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REPORT

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Title:
Rb-Sr dating of cleaved mudstones from eastern and western parts of the Gaissa Nappe Complex, Finnmark

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Summary:

Samples of pervasively cleaved mudstones and claystones from two different parts of the Gaissa Nappe Complex in Finnmark were subjected to Rb-Sr analytical investigation with the aim of trying to determine the metamorphic age of the rocks in this thrust sheet. Although neither of the two groups of samples yielded a true isochron (i.e., MSWD <2.5), the data do support the concept of a probable isochron age at around 480-500 Ma, as can be discerned from the 'isochron fits' of various combinations of the analytical data. Together with the relatively high $^{87}Sr/^{86}Sr$ initial ratios, this result strongly suggests that a Sr-isotopic resetting event occurred at around 480-500 Ma. This event is thought to reflect an overall, pervasive metamorphic imprint on the rock formations of the Gaissa Nappe Complex.

Previous radiometric dating evidence from the Gaissa Nappe Complex has given ambiguous results, some pointing to Finnmarkian (Late Cambrian-Early Ordovician) deformation whereas other data have indicated a Scandian (Late Silurian-Early Devonian) age. The Rb-Sr analytical data reported here do tend to favour a likely Finnmarkian age for the very low-grade metamorphism; and this fits with diverse isotopic data obtained from the overlying nappe complexes, as well as with the biostratigraphic evidence where the youngest rocks in the Gaissa thrust sheet are of Early Tremadoc age.

Keywords: Berggrunn	Datering	Kaledonske fjellkjede
Gaissadekkekomplekset	Strukturgeologi	Finnmarkiske fase

CONTENTS

1. INTRODUCTION

Rock complexes of Neoproterozoic to Early Palaeozoic age dominate the Caledonides of Finnmark, northern Norway. The nappes of the metamorphic allochthon extend over a distance of some 370 km from Kvænangen in the southwest to Varanger Peninsula in the northeast, and overlie a generally thin, parautochthonous to autochthonous sedimentary sequence that was deposited upon a peneplaned surface of Palaeoproterozoic and Archaean crystalline rocks.

The precise ages of the thick metasedimentary successions in the different parts of the Caledonide tectonostratigraphy are poorly known. Fossils are comparatively rare, occurring only in the very highest and lowest of the nappes. Likewise, our knowledge of the exact timing of Caledonian orogenic deformation is far from perfect. Although isotopic dating investigations have been made in certain areas, the data, in most cases, are not sufficiently robust to allow us to state, categorically, that, for example, metamorphism occurred at just one specific time. Only in the highest, Magerøy Nappe, where there are fossiliferous metasedimentary rocks of Late Ordovician to Early Silurian age, can we be sure that, in this particular case, we are dealing with *Scandian* (Silurian to Early Devonian) orogenic deformation. Elsewhere, a case has been presented for suggesting that it is possible to identify an earlier phase of Late Cambrian/Early Ordovician tectonothermal activity, known as the *Finnmarkian* (Sturt et al. 1978, Dallmeyer 1988a), in some of the nappes.

In this report, we present Rb-Sr analytical data from the Gaissa Nappe Complex, which is a part of the Lower Allochthon of Scandinavian Caledonide tectonostratigraphy (Roberts & Gee 1985). The rocks sampled are penetratively cleaved mudstones and claystones from two widely separate areas, in southern Porsangerfjord and in the Vestertana district of innermost Tanafjord. These particular rocks were collected with the aim of trying to determine the age of this pervasive metamorphic fabric, by generating what would hopefully turn out to be meaningful isochrons.

2. GENERAL GEOLOGY

The tectonostratigraphy of the Caledonides in Finnmark has been touched upon in the introductions to several papers on diverse topics, but some of the main contributions to the overall architecture and structure of the principal nappe complexes are those of Sturt et al. (1975), Williams et al. (1976), Chapman et al. (1985), Ramsay et al. (1985), Roberts (1985), Townsend et al. (1986) and Gayer et al. (1985, 1987).

Four major nappes or nappe complexes are recognised, from bottom to top: (1) Gaissa Nappe Complex, (2) Laksefjord Nappe Complex, (3) Kalak Nappe Complex, (4) Magerøy Nappe.

With the exception of the Magerøy Nappe, these various nappe complexes occur fairly widely across the mainland of Finnmark, moreso the Kalak Nappe Complex which extends southwards into the neighbouring county of Troms (Zwaan & Roberts 1978, Zwaan 1988). The Magerøy Nappe occurs exclusively on the island of Magerøya in northwestern Finnmark (Fig. 1).

Briefly, the Gaissa Nappe Complex (also termed informally the Gaissa Thrust Belt, e.g. Gayer et al. 1987, Townsend et al. 1989) is dominated by low-grade, Neoproterozoic to earliest Ordovician, metasedimentary rocks, whilst the Laksefjord and Kalak Nappe Complexes are composed mainly of greenschist- to amphibolite-facies, late Mesoproterozoic to probable early Neoproterozoic, metasedimentary successions with thrust sheets of older Precambrian crystalline rocks. The Kalak also contains the extensive Seiland Igneous Province (Robins 1996). The Magerøy Nappe comprises an amphibolite-facies metasedimentary succession of Ordo-Silurian age which is cut by diverse plutonic rocks varying in composition from mafic/ultramafic to granitic (Andersen 1984, Roberts & Andersen 1985).

The Magerøy Nappe and the Kalak Nappe Complex carry thick mylonites, and locally ultramylonites, at their base. Mylonites also occur along the sole thrust to the Laksefjord Nappe Complex, but the thickness is far less. The floor thrust to the Gaissa Nappe Complex is generally characterised by a 3-5 cm-thick ultracataclasite, rarely protomylonite. Prominent stretching lineations within and above the thrust zones to all these nappes generally denote a translation sense between southeast and east-southeast. Nappe movement was polyphase in the case of the Kalak Nappe Complex, with early ductile SE translation superceded by a more brittle, ESE-directed transport (Gayer et al. 1987). A polyphase, internal deformation history is also recognised in all these nappe complexes, though in the case of the Gaissa this is much less complicated than in the other allochthons (Townsend et al. 1986).

In the Kalak Nappe Complex, there is also evidence from isotopic dating (Daly et al. 1991, Reginiussen et al. 1995) that the lithostratigraphic succession (Sørøy Group) has been involved in a pre-Caledonian, Late Riphean, tectonothermal event, at least in some of the higher thrust sheets. Supportive evidence for this has recently been reported from the correlative Seve Nappe Complex in northern Sweden (Paulsson & Andréasson (2002). This >800 Ma tectonothermal event was provisionally termed the 'Porsanger orogeny' by Daly et al. (1991), a designation that cannot be accepted as the name Porsanger is already used, formally, for a dolomite formation in the Gaissa Nappe Complex (see below). The name 'Sørøyan' has been proposed as a more appropriate term for this event (Robins 1996, Roberts & Robins, submitted ms). The extent of this Late Riphean event is an interesting and important topic that is currently receiving comprehensive research attention (NGU project led by Trond Torsvik; also, University of Dublin project headed by Stephen Daly).

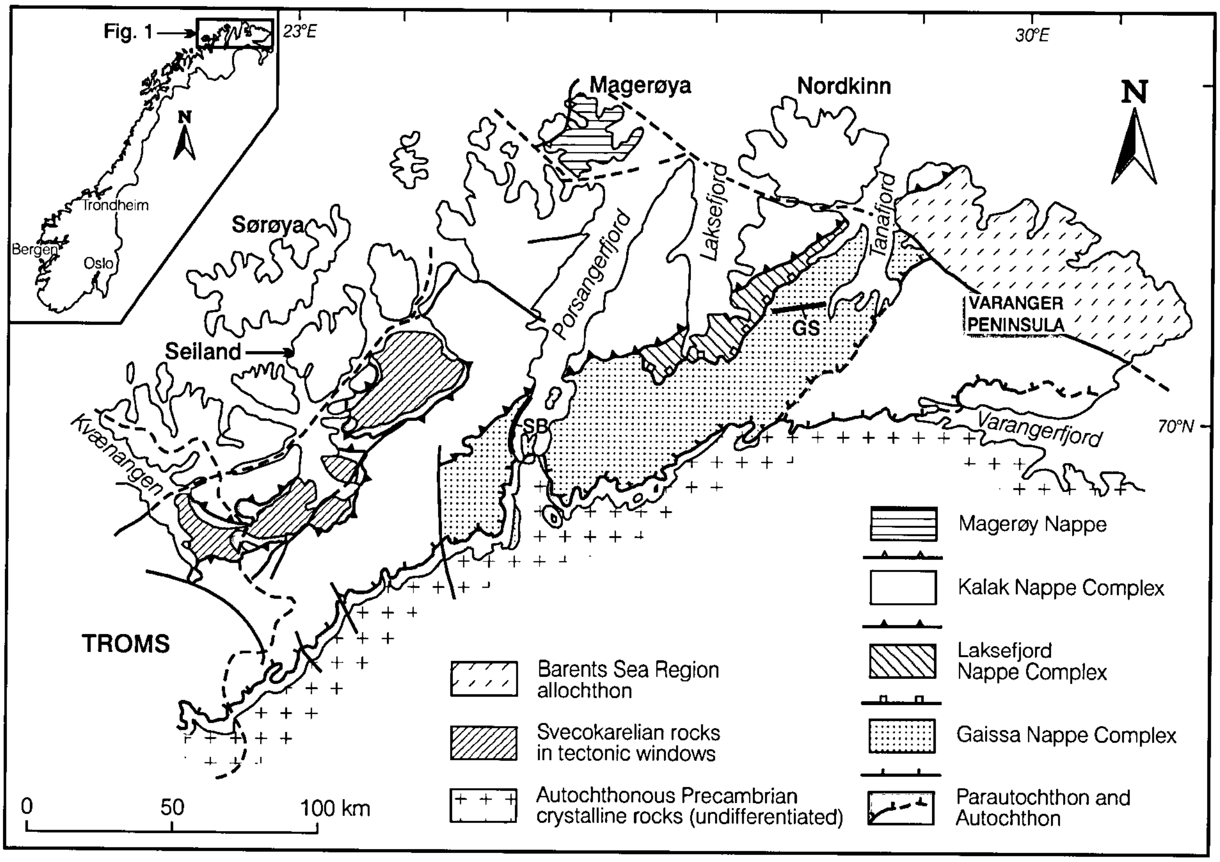


Fig. 1. Simplified tectonostratigraphy of the Caledonides of Finnmark; modified from Roberts (1985). The approximate locations of the two sampling traverses in the Gaissa Nappe Complex are shown, marked by the short, thick lines and the letters GS and SB. Details of precise sample locations, grid references and formation names are given in Table 2.

3. GAISSA NAPPE COMPLEX

Over most of its 200 km strike extent, the Gaissa Nappe Complex lies tectonically above the thin, Vendian to Lower Cambrian, condensed sequence of the Dividal Group (Føyn 1967, 1985). In the east, towards Varanger Peninsula, the precise trasé of the basal thrust plane is uncertain, and different solutions have been proposed (cf. Roberts 1985, Townsend 1986, Rice 1994). This uncertainty relates to the fact that the Gaissa and the subjacent parautochthon share a common lithostratigraphy in the southwestern part of Varanger Peninsula. In this area, and west of the Tana river, bedrock exposure is also comparatively poor.

Between inner Laksefjord and Langfjord, in western Tanafjord, the Laksefjord Nappe Complex tectonostratigraphically overlies the Gaissa, but to the southwest the Laksefjord N.C. is excised and strongly mylonitised rocks of the Kalak Nappe Complex lie directly upon formations of the Gaissa Nappe Complex (Gayer et al. 1987, Roberts 1998).

The lithostratigraphy of the Gaissa allochthon is shown in Table 1. Formations of the Late Riphean *Tanafjorden Group* occur throughout the nappe complex, but are more extensively exposed in the southwest. The oldest unit, the Airoaivi Group (Townsend et al. 1989), is exposed in the southwesternmost part of the nappe, west of Lakselv. The Vendian to basal Cambrian *Vestertana Group* is present from south of Laksefjord northeastwards to the southwestern parts of Varanger Peninsula, whereas the youngest unit, the Cambrian to Lower Tremadoc *Digermul Group* (Reading 1965, Banks et al. 1971, Nikolaisen & Henningsmoen 1985), occurs only on the Digermul Peninsula.

Although the various formations of these groups can be followed over distances of 200 km or more, there are facies variations and other changes which have given rise to a slightly different stratigraphic nomenclature in parts of the succession from Porsangerfjord to Varanger (Siedlecki 1980, Rice & Townsend 1996, Roberts 1998). In the Porsangerfjord district, for example, the Porsanger Formation at the top of the Tanafjorden Group overlies the Stabbursdal Formation. On Varanger, the upper member of the Grasdal Formation is equivalent to the Porsanger Formation, and the lower member of the Grasdal correlates with the Stabbursdal.

In southwestern areas, towards Porsangerfjord, the Gaissa Nappe Complex is composed of a series of westerly dipping, imbricate thrust sheets, separated into four structural zones, including two duplexes (Townsend et al. 1986). A somewhat simpler structural picture obtains some 200 km farther to the northeast on Varanger Peninsula. The details do not concern us here. In general, mesoscopic folds are common, trending between N-S and NE-SW. They are open to close, asymmetric folds, verging c. ESE, and carry a pervasive axial-planar cleavage of anchizone metamorphic grade (Williams 1979, Townsend et al. 1986, Rice et al. 1989). In interbeds of mudstone type, the cleavage is more or less a true slaty cleavage.

Group	Formation	Biostratigraphic age
	Berlogaissa	Lower Tremadoc
Digermulen	Kistedalen	Middle/Upper Cambrian
	Duolbasgaissa	Lower Cambrian
	Breidvika	Lower Cambrian
	Stappogiedde	}
Vestertana	Mortensnes	} Vendian
	Nyborg	}
	Smalfjord	}
	Porsanger	}
	Stabbursdal	}
	Hanglecærro	}
Tanafjorden	Vagge	}
	Gamasfjellet	} Upper Riphean
	Dakkovarre	}
	Stangenes	}
	Grønneset	}
	Åbbardasras'sa	}
Airoaivi	Nav'kaoaivi	}
	Adnevarri	}
	Bal'dneras'sa	}

Table 1. Lithostratigraphy of the Riphean to Lower Ordovician (Tremadoc) succession occurring within the Gaissa Nappe Complex, Finnmark. Division into formations for the Digermulen, Vestertana and Tanafjorden Groups is based largely on Banks et al. (1971), Siedlecka & Siedlecki (1971) and Williams (1976). Subdivisions of the Airoaivi Group are from Townsend et al. (1989). See also the 1:250,000 map-sheets 'Vadsø' (Siedlecki 1980) and 'Honningsvåg' (Roberts 1998); and the 1:500,000 bedrock map-sheet of Finnmark county (Siedlecka & Roberts (1996).

4. Rb-Sr DATING

4.1 Sampling and lithologies

With the purpose of trying to determine the metamorphic age of the rocks of the Gaissa Nappe Complex, sampling was carried out in two areas: (1) along the main road between inner Vestertana and the sole thrust to the Laksefjord Nappe Complex, east of Ifjord, over a distance of roughly 20 kilometres; (2) along the road and coast north and south of Stabbursnes, western and inner part of Porsangerfjord, a distance of 12-13 km (Fig. 1). Sampling was concentrated on the most pelitic and better cleaved rock types in several formations. A list of the samples, formation affiliations, general features and grid references is given in Table 2.

4.2 Analytical techniques

Rb and Sr concentrations were determined by isotope dilution technique using a combined spike of enriched ^{87}Rb and ^{84}Sr, as described by Boelrijk (1968). The uncertainty of the method is estimated to 0.5% in the Rb/Sr ratios. All isotopic measurements were carried out on a VG354 TIMS instrument at the Mineralogical-Geological Museum, University of Oslo, following methods similar to those described by Jacobsen & Heier (1978). During the period of analysis the NBS987 Sr-isotopic standard yielded an average of 0.71024 ± 3. Isochron calculations were carried out according to the method described by York (1969). The calculations were based on the value of 1.42×10^{-11} a^{-1} for the decay of ^{87}Rb (Steiger & Jäger 1977). All results are given as 2σ errors.

4.3 Results

The results of the elemental and isotopic determinations and the calculated Rb/Sr and corresponding ^{87}Rb/^{86}Sr ratios are presented in Table 3. The results of the isochron calculations are listed in Table 4. The data are also plotted in Figs. 2 a & b.

As can be seen from Table 4, cases 1 and 3, neither of the two groups of samples yielded any true isochron (i.e., MSWD <2.5). There are no clear-cut indications or reasons for leaving any one or more samples out of the calculations. The semi-linear relationship of the data as seen in Figs. 2 a & b, probably reflects random secondary effects on the Rb/Sr system in the mudstone and claystone rocks. However, the close and true isochron ages indicated by cases 2, 4 and 5 (Table 4), and the relatively high ^{87}Sr/^{86}Sr initial ratios (0.732-0.735), suggest an event of Sr-isotopic resetting at around 500-480 Ma, which is thought to reflect an overall,

Sample Number	Formation	Characteristics	Map reference
GS.1	Nyborg	Green-grey slaty mudstone	2965 1510
GS.2	Nyborg	Green-grey slaty mud/claystone	2960 1510
GS.3	Nyborg	Green-grey slaty mudstone	2955 1510
GS.4	Mortensnes	Grey, cleaved tillite matrix	2970 1510
GS.5	Nyborg	Red/maroon slaty mudstone	2650 1455
GS.6	Nyborg	Green, cleaved mud/claystone	2650 1455
GS.7	Stappogiedde	Grey-green, cleaved claystone	2135 1350
GS.8	Breidvik	Grey-green, cleaved claystone	1755 1520
GS.9	Breidvik	Green-grey, cleaved clay/mudstone	1600 1665
GS.10	Breidvik	Red/maroon, cleaved mudstone	1600 1665
GS.11	Stappogiedde	Grey-green, cleaved claystone	1130 1530
GS.12	Breidvik	Red/maroon, cleaved mudstone	1020 1575
GS.13	Breidvik	Green, cleaved mud/claystone	1020 1575
GS.14	Breidvik	Green-grey, cleaved claystone	0770 1600
GS.15	Breidvik	Green-grey, slate/phyllite	0730 1630
SB.1	Stabbursdal	Maroon, cleaved mudstone	2460 9465
SB.2	Stabbursdal	Grey, cleaved claystone	2460 9465
SB.3	Stabbursdal	Red.brown, cleaved mudstone	2405 9425
SB.4	Stabbursdal	Red-brown, cleaved mudstone	2290 9350
SB.5.	Stabbursdal	Grey/maroon, cleaved mudstone	2210 9305
SB.6	Stabbursdal	Grey, cleaved claystone	2215 9205
SB.7	Stabbursdal	Maroon, cleaved mudstone	2030 8765
SB.8	Stabbursdal	Dark grey/black, cleaved mudstone	2085 8765
SB.9	Dakkovarre	Dark grey, cleaved claystone	2075 8295

Table 2. Sample numbers, formation names, rock characteristics and map/grid references. Samples GS.1-6, 1:50,000 map-sheet 'Smalfjord', 3-NOR edition: samples GS.7-15, 1:50,000 map-sheet 'Ifjordfjellet', 3-NOR edition; samples SB.1-9, 1:50,000 map-sheet 'Lakselv', 4-NOR edition.

5. DISCUSSION

5.1 Gaissa Nappe Complex

Although not definitive, the results of this Rb-Sr analytical investigation strongly suggest that resetting of the Sr isotope system occurred at around 480-500 Ma. Moreover, the very high initial $^{87}Sr/^{86}Sr$ ratio further suggests that this resetting can, in all probability, be ascribed to a pervasive metamorphic imprint on the rock formations of the Tanafjorden and Vestertana Groups. This calls for an assessment of earlier isotopic studies from this particular nappe complex.

The earliest radiometric work on the Gaissa is that of Pringle (1973; and in Sturt et al. 1975) who reported a Rb-Sr whole-rock isochron age of 504 ± 7 Ma (recalculated to a 1.42 decay constant), interpreted as the age of cleavage formation in pelites of the Stappogiedde Formation. This 'isochron' was subsequently rejected by Dallmeyer & Reuter (1989) and Dallmeyer et al. (1989) on the grounds that complete isotopic equilibration was probably not achieved, and thus detrital Rb-Sr systems were not fully rejuvenated.

The next investigation was that of Dallmeyer (1988b), based on $^{40}Ar/^{39}Ar$ geochronology of whole-rock, cleaved slate samples from four undetermined locations within the Gaissa Nappe Complex. Spectra of samples taken from the hinge zones of cleavage-related folds gave "well-defined plateaux…..which correspond to ages of 474 and 482 Ma." These ages were interpreted by Dallmeyer (1988b) to approximately date cleavage formation at these locations, a metamorphic event which this same author considered was probably related to late-stage Finnmarkian tectonothermal activity.

Subsequently, Dallmeyer et al. (1989) carried out a joint $^{40}Ar/^{39}Ar$ and K-Ar study on five samples of penetratively cleaved pelites from Gaissa formations, and then came to a different conclusion, namely that the earliest metamorphism had a maximum age of c. 440 Ma. Although whole-rock, $^{40}Ar/^{39}Ar$, incremental-release, total-gas ages for the five samples ranged between c. 474 and 550 Ma, more reliance was placed on one sample from the southwestern Gaissa, in Porsangerfjord, where the <0.5 μm size fraction of illite gave a K-Ar apparent age of 440.2 ± 9.4 Ma. In this same paper (Dallmeyer et al. 1989), another <0.5 μm size-fraction, apparent age of 463.6 ± 9.9 Ma, from the northeastern part of the Gaissa, was not discussed

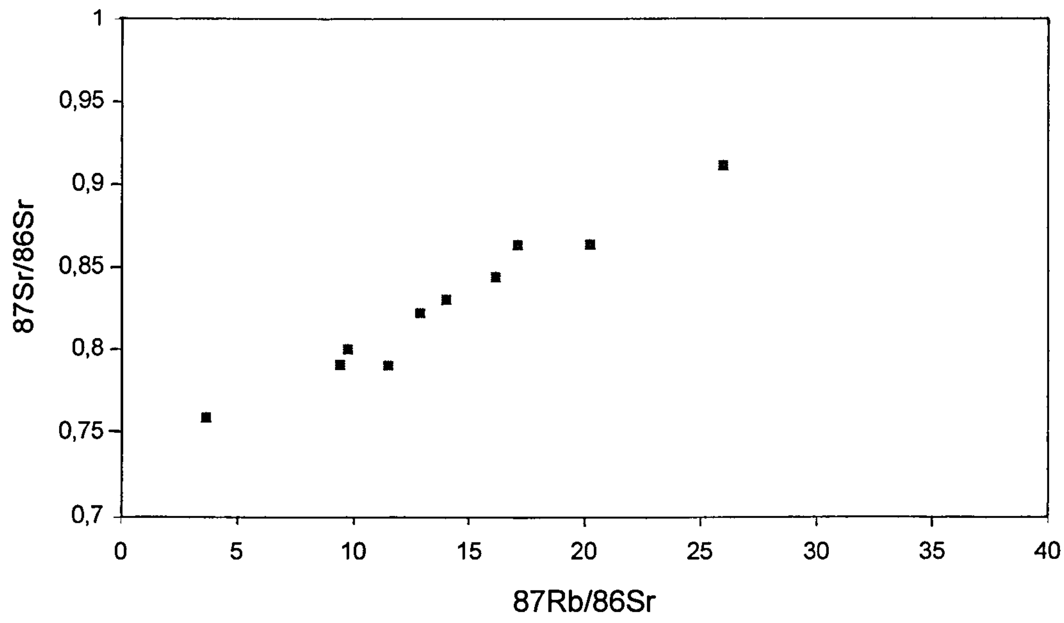
Table 3. Rb and Sr analytical data. (Rb and Sr concentration errors approx. 1.5%)

Sample	Rb(ppm)	Sr(ppm)	Rb/Sr	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	SE
GS1	243.49	27.66	8.084	25.980	.91125	± .00003
GS2	170.60	31.00	5.505	16.141	.84400	± .00003
GS3	204.73	29.70	6.893	20.246	.86354	± .00005
GS4	142.79	112.83	1.266	3.680	.75885	± .00003
GS5	218.95	65.44	3.346	9.768	.80013	± .00003
GS7	165.95	42.11	3.941	11.493	.79015	± .00003
GS10	124.33	38.41	3.237	9.440	.79055	± .00003
GS12	213.07	48.35	4.407	12.893	.82193	± .00003
GS13	150.41	25.85	5.820	17.094	.86324	± .00003
GS15	129.99	27.17	4.784	14.007	.83016	± .00003
SB1	258.40	20.36	12.690	37.722	.98833	± .00003
SB2	233,00	30.56	7.625	22.471	.89746	± .00003
SB3	218.06	53.10	4.107	12.014	.82162	± .00003
SB5	186.61	65.10	2.866	8.364	.79487	± .00003
SB7	184.61	83.87	2.201	6.065	.78028	± .00003
SB8	224.07	81.21	2.759	8.065	.81390	± .00003
SB9	148.65	100.17	1.484	4.318	.76521	± .00003

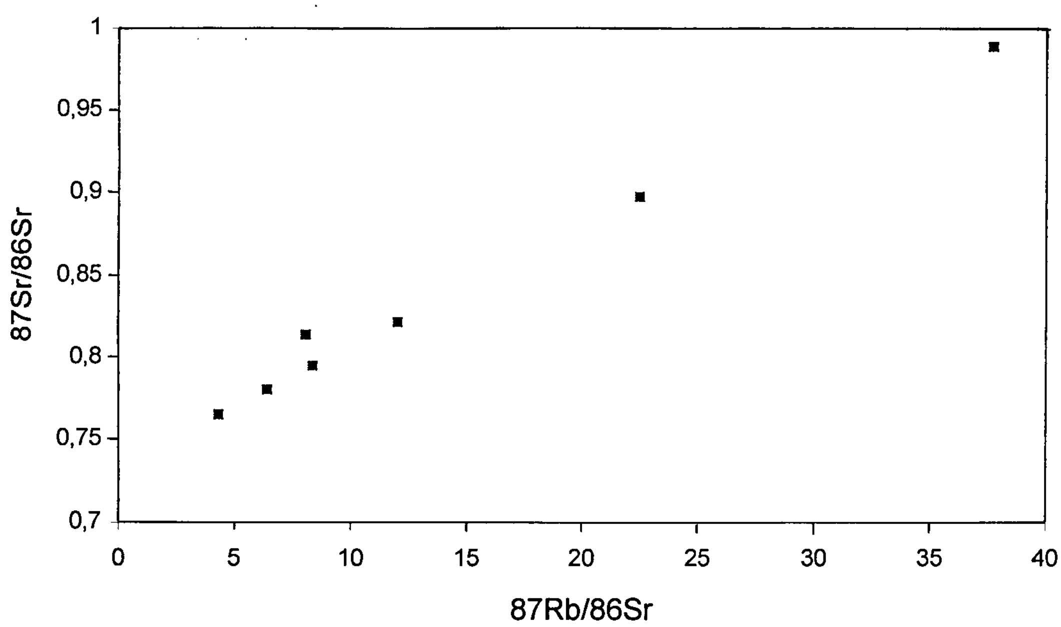
Table 4. Isochron calculations.

Case	Samples	Age	error	$(^{87}Sr/^{86}Sr)_I$	error	MSWD
1	all GS samples	480	± 60	.7319	± .007	125
2	all except GS3, GS7, GS13	475	± 32	.7334	± .004	25
3	all SB samples	548	± 128	.7339	± .014	226
4	all except SB8	495	± 22	.7351	± .002	9
5	all except SB1, SB8	512	± 10	.7336	± .001	.1

$(^{87}Sr/^{86}Sr)_I$ = calculated initial ratio of $^{87}Sr/^{86}Sr$



(a)



(b)

Fig. 2. The analysed samples plotted on a $^{87}Sr/^{86}Sr$ *versus* $^{87}Rb/^{86}Sr$ diagram. (a) The sample series 'GS', from the northeastern part of the Gaissa Nappe Complex (cf. Fig. 1). (b) The sample series 'SB' from the western part of the Gaissa Nappe Complex. The analytical data and isochron calculations are shown in Tables 3 and 4, respectively.

Preference for the one K/Ar apparent age at the expense of the other K-Ar and $^{40}Ar/^{39}Ar$ data was influenced by the work of Reuter (1987) in the Rheinisches Schiefergebirge in Germany, who had showed that only the very smallest size fraction was compatible with the geological constraints in that area. Coarser size fractions were found to retain a detrital memory, and thus gave imprecise, 'mixed' ages. Dallmeyer et al. (1989) therefore preferred to reject the $^{40}Ar/^{39}Ar$ analyses; and, at the same time, Dallmeyer's (1988b) own earlier work and conclusions from rocks of the Gaissa Nappe Complex were also rejected. They also argued that an Early Silurian metamorphic age was more consistent with "that of the Scandian orogenesis recorded within late Proterozoic through Early Silurian autochthonous/parautochthonous metasedimentary sequences exposed in the central and southern Scandinavian Caledonides." However, this contention, that deformation of Scandian age within the Lower Allochthon in southern areas must also be Scandian 1000 km farther north, is clearly open to debate.

In a palaeomagnetic study of low-grade sedimentary rocks from the parautochthon and Gaissa Nappe Complex of southwestern Varanger Peninsula, Bylund (1994) observed that two of three samples from sites within the Gaissa along the shores of Tanafjord yielded data which indicated that a remagnetization had occurred in these rocks in Early Ordovician time. The implications of these observations were not discussed further.

Field evidence from basal parts of the Gaissa Nappe shows that thrusting post-dated the peak of metamorphism and cleavage generation. One sample of ultracataclasite from the sole thrust (from Handelsbukt, c. 12 km ENE of Lakselv) has been dated by the K-Ar method, and has given an age of 391 ± 9 Ma (J.G. Mitchell, unpubl. data, pers. comm. 1989; reported in Roberts & Sundvoll 1990, with permission). This Mid Devonian age is comparable to dates generated from shear-banded mylonites at the base of the Kalak Nappe Complex (see below).

5.2 Laksefjord and Kalak Nappe Complexes

In order to fully appreciate the data presented in this report, it is relevant to consider some of the published isotopic data from the suprajacent Laksefjord and Kalak Nappe Complexes.

The first and only attempt at dating the penetrative slaty cleavage in pelites of the Friarfjord Formation, *Laksefjord Nappe Complex*, is that of Pringle in Sturt et al. (1978). This generated a Rb-Sr whole-rock isochron age of 492 ± 45 Ma (recalculated using a 1.42 decay constant), which was interpreted to date the peak of metamorphism. The rocks of the Laksefjord Nappe Complex were thus considered by Sturt et al. (1978) to have been involved in Finnmarkian orogenic deformation.

Several isotopic dating studies have been carried out within the supracrustal and magmatic rocks of the *Kalak Nappe Complex*. A complete listing of references and data is inappropriate for this report, but it is sufficient to state that evidence has been forthcoming for both Scandian and Finnmarkian metamorphic events. Early K/Ar and Rb/Sr studies in West Finnmark (Sturt et al. 1967, Pringle & Sturt 1969) laid a basis for recognising an early Caledonian, Finnmarkian event in rocks of the Kalak Nappe Complex (Sturt et al. 1978). Although these early data, and their interpretation, were shrouded in controversy (Krill & Zwaan 1987, Binns 1989, Townsend & Gayer 1989), subsequent and more precise $^{40}Ar/^{39}Ar$ and Sm-Nd dating from different areas (Dallmeyer 1988a, Dallmeyer et al. 1988, 1991, Mørk et al. 1988) confirmed this important orogenic phase. Here, it was noted that post-metamorphic cooling dates of c. 490 Ma are locally recorded by hornblende. However, the effects of the Scandian metamorphic overprint were quite pronounced, and "of sufficient magnitude to everywhere rejuvenate Ar systems in muscovite and nepheline and locally in hornblende" (Dallmeyer 1988a). In this interpretation, rapid post-metamorphic cooling through hornblende and muscovite closure temperatures occurred in the time range c. 425-415 Ma.

In an investigation involving Rb-Sr whole-rock and thin-slab dating of mylonites from the Kalak Thrust Zone near Børselv, eastern Porsangerfjord, one set of 11 samples yielded an isochron age of 479 ± 15 Ma (MSWD – 2.26) (Roberts & Sundvoll 1990). In another sample series taken from close to the base of the thrust zone, two separate subsets of thin slabs of top-east, shear-banded mylonites gave isochron ages of 385 ± 29 (MSWD – 2.51) and 380 ± 22 (MSWD – 3.04) Ma, respectively. This thin-slab dating indicates resetting of the Rb-Sr isotope systems on a local scale in Mid Devonian time, broadly coeval with the latest phase of nappe translation. Although the c. 480 Ma date could be taken to indicate ductile mylonite generation at around the transition from Tremadoc to Arenig time, Roberts & Sundvoll (1990) were careful to point out complications related to the Rb-Sr isotope system with these particular samples.

In northwestern Varanger Peninsula, a preliminary $^{40}Ar/^{39}Ar$ study on the penetrative cleavage in phyllites of the Berlevåg Formation in the Tanahorn Nappe, considered to be probably a part of the Kalak Nappe Complex, has given diverse Early to Mid Ordovician ages (Frank & Rice 1999). Although the data presented in this abstract are insufficiently precise to allow firm conclusions to be made, there are nevertheless clear indications that the main syn-metamorphic fold deformation in this thrust sheet is pre-Scandian and of Ordovician age.

In summary, there is evidence, both in the literature and from ongoing research, that parts of the metamorphic allochthon of Finnmark were involved in early Caledonian (Late Cambrian to Early Ordovician) orogenic deformation, particularly at the Middle and lowermost Upper Allochthon levels represented by the Laksefjord and Kalak Nappe Complexes. In the Gaissa Nappe, the evidence has been ambiguous. While early radiometric work provided indications of a Finnmarkian event, Dallmeyer and coworkers rejected these data, thereby denying the existence of an Early Ordovician tectonothermal event in the metasedimentary rocks of the Gaissa Nappe Complex.

The Rb-Sr analytical data presented in this report therefore bring us back to square one. While we prefer to keep an open mind in this particular instance, in view of the interpretative problems associated with the Rb-Sr dating method, it is pertinent to note that the strong indications of a metamorphic event at around 480-500 Ma fits well with the biostratigraphic evidence from the youngest rocks in the nappe, the Digermul Group, which extend up into the Early Tremadoc. With the Cambrian-Ordovician boundary now defined at c. 490 Ma and the base Arenig at c. 480 Ma (Davidek et al. 1998, Landing et al. 2000), then deformation in the Gaissa could conceivably have started shortly after deposition of the Berlogaissa Formation. Although paleocurrent data are lacking from most of the Digermul Group, Reading (1965) has noted the sudden incursion of scour-and-fill cross-bedding close to the exposed top of the Berlogaissa. Speculatively, this may be indicating the onset of a fluvial regime as an emergent topography developed in the west and northwest ahead of a rising Finnmarkian mountain chain. A detailed sedimentological study of the three formations of the Digermul Group would be a prerequisite for taking these ideas further.

6. CONCLUSIONS

Samples of pervasively cleaved mudstones and claystones from two different parts of the Gaissa Nappe Complex in Finnmark were subjected to Rb-Sr analytical investigation with the aim of trying to determine the metamorphic age of the rocks in this thrust sheet. Although neither of the two groups of samples yielded a true isochron (i.e., MSWD <2.5), the data do support the concept of a probable isochron age at around 480-500 Ma, as can be discerned from the 'isochron fits' of various combinations of the analytical data. Together with the relatively high $^{87}Sr/^{86}Sr$ initial ratios, this result strongly suggests that a Sr-isotopic resetting event occurred at around 480-500 Ma. This event is thought to reflect an overall, pervasive metamorphic imprint on the rock formations of the Gaissa Nappe Complex.

Previous radiometric dating evidence from the Gaissa Nappe Complex has given ambiguous results, some pointing to Finnmarkian deformation whereas other data have indicated a Scandian age. The Rb-Sr analytical data reported here do tend to favour a likely Finnmarkian age for the very low-grade metamorphism; and this fits with diverse isotopic data obtained from the overlying nappe complexes, as well as with the biostratigraphic evidence where the youngest rocks in the Gaissa are of Early Tremadoc age.

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