Rb-Sr, U-Pb and Sm-Nd Isotopic Dates from Precambrian Rocks of Finnmark

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Rb-Sr and Sm-Nd whole-rock dates, U-Pb zircon dates, and Rb-Sr biotite dates are presented for pre-Caledonian rocks of Finnmarksvidda, the Alta-Kvænangen window, and Sørvaranger. A Sm-Nd whole-rock date of 2085 ± 85 Ma was obtained from komatiites of the Karasjok Greenstone Belt. Granite of the Jer'gul Gneiss Complex, eroded by the basal unconformity of the Karasjok Greenstone Belt, yielded a Rb-Sr whole-rock date of 2110 ± 105 Ma. These results suggest that the Karasjok Greenstone Belt is Early Proterozoic, and not Archean as earlier assumed. The Kautokeino Greenstone Belt and Raipas Group may have similar ages, but dating attempts were not successful. Svecokarelian intrusions group into older intermediate rocks with intrusive ages of about 1820 Ma, and younger granitic rocks with ages of about 1650-1750 Ma. Biotite dates are mainly between 1486 - 1633 Ma, and presumably reflect the age of uplift and cooling.

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Introduction

Isotopic studies form an integral part of the current geological mapping and research in Finnmark. The rocks are unfossiliferous, being both older Precambrian and metamorphosed, so that geological interpretations must depend in part upon isotopic dating. In addition, bedrock exposure is generally very limited. For many rock units no contact relationships can be studied, and even relative ages cannot be established from direct mapping and field observations.

Previous isotopic data are very few in number. In connection with detailed studies in Finland, Meriläinen (1976) analyzed a few zircons from Norwegian rocks, but the zircon data are very discordant and do not define discordia lines. Some unpublished work was available from Sørvaranger (Råheim & Bugge 1979), and from the Jer'gul Gneiss Complex (Priem 1968) but no other isotopic dates existed from the rocks of inner Finnmark.

The lithostratigraphy and geology of the rocks are described elsewhere (see Siedlecka et al. 1985). In simplest terms, the region consists of gneiss complexes and supracrustal belts with N-S orientations. From west to east, the main units are (Fig. 1): the Rai'saedno Gneiss Complex, the Kautokeino Greenstone Belt, the Jer'gul Gneiss Complex, the Karasjok Greenstone Belt, the Tanaelv Migmatite Belt, the Levajok Granulite Belt, the Baisvarri Gneiss Complex, and several major rock units of the Sørvaranger district. All the main units were apparently affected by the deformation, metamorphism, and plutonism of the Svecokarelian event (c. 1900-1750 Ma).

The dating reported here includes mainly intrusive rocks. Intrusive rocks generally yield reliable dates with relatively small errors, and require less detailed knowledge of the rocks for accurate interpretation. As our general knowledge of the rocks improves, more problematic rocks are being studied.

Analytical methods

For the U-Pb analyses (Table 2), zircon was separated at Norges Geologiske Undersøkelse (N.G.U.). The separation procedure involved stepwise crushing and sieving of a c. 50 kg sample for separation of the heavy fraction on a sluice-table. The strongly magnetic heavy component was then removed, and the zircons concentrated using heavy liquids and a Frantz magnetic separator. Final purification of the zircons and U-Pb analyses were performed commercially by Geospec Consultants Ltd., Edmonton, Canada. Errors in $^{207}Pb/^{235}U$ and $^{206}Pb/^{238}U$ are estimated to be less than 0.5 %.

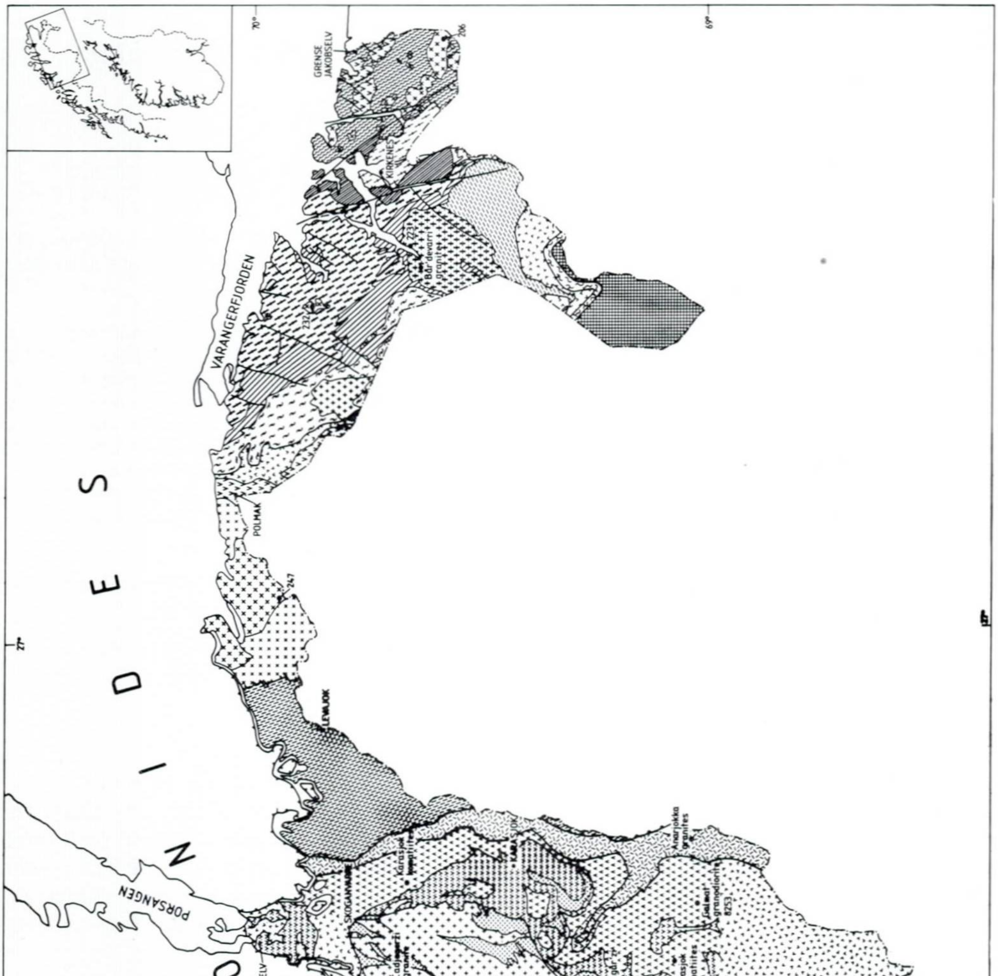

Fig. 1. Locations of rocks and minerals studied. Geological map from Siedlecka et al. (1985).

$^{206}Pb/^{238}U$ are estimated to be less than 0.5 %.

For the Rb-Sr whole-rock analyses (Tables 1 & 3), rocks were crushed and preliminary concentrations of Rb and Sr were determined at N.G.U. Samples were then selected for isotopic analysis, and Rb and Sr concentrations were determined with greater precision on the Philips Xray fluorescence spectrometer at the Mineralogisk-Geologisk Museum in Oslo, using the background correction method of Pankhurst & O'Nions (1973). For biotites and whole-rocks with Rb<50, Rb and Sr concentrations were measured by isotope dilution using a mixed ^{87}Rb-^{84}Sr spike.

Chemical separation of Rb and Sr for mass spectrometry was carried out at N.G.U. Samples were dissolved following conventional HF-HNO_3-HCl dissolution procedures. Rb and Sr were separated in columns containing Bio Rad Ag 50W-x8 ion exchange resin using HCl as elutant. Rb-Sr mass spectrometry was performed on the Vacuum Generators MM 30 mass spectometer at the Mineralogisk-Geologisk Museum in Oslo. The mean of 23 analyses of standard NBS 987 done on this mass spectrometer during the past years is $^{87}Sr/^{86}Sr = .71026 \pm 6$ (1σ). Variable mass discrimination in $^{87}Rb/^{86}Sr$ was corrected by normalizing $^{88}Sr/^{86}Sr$ to 8.3752. The ^{87}Rb decay constant used was 1.42×10^{-11} a^{-1}, and the data were regressed by the method of York (1969). In assigning errors, the coefficient of variation was taken as 1% for $^{87}Rb/^{86}Sr$. The errors for the $^{87}Sr/^{86}Sr$ measurements are listed in Table 3.

For the Sm-Nd analyses of the Karasjok komatiites (Table 4), chemical separation of Sm and Nd was carried out at the Mineralogisk-Geologisk Museum, using a 2-column ion exchange procedure. First, major elements Rb, Sr, Ba, and REE were separated using Bio Rad AG50W-x12 resin and HCl followed by HNO_3 elutant. Second, an adaptation of the normal chromatography method of Richard et al. (1976) employing hydrogen phosphate-coated teflon powder and HCl elutant is used to separate Sm and Nd (Details of this procedure are available from E.W.M.). Sm and Nd concentrations were determined by isotope dilution using a mixed ^{147}Sm-^{146}Nd spike, on an aliquot of the sample used for isotopic measurements. Sm and Nd isotopic measurements were made on the Vacuum Generators 354, 5-collector mass spectrometer at the Mineralogisk Geologisk Museum. The mean of 19 analyses of Johnson and Matthey Nd-203 carried out during the past 6 months is $^{143}Nd/^{144}Nd = .511125 \pm 4$ (1σ) and $^{145}Nd/^{144}Nd = .348412 \pm 4$ (1σ). Sm and Nd analyses of the Cas'kejas amphibolites (Table 4) were obtained commercially from the Scottish Universities Research and Reactor Centre, East Kilbride. All the Sm-Nd data were normalized to $^{146}Nd/^{144}Nd = .7219$. The ^{147}Sm decay constant used was 6.54×10^{-12} a^{-1}. In assigning errors, the coefficient of variation was taken as 0.25 % for $^{147}Sm/^{144}Nd$. The errors for the $^{143}Nd/^{144}Nd$ measurements are listed in Table 4.

In this report we use the term 'date' in reference to a specific isotopic result. Different dates may be obtained, depending on which samples are included in the calculations. The term 'age' is reserved for those dates which may be interpreted as a meaningful geological event.

Major-element chemical analyses (Table 5) were done at N.G.U. using XRF and wet chemical methods. Rare earth elements (Table 6) were analyzed by neutron activation at the Institutt for Energiteknikk, Kjeller.

Biotite Dates and Model Dates

Rb-Sr biotite dates

Rb-Sr biotite dates are two-point 'isochrons', produced from a single whole-rock sample together with biotite separated from the same sample. Biotite has relatively large Rb concentrations, and the Rb/Sr spread for the biotite - whole rock pair is generally very large, giving the dates relatively small calculated errors. However, since each date includes only two points, which must fit the line perfectly, there is no control of possible isotopic disturbance or disequilibrium. The most common interpretation is that biotite yields a Rb-Sr date corresponding to the age of cooling to the blocking temperature of about 300 - 350°C (Jäger 1979). The biotite dates from Finnmarksvidda are tentatively interpreted as the age of uplift and cooling of the terrane. With an estimated geothermal gradient of about 20 degrees per km, the dates would represent the time of uplift to a depth of about 15 km.

The dates of 1486 - 1633 Ma (Table 1, Fig. 1) are similar to dates from nearby areas of Finland and Sweden (cf. Skiöld 1979a). The younger date of 1208 Ma from the center of the Jer'gul Gneiss Complex (sample 412) compares well with a similarly young biotite date previously

Table 1

Rb-Sr Biotite Dates and Rock Model Dates

Sample No.	Map sheet Coordinates	Sample (Type)	Rb	Sr	$\frac{^{87}Rb}{^{87}Sr}$	$\frac{^{87}Sr}{^{86}Sr}$	SE	Biotite Date	±	Rock model date (with IR=.703±3)
82351	Čier'te	Gneiss	108	436	.719	.72394	8			2022±286
	414750	Biotite	741	39	62.5	2.05035	45	1496	30	
404	Lavvoa'vi	Granite	189	51	10.97	.94647	6			1546±24
	035364	Biotite	1295	22	264	6.39652	57	1501	31	
408	Lavvoa'vi	Gneiss-granite	114	656	.504	.71729	6			1969±408
	030550	Biotite	626	26	82.7	2.64543	39	1633	32	
503	Lavvoa'vi	Granodiorite	152	376	1.172	.73448	7			1867±177
	057431	Biotite	1041	24	169	4.51063	37	1567	31	
412	Niei'davarri	Gneiss-granite	87	481	.524	.72116	8			2399±390
	911438	Biotite	712	63	34.6	1.31097	16	1208	24	
113	Masi	Gneiss	126	275	1.330	.74988	5			2440±155
	170055	Biotite	625	64	29.9	1.38721	9	1554	32	
8253	Galmatskai'di	Granodiorite	64	989	.185	.70804	9			1893±1112
	324603	Biotite	312	87	10.67	.96472	10	1703	34	
247	Luossanjar'ga	Gneiss	74	385	.556	.71686	12			1734±371
	115656	Biotite	374	42	27.28	1.42517	61	1842	37	
232	Bugøyfjord	Pegmatite	146	23	19.35	1.25529	15			1982±22
	842557	Biotite	1082	15	360	8.52026	85	1486	31	
223	Høybuktmoen	Granite	294	90	9.74	1.02461	8			2288±62
	987313	Biotite	478	21	67.8	1.08898	94	78	3	
206	Jakobselva	Granite	148	164	2.63	.79476	7			2415±162
	157183	Biotite	449	26	51.0	1.00353	15	303	6	

obtained by Priem (1968). These young dates may indicate that the gneiss dome was formed by post-tectonic uplift that continued 200-300 Ma longer than in other areas. Another possibility is that a higher geothermal gradient existed beneath the gneiss complex, so that the rocks remained hotter than the blocking temperature even at shallower depth. The heat source for such an anomaly could have been an upwelling of the mantle, a theory supported by a marked positive long wave-length gravity anomaly coinciding with the Jer'gul Gneiss Complex. The relatively old dates of 1703 and 1842 Ma from the Karasjok Greenstone Belt and Baisvarri Gneiss Complex (samples 8253, 247) suggest that these areas were uplifted and cooled relatively early. The very young dates of 78 and 303 Ma from Sørvaranger must be considered unreliable until further analyses are made. They may indicate contamination, disequilibrium, or weathering of biotite in the samples.

Whole-rock Model Dates

The single whole-rock isotopic analysis necessary for each biotite date provides additional insight into the origin of the rock. If the initial Sr ratio is estimated, a Rb-Sr model date may be calculated. Alternatively, if the age of the rock is independently known, an initial ratio may be calculated. The estimates and calculations for the 11 samples are listed in Table 1.

To see how the rock model dates may be used, consider the example of Cier'te, sample 82351. The rock model date with an estimated initial ratio of .703 ± 3 is 2022 ± 286 Ma. With the lowest reasonable initial ratio of .700 (.703 - 3), the oldest possible Rb-Sr date from this rock would be about 2308 Ma (2022 + 286). Even if additional samples were analyzed, there would be no possibility of obtaining a significantly older Rb-Sr date that included this sample.

No minimum Rb-Sr model date can be estimated. The younger model dates listed correspond to an initial ratio of .706, but this is not a minimum date, because the actual intial ratio may be higher and the correct date correspondingly younger. The younger dates listed in Table 1 are provided as an indication of the uncertainty.

Gneiss Terranes

Cier'te Gneiss (Rai'sædno Gneiss Complex)

The Raisæd'no Gneiss Complex is the gneissic basement of westernmost Finnmarksvidda. Parts of the complex have been mapped and described (Fareth et al. 1977). The complex is dominated by plutonic rocks, with minor layers of quartzite, amphibolite and calc-silicate gneiss.

The dated rock is from map-sheet Čier'te, near the center of a large gneiss dome, about 300 m from the nearest mapped layer of amphibolite/ gabbro. The gneiss is a homogeneous, weakly foliated granodiorite consisting of plagioclase, K-feldspar, quartz and biotite. Minor secondary chlorite and saussuritization of plagioclase are seen in thin-section. The sample contained a few fractures, along which the feldspars are pink colored and altered. Field relationships show the gneiss to be one of the younger granitic rocks of the gneiss complex.

The zircons are well formed euhedral crystals, and many of the larger grains have small rounded cores. Five zircon separates from the same large rock sample were analyzed. Samples 2-5 form a discordia line with an upper intercept of 1824 + 89/-54 Ma (Fig. 2). Large colorless zircons without overgrowths were picked and analyzed as sample 1. This sample plots below the discordia, and yields a $^{207}Pb/^{206}Pb$ date of 1986 Ma.

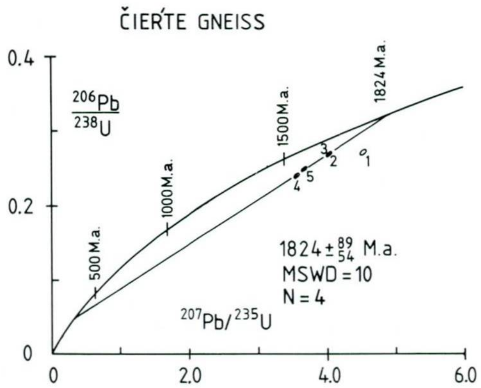

Fig. 2. U-Pb concordia diagram for zircon analyses of the Cier'te gneiss of the Rai'sædno Gneiss Complex. Data in Table 2.

The large gneiss sample had too little variation in Rb/Sr to be subdivided for a Rb-Sr isochron. However, part of the sample was analyzed and yielded a model date of 2022 ± 286 Ma, and a maximum Rb-Sr model date of about 2308 Ma (see Table 1, and previous discussion).

No conclusive interpretation of these dates is possible. The zircon cores represent a small percent of the total zircon material, and may be derived from the older parent rock during generation of the magma. The date of 1824 Ma may be a mixed date, but is presently considered to be the age of the zircon overgrowths and the igneous crystallization of the rock. If 1824 Ma is the correct magmatic age, the rock had an initial Sr ratio of about .704. This value is low, but indicates some crustal contribution. If the picked zircons of sample 1 represent core material without overgrowths, the date of 1986 Ma may indicate a minimum age of the cores.

The older gneisses of the Rai'sædno Gneiss Complex are probably Archean, but no other isotopic dates are available. Archean dates of about 2800 Ma have been obtained from gneiss complexes along strike to the south in Sweden (Welin et al. 1971, Skiöld 1979b).

Cudejåkka Gneiss (Jer'gul Gneiss Complex)

The Jer'gul Gneiss Complex is the gneissic basement of central Finnmarksvidda. The complex contains both older migmatitic gneiss and younger felsic and mafic intrusions. The gneisses are assumed to be largely Archean, but the available isotopic dates are not definitive. Three zircon analyses had been made (Meriläinen 1976) but they are strongly discordant and not colinear. Only when the zircons are grouped together with zircons from Archean gneisses east and south of the granulite belt in Finland do they form a discordia line with an upper intercept date of about 2730 Ma (Meriläinen 1976). If grouped with other zircons, a younger discordia line would be formed.

Samples were collected from the creek Cudejåkka, in the eastern central part of the gneiss dome. The Cudejåkka gneiss is intrusive into older migmatitic gneisses. It is strongly foliated, and locally migmatitic and intruded by younger granitic veins, which were avoided in sampling. The rock is a homogeneous grey tonalitic gneiss consisting of about 50 % plagioclase, 30 % quartz, 5 % microcline and minor biotite.

Eight large samples were analyzed for Rb-Sr dating, but no date was obtained. In Fig. 3, two reference lines are shown. The 2745 Ma reference line is a model date, calculated using the average values of the upper 5 samples, together with a model initial ratio of .703. The 1735 Ma reference line is calculated from the three points with lower values. Neither of these reference lines should be quoted as meaningful ages.

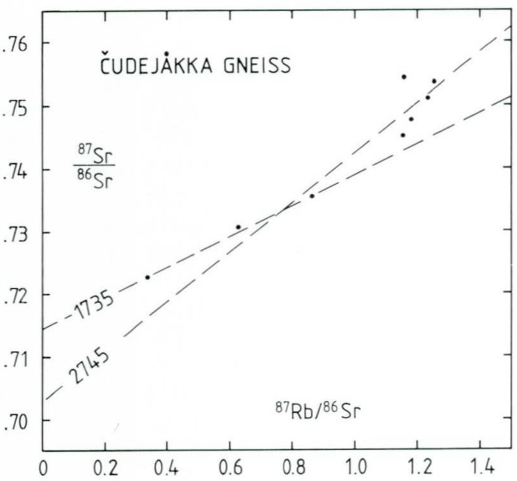

Fig. 3. Rb-Sr isochron diagram for whole-rock samples of Cudejåkka gneiss of the Jer'gul Gneiss Complex. Data in Table 3.

Čadjegorži Granite (Jer'gul Gneiss Complex)

The northern part of the Jer'gul Gneiss Complex is unconformably overlain by conglomerate and terrigenous clastic sediments of the Skuvvanvarre Formation (Siedlecka 1985). Near the waterfall Čadjegorži the conglomerate and angular unconformity are very well preserved (Skålvoll 1964).

Here the Jer'gul Gneiss Complex consists of green-grey gneiss mixed with younger pink granite. The contacts between the gneiss and granite are gradational, and in the area sampled only diffuse relicts of the gneiss are visible within the granite.

Seven large samples (c. 8 kg each) of the granite were collected. They consist of about 40% plagioclase, 25% K-feldspar, 30% quartz, and very small amounts of epidote and green biotite. The rocks were metamorphosed at low grade, as indicated by the epidote and saussuritization of the plagioclase.

One sample (83302) had a pitted calcareous suface, and is not included in the regression. The six best samples produce a Rb-Sr isochron date of 2110 ± 105 Ma (Fig. 4). The initial ratio (.70491 ± 92) is relatively low for a rock of granitic composition, but is higher than Late Archean or Early Proterozoic mantle values. It may indicate assimilation of older gneiss into the granite, or that the granite may have formed by melting of older gneiss.

Because of the excellent fit of the points (MSWD = 1.4), the relatively low initial ratio and the large sample size, the date is interpreted as the age of crystallization of the granite. The granite is clearly older than the nearby unconformity, and the date apparently indicates the maximum age for the unconformity and overlying sediments.

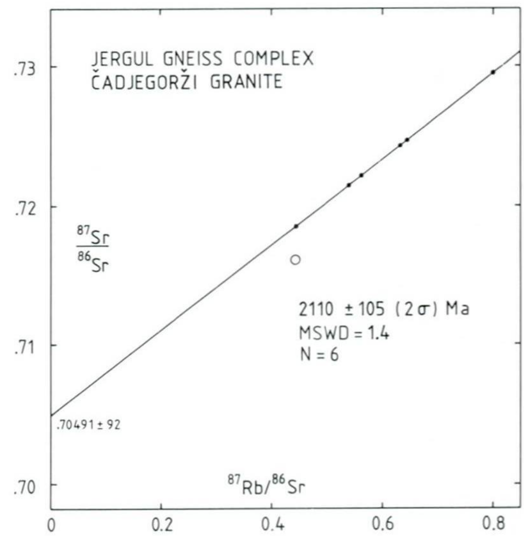

Fig. 4. Rb-Sr isochron diagram for whole-rock samples of Čadjegorži granite of the Jer'gul Gneiss Complex. Data in Table 3.

Bår'devarri Granite (Neiden Granite Complex)

The Neiden granite complex in Sørvaranger is dominated by strongly foliated porphyric granite and granodiorite which intrude the gneisses and banded iron formation of the Bjørnevann group (Wiik 1969). Two zircon analyses have been published from the Neiden Complex. The analyses are grouped together with zircon analyses from other rocks in Finland, and give a discordia line with an upper intercept date of about 2480 Ma (Meriläinen 1976). An unpublished Rb-Sr whole-rock date (Råheim, pers. comm. 1984) yielded an errorchron of about the same date.

Within the Neiden Granite Complex several bodies of unfoliated and homogeneous granites and quartz monzonites intrude the foliated rocks. The dated granite samples are from a small post-tectonic body of medium-grained biotite-bearing granite. Six samples were analyzed. Five of the samples were rather similar, while one sample (B2) has only half as much Sr as the others. The five similar samples yield an isochron with a date of 1673 ± 165 Ma and initial Sr ratio .702 ± 9 (Fig. 5). Sample B2 falls below the line, and is not included in the regression. If it were included, the line would be essentially a two-point errorchron, with the five similar rocks forming only a single point. The isochron date is interpreted as the intrusive age of the Bår'devarri granite.

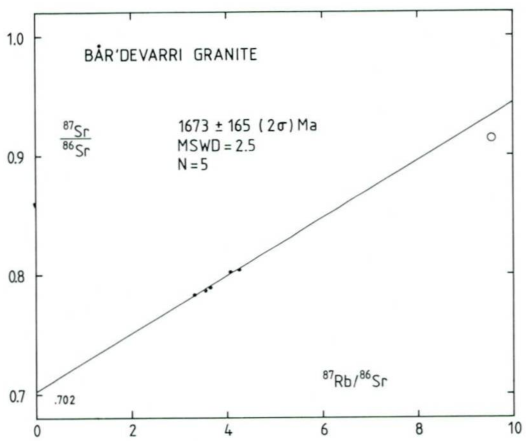

Fig. 5. Rb-Sr isochron diagram for whole-rock samples of Bår'devarri granite of the Neiden Granite Complex. Data in Table 3.

Supracrustal Units

Karasjok Komatiites (Karasjok Greenstone Belt)

The Karasjok Greenstone Belt includes the metasedimentary and metavolcanic rocks lying above and east of the Jer'gul Gneiss Complex. The rocks have been interpreted as Archean because strongly discordant zircons from a cross-cutting albite diabase near Karasjok gave a $^{207}Pb/^{206}Pb$ date of about 2500 Ma, with $^{207}Pb/^{235}U$ and $^{206}Pb/^{238}U$ dates of about 1930 Ma and 1455 Ma, respectively. The rock has been resampled, but not enough zircon was obtained for analysis.

The volcanic rocks are clearly divided petrographically and chemically into two groups - ultramafic komatiites and basaltic amphibolites (Henriksen 1983). Eight komatiitic rocks were analyzed from five locations widely spaced along the length of the greenstone belt. The locations are in the eastern parts of the belt, where metamorphism is of low grade and the degree of deformation is generally less.

The eight samples define a Sm-Nd whole-rock errorchron (Fig. 6) with a date of 2085 ± 85 Ma and initial ratio $^{143}Nd/^{144}Nd$ = .51015 ± 10. The MSWD value of 7 indicates only minor scatter of the data points about the best-fit regression line.

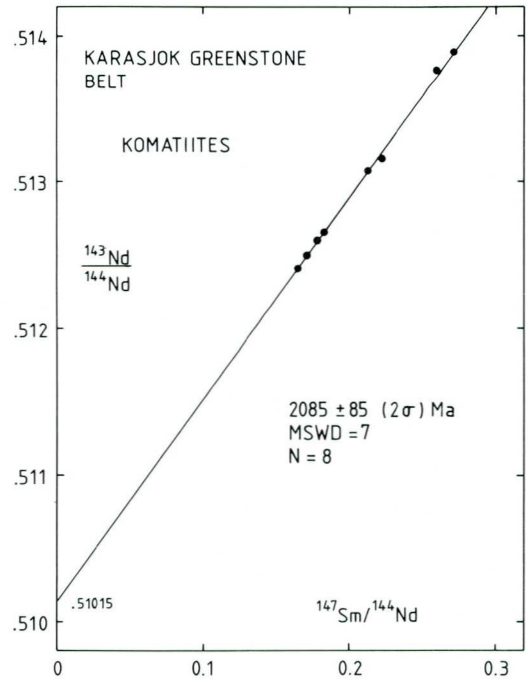

Fig. 6. Sm-Nd isochron diagram for whole-rock samples of Karasjok komatiites of the Karasjok Greenstone Belt. Data in Table 4.

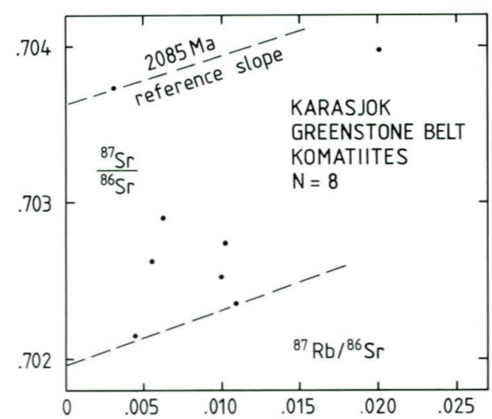

Fig. 7. Rb-Sr isochron diagram for whole-rock samples of Karasjok komatiites of the Karasjok Greenstone Belt. Data in Table 3.

The date is interpreted as the age of igneous formation of the komatiites, and suggests an Early Proterozoic age for the Karasjok Greenstone Belt. The initial Nd ratio is high compared to the CHUR value at 2085 Ma (Jacobsen & Wasserburg 1984) and is equivalent to ε_{Nd} of + 4.1 (DePaolo & Wasserburg 1976). This indicates that the komatiites were derived from a LREE-depleted source region. The initial ratio lies close to the depleted mantle evolution curve of DePaolo (1981). Depletion of the mantle source may be related to the formation of Archean crustal material, such as the older rocks of the Jer'gul and Baisvarri Gneiss Complexes.

The depleted mantle source must have been nearly homogeneous over the length of the greenstone belt, as the various komatiites had similar Nd ratios at the time of formation. It is unlikely that the errorchron reflects a metamorphic or secondary age, because if such secondary disturbance significantly affected the isotopic values, they would probably show more local variation, resulting in a poorer fit to the regression line and a much higher MSWD.

Rb-Sr analyses were made of the same eight samples of komatiite. The samples have extremely low Rb/Sr values, and show only a scattered plot on a Rb-Sr isochron diagram (Fig. 7). The samples contain less than 1 ppm Rb (Table 3), so that even slight geological alteration or laboratory contamination would be significant. Using the established age of 2085 Ma, an initial Sr ratio may be estimated to be between about .7019 and .7036 (Fig. 7), but also this value is disturbed. Most of the data points lie above the reference isochron with a date of 2085 Ma and a bulk earth initial ratio, suggesting that some of the rocks have gained radiogenic Sr during metamorphism.

Cas'kejas Amphibolites (Kautokeino Greenstone Belt)

The Cas'kejas Formation is the westernmost unit of the Kautokeino Greenstone Belt. The rocks can possibly be correlated with the Suoluvuobmi Formation in the eastern part of the greenstone belt, and the Kvenvik greenstone in the Alta-Kvænangen tectonic window (Siedlecka et al. 1985). Except for the rocks of the Gåldenvarri Formation, these rocks are thought to be among the oldest igneous rocks in the Kautokeino Greenstone Belt.

Samples were collected along a 250 m profile across strike, about 4 km south of the Bidjovagge mine. The rocks include both layered fine-grained amphibolites, and more massive medium-grained rocks. All the rocks have similar chemistry (Table 4), and plot as tholeiitic ocean floor basalts on trace element discrimination diagrams. Recent mineral studies indicate lower amphibolite-facies metamorphism (Sandstad, in prep.).

The 5 samples showing the greatest Sm/Nd spread were chosen on the basis of preliminary REE data (Table 6) and analyzed isotopically. The points define a Sm-Nd errorchron with a date of 2279 ± 300 Ma and an initial Nd ratio of .50982 ± 40 (Fig. 8). The age and intercept errors are large, because of the small Sm/Nd spread. The scatter of the points about the best-fit line (MSWD = 8) may be the result of metamorphic disturbance. The fine-grained rocks (samples A2 and A6) may be metatuffs with somewhat modified initial Nd ratios.

The five-point whole-rock date may best represent the age of Cas'kejas volcanism, but the 2-sigma errors are large. The date of 2279 Ma must not be quoted without reference to the ± 300 Ma uncertainty.

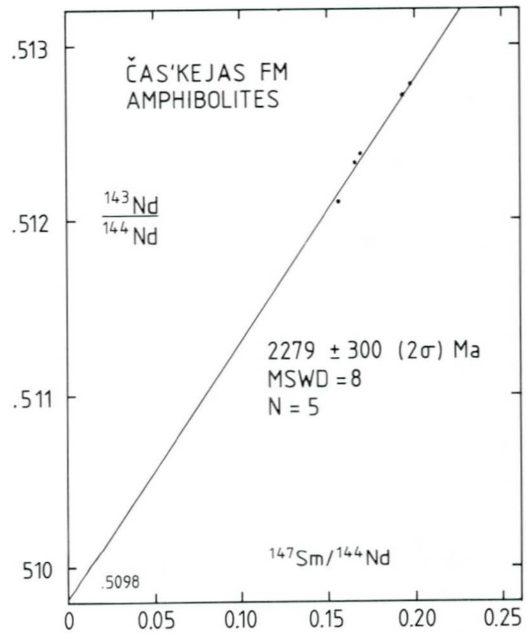

Fig. 8. Sm-Nd isochron diagram for whole-rock samples of Cas'kejas amphibolites of the Kautokeino Greenstone Belt. Data in Table 4.

Kvenvik Greenstones (Raipas Group)

The rocks of the Raipas Group which are exposed in tectonic windows in outer Finnmark, include the least deformed and metamorphosed Precambrian greenstones of Finnmark. K-Ar data on whole-rock samples gave a great variation in dates, indicating both loss and gain of radiogenic Ar (Gautier et al. 1979). K-Ar results on hornblende gave more consistent dates of about 1840 Ma, interpreted as the age of regional metamorphism (Pharaoh et al. 1982). The Kvenvik greenstones of the Alta-Kvænangen window were mapped and described by Zwaan & Gautier (1980). The rocks have recently been the focus of more detailed petrologic and geochemical study, to characterize the effects of sea floor spilitization, oxidation and low-grade metamorphism (Bergh & Torske 1985).

Samples were collected from various greenstone layers to maximize the spread in Sm-Nd for a possible whole-rock date, but preliminary REE analysis (Table 6) showed the rocks to contain insufficient Sm/Nd spread. However, five of the rocks did show a sufficient spread in Rb/Sr values, and isotopic analyses were made to help understand the Rb-Sr systematics.

The analyses define a Rb-Sr errorchron date of 1135 ± 883 Ma, with an MSWD of 259. The regression date is considered to be meaningless, and the errorchron is not drawn in Fig. 9.

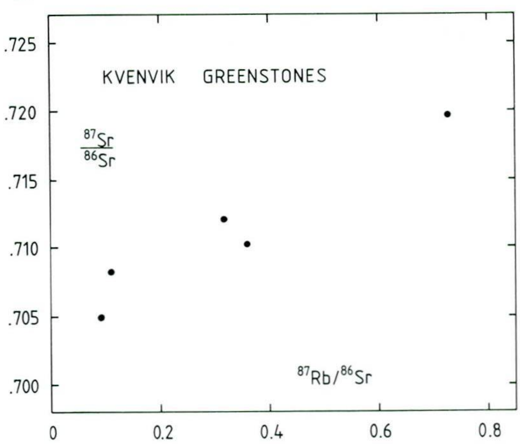

Fig. 9. Rb-Sr isochron diagram for whole-rock samples of Kvenvik Greenstones of the Raipas Group in the Alta-Kvænangen tectonic window. Data in Table 3.

If the greenstones are presumed to be 1850 Ma or older with an initial Sr ratio of about .703, nearly all the points lie below or to the right of the reference line on a Rb-Sr diagram (Fig. 9). Either systematic loss of Sr or gain of Rb could yield such results. A model date from this rock would be misleadingly young.

Intrusions Within Supracrustal Units

Neidagår'zi Albite Diabase (Kautokeino Greenstone Belt)

The term albite diabase, as commonly used in the northern Baltic Shield, denotes rocks which contain albite as the main feldspar.

Meriläinen (1961) gave a description of the rock type. The Neidagår'zi albite diabase consists of albite, hornblende, biotite, clinopyroxene and magnetite, and shows an unfoliated coarse-grained texture.

Many of the albite diabases of the Kautokeino Greenstone Belt intruded as dikes along steep fault zones, after the main deformation and metamorphism (Olesen & Solli 1985). They themselves may be faulted and weakly folded. The Neidagår'zi albite diabase is only slightly disturbed. It apparently intruded as a sill within the quartzite and amphibolite of the Masi and Gåldenvarri Formations (Solli 1983).

The zircons in the rock were probably strongly fractured, because the zircon separates are angular fragments lacking crystal form. U-Pb analyses show the zircons to be strongly discordant (Fig. 10), which may indicate loss of Pb in connection with the fracturing. The four zircon separates define a discordia line with upper and lower intercepts of 1815 ± 24 Ma and 192 ± 24 Ma, respectively. Extra zircons from separate 7 M were leached in dilute HF and HNO_3 acid, but the analytical result was not more concordant.

The date of 1815 ± 24 Ma is interpreted as the intrusive age of this and the other late-tectonic albite diabases of the Kautokeino Greenstone Belt.

Dat'kuvarri Granodiorite (Kautokeino Greenstone Belt)

The Dat'kuvarri granodiorite was first mapped and described by Holmsen et al. (1957). It is one of the few felsic intrusions in the northern part of the Kautokeino Greenstone Belt. It clearly cuts the foliation in the schist of the Suoluvuobmi Formation. However, the granodiorite is weakly foliated and is interpreted to be late tectonic.

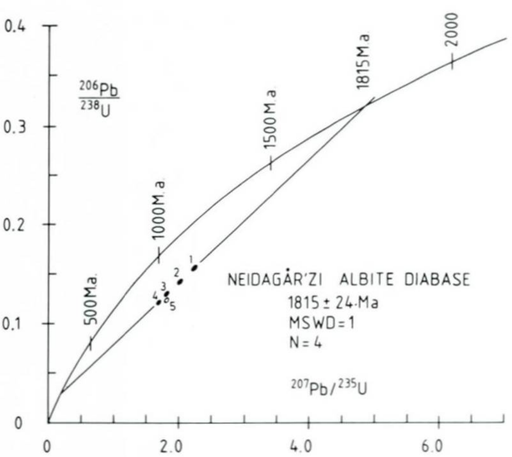

Fig. 10. U-Pb concordia diagram for zircon analyses of the Neidagår'zi albite diabase in the Kautokeino Greenstone Belt. Data in Table 2.

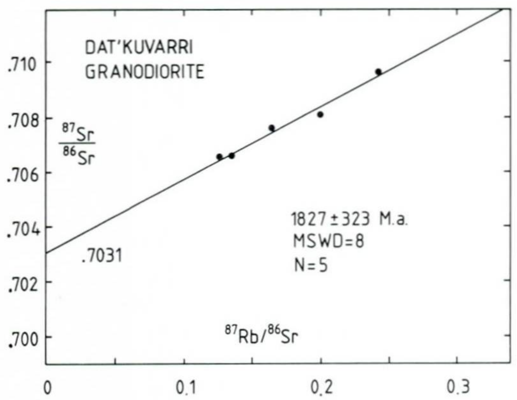

Fig. 11. Rb-Sr isochron diagram for whole-rock samples of Dat'kuvarri granodiorite in the Kautokeino Greenstone Belt. Data in Table 3.

The rock is light-colored, and consists of about 60 % sericitized plagioclase, 20 % quartz, 10 % microcline, and minor muscovite.

Many samples were collected, but only five showed sufficient Rb-Sr spread for dating. The five analyses define an errorchron with a date of 1827 ± 323 Ma, and an initial Sr ratio of .7031 ± 8 (Fig. 11). The date is interpreted as the intrusive age. The relatively low initial ratio suggests that the magma was derived directly from either the upper mantle, lower crust, or rocks of the greenstone belt. It was probably not derived from older gneissic basement such as the Jer'gul or Rai'sædno Gneiss Complexes.

Riednjajav'ri Quartz Monzonite (Kautokeino Greenstone Belt)

The Riednjajav'ri quartz monzonite is over 90 km^2 in area, but is exposed in only few outcrops. From geological mapping and geophysical study (Sandstand & Olesen 1984, Olesen & Solli 1985), the rock appears to discordantly cut the graphitic schist and layered amphibolite of the Cas'kejas Formation.

The rock is medium-grained and massive to weakly foliated. It consists mainly of plagioclase, perthite, quartz, amphibole and biotite, with accessory epidote, zoisite, sphene, rutile, muscovite, garnet and magnetite. Amphibole is partly altered to biotite, and plagioclase is saussuritized. The rock varies in composition from diorite to the dominant quartz monzonite, and most of the samples were from the more mafic part.

The 10 samples define a Rb-Sr errorchron with a date of 1821 ± 143 Ma and an initial Sr ratio of .703 ± 1 (Fig. 12). The date is interpreted to be the age of intrusion, and the low initial ratio suggests that the magma was not derived from the older gneisses of the adjacent Rai'sædno Gneiss Complex.

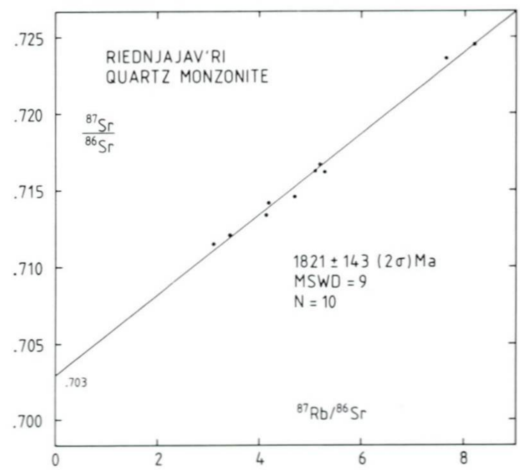

Fig. 12. Rb-Sr isochron diagram for whole-rock samples of Riednjajav'ri quartz diorite in the Kautokeino Greenstone Belt. Data in Table 3.

Giev'dnegoi'ka Granite (Kautokeino Greenstone Belt)

The Giev'dnegoi'ka granite is a late- or post-tectonic leucocratic granite located near the contact between the Jer'gul Gneiss Complex

Table 2

U-Pb Data

No.	Sample	Weight (mg)	207/206	208/206	204/206	8/4	U(%)	Pb(%)	Common Pb (%)	$\frac{^{207}Pb}{^{235}U}$	$\frac{^{206}Pb}{^{238}U}$
Rai'sædno Gneiss Complex (82351) Map-sheet Čier'te 1733 II UTM coordinates 412710											
1	ONM +200 PIC	3.10	0.14647	0.19819	0.00182	108.7	0.04	0.01	4.69	4.5373	0.2697
2	ONM +200	21.50	0.12301	0.21764	0.00099	218.8	0.10	0.03	4.57	4.0290	0.2669
3	ONM -200	29.90	0.12363	0.23356	0.00112	208.6	0.12	0.04	5.34	4.0318	0.2698
4	OM 1NM +200	30.20	0.12157	0.22990	0.00102	224.6	0.10	0.03	4.84	3.5651	0.2403
5	OM 1NM -200	56.00	0.12176	0.25008	0.00108	231.8	0.15	0.04	5.16	3.6788	0.2493
Neidagårzi Albite Diabase Map-sheet Masi 1933 IV UTM Coordinates 022885											
1	ONM+OM	3.00	0.31684	0.75190	0.01552	48.4	0.07	0.02	49.39	2.2301	0.1551
2	3M	8.16	0.12145	0.29018	0.00137	211.9	0.08	0.01	5.98	2.0086	0.1419
3	5M	14.11	0.12670	0.33675	0.00185	182.2	0.09	0.02	8.23	1.8016	0.1290
4	7M	17.55	0.14999	0.44340	0.00360	123.3	0.11	0.02	14.98	1.6694	0.1204
5	7M (L)	9.74	0.11465	0.17070	0.00063	271.3	0.05	0.01	2.70	1.8075	0.1236
Galmat Granodiorite (8253) Map-sheet Galmatskai'di 2033 II UTM Coordinates 324603, 315606											
1	ONM +200	14.26	0.11814	0.11592	0.00030	383.6	0.10	0.03	1.50	4.5125	0.2870
2	ONM +200	29.19	0.11957	0.05253	0.00043	122.3	0.11	0.03	2.36	4.3785	0.2792

Sample abbreviations: 0, 3, 5, 7 = Inclination in degrees, Frantz magnetic separator
M, NM = Magnetic, non-magnetic zircon fractions
+200, -200 = Sieve mesh size

and the Kautokeino Greenstone Belt. The granite includes xenoliths of amphibolite and quartzite, apparently from the greenstone belt. However, the area of exposure is less than 1 km² and the contacts are not seen. The rock is unfoliated and has a bimodal grain size distribution, with parts about 0.2 mm and others 10 mm to pegmatitic. It represents a highly differentiated magma, as indicated by its characteristic chemistry and Mo, W, and F mineralizations (Olerud 1984).

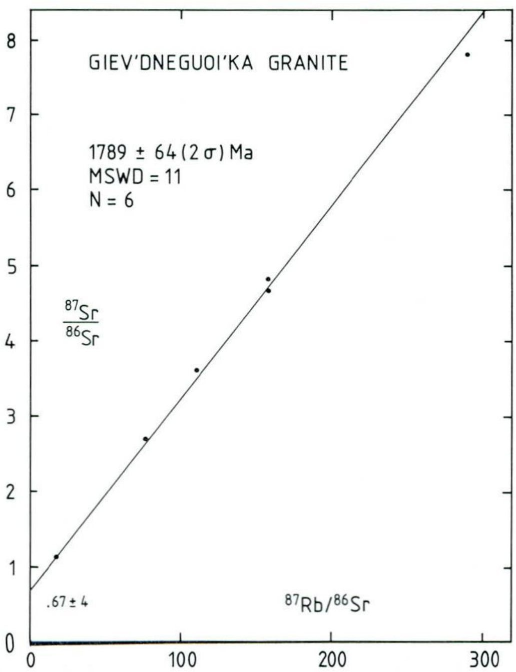

Fig. 13. Rb-Sr isochron diagram for whole-rock samples of Giev'dneguoi'ka granite in the Kautokeino Greenstone Belt. Data in Table 3.

Rb-Sr analyses of six samples show a great spread in Rb/Sr values, but the points are not perfectly colinear (Fig. 13). The best-fit regression line defines an errorchron date of 1789 ± 64 Ma, with an initial ratio of .670 ± 41, and MSWD = 11. However, only the upper error limit of the initial ratio is reasonable, so the lower error limit of the date (c. 1725 Ma) is probably closer to the real age. This granite is the youngest igneous rock known in the Kautokeino Greenstone Belt.

Stuorragår'zi Granite (Karasjok Greenstone Belt)

The Stuorragår'zi granite intrudes mainly the older foliated gneisses of the Jer'gul Gneiss Complex, but some apophyses are also seen in amphibolite of the Karasjok Greenstone Belt. The granite is pink, medium- to coarse-grained, and consists of microcline, plagioclase, quartz and rutile, with no other mafic minerals. Small spots of brown carbonate are common, but were avoided in sampling. The 5 samples of granite yielded a Rb-Sr errorchron

(Fig. 14)with a date of 1730 ± 117 Ma, and an initial Sr ratio of .715, and MSWD = 4. The date is interpreted as the intrusive age, and the relatively high initial ratio suggests that the granite may have been derived in part by melting of gneisses of the Jer'gul Gneiss Complex. The granite is unfoliated and post-kinematic with respect to deformation of the Karasjok Greenstone Belt.

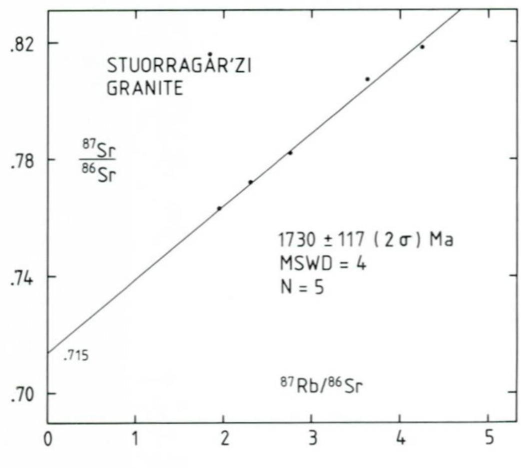

Fig. 14. Rb-Sr isochron diagram for whole-rock samples of Stuorragår'zi granite in the Karasjok Greenstone Belt. Data in Table 3.

Galmat Granodiorite (Karasjok Greenstone Belt)

A number of small bodies of granodiorite have been mapped within the Karasjok Greenstone Belt. They are most commonly observed within amphibolite, and contain plagioclase, K-feldspar, quartz, hornblende and biotite. Where observed within metasedimentary units they locally contain white mica and no hornblende. Intrusive relationships in both metasediments and amphibolites have been seen (e.g. UTM 201894), but generally the granodiorites are very strongly deformed together with the host rocks, and are interpreted as early kinematic.

Several granodiorite bodies are relatively well exposed in the amphibolites on the mountain Galmat in the southern part of the Karasjok Greenstone Belt. Most contacts observed here are sharp and concordant, but parts of one contact are diffuse, with amphibolite veined by injected granodiorite. A few xenoliths of folded amphibolite within granodiorite were also found. Parts of some contacts are sheared and retrograded with formation of epidote and pink coloration of plagioclase.

Samples were collected from three separate but similar hornblende-bearing granodiorite bodies. The samples showed no spread in Rb/Sr values, and only one sample was analyzed isotopically. With an assumed initial Sr ratio of .703, this sample gives a Rb-Sr model date of 1893 Ma, but the uncertainty is very large because of the Rb/Sr ratio is so low (Table 1).

A suite of zircons was separated from one of the granodiorite bodies. The zircons are euhedral, colorless and unzoned. The two zircon separates analyzed give an upper intercept date of about 1890 Ma (Fig. 15), which is interpreted as the age of the igneous crystallization.

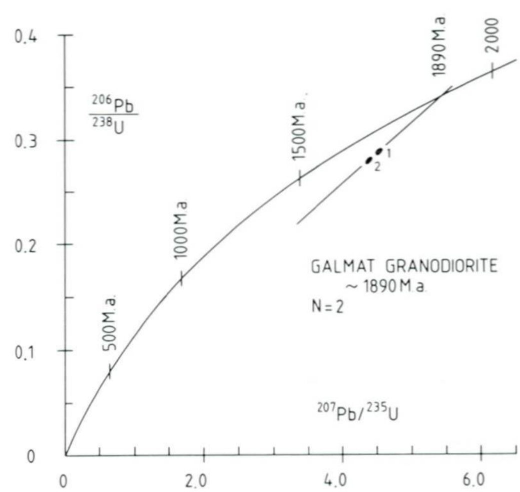

Fig. 15. U-Pb concordia diagram for zircon analyses of the Galmat granodiorites in the Karasjok Greenstone Belt. Data in Table 2.

Anarjåkka Granites (Tanaelv Migmatite Belt)

Pink microcline granites are common in the rocks of the Tanaelv Migmatite Belt about 50 km south of Karasjok. The granites are generally weakly foliated but some are massive, occurring as sills within the migmatitic amphibolites and gneisses. They appear to be younger than the more strongly foliated granitic veins and leucosomes within the migmatites.

Samples from four separate granites were collected for Rb-Sr dating. Each granite is a separate sill, several meters thick, intruded into the migmatitic amphibolite. All four of the granites are sampled from within one square kilometer area. They consist of microcline, plagioclase and quartz, with accessory biotite, magnetite and garnet. The samples were rather similar, but granite B was more strongly jointed, while granite C was more weathered, and granite D contained some green saussuritized plagioclase.

Isotopic results from the four granites are as follows: A: 1676 ± 95 Ma, IR=.713 ± 6, MSWD = 0.7, N = 4 samples. B: 1783 ± 37 Ma, IR=.716 ± 3, MSWD = 0.01, N = 4 samples. C: 1875 ± 67 Ma, IR=.717 ± 2, MSWD = 5.4, N = 4 samples. D: 1767 ± 55 Ma, IR=.712 ± 3, MSWD = 5.0, N = 6 samples.

Granites A and B yield isochrons with MSWD < 2.5 (Fig. 16), and these dates are considered to be more reliable than dates from granites C and D. The dates are interpreted as reflecting the age of intrusion, and judging from isochrons of granites A and B an intrusive age of about 1750 Ma may be most accurate. The deformation was apparently finished before about 1730 Ma, the date of the Nattanen post-tectonic granites in Finland (Meriläinen 1976) and the Stuorragår'zi granite (Fig. 14). The initial ratios of about .714 are relatively high. They are typical for anatectic granites derived from partial melting of older rocks with abundant Rb. The source was surely the gneisses within the Tanaelv Migmatite Belt.

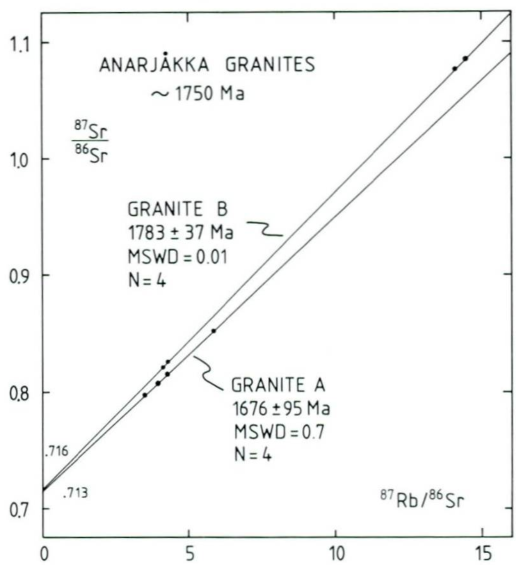

Fig. 16. Rb-Sr isochron diagram for whole-rock samples of Anarjåkka granites in the Tanaelv Migmatite Belt. Data in Table 3.

Discussion

Interpretation of Dates and Errors

We will not undertake a lengthy discussion of the interpretation of individual dates. The interpretations given above are those preferred on the basis of available data. As more geologic and isotopic data are obtained, some of the dates might be re-interpreted to be reset, or found to be metamorphic ages. In nearby areas of northern Sweden, some Rb-Sr dates have been significantly younger than corresponding U-Pb zircon dates (discussed by Witschard 1984). In both the Lina granite and Porphyry groups, some rocks have given Rb-Sr whole-rock dates as young as 1550 - 1600 Ma (Welin et al. 1971, Gulson 1972), while U-Pb zircon dates are 1780 - 1880 Ma (Skiöld 1982, Skiöld & Cliff 1984). It is not clear if any of the young whole-rock dates of the 1550-1600 Ma interval represent an intrusive event. Mineral dates of c. 1500 Ma are tentatively suggested to represent uplift and cooling (Skiöld 1979a, Wilson 1980). There is no evidence for magmatism or Rb-Sr whole-rock disturbance of this age in Finnmark or adjacent parts of Finland (see Meriläinen 1976, Bernard-Griffiths et al. 1984).

All errors are quoted at the 2-sigma level of confidence. This means that if additional data of the same sort were obtained, the new dates (and/or initial ratios) would lie within the error range in about 95 % of all cases. Some authors quote 1-sigma errors, which are half as large, but the confidence level is only about 68%. Error calculations include statistical uncertainties due to limited data or randomly disturbed data, but do not account for the possibility of systematic geological disturbance. Isotopic ratios are commonly disturbed, as indicated by high MSWD values. If such disturbance is systematic and not random, the true ages may be outside the 2-sigma error range for some of the errorchrons.

Several of the dates presented here have error ranges and MSWD values larger than in other published isotopic studies. We consider these dates to be useful and include the results, but recommend that they be used with caution. It is always best to quote the 2-sigma error margin as well as the date, and to use the term 'errorchron' (Brooks et al. 1972) for isochrons in which the MSWD is >2.5.

Table 3 Rb-Sr Data

Čudejåkka Gneiss

Map-sheet Soussjav'ri 1933 I UTM coordinates 830943

Sample No.	Rb	Sr.	Rb/Sr	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	SE
83401	178	596	.298	.864	.73568	3
83402	205	514	.399	1.1591	.75448	9
83403	69	586	.117	.339	.72293	5
83404	110	510	.217	.629	.73064	7
83405	132	332	.398	1.156	.74535	9
83406	203	478	.425	1.234	.75129	15
83407	180	434	.432	1.255	.75398	7
83408	188		.406	1.179	.74778	7

Čadjegořzi Granite

Map-sheet Skoganvarre 2034 IV UTM coordinates 286406

Sample No.	Rb	Sr.	Rb/Sr	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	SE
83301	72	325	.2216	.6422	.72480	7
83302	73	475	.1527	.4421	.71621	9
83303	72	387	.1874	.5429	.72139	10
83304	72	329	.2180	.6317	.72434	8
83305	63	413	.1423	.4411	.72964	8
83306	91	330	.2758	.7996	.72964	9
83307	64	333	.1925	.5577	.72239	3

Bår'devarri Granite

Map-sheet Neiden 2334 II UTM coordinates 939296

Sample No.	Rb	Sr.	Rb/Sr	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	SE
B1	207	166	1.25	3.65	.79040	9
B2	254	78	3.23	9.53	.91501	12
B3	207	142	1.46	4.26	.80471	6
B4	197	173	1.14	3.32	.78394	9
B5	222	182	1.22	3.56	.78684	9
B6	245	175	1.40	4.09	.80223	7

Karasjok Komatiites
(Locations given in Table 4)

Sample No.	Rb	Sr.	Rb/Sr	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	SE
4482	.076	71.42	.0011	.0031	.703739	18
123	.253	36.34	.0070	.0201	.703980	50
104E	.243	64.54	.0038	.0109	.702364	22
104F	.110	72.37	.0015	.0044	.702159	24
104G	.093	43.29	.0021	.0062	.702900	22
105	.246	69.50	.0035	.0102	.702740	20
11Å	.276	80.24	.0034	.0100	.702532	16
83631	.272	143.26	.0020	.0055	.702636	18

Kvenvik Greenstones

Map-sheet Alta 1834 I UTM coordinates 810600

Sample No.	Rb	Sr.	Rb/Sr	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	SE
DA 5	18.75	145.9	.129	.3179	.71043	6
DA 6	6.65	208.1	.032	.09248	.70517	8
DA 7	18.23	72.7	.251	.7259	.71986	41
DA 8	20.18	163.0	.124	.3582	.71217	5
DA 10	6.36	167.6	.038	.10969	.70839	4

Dat'kavarri Granodiorite

Map-sheet Carajav'ri 1833 I UTM coordinates 917936

Sample No.	Rb	Sr.	Rb/Sr	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	SE
107	39	845	.0461	.133	.70660	6
109	44	1007	.0437	.126	.70657	9
110	51	610	.0836	.242	.70964	11
112	39	679	.0574	.166	.70766	9
113	43	613	.0701	.203	.70811	4

Table 3 (continued)

Rb-Sr
Data

Riednjajav'ri Quartz Monzonite

Map-sheet Siebe 1832 I UTM coordinates 853304

Sample No.	Rb	Sr.	Rb/Sr	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	SE
722/1	85	468	.182	.526	.71620	8
722/2	84	583	.144	.417	.71426	8
722/3	69	583	.118	.342	.71203	15
722/4	82	576	.142	.411	.71350	7
722/5	99	551	.179	.518	.71667	7
722/6	86	530	.162	.469	.71461	7
722/7	72	677	.107	.310	.71152	7
724	127	726	.175	.507	.71627	8
719	147	555	.265	.767	.72375	3
739	140	495	.283	.820	.72451	8

Giev'dvegoi'ka Granite

Map-sheet Cappuluobbal 1933 III UTM coordinates

Sample No.	Rb	Sr.	Rb/Sr	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	SE
4011	1048	17.62	59.5	291.8	7.82076	237
4012	520	13.15	39.5	158.7	4.66897	143
4013	84.3	13.51	6.24	18.84	1.15118	28
4014	403.6	13.46	29.98	111.4	3.61416	110
4015	248.4	11.12	22.35	77.26	2.70221	150
4016	549	14.08	39.00	158.3	4.83030	50

Stuorragår'zi Granite

Map-sheet Bæivasgied'di 2033 IV UTM coordinates 143887

Sample No.	Rb	Sr.	Rb/Sr	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	SE
8361	81	65	1.240	3.62	.80741	8
8363	86	91	.941	2.74	.78284	6
8365	51	76	.667	1.94	.76312	8
8366	59	75	.791	2.30	.77235	9
8368	86	59	1.454	4.25	.81827	8

Anarjåkka Granites

Map-sheet Galmatskai'di 2033 II

Granite A UTM coordinates 48806325

Sample No.	Rb	Sr.	Rb/Sr	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	SE
A-82251	149	124	1.200	3.50	.79711	5
A-82252	148	110	1.346	3.93	.80895	7
A-82253	151	104	1.451	4.24	.81553	8
A-82254	194	97	1.999	5.87	.85414	8

Sample No.	Rb	Sr.	Rb/Sr	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	SE
Granite B	UTM		coord.	48706310		
B-82255	224	48	4.70	14.09	1.07733	9
B-82256	220	46	4.82	14.46	1.08691	8
B-82257	157	111	1.409	4.12	.82184	3
B-82258	161	110	1.471	4.30	.82636	7
Granite C	UTM		coord.	48806300		
C-82259	138	77	1.806	5.29	.84393	7
C-822510	150	69	2.18	6.42	.87578	9
C-822511	44	83	.528	1.533	.75102	7
C-822512	129	44	2.94	8.68	.92501	6
Granite D	UTM		coord.	48806290		
D-822513	138	104	1.334	3.90	.81249	11
D-822514	133	61	2.19	6.44	.87361	9
D-822515	129	86	1.489	4.36	.82458	9
D-822516	280	40	7.59	23.2	1.28469	7
D-822517	108	179	.601	1.75	.75531	7
D-822518	159	72	2.22	6.54	.87963	5

Table 4 Sm-Nd Data

Karasjok Komatiites

Sample No.	Map UTM	Sm Nd	Sm/Nd	$^{147}Sm/^{144}Nd$	$^{143}Nd/^{144}Nd$	SE
4482	2034 II 381338	1.268 2.830	.4481	.2720	.513891	18
123	2033 IV 299018	1.321 3.083	.4285	.2600	.513769	26
104E	2033 III 150640	2.229 11.001	.2026	.1781	.512601	12
104F	2033 III 150640	1.135 3.243	.3500	.2124	.513081	10
104G	2033 III 150640	.853 2.329	.3663	.2224	.513157	10
105	2033 III 159649	3.377 11.941	.2828	.1716	.51250	
11Å	2033 III 192672	3.136 11.594	.2705	.1641	.512419	12
83631	2033 III 184796	2.455 8.147	.3013	.1830	.512660	14

Ĉas'kejas Amphibolites

Map-sheet Raisjav'ri 1833 III UTM coordinates 588 830

Sample No.	Sm Nd	Sm/Nd	$^{147}Sm/^{144}Nd$	$^{143}Nd/^{144}Nd$	SE
A2	3.082 11.23	.2744	.16585	.512325	20
A4	3.416 13.23	.2582	.15602	.512105	31
A6	2.491 8.968	.2778	.16791	.512385	25
A8	1.839 5.624	.3270	.19769	.512772	22
A10	2.978 9.346	.3186	.19266	.512719	27

Geochronological Synthesis

Although the error ranges of the individual dates are large, several general interpretations can be made on the basis of the new data.

Archean dates were not obtained for any of the rocks. The oldest rocks in the gneiss complexes are heterogeneous and migmatitic, and no dating of these rocks was attempted. If a date were obtained from such rocks, its interpretation would not have been clear without more detailed petrologic and field data than now available. Archean dates have been obtained from similar gneiss complexes in northern Sweden and Finland (Matisto 1969, Welin et al. 1971, Meriläinen 1976, Skiöld 1979), and it is presumed that the oldest rocks in each gneiss complex are of Archean age.

The Karasjok Greenstone Belt is now considered to be Early Proterozoic and not Archean as previously suggested (Meriläinen 1976). This interpretation is based on both the Sm-Nd whole rock date of 2085±85 from the Karasjok komatiites, and the maximum date of 2110 ± 105 Ma for the unconformity beneath the greenstone belt.

This unconformity may be correlated with one near the base of the Kautokeino Greenstone Belt (Siedlecka et al. 1985), which is therefore also interpreted as younger than 2110±105 Ma. The very lowest part of the Kautokeino Greenstone Belt, the Gåldenvarri Formation, appears to underlie this unconformity, and it may be Archean. Other support for the Early Proterozoic age of the Kautokeino Greenstone Belt is the Sm-Nd whole-rock date of 2279±300 Ma from the Cas'kejas amphibolites. The Kautokeino greenstones may be correlated with the Kiruna greenstones. Metamorphic minerals from one of the Kiruna greenstones yielded a Sm-Nd date of 1932±45 Ma (Skiöld & Cliff 1984), which is interpreted as a metamorphic

Table 5 Chemical Analyses of Supracrustal Rocks

Sample	SO_2	T_1O_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	MnO	P_2O_5	H_2O	CO_2	Total
4482	41.79	.70	5.86	2.26	9.45	22.63	8.53	-	-	.16	.03	6.30	3.22	100.93
123	42.21	680	5.40	5.23	8.12	22.85	6.31	.4	-	.18	.03	6.09	.64	98.14
104E	43.03	1.47	8.23	2.62	10.63	15.98	11.03	1.4	.12	.21	.12	4.16	1.01	99.61
104F	40.29	.73	4.51	3.52	8.54	27.48	3.52	.1	-	.17	.05	8.28	2.37	99.56
104G	46.78	.52	3.72	2.44	9.53	23.05	5.83	.3	-	.24	.02	5.40	1.22	99.05
105	45.34	1.77	7.48	2.70	10.79	16.83	9.23	1.4	.08	.19	.13	3.96	.16	99.96
116A	41.23	1.44	10.96	2.71	11.77	17.70	7.76	.9	.11	.17	.13	5.26	.13	100.27
83631	41.34	1.21	8.50	1.67	11.52	17.78	8.03	.7	.06	.17	.09	4.10	3.56	98.73
A2	50.31	1.25	14.33	2.68	13.04	7.42	6.77	3.1	.12	.20	.08	1.29	-	100.58
A4	49.32	1.30	13.35	2.47	9.75	7.84	10.76	2.4	.62	.16	.13	1.34	.14	99.60
A6	52.38	1.03	14.26	2.74	12.05	6.48	5.86	3.6	.13	.22	.04	.94	-	99.73
A8	47.99	.90	15.20	2.28	9.79	8.75	10.79	2.3	.38	.22	.06	1.46	.11	100.23
A10	49.83	1.49	15.15	2.54	15.01	6.46	8.22	.6	.23	.22	.07	1.11	-	100.93
DA5	48.81	1.42	12.97	2.22	10.57	6.79	10.95	1.9	1.9	.20	.10	2.52	.11	100.46
DA6	48.71	1.53	13.12	3.31	10.25	6.24	10.31	2.2	2.2	.19	.11	2.49	.09	100.75
DA7	49.10	1.92	11.42	8.95	7.08	4.79	10.33	1.4	1.4	.23	.15	3.36	.12	99.95
DA8	53.84	1.18	12.02	1.84	10.60	7.82	4.06	2.5	2.5	.16	.06	2.55	.22	99.35
DA10	47.83	1.55	13.18	1.55	12.34	6.32	12.18	1.9	1.1	.21	.11	2.80	.20	101.27

Table 6 REE Analyses of Supracrustal Rocks

Sample	La	Ce	Nd	Sm	Eu	Tb	Yb	Lv
44828	.36	3.1	2.8	1.23	.15	.16	.68	.12
123	.87	1	3.5	1.4	.59	.28	.84	.12
104E	4.4	14	11.7	3.3	1.69	.46	1.4	.22
104F	.94	8	5.4	1.2	.29	.10	.70	.10
104G	.45	2	2.2	.83	.24	.15	.54	.09
105	7.7	12	13.8	3.8	.91	.47	1.6	.22
116A	6.7	14	11.2	3.1	1.03	.31	1.3	.25
83631	4.6	9	8.2	2.5	.95	.38	1.2	.21
A2	6.9	18	10.7	3.04	1.15	.42	2.0	.30
A4	8.1	21	12.6	3.29	1.17	.41	1.6	.27
A6	5.1	14	7.1	2.52	.94	.35	2.1	.31
A8	2.6	5.8	4.4	1.85	.74	.26	1.7	.20
A10	4.0	11	8.6	2 .88	1.20	.40	2.0	.35
DA5	5.5	16	12.0	3.2	1.27	.43	2.2	.32

age. Recent zircon dating of an albite diabase sill within the Kiruna greenstones shows that the oldest mafic volcanic rocks are at least 2200 Ma old (T. Skiöld, pers.comm. 1985).

A clear pattern emerges from the dates of the intrusive rocks. The peak of intrusion of intermediate rocks, such as the Dat'kuvarri granodiorite, Riednjajav'ri quartz monzonite, Cier'te gneiss, and Galmat granodiorite, was about 1820 Ma or older. The main granitic plutonism, including the Giev'dnegoi'ka granite, Stuorragår'zi granite, Anarjåkka granites, and Bår'devarri granite, was younger, about 1650 - 1750 Ma.

In northern Sweden and Finland, a similar pattern has been identified from zircon dating (Skiöld 1981, 1985; Lehtonen 1984), although the ages are somewhat older. There the early orogenic Svecokarelian intermediate plutonic rocks are c. 1880 Ma and separated from the c. 1800 Ma granites by a main phase of folding and regional metamorphism.

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