Rb-Sr age of the Blåfjellhatten granite in the Olden Window, Central Norway

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Rb/Sr isotope whole-rock dating of undeformed and unaltered parts of the Blåfjellhatten granite has yielded an isochron age of 1356 ± 29 Ma with I.R. = 0.7245 ± 0.0027, interpreted as the age of intrusion. This age contrasts with an earlier interpretation of the granite as part of the 1780-1650 Ma Transscandinavian Granite-Porphyry Belt and with other dates from the Grong-Olden Culmination and other basement windows in the Central Norwegian Caledonides. The new data indicate that the Blåfjellhatten granite is not directly related to any of the major tectonothermal events of the Baltic Shield.

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Introduction

A number of structural basement windows occur in the Scandinavian Caledonides (e.g. Gee et al. 1985) (Fig. 1) in which generally variably reworked Proterozoic and minor Archaean gneisses, granites and supracrustal rocks are exposed. These windows are thought to expose parautochthonous or allochthonous basement to the Caledonian nappes. Recent geophysical interpretations (Hurich et al. 1988, 1989) indicate the presence of Caledonian shear zones beneath some of these basement windows, suggesting that at least some of the windows are antiformal structures related to basement imbrication. Although having been involved in Caledonian orogenesis, rocks within the basement windows generally show a Precambrian evolution similar to the one recorded in the autochthonous Baltic craton to the east (cf. Gorbatschev 1985). In this paper we investigate the Blåfjellhatten granite in the Grong-Olden Culmination (Fig. 1) which has been considered part of the Transscandinavian Granite-Porphyry Belt (Gorbatschev 1985).

Geological setting

The Olden Window, or Nappe (Asklund 1938), forms the southeastern part of the Grong-Olden Culmination (Figs. 1 and 2) (Foslie 1959, 1960, Roberts 1989). It consists of Proterozoic, mainly acidic to intermediate igneous and volcanic rocks overlain by a sheared sequence

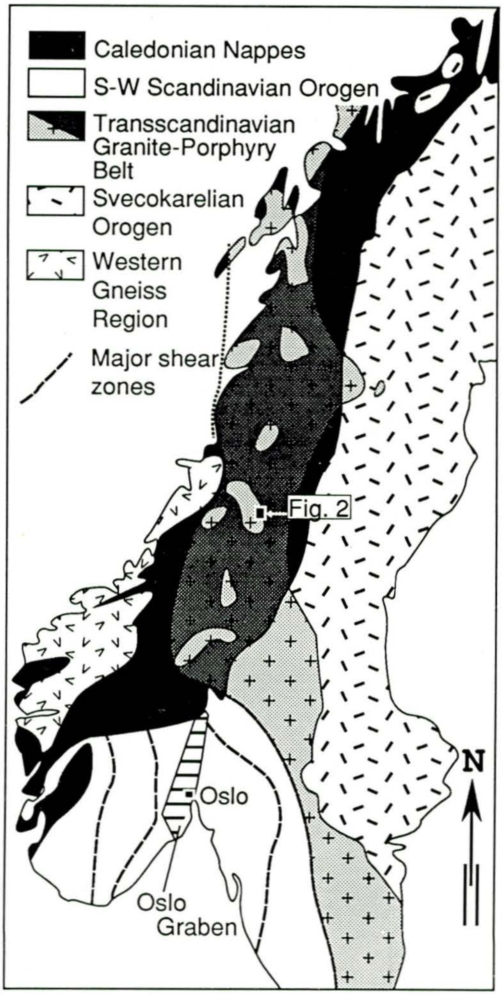

Fig. 1. Main geological provinces in Norway and Sweden. Modified from Gaal & Gorbatchev (1987). The Oslo Rift is indicated by a barred ornament.

of limestone, phyllite and quartzite of assumed Early Palaeozoic age. The contact between the Proterozoic rocks and the metasedimentary cover appears to be a variably tectonized primary contact. The sheared metasedimentary sequence marks the thrust contact with the overlying Formofoss Nappe Complex which generally consists of somewhat more strongly reworked, but otherwise very similar rocks to those within the window. Caledonian structures (rotated dykes, deflection of pre-existing foliation, shear-bands, etc.) in the upper part of the window and in the Formofoss Nappe Complex are consistent with a top-to-east sense of shear.

In the Blåfjellhatten area (Fig. 2), the Proterozoic rocks consist of gneisses, granite, microgranite and porphyritic, felsic metavolcanites of rhyodacitic composition (D.Roberts pers. comm. 1990) (Fig. 2). The metavolcanic rocks have a layering or lamination which is believed to represent primary flow banding variably modified by possible pre-granite deformation and later by Caledonian deformation. This composite foliation appears to be cut by the coarse-grained, light-grey Blåfjellhatten granite and an associated microgranite (Fig. 2). The relationship between granite and microgranite is generally complex. In some places the contact is gradational, whereas in other places dykes of the granite are observed in the microgranite and vice versa. Most likely, the two are contemporaneous. Poorly defined inclusions of gneiss are, however, observed east of Lakavatnet.

The Caledonian imprint on the Blåfjellhatten granite is generally very weak in the study area (Fig. 2). A mesoscopic foliation is locally developed, especially close to the Caledonian thrusts. Alteration and local foliation development is, however, also associated with the fracture system indicated on the map (Fig. 2), and locally with the contact to the older, felsic, metavolcanic rocks.

Southeast of the Blåfjellhatten granite is the very similar, but more deformed and altered Olden granite (cf. Klingspor & Troëng 1980) (Fig. 2). Both granites have been mapped into the Swedish part of the Olden Window where a minimum age of 1500 Ma for the Olden granite (Rb/Sr whole rock) was suggested by Klingspor & Troëng (1980). Additional isotopic analyses by Stuckless & Troëng (1984) indicated an age of about 1650 Ma for the Olden granite. However, a considerable Caledonian influence is reflected by the disturbed Rb-Sr system, and from Caledonian K-Ar ages of metamorphic biotites in the Olden granite. Both the Olden and the Blåfjellhatten granite have been considered to be part of the Transscandinavian Granite-Porphyry Belt (Gorbatschev 1985) (Fig. 1) that formed between 1780 and 1650 Ma ago (Stuckless et al. 1982, Patchett et al. 1987).

A number of mafic dykes and sheets crosscut all other rocks in the Olden Window (Fig. 2). The dykes, which are variably metamorphosed and foliated, are closely associated with an apparently contemporaneous fracture system of predominately NE-SW trend in the study area. A correlation of these dykes with dolerites of the Central Scandinavian Dolerite Group (1200 Ma) (Gorbatschev et al. 1979) and 900-1000 Ma dolerites along the Sveconorwegian front has been suggested (Johansson 1980).

Sampling and results

Twelve samples of the coarse-grained Blåfjellhatten granite were collected. Localities where the granite appeared to be relatively unaffected by deformation and alteration were chosen. The microgranite and the metavolcanic rocks were not sampled for age determination. Closer investigation of the samples resulted in the selection of five samples for age determination, where no mesoscopic sign of alteration or deformation structures could be identified. Each of these samples weighed approximately 5 kg, and their locations are shown in Fig. 2. The other seven samples showed either a weak foliation, decolouring or other signs of alteration, and were not analysed isotopically. The five granite samples are very similar in mineralogy, texture and composition, and are representative for the pale grey, coarse-grained, Blåfjellhatten granite. The granite contains perthitic microcline phenocrysts from 1 to 10 mm in size in a groundmass consisting of albite-free microcline, quartz, magmatic biotite, and some albite or plagioclase. Biotite tends to form small clusters in the granite. Haematite, magnetite, chlorite, apatite, allanite, muscovite, sphene and zircon are the most common accessory phases.

Some of the perthitic phenocrysts have

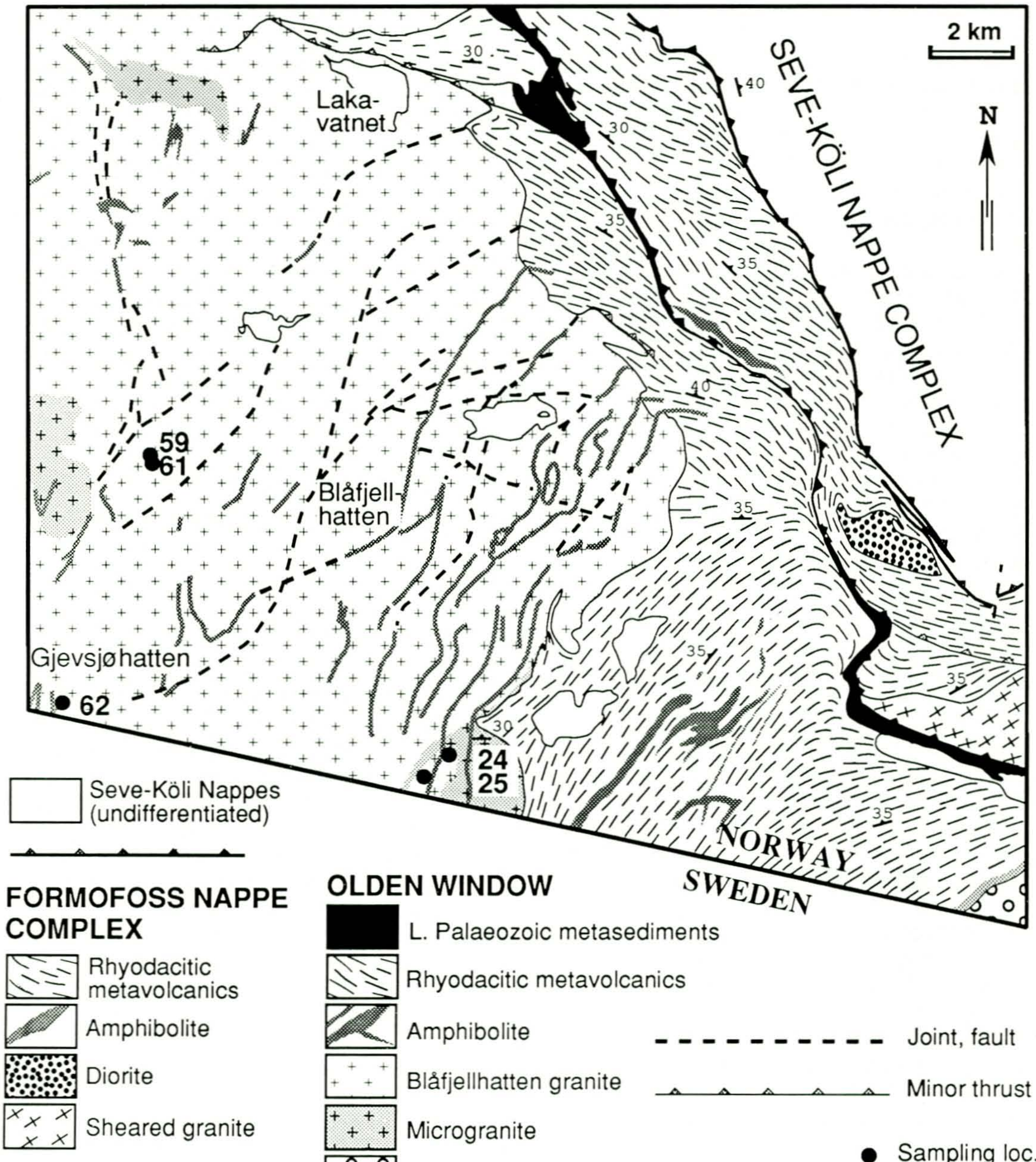

Fig. 2. Geological map of the study area. The area covered corresponds to the 1:50,000 map-sheet 1923-II Blåfjellhatten. From Fossen & Nissen (1990); based on maps by Foslie (1959, 1960).

cracks healed by small microcline and locally quartz grains. Similar deformation of larger quartz grains is locally observed, where cracks are also filled by unstrained microcline and minor quartz. This deformation is clearly related to the emplacement of the granite. However, rare kinking of feldspar grains may alternatively be interpreted as modest Caledonian deformation. In the case of the five samples chosen for isotope analysis, Caledonian defor-

Table 1. Chemical analyses of the twelve samples collected from the Blåfjellhatten granite (weight %).

	24	25	59	61	62	26	27	28	29	30	31	60
SiO_2	75.49	72.92	71.04	73.32	73.02	71.38	70.90	70.82	72.76	77.76	76.96	71.29
Al_2O_3	12.93	13.65	14.39	13.96	13.78	14.18	14.39	13.42	13.86	12.34	12.06	13.31
CaO	0.50	0.88	1.17	1.15	0.83	1.02	1.09	0.94	0.71	0.16	0.55	1.05
MgO	0.12	0.25	0.32	0.32	0.47	0.30	0.35	0.26	0.19	0.15	0.04	0.30
Fe_2O_3	0.58	0.66	0.71	1.01	0.20	0.78	0.75	0.64	0.41	0.00	0.00	0.63
FeO	0.76	1.33	1.54	1.38	1.56	1.39	1.62	1.50	1.28	0.67	0.77	1.50
Na_2O	3.71	3.66	3.98	3.79	4.04	3.82	3.98	3.66	3.94	3.92	3.51	3.59
K_2O	5.62	5.75	5.66	5.44	4.78	5.80	5.50	5.68	5.67	4.77	5.01	5.56
TiO_2	0.18	0.38	0.47	0.46	0.23	0.42	0.41	0.36	0.28	0.07	0.07	0.40
MnO	0.04	0.06	0.07	0.07	0.05	0.06	0.06	0.06	0.04	0.01	0.02	0.06
P_2O_5	0.02	0.06	0.07	0.07	0.06	0.06	0.06	0.06	0.04	0.01	0.01	0.06
CO_2	0.04	0.03	0.23	0.01	0.00	0.01	0.01	0.03	0.00	0.32	0.02	0.08
H_2O	0.22	0.41	0.41	0.41	0.35	0.39	0.48	0.40	0.45	0.35	0.37	0.36
Total	100.21	101.04	101.06	101.39	99.37	99.62	99.60	97.83	99.63	100.53	99.392	98.19

Table 2. Rb/Sr data for the Blåfjellhatten granite.

Sample No	Rb ppm	Sr ppm	Rb/Sr	$^{87}Rb/^{86}Sr$	SE	$^{87}Sr/^{86}Sr$	SE
24	250	29	8.421	25.59	0.2559	1.2223	0.00010
25	271	87	3.115	9.18	0.0919	0.9045	0.00003
59	238	101	2.356	6.91	0.0692	0.8578	0.00003
61	203	105	1.933	5.66	0.0566	0.8335	0.00003
62	151	101	1.495	4.36	0.0437	0.8102	0.00003

Table 3. UTM coordinates for the sampling locations. All coordinates are from 1:50,000 map-sheet 1923-II Blåfjellhatten (Fig. 2).

No.	24	25	26	27	28	29	30	31	59	60	61	62
UTM	235074	231071	153211	154210	156218	160211	243234	241233	162148	162148	162148	142092

mation is either extremely weak or absent.

The only microscopical difference between the samples is that of a slightly lower content of albite in the matrix in sample 61 than in the others, and symplectitic intergrowth textures in sample 62. Geochemically (Tables 1 and 2), the granite samples also appear to be similar, except for a relatively large spread in $^{87}Rb/^{86}Sr$. This spread may indicate a zonation of the granite, although no such zonation has been recognised in the field.

The regression analysis of the samples (Fig. 3) gives a date of 1356 ± 29 Ma and an initial $^{87}Sr/^{86}Sr$ ratio of 0.7245 ± 0.0027 with a MSWD of 1.01.

Discussion

The 1356 ± 29 Ma age of the Blåfjellhatten granite is considered to represent an intrusive age as virtually undeformed and unaltered portions of the granite were dated. It is, however, at variance with the interpretation of the granite as part of the 1780-1650 Ma old Transscandinavian Granite-Porphyry Belt (Gorbatschev 1985, Johansson 1988), and with age estimates of 1530-1635 Ma (Klingspor & Troëng 1980) and 1650 Ma (Stuckless & Troëng 1984) for the Olden granite. Klingspor & Troëng analysed a considerably deformed and altered part of the Olden granite, and their data indicate that their samples are clearly isotopically disturbed (MSWD=170). However, their data, together with the present results, suggest that the Blåfjellhatten and Olden granites represent two entirely different granites with different initial isotopic ratios. The two granites are, however, comparable with respect to Rb and Sr contents (Table 2, Klingspor & Troëng 1980).

Similar problems were encountered by Reymer (1979) who carried out a Rb-Sr study of granitic gneisses in the nearby Formofoss Nappe Complex. Reymer's analyses did not form an isochron array but rather showed a scatter about a 1700 Ma reference line.

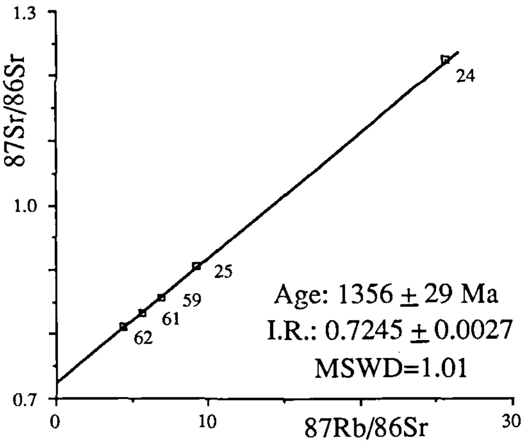

Fig. 3. Rb/Sr isochron diagram for the Blåfjellhatten granite.

Finally, the Blåfjellhatten granite has a higher initial ratio (0.7245 ± 0.0027) than typical granites of the Transscandinavian Granite-Porphyry Belt (e.g. Welin & Lundqvist 1977) and the 1500-1700 Ma granites in the Western Gneiss Region (e.g. Tucker & Krogh 1988), possibly indicating that it formed from a more mature continental crust.

Conclusions

The present study shows that the Blåfjellhatten granite in the Olden Window is significantly younger than was previously suggested. With an isochron age of 1356 ± 29 Ma, it is younger than the granites of the Transscandinavian Granite-Porphyry Belt (Gorbatschev 1985) and granites and granitic gneisses in the Nordland basement windows (Wilson & Nicholson 1973, Griffin et al. 1974, Andresen 1979, Bartley 1981, Cribb 1981, Wilson 1981), and differs in age from dated granites and granitic gneisses of the Western Gneiss Region (Tørudbakken 1981, Kullerud et al. 1986, Tucker et al. 1987). It is also older, and has a higher initial Sr isotopic ratio, than the many early Sveconorwegian (Grenvillian) granites (1250-1100 Ma) of the Western Gneiss Region and the SW Scandinavian orogen (Fig. 1) of southern Norway. Thus, while the Blåfjellhatten granite appears to be unrelated to the major Proterozoic magmatic and tectonothermal events, it does lend support to the idea of sporadic igneous activity in the time interval 1500-1250 Ma (Gorbatschev 1985).

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Appendix

The Rb-Sr ratios were determined by X-ray fluorescence spectrometry. Measurements of unspiked $^{87}Sr/^{86}Sr$ were carried out on a VG Micromass 30 at Mineralogisk-Geologisk Museum, Oslo, and the methods used are the same as those described by Pankhurst & O'Nions (1973). Variable mass discrimination was corrected by normalization of $^{87}Sr/^{86}Sr$ to 8.3752. The ^{87}Sr decay constant used is 1.42 x 10^{-11} y^{-1} and the regression technique is that of York (1969). Ages and intercept errors are noted at the 2σ level.

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