanks and the effects of mass discrimination. Interfering isotopes produced during irradiation were corrected using the factors reported by Dalrymple *et al.* (1981) for the TRIGA Reactor. Apparent $^{40}Ar/^{39}Ar$ ages were calculated from corrected isotopic ratios using the decay constants and isotopic abundance ratios listed by Steiger & Jäger (1977) following the methods described in Dallmeyer & Keppie (1987).

Intralaboratory uncertainties have been calculated by statistical propagation of uncertainties associated with measurement of each isotopic ratio (at two standard deviations of the mean) through the age equation. Interlaboratory uncertainties are *c.* ± 1.25–1.50% of the quoted age. Total-gas ages have been computed for each sample by appropriate weighting of the age and percent ^{39}Ar released within each temperature increment. A 'plateau' is considered to be defined if the ages recorded by two or more contiguous gas fractions (with similar apparent K/Ca ratios) each representing > 4% of the total ^{39}Ar evolved (and together constituting > 50% of the total quantity of ^{39}Ar evolved) are mutually similar within a ± 1% interlaboratory uncertainty. Analysis of the MMhb-1 monitor indicates that apparent K/Ca ratios may be calculated through the relationship 0.518 (± 0.005) × $(^{39}Ar/^{37}Ar)_{corrected}$. Regression techniques followed the

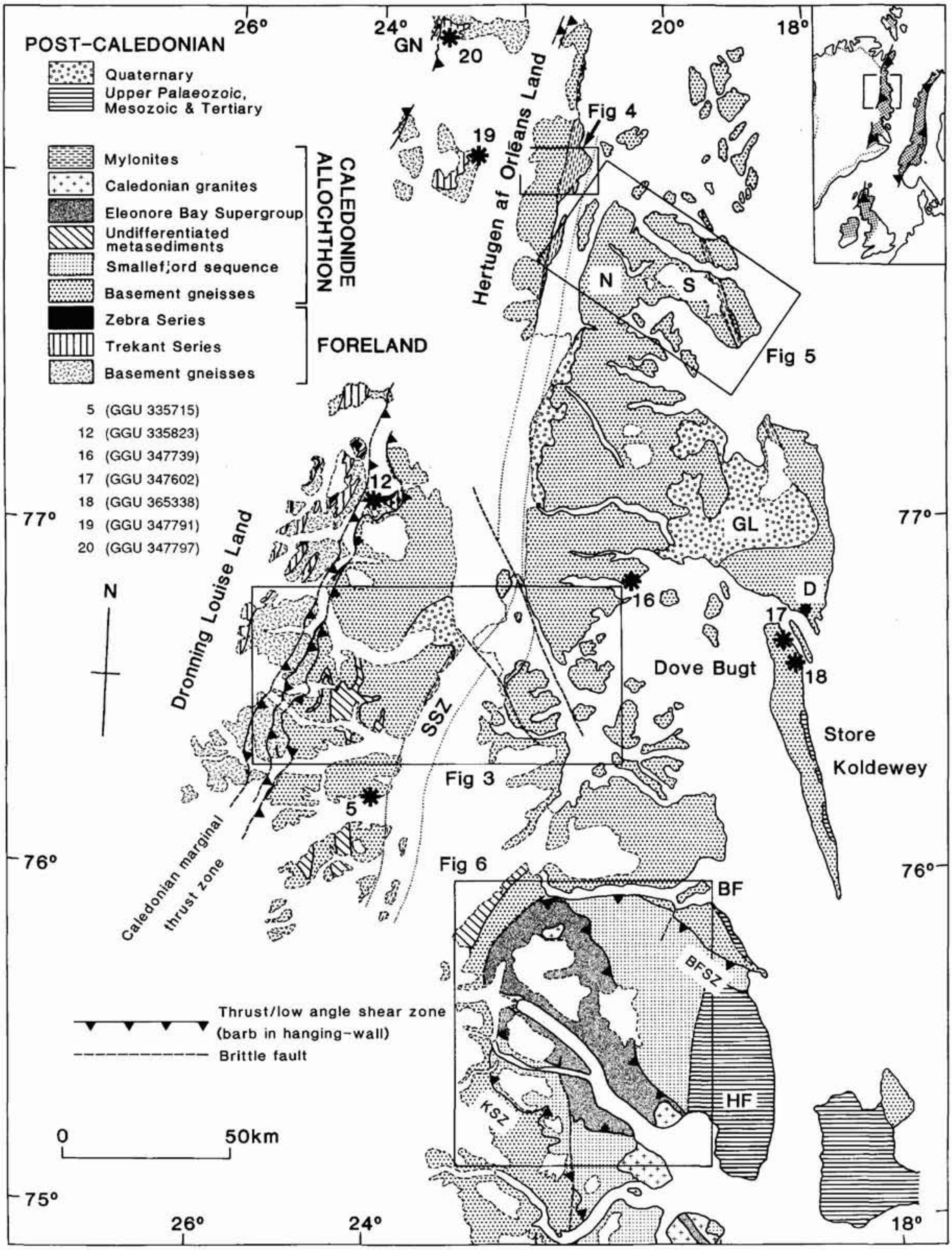

Fig. 1. Geological map of North-East Greenland (75°–78°30'N) (from Dallmeyer *et al.*, 1994). Inset indicates relative positions of East Greenland (Laurentia) and Scandinavia (Baltica) in a pre-drift reconstruction. Numbers identify $^{40}Ar/^{39}Ar$ sample localities. GN, Garde Nunatak; N, Nordmarken; S, Stormlandet; GL, Germania Land; D, Danmarkshavn; SSZ, Storstrømmen shear zone; BF, Bessel Fjord; HF, Hochstetter Forland; BFSZ, Bessel Fjord shear zone; KSZ, Kildedalen shear zone. Areas of Figures 3–6 are outlined.

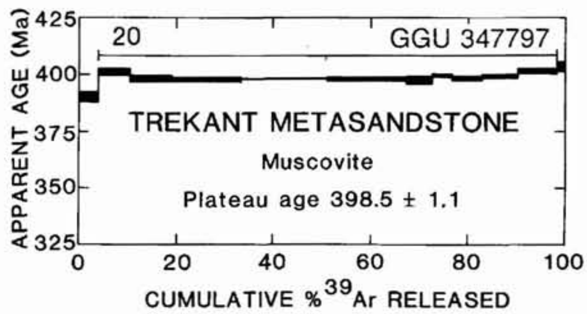

Fig. 2. $^{40}Ar/^{39}Ar$ apparent age spectrum of a muscovite concentrate from cleaved Trekant metasandstone within the Caledonian thrust zone exposed at Garde Nunatak (location shown in Fig. 1) (from Dallmeyer *et al.*, 1994). Analytical uncertainties (two sigma, intralaboratory) are represented by vertical width of bars. Experimental temperatures increase from left to right. Plateau increments delineated by bar.

methods of York (1969). A mean square of the weighted deviates (MSWD) has been used to evaluate isotopic correlations. The full list of $^{40}Ar/^{39}Ar$ analytical data is available as Supplementary Publication No SUP 18089 (41 pp.) from the British Library Document Supply Centre, Boston Spa, Wetherby, W. Yorks, LS23 7BQ, U.K., and the Geological Society of London Library.

$^{40}Ar/^{39}Ar$ results

$^{40}Ar/^{39}Ar$ incremental release ages have been determined for forty-one hornblende and twenty-four muscovite concentrates from metamorphic and igneous rock units exposed in the region 75°–78°N. Sample locations are indicated in Figs 1, 3–6. Geologically significant results are displayed as age spectra in Figs 2–7. Most of the hornblende concentrates display slightly discordant $^{40}Ar/^{39}Ar$ age spectra in which variable apparent ages are

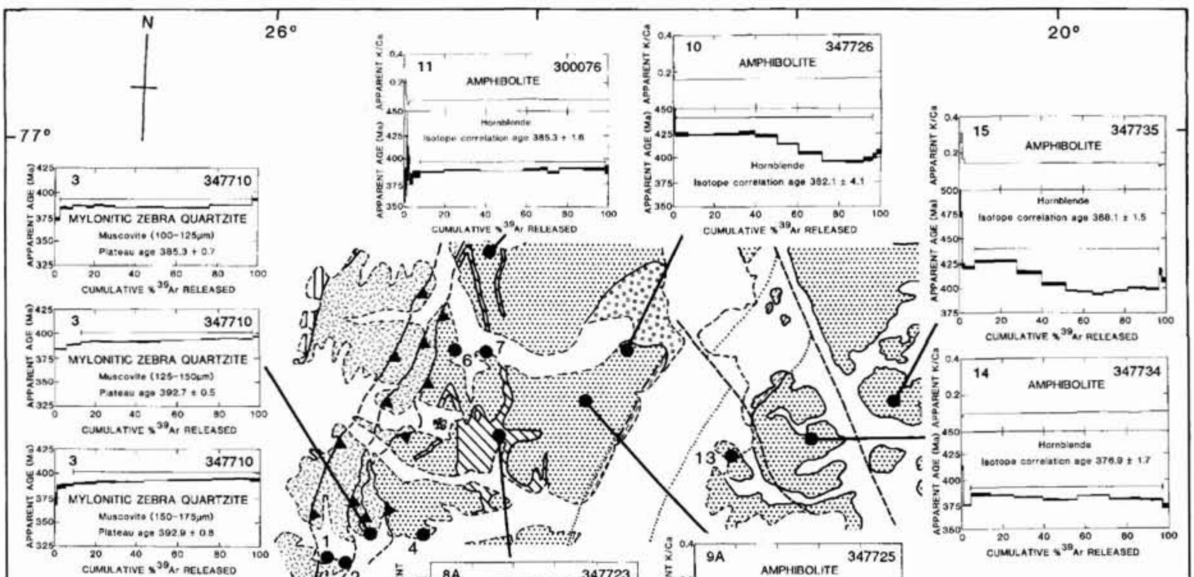

Fig. 3. $^{40}Ar/^{39}Ar$ apparent age and apparent K/Ca spectra of hornblende and muscovite concentrates from various lithological units exposed in central Dronning Louise Land and western Dove Bugt (from Dallmeyer *et al.*, 1994). Data plotted as in Figure 2. Bold numbers identify localities which did not yield meaningful hornblende plateau or isotope correlation ages.

recorded at low experimental temperatures. These are matched by variations in apparent K/Ca ratios, which suggest experimental evolution of argon at low temperatures from compositionally distinct and relatively nonretentive phases. These could be represented by: (1) very minor, optically undetectable, mineralogical contaminants in the concentrates; (2) petrographically unresolvable exsolution or compositional zoning; or (3) intracrystalline inclusions. In general, most gas fractions evolved from hornblende concentrates at intermediate and high experimental temperatures were characterised by similar intrasample apparent K/Ca ratios. These suggest that experimental evolution of gas occurred from compositionally uniform populations of intracrystalline sites. Apparent K/Ca ratios for the twenty-four muscovite concentrates are very large and show no significant or systematic variations in any of the $^{40}Ar/^{39}Ar$ analyses. Therefore they are not included with the age spectra displayed in Figs 2–7. Radiogenic yields obtained from muscovite analyses were all in excess of 99.9%, therefore precluding the necessity to calculate isotope correlation ages.

Foreland and thrust zone

Muscovite concentrated from cleaved Trekant Series metasandstone (sample 20) collected within the foreland at Garde Nunatak (Fig. 1) records a plateau age of *c.* 399 Ma (Fig. 2). Concentrates of three size fractions of muscovite were also separated from mylonitic quartzite (sample 3, Zebra Series protolith) collected within the Caledonian thrust zone in Dronning Louise Land (Fig. 3). These record plateau ages ranging between *c.* 393 Ma and *c.* 385 Ma (Fig. 3). These ages are interpreted as dating the last cooling through temperatures required for intracrystalline retention of argon following ductile deformation within the foreland and the thrust zone. Although not experimentally calibrated in detail, using the preliminary data of Robbins (1972) in the diffusion equations of Dodson (1973) suggests muscovite closure temperatures of *c.* 375° ± 25°C.

Basement and cover, eastern Dronning Louise Land and Hertugen af Orléans Land

Samples of banded amphibolite (8A) and garnet-muscovite-biotite schist (8B), probably correlative with the Trekant Series, were collected within a synclinal infold in basement gneisses in eastern Dronning Louise Land (Fig. 3). The amphibolite may represent a metamorphosed mafic volcanic horizon within the cover succession. A hornblende concentrate from the amphibolite displays an internally discordant spectrum (Fig. 3); however, increments evolved at intermediate and high experimental temperatures record similar apparent ages which define a plateau of *c.* 395 Ma. $^{36}Ar/^{40}Ar$ *vs.* $^{39}Ar/^{40}Ar$ isotope correlation of the plateau data are well-defined (MSWD = 0.15), and correspond to an inverse ordinate intercept ($^{40}Ar/^{36}Ar$ ratio) of *c.* 1900. This is markedly larger than the $^{40}Ar/^{36}Ar$ ratio in the present-day atmosphere, and suggests significant intracrystalline contamination with extraneous ('excess') argon components. Use of the inverse ordinate intercept ($^{40}Ar/^{39}Ar$ ratio) in the age equation results in a plateau isotope correlation age of *c.*390 Ma. Because calculation of isotope correlation ages do not require assumptions of $^{40}Ar/^{36}Ar$ ratios, they are considered more reliable than ages which are directly calculated from the analytical data. The *c.* 390 Ma age is therefore considered geologically significant, and is interpreted as dating the last cooling through temperatures required for intracrystalline argon retention in constituent hornblende grains (*c.* 500° ± 25°C; Harrison, 1981). Muscovite from the schist (8B) records a plateau age of *c.* 381 Ma.

Hornblende concentrates were prepared from eight samples of variably foliated, discordant amphibolites within reworked basement gneisses exposed in eastern Dronning Louise Land. These are thought to represent metamorphosed equivalents of the Midsommersø Dolerites. Samples were collected both within (1, 2 and 12) and outside (4–7 and 11) of the Caledonian thrust zone (Figs 1, 3). The concentrate from sample 11 is characterised by an intermediate- and high-temperature plateau age of *c.* 388 Ma (Fig. 3). Isotope correlation of the plateau data corresponds to a younger age of *c.* 385 Ma. The remaining seven samples display variably discordant spectra with total-gas ages ranging between *c.* 1722 Ma (12) and 464 Ma (5). Meaningful isotope correlations are not defined by any combinations of the analytical data, and the spectra are interpreted to reflect the results of complex intracrystalline contamination with variable extraneous argon components. No geologic significance is attached to any of the total-gas ages recorded by hornblende from these seven samples.

Hornblende concentrates were prepared from amphibolite and gneiss samples collected within various basement gneisses exposed in eastern Dronning Louise Land (9A and 10) and Hertugen af Orléans Land (19, 21 and 22). That from sample 22 displays an age spectrum in which intermediate- and high-temperature increments correspond to a plateau of *c.* 444 Ma (Fig. 4). Isotope correlation of these data yields a slightly younger age of *c.* 438 Ma. Concentrates from samples 9A, 10 and 21 are characterised by discordant spectra in which apparent ages systematically decrease throughout intermediate- and high-temperature increments (Figs 3, 4). For samples 9A, 10 and 21 these increments yield well-defined isotope correlation ages which range between *c.* 403 Ma (21) and 380 Ma (9A). No meaningful isotope correlation was defined in the analysis of sample 19. A muscovite concentrate prepared from a sample of paragneiss (9B) records a *c.* 373 Ma plateau age (Fig. 3).

Storstrømmen shear zone

Hornblende and muscovite concentrates were prepared from various mylonitic rock units exposed within and adjacent to the Storstrømmen shear zone in Hertugen af Orléans Land (Fig. 4). Hornblende concentrates from samples of mylonitic amphibolite (24A and 28A) and gneiss (27A and 30) all display internally discordant release spectra as a result of complex intracrystalline contamination with extraneous argon components. Total-gas ages range between *c.* 964 Ma (28A) and *c.* 524 Ma (27A). No meaningful isotope correlations are defined by any combinations of the data; therefore no geologic significance is attributed to any of the total gas ages.

Muscovite concentrates were prepared from seven samples (23, 24B, 25, 26, 27B, 29 and 31) of variably mylonitic granite, gneiss and felsic pegmatite. In addition, muscovite was separated from mylonitic metagabbro at location 28B. Muscovite from the metagabbro recorded a plateau age of *c.* 415 Ma (Fig. 4). The other seven muscovite concentrates yielded distinctly younger plateau ages ranging between *c.* 382 Ma (mylonitic gneiss, location 29) and *c.* 370 Ma (mylonitic pegmatite, location 27B) (Fig. 4).

Basement east of the Storstrømmen shear zone

Hornblende was separated from fourteen samples of amphibolite and basement gneiss exposed in Dove Bugt (13–17) and Nordmarken (32–38) (Figs 1, 3, 5). In addition, hornblende concentrates were prepared from two samples (39 and 49) of foliated metagabbro collected in eastern Stormlandet (Fig. 5). Concentrates from four samples of amphibolite and gneiss (14, 35, 36 and 38) were characterised by intermediate- and high-temperature age plateaux (Figs 3–5). Isotope correlation of the

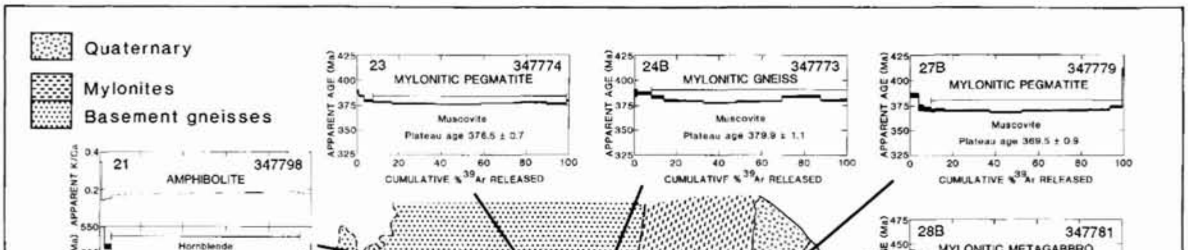

Fig. 4. $^{40}Ar/^{39}Ar$ apparent age and apparent K/Ca spectra of hornblende and muscovite concentrates from various lithological units exposed in eastern Hertugen af Orléans Land (from Dallmeyer *et al.*, 1994). Data plotted as in Figure 2. SSZ, Storstrømmen shear zone.

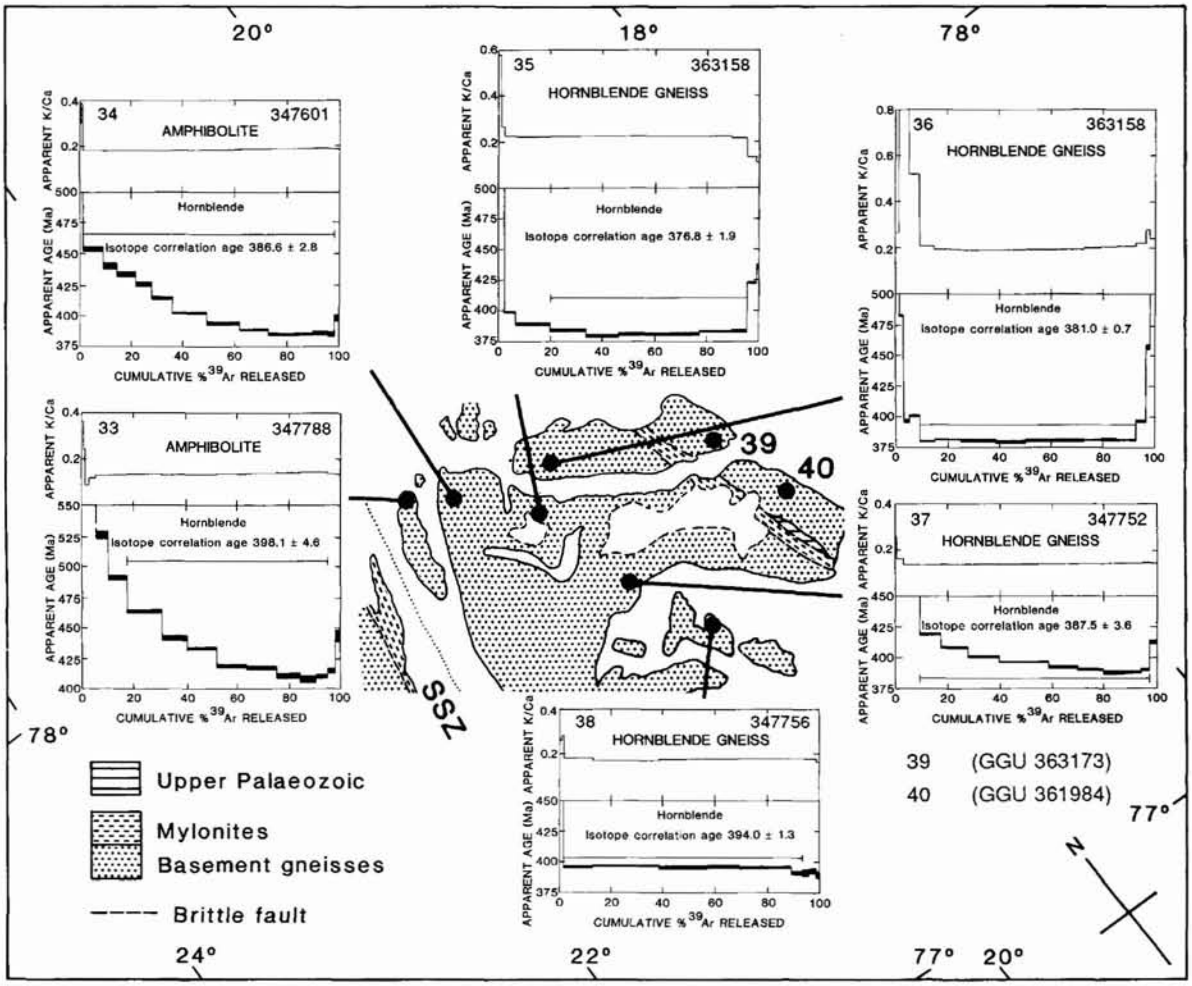

Fig. 5. $^{40}Ar/^{39}Ar$ apparent age and apparent K/Ca spectra of hornblende concentrates from various lithological units exposed in Nordmarken and Stormlandet (from Dallmeyer *et al.*, 1994). Data plotted as in Figure 2. SSZ, Storstrømmen shear zone.

plateau data yields slightly younger ages which range between *c.* 394 Ma (38) and 377 Ma (14). Hornblende concentrates from five samples of amphibolite and gneiss (15, 32, 33, 34 and 37) display internally discordant spectra in which apparent ages systematically decrease throughout intermediate- and high-temperature portions of the analyses (Figs 3–5). Isotope correlation ages range between *c.* 398 Ma (33) and *c.* 385 Ma (32), and are considered geologically meaningful. The release spectra displayed by hornblende concentrates from three amphibolite samples (13, 16 and 17; Figs 1, 3) and the two metagabbro samples (39 and 40; Fig. 5) are internally discordant and yield no meaningful isotope correlations.

Hornblende was separated from six samples collected within basement units exposed south of Bessel Fjord (Fig. 6). These included amphibolite or orthogneiss (41, 51, 53 and 54) and paragneiss (42 and 47). Hornblende concentrates from samples 41 and 54 are characterised by internally discordant $^{40}Ar/^{39}Ar$ spectra in which apparent ages systematically decrease throughout intermediate- and high-temperature segments of each analysis (Fig. 6). Isotope correlations are well-defined by these data in both samples, and yield geologically significant ages of *c.* 379 Ma (41) and *c.* 392 Ma (54). Hornblende concentrates from the remaining four samples display internally discordant age spectra, and no geologically meaningful results are defined by these data.

Muscovite-bearing lithologies are only locally exposed within basement rocks east of the Storstrømmen shear zone. Muscovite from a late-tectonic felsic pegmatite (sample 18) collected on Store Koldewey (Fig. 1) records a plateau age of *c.* 314 Ma (Fig. 7). The pegmatite post-dates penetrative ductile deformation within host gneisses, and locally displays a cataclastic overprint in brittle deformation zones. The age is interpreted to date post-magmatic cooling of the pegmatite.

Smallefjord sequence

A hornblende concentrate was prepared from amphibolite (52) collected within the Smallefjord sequence (Fig. 6). This records an intermediate- to high-temperature plateau corresponding to an age of *c.* 432 Ma (Fig. 6). Isotope correlation of the plateau data yields an age of *c.* 426 Ma. Hornblende from another amphibolite (55A) displays an internally complex release spectrum as a result of multicomponent contamination with extraneous argon. Muscovite from a felsic gneiss (55B) records a *c.* 401 Ma plateau age (Fig. 6).

Eleonore Bay Supergroup

Muscovite concentrates separated from garnet-bearing schists (45 and 48) exposed within lower parts of the Eleonore Bay Supergroup (Nathorst Land Group, Sønderholm & Tirsgaard, 1993) record plateau ages of *c.* 415 Ma (45) and *c.* 400 Ma (48) (Fig. 6).

Caledonian granites and pegmatites

Muscovite concentrates prepared from the post-kinematic Bredefjord (44) and Knæksø (46) granites which intrude the Eleonore Bay Supergroup (Fig. 6) record plateau ages of *c.* 411 Ma (44) and *c.* 423 Ma (46). These ages are interpreted to date post-magmatic cooling of the intrusions.

Muscovite separated from an undeformed granite sheet which intrudes the Smallefjord sequence (55C) records a

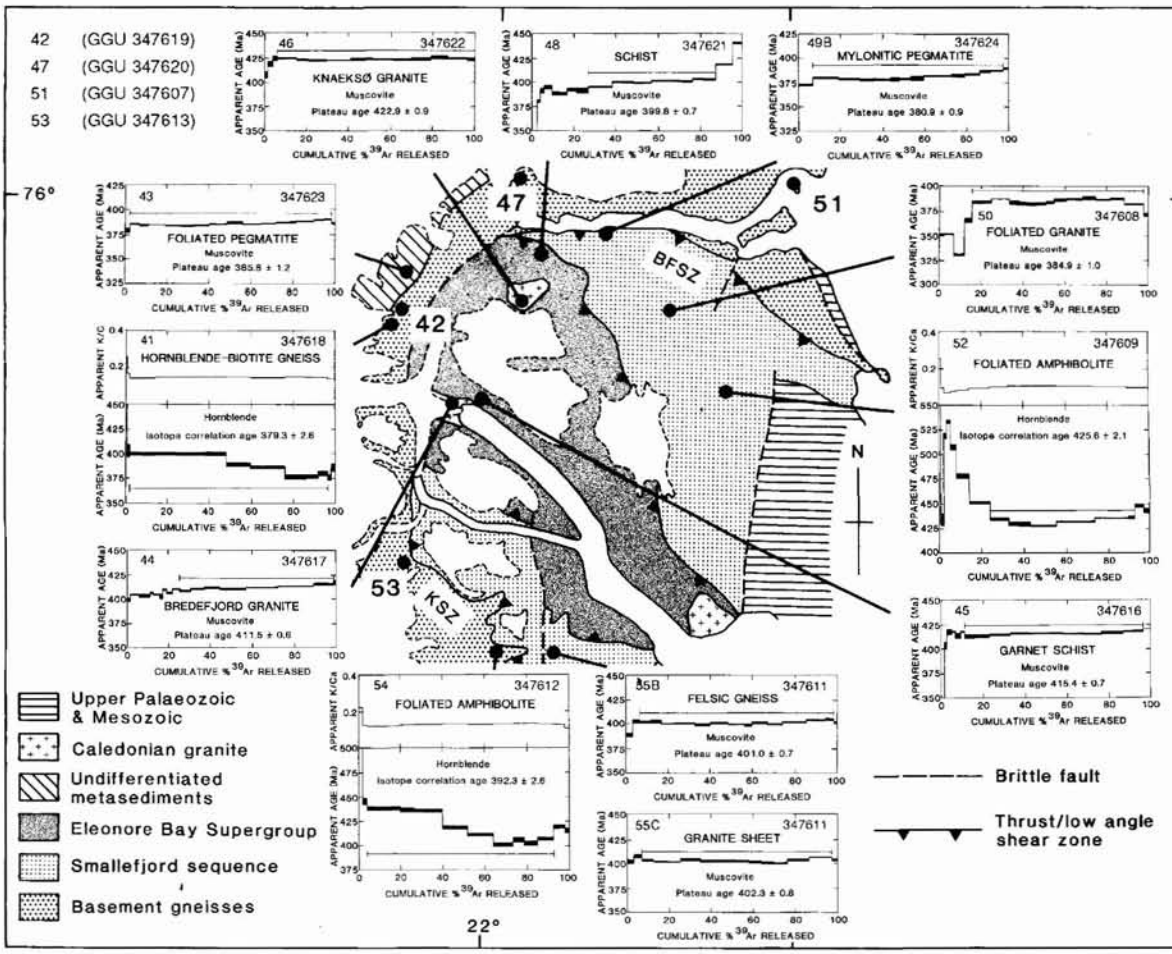

Fig. 6. $^{40}Ar/^{39}Ar$ apparent age and apparent K/Ca spectra of hornblende and muscovite concentrates from various lithological units exposed south of Bessel Fjord (from Dallmeyer *et al.*, 1994). Data plotted as in Figure 2. BFSZ, Bessel Fjord shear zone; KSZ, Kildedalen shear zone.

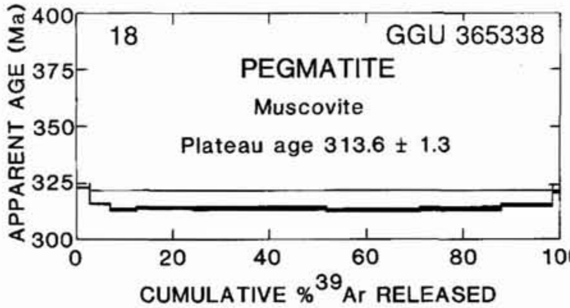

Fig. 7. $^{40}Ar/^{39}Ar$ apparent age spectrum of a muscovite concentrate from a late-tectonic, felsic pegmatite within basement gneisses exposed on Store Koldewey (location shown in Figure 1) (from Dallmeyer *et al.*, 1994). Data plotted as in Figure 2.

c. 402 Ma plateau age (Fig. 6). In contrast, muscovite separated from a pre- to syn-tectonic foliated granite (50) which intrudes the Smallefjord sequence records a younger plateau age of *c.* 385 Ma (Fig. 6). Muscovite separated from a felsic pegmatite (43) which intrudes metasedimentary rocks of unknown affinities west of Bessel Fjord (Fig. 6) also records a *c.* 386 Ma plateau age (Fig. 6).

Bessel Fjord shear zone

Mylonitic amphibolite (49A) and mylonitic felsic pegmatite (49B) were collected within the Bessel Fjord shear zone (Fig. 6). Hornblende from the amphibolite is characterised by an internally complex $^{40}Ar/^{39}Ar$ release spectrum which yields no meaningful geologic results. Muscovite from the deformed pegmatite records a *c.* 381 Ma plateau age (Fig. 6).

Geological significance

$^{40}Ar/^{39}Ar$ mineral cooling ages range between *c.* 438 Ma and *c.* 370 Ma (late Ordovician – middle Devonian). Caledonian metamorphism was sufficient to effect complete rejuvenation of hornblende intracrystalline argon systems within the (early Proterozoic) basement gneisses. Evaluation of the significance of these ages has to consider the evidence from U-Pb SHRIMP dating of zircons for Caledonian metamorphic events at 445 ± 10 Ma and 404 ± 6 Ma (A. P. Nutman, personal communication; Kalsbeek *et al.*, 1993). It is therefore probable that the range of mineral cooling ages is composite in origin and results from polyphase Caledonian metamorphism.

Mineral cooling ages obtained for the post-kinematic Knæksø (*c.* 422 Ma) and Bredefjord (*c.* 412 Ma) granites place upper limits on the timing of garnet-grade metamorphism of host Eleonore Bay Supergroup units. This may have occurred during the late Ordovician (*c.* 445 Ma) event recorded by U-Pb SHRIMP analysis of zircons within the Smallefjord sequence (A. P. Nutman, personal communication). Mineral cooling ages which may also record cooling following late Ordovician metamorphism of these rocks include the hornblende age of *c.* 426 Ma obtained from a Smallefjord sequence amphibolite (sample 52), and the muscovite age of *c.* 415 Ma obtained from an Eleonore Bay Supergroup schist (sample 45).

The majority of $^{40}Ar/^{39}Ar$ mineral cooling ages obtained from basement gneisses and cover sequences elsewhere in the region range between *c.* 400 Ma and *c.* 370 Ma. It is possible that these ages also result from regional cooling and uplift following late Ordovician metamorphism and deformation. However, a hiatus of 45–75 Ma between peak metamorphism and cooling through the temperatures required for intracrystalline retention of argon in hornblende and muscovite seems unreasonably long by comparison with other collisional orogens (e.g. Cliff, 1985; Treloar & Rex, 1990; Dallmeyer *et al.*, 1992). U-Pb analysis of zircons within basement gneisses in the Dove Bugt region provides evidence for early Devonian metamorphism (404 ± 6 Ma; Kalsbeek *et al.*, 1993), and it is therefore likely that the *c.* 400–370 Ma mineral ages mainly record cooling following this later metamorphic event.

A muscovite concentrate obtained from the Caledonian foreland at Garde Nunatak (sample 20) preserves a cooling age of *c.* 399 Ma. The dated sample of cleaved Trekant Series metasandstone appears to have experienced metamorphism at no higher grade than middle greenschist facies, and therefore the cooling age is thought to date closely the time of folding, cleavage development and local thrusting within this segment of the foreland. Muscovite concentrates from mylonites within the marginal thrust zone (sample 3) preserve slightly younger cooling ages of *c.* 393–385 Ma. Thin-section analysis of these mylonites indicates that they record deformation within the greenschist facies. Quartz forms ribbons which are characterised by undulose extinction, deformation bands and sutured grain boundaries (cf. type 1 ribbons of Boullier & Bouchez, 1978). There is only minor evidence for recovery and recrystallisation following deformation. Feldspar grains appear to have deformed mainly by brittle fracturing. Deformation therefore probably occurred at temperatures only slightly higher than that required for argon retention in muscovite. For this reason, the cooling ages obtained from these mylonites are thought to date closely regional thrusting. The dated samples were obtained from middle parts of the foreland-propagating imbricate zone (Strachan *et al.*, 1992), and do not, therefore, place an upper limit on thrusting which may have continued possibly until *c.* 380 Ma.

East of the Storstrømmen shear zone, displacements along the Kildedalen and Bessel Fjord shear zones were associated with penetrative deformation of the Smallefjord sequence (Friderichsen *et al.*, 1994). Constraints on the timing of this deformation event are provided by U-Pb zircon ages of 409^{+4}_{-9} Ma and *c.* 400 Ma for emplacement of pre- to syn-kinematic granitoids which intrude the Smallefjord sequence (Hansen *et al.*, 1994). An upper limit for deformation is provided by the muscovite cooling ages of *c.* 401 Ma (55B) and *c.* 402 Ma (55C) obtained from, respectively, a Smallefjord sequence felsic gneiss and a post-kinematic granite sheet.

The muscovite cooling ages of *c.* 399–385 Ma recorded within the foreland and the marginal thrust zone are older than: (1) the majority of hornblende ages (*c.* 390–380 Ma) in eastern Dronning Louise Land, Dove Bugt and Nordmarken; and (2) muscovite ages (*c.* 380–370 Ma) in eastern Dronning Louise Land and the Storstrømmen shear zone. It seems unlikely that the youngest of these ages closely date deformation. Thin-section analysis of dated samples within the Storstrømmen shear zone, for example, indicates that deformation occurred dominantly within the low amphibolite facies. Hornblende and oligoclase/andesine are stable phases in some mylonites, and feldspar displays evidence for widespread ductile recrystallisation. Quartz has almost completely recovered and recrystallised following mylonitisation (Strachan & Tribe, 1994). The eastward decrease in cooling ages is interpreted mainly to date uplift either during or after regional upright folding. Major folds in the east of the region, at least in part apparently developed 'out-of-sequence' after initial thrusting and folding in Dronning Louise Land, and following sinistral displacements along the Storstrømmen shear zone (Dallmeyer *et al.*, 1994).

A tectonic framework for the polymetamorphic history outlined above is necessarily speculative because of uncertainties in the timing of deformation events in relation to metamorphic episodes. A late Ordovician tectonothermal event has been demonstrated within the Smallefjord sequence (and Eleonore Bay Supergroup?) rocks above the Kildedalen and Bessel Fjord shear zones. The regional extent and nature of this event is uncertain. Two cooling ages obtained in the north of the region are anomalously 'old' : the *c.* 438 Ma age for hornblende within a basement gneiss (sample 22) in Hertugen af Orléans Land, and the *c.* 415 Ma age for muscovite within mylonitic metagabbro (sample 28B) from the Storstrømmen shear zone. It is possible that these are the result of cooling following late Ordovician metamorphism, and that intracrystalline argon systems within these samples were not reset during subsequent early Devonian metamorphism. The late Ordovician tectonothermal event may therefore have been widespread, although largely overprinted in the area north of Bessel Fjord. Widespread early Devonian metamorphism is interpreted to have accompanied thrust (Dronning Louise Land), extensional (Kildedalen and Bessel Fjord shear zones) and sinistral strike-slip (Storstrømmen shear zone) displacements, and regional upright folding.

The *c.* 314 Ma cooling age recorded by muscovite in an undeformed felsic pegmatite exposed on Store Koldewey compares with mineral cooling ages of *c.* 320 Ma obtained from gneisses exposed at Danmarkshavn (Rb-Sr and K-Ar on biotite) by Steiger *et al.* (1976). Similar felsic pegmatites are exposed in discrete swarms in eastern Germania Land and Store Koldewey. Here they post-date ductile deformation in host gneisses, and are variably affected by brittle deformation. The cooling ages reported by Steiger *et al.* (1976) may record a thermal disturbance associated with pegmatite intrusion.

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