RECONNAISSANCE Rb-Sr INVESTIGATION OF SALIC, MAFIC AND ULTRAMAFIC ROCKS IN THE ØKSFJORD AREA, SEILAND PROVINCE, NORTHERN NORWAY*

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A coarse-grained syenite perthosite within the Øksfjord area of the Seiland petrographic complex in northern Norway defines an apparent Rb-Sr whole-rock isochron age of 625 m.y. The intrusion of the syenite perthosite is believed to postdate the intrusion and subsequent granulite-facies metamorphism of the gabbro gneiss and other foliate igneous rocks that make up the bulk of the province. The meta-gabbros, meta-syenites, and quartz-garnet-hypersthene gneisses that enclose the perthosite scatter about a Rb-Sr isochron of 1300 m.y., but this cannot be considered a valid event. There is a possibility that a Precambrian event occurred at about 1600 m.y. and that subsequent (Caledonian?) shearing opened some rocks to the partial gain and loss of radiogenic Sr^{87}. It is also possible that some of the quartz-bearing gneisses are metasediments with no genetic relationship to the associated meta-syenites and meta-gabbros. Under this model, a best-fit isochron age of these gneisses (around 1034 m.y.) could be interpreted as a provenance age and would not, in itself, be proof that the rocks of the Seiland province had a Precambrian origin. A biotite–whole rock Rb-Sr age of 445 m.y. from a pegmatite within the complex suggests that Caledonian effects included either the intrusion of pegmatites or the resetting of mineral ages.

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A massif of igneous and crystalline rocks, collectively called the 'Seiland petrographic province' (Barth 1953), covers the islands of Seiland, Stjernøy, and southeast Sørøy, and most of the large peninsula between Kvænangen and Altafjorden in western Finnmark, northern Norway. This complex has received relatively extensive study compared to other areas of northern Norway. Nevertheless, the association of a bewildering array of salic, mafic, and ultramafic rocks with both igneous and metamorphic fabrics has resulted in a variety of proposed origins and histories. Despite its obvious igneous, metamorphic, and structural complexity, however, the Seiland petrographic province is generally believed to have formed during Caledonian orogeny (Oosterom 1963, Ball et al. 1963, Sturt & Ramsay 1965, Stumpfl & Sturt 1965). However, Rb-Sr whole-rock results presented in this paper suggest that some portions of the Seiland petrographic province may have had a pre-Caledonian origin.

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Regional setting

Fig. 1 is a simplified tectonic map of northern Norway. The Caledonides consist predominantly of allochthonous late Precambrian and early Paleozoic rocks that were thrust toward the east over the Precambrian rocks of the Baltic Shield. The chronology of the Baltic Shield rocks in this region has not been extensively studied. Rb-Sr whole-rock ages of 1786 and 1781 million years have been reported from the Gavnevann Granite in southeastern Finnmark (Priem 1968, unpublished data). Heier & Compston (1969) measured Rb-Sr whole-rock isochron ages of 1550 ± 35 m.y. for the basal gneisses in the Tysfjord culmination, south and west of Narvik, and 1715 ± 90 m.y. for the Precambrian rocks in the Rombak window, east of Narvik (Fig. 1). These measurements indicate that most of the autochthonous Precambrian rocks of the Baltic Shield in northern Norway belong to the Svecofennian geochronological province.

Seiland petrographic province

The crystalline rocks of the Seiland petrographic province tectonically overlie the late Precambrian succession in western Finnmark (Fig. 1). The pro-

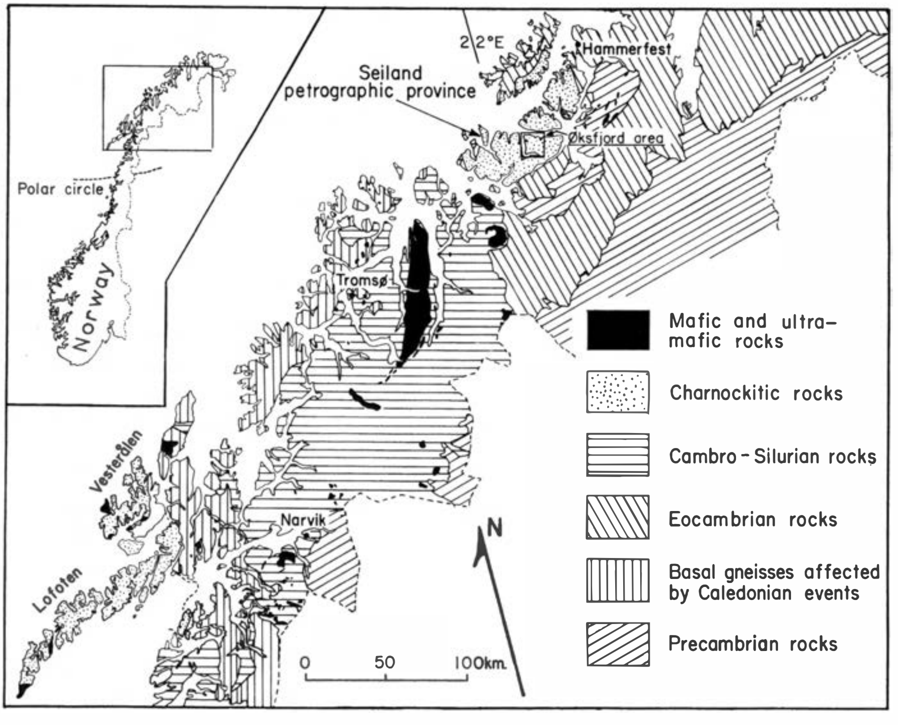

Fig. 1. Simplified geologic map of northern Norway showing major tectonic provinces and location of the Øksfjord area. The insert shows the area of Norway covered by the figure.

vince consists predominantly of igneous rocks of which the bulk are layered gabbro associated with lesser quantities of syenite, monzonite, anorthosite, peridotite, and pyroxenite. Marble, calc-silicate, and other metasedimentary rocks form minor intercalations within the more abundant igneous rocks. Garnet and hypersthene-bearing gneisses containing variable amounts of quartz occur as thin and, in the western part of the province, thick layers (Ball et al. 1963). The gabbro and related rocks commonly retain layered patterns that resemble the layered mafic-ultramafic rocks of the Stillwater type (Oosterom 1963). Most of the rocks display recrystallization fabrics that, along with the phase assemblages of the hypersthene-bearing gneisses, indicate much of the Seiland province was metamorphosed under granulite facies conditions. However, some olivine-bearing gabbros, anorthosites and peridotites have igneous textures and presumably intruded after metamorphism. The rocks on Stjernøy, Sørøy and Seiland are intruded by bodies of the carbonatite-nepheline syenite association. Finally, igneous masses consisting predominantly of perthitic or antiperthitic feldspar and orthopyroxene (perthosites) occur locally. Their relationship to other rocks with igneous textures is uncertain.

Barth (1953), Krauskopf (1954), and Heier (1961) tentatively suggest that the layered meta-gabbro and the associated layers of syenite, marble, and quartz-bearing granulite are a metamorphosed supracrustal series of lava flows and sediments, and that these rocks were subsequently intruded by olivine gabbro, peridotite, and anorthosite. Oosterom (1963) proposes that the intrusives were formed by differential anatexis of the basic volcanics and intercalated sediments during granulite metamorphism. Ball et al. (1963), on the other hand, interprets the meta-gabbro and meta-syenite as portions of a mafic-ultramafic complex that had intruded a series of sedimentary rocks and subsequently been metamorphosed and deformed. These rocks, in turn, are thought to have been intruded by peridotitic dikes and associated (and possibly related) gabbro-peridotite-anorthosite complexes. Sturt & Ramsay (1965) and Stumpfl & Sturt (1965) believe that Caledonian metasediments on Sørøy were intruded by gabbroic, ultrabasic, dioritic, monzonitic, and granitic masses at a number of different stages during the structural and metamorphic development of the island. They suggest the various igneous rocks show diverse states of metamorphism as a result of their position in the intrusion-deformation sequence. Most investigators agree that these events were followed by the intrusion of the carbonatite-nepheline syenite association. K-Ar age determinations from these undersaturated rocks give ages of 480–491 and 384–420 m.y. (Sturt et al. 1967), suggesting intrusion during the Caledonian orogeny.

Description of samples

Samples for this study were collected from the Øksfjord area, in the southeastern portion of the Seiland province (Fig. 1). This area has been mapped

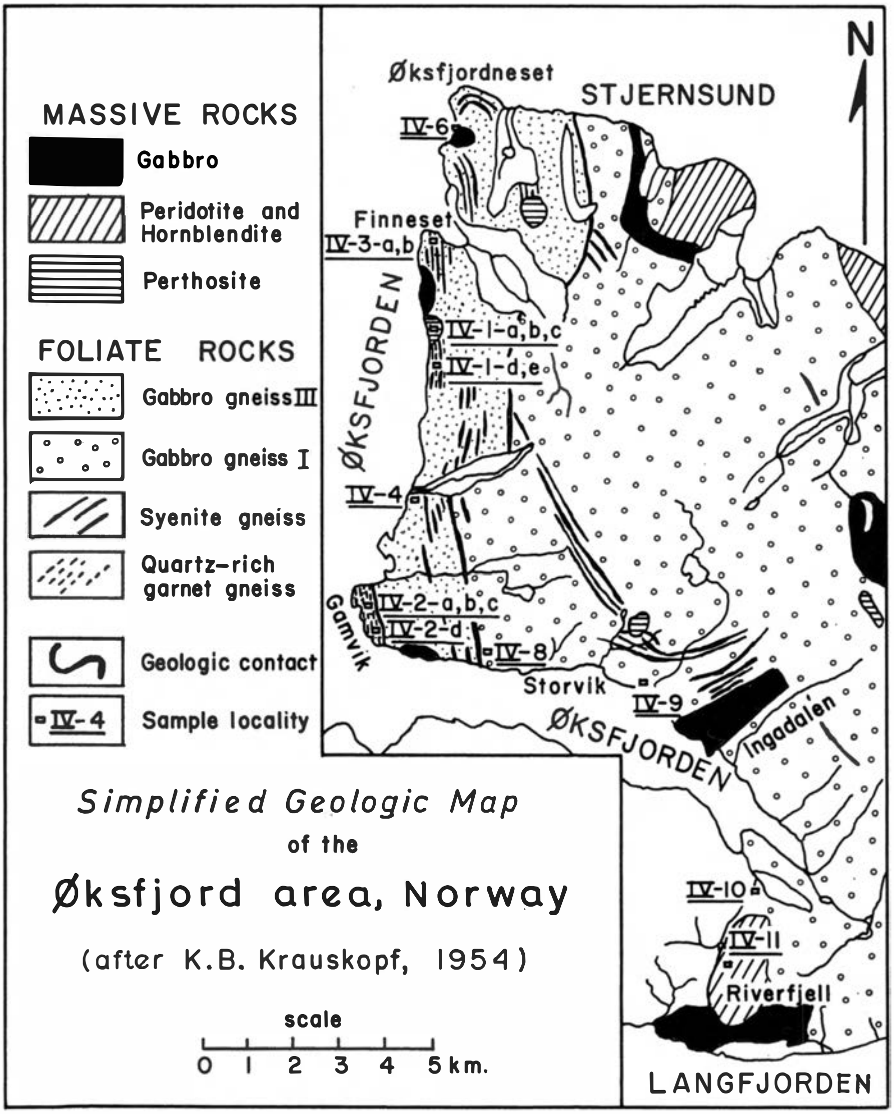

Fig. 2. Generalized geologic map of the Øksfjord area, Seiland petrographic province, northern Norway, showing distribution of major rock types and sample localities (after K. B. Krauskopf 1954).

by Krauskopf (1954), and contains most of the important rock types found in the province. Fig. 2 is a simplified geologic map of the Øksfjord area showing the sample localities. Table 1 gives abbreviated petrographic descriptions of the analyzed material. Most rocks could be placed in one of two categories: massive or very weakly foliate rocks, and strongly foliate rocks. With one exception, all rocks with metamorphic fabrics were collected from the east shore of Øksfjord from Gamvik north to Øksfjordneset. Krauskopf (1954) maps these rocks as Gabbro gneiss III, and characterizes the unit as being associated with the only quartz-bearing gneiss on the Øksfjord peninsula. These quartz-bearing rocks (IV-1-d, IV-1-e, IV-2-a, IV-2-b, IV-2-c) also contain perthite, orthopyroxene, clinopyroxene, garnet, and, in some samples, sillimanite, and clearly were metamorphosed under granulite facies conditions. The quartz-rich gneisses from Gamvik (IV-2-a, IV-2-b, IV-2-c) are finer-grained than most of the other rocks of the area and are seen to have mylonitic textures under the microscope; they evidently were sheared some time after recrystallization in the granulite facies. Quartz-free feldspathic rocks (IV-3-a, IV-3-b), although mapped as 'syenite gneiss' (Krauskopf 1954), contain more plagioclase than orthoclase, and may more properly be called 'monzonite gneiss'. Sample IV-4 is a typical, recrystallized gabbro that presumably was metamorphosed along with the associated salic granulite-facies rocks.

Most of the meta-gabbro of the Øksfjord area lacks interlayers of quartz-rich gneiss, and is mapped separately (Fig. 2) as Gabbro gneiss I (Krauskopf 1954). Despite this distinction, the rocks of this unit are believed to have suffered basically the same history as those in the Gabbro gneiss III unit. Sample IV-8 (meta-anorthosite), for example, has a strong metamorphic fabric and presumably recrystallized under granulite-facies conditions.

Massive, non-foliate rocks are common throughout the area and occur in both Gabbro gneiss I and Gabbro gneiss III complexes. Syenite- and monzonite-perthosite with coarse-grained, igneous textures occur both as concordant lenses and layers (IV-9) and as discordant masses (IV-1-a, IV-1-b, IV-1-c) with clear intrusive relationships to the enclosing meta-gabbro. Gabbro pegmatites (IV-6) with partially concordant and partially discordant contacts are also abundant.

Sample IV-10, when originally collected just south of the eastern tip of Øksfjord (Fig. 2), was believed to be a meta-gabbro from the Gabbro gneiss I complex. However, the gabbro reveals no discernible metamorphic fabric under the microscope, and, unlike the typical gabbro gneiss of the Øksfjord area, contains olivine as a major phase. The olivine is rimmed by an inner zone of orthopyroxene and an outer zone of myrmekitic spinel and orthopyroxene with or without clinopyroxene where it borders on plagioclase. Immediately south of the olivine gabbro sample locality is the large, apparently intrusive (Fig. 2) Riverfjell peridotite body (IV-11). Oosterom (1963) classifies mineralogically and petrographically similar mafic and ultramafic rocks on Stjernøy as members of the 'ultramafic sequence'. It is clear that samples IV-10 and IV-11 should be classified as non-foliate or massive rocks with predominantly igneous textures.

Sample IV-2-d is a coarse-grained quartz-alkali feldspar-biotite pegmatite from Gamvik. The pegmatite mass contains abundant, irregular fractures and the biotite within it is locally chloritized. Biotite (carefully cleaned of secondary chlorite) was separated from the rock to determine a minimum of Rb-Sr age for the last phase of igneous or metamorphic activity in the Øksfjord area.

Table 1. Simplified petrographic descriptions of analyzed samples from the Øksfjord area, northern Norway.

Sample	Rock type	Locality	Mineralogy	Texture	Remarks
			Massive or Weakly Foliate Rocks		
IV-1-a IV-1-b IV-1-c	Syenite perthosite	2 km south of Finneset	90 % Perthite, some Opx, trace Cpx, Ore, and secondary Amph	Coarse Perthite and Opx porphyroclasts in fine Perthite groundmass	Primary igneous texture slightly cataclastically deformed
IV-9	Monzonite perthosite	Between Storvik and Ingadalen	Coarse Antiperthite and primary (?) Amph, some medium grained Cpx and Opx	Mortar texture around large, partially exsolved Antiperthite	
IV-6	Gabbro pegmatite	1 km south of Øksfjordneset	Coarse Plag, Cpx, Opx intergrown with Amph, Ore, Calcite. Scattered Gar	Pegmatitic; symplectitic Opx-Cpx replaces Opx; Amph shows triple points	Textures suggest slow cooling with subsolidus recrystallization
IV-11	Peridotite	Just west of Riverfjell	Ol and Cpx, lesser Opx, some Ore, Spinel, and secondary Amph and Bi	Medium-grained, equigranular. No preferred orientations	Euhedral Ol in large anhedral Cpx suggests Ol crystallized first
IV-10	Olivine gabbro	1 km south of east tip of Øksfjorden	Predominantly Ol, Plag, Cpx, and Spinel; secondary Spinel, Opx and Amph	Irregular Plag clusters in interlocking networks of Ol, Amph, and Cpx	Opx and Opx + Sphene + Cpx myrmekite zones successively zone Ol where in contact with Plag
IV-2-d	Pegmatite	Gamvik	Qtz, Bi, and alkali Felds.	Pegmatitic	Some Chl replaces Bi
			Strongly Foliate Rocks		
IV-1-d IV-1-e	Quartz-bearing garnet gneiss	3 km south of Finneset	Perthite, Plag, and Qtz with Gar porphyroblasts; some Ore, Sillimanite, and secondary Bi and Musc	Coarse-grained, gneissic; fabric caused by flattened mafic clots and lensoid Qtz pods	Very strong metamorphic fabric
IV-2-a IV-2-b IV-2-c	Quartz-rich gneiss	Gamvik	Plag and Qtz, lesser Gar, Opx, Perthite, and Bi. Sillimanite in IV-2-b	Fine-grained, equigranular. Qtz and mafics strongly flattened	Sheared fabric suggests cataclasis after crystallization
IV-3-a IV-3-b	'Syenite' gneiss	Finneset	Plag and Cpx, some Antiperthite; trace Opx and Ore	Medium-grained, equigranular: thin mafic layers	
IV-4	Gabbro gneiss	Fruvikdalen	Plag and Cpx; some Opx, skeletal Ore, and secondary Bi	Cpx and Plag flattened and strung out	Deformed secondary minerals suggests shearing
IV-8	Meta-anorthosite	Between Storvik and Gamvik	Mostly Plag; some mafic clots of Opx, Cpx and some secondary Amph and Bi	Oriented Bi flakes and flattened mafic clots form foliation	

Analytic techniques

Whole-rock samples and the biotite-concentrate from sample IV-2-d were crushed to less than 200-mesh and analyzed for rubidium-strontium by standard isotope-dilution techniques using Rb^{87} and Sr^{84} spikes. The concentration measurements were made on a 6-inch radius, 60° sector field mass spectrometer equipped with a triple filament, thermionic source. The present day Sr^{87}/Sr^{86} ratios of most samples were measured directly on a similar 12-inch mass spectrometer. All Sr^{87}/Sr^{86} ratios were normalized to an Sr^{86}/Sr^{88} value of 0.1194. The ion beam in both mass spectrometers is collected in a Faraday cage, amplified by a vibrating reed electrometer, and displayed on an expanded scale chart recorder.

Isochrons were fitted to the data by the regression method of McIntyre et al. (1966). The estimated variance for the Rb^{87}/Sr^{86} ratio is $26.30 \times 10^{-6} \times [Rb^{87}/Sr^{86}]^2$ ($\mu = 10$). The decay constant of Rb^{87} was taken to be $1.39 \times 10^{-11} yr^{-1}$ and all Rb-Sr dates cited from the literature have been recalculated to this value.

Results

The analyses of all Øksfjord area samples are listed in Table 2. Regression details (see McIntyre et al. 1966) for various groupings of Øksfjord area samples are presented in Table 3. All the massive rocks, plotted on a Rb-Sr isochron diagram in Fig. 3 are collinear within experimental error (Table 3, regression 1) and define a Model 1 isochron age of 625 ± 17 m.y. and an initial Sr^{87}/Sr^{86} ratio of 0.7032 ± 0.0006. The monzonite perthosite (IV-9), gabbro pegmatite (IV-6), olivine gabbro (IV-10) and peridotite (IV-11) have Rb^{87}/Sr^{86} ratios of less than 0.04, and do not themselves define a meaningful isochron age (see insert in Fig. 3). Deleting these samples from the regression does not significantly change the indicated age and initial Sr^{87}/Sr^{86} ratio, but does decrease the precision of the determinations (Table 3, regression 2). Thus, the 625 m.y. age for non-foliate rocks is essentially based on the three samples (IV-1-a, IV-1-b, IV-1-c) from the syenite perthosite body two kilometers south of Finneset.

The analyses of the strongly foliate rocks (Table 3, regression 4), plotted in Fig. 4, are not collinear. Their scatter is far greater than that attributable to experimental error (MSWD=36) and the crude apparent age of about 1300 m.y. is probably meaningless. If the sheared quartz-rich gneiss samples (IV-2-a, IV-2-b, IV-2-c) are deleted from consideration (Table 3, regression 5), the apparent age of the foliate rocks increases to about 1580 m.y. (Model 3), but the scatter is still large (MSWD=24). Part of this scatter is caused by the anomalously high present day Sr^{87}/Sr^{86} ratio (0.708) of the gabbro gneiss (IV-4). By arbitrarily removing the gabbro gneiss (Table 3, regression 6) in addition to the sheared rocks, from the regression, the apparent age of the foliate rocks is increased to 1645 ± 201 m.y. (Model 2) and their

Table 2. Rb-Sr analytical data for the massive and foliate rocks of the Øksfjord area, Seiland petrographic province, northern Norway.

Sample	Rock type	Rb ppm	Sr ppm	Rb^{87}/Sr^{86}	Sr^{87}/Sr^{86}
			Massive or Weakly Foliate Rocks		
IV-1-a	syenite perthosite	87.1	46.8	5.38	0.7500
IV-1-b	syenite perthosite	90.3	57.3	4.56	0.7432
IV-1-c	syenite perthosite	62.5	228	0.787	0.7010
IV-9	monzonite perthosite	33.4	2487	0.0386	0.7034
IV-6	gabbro pegmatite	6.08	636	0.0275	0.7032
IV-11	peridotite	0.419	152	0.0121	0.7033
IV-10	olivine gabbro	1.02	928	0.00316	0.7035
IV-2-d	quartz-biotite-alkali feldspar pegmatite	298	326	2.64	0.7388
Biotite	concentrate of IV-2-d	835	13.4	202	1.975
			Strongly Foliate Rocks		
IV-1-d	quartz-bearing garnet	108	256	1.22	0.7328
IV-1-e	gneiss	115	280	1.19	0.7298
IV-2-a	quartz-rich gneiss	42.3	80.3	1.49	0.7329
IV-2-b	quartz-rich gneiss	62.7	78.1	2.32	0.7496
IV-2-c	quartz-rich gneiss	30.7	181	0.488	0.7198
IV-3-a	'syenite' gneiss	25.2	620	0.117	0.7061
IV-3-b	'syenite' gneiss	30.0	755	0.114	0.7054
IV-4	gabbro gneiss	3.19	448	0.0205	0.7080
IV-8	meta-anorthosite	12.5	1973	0.0183	0.7040

initial Sr^{87}/Sr^{86} ratio is set at 0.7033 ± 0.0010 (Fig. 4). Excluding anorthosite as well from the last regression does not significantly change this age and initial ratio. Regression 7 in Table 1 considers only the quartz-bearing gneisses and gives a Model 2 age of 1034 ± 204 m.y.

The Rb-Sr results from the pegmatite (IV-2-d) at Gamvik are plotted in Fig. 5. The slope of the line connecting the whole-rock and biotite data gives a calculated age of 445 m.y. The very high Rb^{87}/Sr^{86} ratio of the biotite (about 202) renders the age relatively insensitive to analytic errors for the whole-rock. Assuming an initial Sr^{87}/Sr^{86} ratio of 0.703 for the biotite changes the computed age only slightly (to 455 m.y.).

Discussion

The data from the metamorphic rocks (Fig. 4) is so badly scattered that a best-fit age to all the data should probably be rejected as meaningless. The quartz-bearing gneiss may have had a sedimentary origin whereas the syenite gneiss, gabbro gneiss, and meta-anorthosite presumably had an igneous origin. If so, the regression of the quartz-bearing gneiss plotted on Fig. 4 should exclude all meta-igneous rocks. The resulting best-fit line yields a Model 2 age of 1034 ± 204 m.y. (Fig. 4) and an initial Sr^{87}/Sr^{86} ratio of 0.7128 ± 0.0030. This age could mark a time of isotopic homogenization

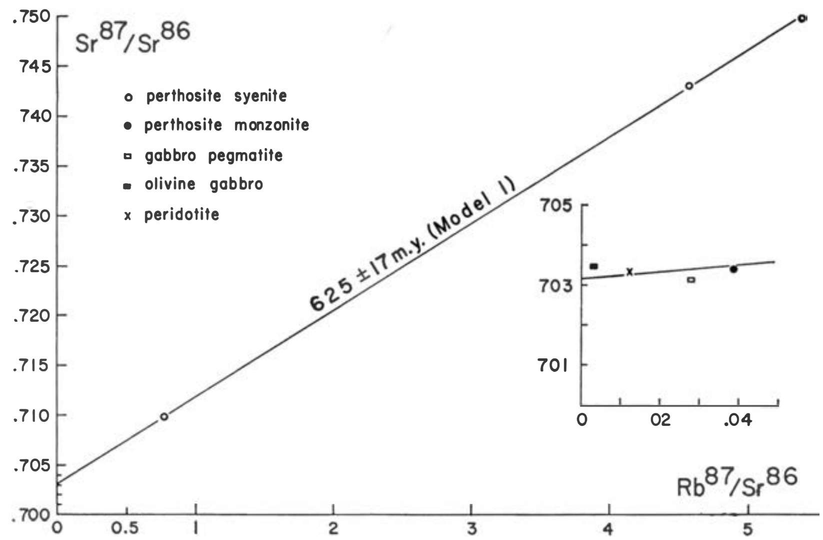

Fig. 3. Isochron plot of analytic results from the massive or non-foliate rocks of the Øksfjord area. The line in the insert has the same slope as the line connecting the syenite perthosite samples.

Table 3. Isochron ages as estimated by alternative regression methods (McIntyre et al. 1966).

Regression	Model	Mean square of weighted deviates	Age estimate (m.y.)	Initial Sr^{87}/Sr^{86} estimate
1. All massive or weakly foliate rocks (7 samples)	1	0.20	625 ± 17	0.7032 ± 0.0006
2. Syenite perthosite only (3 samples)	1	0.33	627 ± 135	0.7031 ± 0.0074
3. IV-6, IV-9, IV-10, and IV-11	1	0.12	–188 ± 5500	0.7034 ± 0.0019
4. All strongly foliate rocks (9 samples)	1 2 3	36.14	1300 ± 38 1007 ± 935 1278 ± 220	0.7073 ± 0.0005 0.7073 ± 0.0011 0.7074 ± 0.0035
5. As above, less sheared quartz-rich gneisses (6 samples)	1 2 3	24.18	1538 ± 73 1108 ± 7572 1579 ± 305	0.7051 ± 0.0006 0.7055 ± 0.0036 0.7044 ± 0.0030
6. Regression 5 less IV-4 (5 samples)	1 2 3	3.75	1654 ± 93 1645 ± 201 1654 ± 182	0.7032 ± 0.0010 0.7033 ± 0.0010 0.7033 ± 0.0020
7. Quartz-bearing gneisses only, IV-1-d, IV-1-e, IV-2-a, IV-2-b, & IV-2-c	1 2 3	9.18	1021 ± 87 1034 ± 204 1034 ± 236	0.7130 ± 0.0017 0.7128 ± 0.0030 0.7128 ± 0.0048

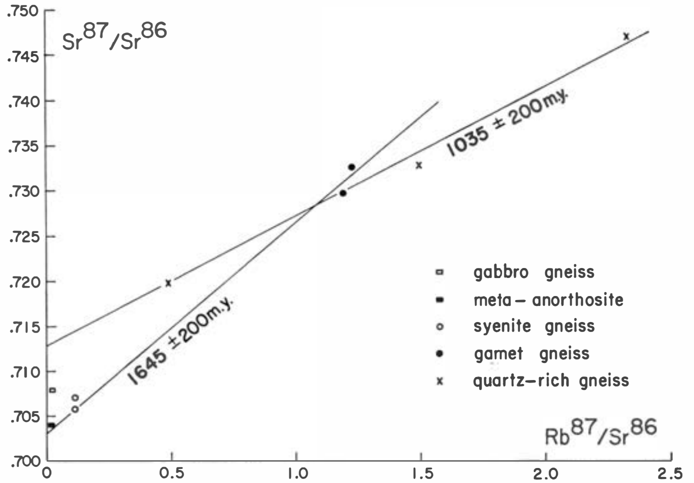

Fig. 4. Isochron plot of analytic results from the strongly foliate (i.e., metamorphosed) rocks of the Øksfjord area. The two lines plotted in the figure are for reference and, in themselves, do not define true isochron 'ages'.

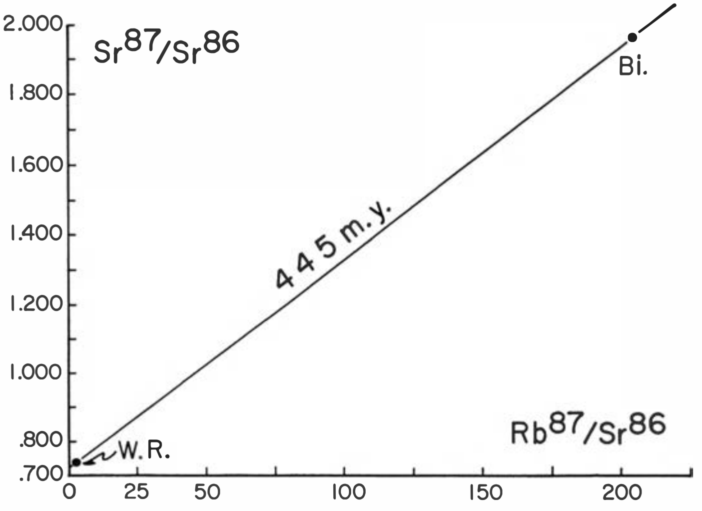

Fig. 5. Isochron plot of whole rock sample and biotite concentrate from quartz-biotite-alkali feldspar pegmatite (IV-2-d) at Gamvik, Øksfjord area.

during sedimentation (or diagenesis) or during metamorphism, a suggestion that gains some support from the high initial Sr^{87}/Sr^{86} ratio. However, this age may also roughly date the terrain from which the sediments were derived (provenance age). Thus, the data does not exclude the possibility that at least some of the quartz-bearing gneisses are metamorphosed Caledonian sediments, as has been suggested by Oosterom (1963), Ball et al. (1963), Sturt & Ramsay (1965) and others.

Alternatively, the present day scatter of the data in Fig. 4 could also have occurred if the rocks were open to the variable gain or loss of rubidium, common strontium, and/or radiogenic strontium subsequent to their formation with a common initial Sr^{87}/Sr^{86} ratio. Cases are known of loss (Lanphere et al. 1963, Pidgeon 1967) and gain (Wasserburg et al. 1964) of radiogenic Sr^{87} over large rock volumes, and it is possible that the more sheared rocks of the Øksfjord area, particularly the cataclastically deformed quartz-bearing gneisses from Gamvik (IV-2-a, IV-2-b, IV-2-c), underwent a similar sort of isotopic exchange process. Under this model, the apparent isochron age defined by the relatively unsheared metamorphic rocks (1580 ± 305 m.y.) would be more meaningful than one defined by both sheared and unsheared rocks. There is still considerable scatter to the data, however, caused mostly by the unusually high present day Sr^{87}/Sr^{86} ratio (0.708) of the meta-gabbro (IV-4). The arbitrary exclusion of sample IV-4 from the regression increases the apparent age of the unsheared metamorphic rocks to 1645 ± 201 m.y. (Fig. 4).

The significance, if any, of this 1580 to 1645 m.y. old age is difficult to assess. Possibly some of the rocks in the Seiland province belong to the Svecofennian geochronological province of the Baltic Shield. It should be emphasized, however, that other interpretations of the data are equally likely, including the one based on a metasedimentary origin for the quartz-bearing granulites suggested above.

The 625 m.y. apparent age (Fig. 3) for the syenite perthosite body south of Finneset is unusual. Very few rocks from either the Caledonides or the nearby Baltic Shield were formed at this time (Neumann 1960) and Broch (1964) suggests that the interval between 625 and 725 m.y. was a quiescent period. The data plotted on Fig. 3 are consistent with, but do not prove, the interpretation that the perthosites are contemporaneous with the gabbro pegmatites, olivine gabbros, and peridotites of the region. The perthosites intrude the gabbro gneiss and related foliate rocks of the Øksfjord area (Fig. 2); their intrusion therefore postdates the igneous and metamorphic events responsible for the metamorphosed rocks of the Seiland province. If the 625 m.y. apparent age for the perthosite is interpreted as a meaningful intrusion age, it would imply that the enclosing metamorphic rocks of the Øksfjord area had a pre-Caledonian origin. However, the 625 m.y. age is based, essentially, on only 3 analyses, and should not be accepted uncritically, especially since a 625 m.y. intrusion age would be relatively unusual for the Norwegian Caledonides.

Ball et al. (1963), Sturt & Ramsay (1965), and Stumpfl & Sturt (1965) describe structures within the rocks of the Seiland province that they are able to relate to the Caledonian Orogenic Cycle. A Rb-Sr whole-rock isochron age of 530 ± 35 m.y. for an aplogranophyre vein in the Hasvik Gabbro from the island of Sørøy (Pringle & Sturt 1969) indicates at least some igneous intrusion occurred during the Caledonian Orogeny. Furthermore, the presence of Archaeocyathid-bearing calc-silicate and limestone rafts within the Storelv Gabbro on Sørøy (Holland & Sturt 1970) indicates that this Caledonian igneous activity included the intrusion of gabbros. Similarly, the biotite – whole-rock age of 445 m.y. (Fig. 5) from the Gamvik pegmatite suggests that Caledonian thermal effects in the Øksfjord area must have been sufficient to reset Rb-Sr mineral ages. Caledonian shearing may have been responsible for the proposed redistribution of radiogenic Sr^{87} in the quartz-rich gneisses from Gamvik. Thus, there is abundant evidence that the rocks of the Seiland petrographic province were subject to Caledonian deformation, metamorphism, and igneous intrusion.

Nevertheless, it remains to be explained how a syenite perthosite and the enclosing metamorphic rocks from the Øksfjord area give apparent Rb-Sr whole-rock isochron ages that are significantly pre-Caledonian. Although other interpretations of the data are possible, the preferred hypothesis in this paper is that some portions of the Øksfjord area had a pre-Caledonian origin. It is proposed that some of the strongly foliate salic, mafic and ultramafic rocks from this area, particularly the sillimanite-bearing garnet gneisses, may have originated as long as 1600 m.y. ago. Hopefully, further field and isotopic investigations will yield a more definitive interpretation of these results.

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