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Isotopic age determinations in Bergslagen, Sweden: VII. The Fellingsbro-type Granite east of Kopparberg

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Abstract

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Rb-Sr whole-rock analysis of seven samples of the Fellingsbro-type Younger Granite east of Kopparberg gives an age of 1715 ± 50 Ma and an initial $^{87}Sr/^{86}Sr$ ratio of 0.7046 ± 0.0026 (errors 95% confidence level). This age falls in the age range determined for the Younger Granites of the Värmland-Småland, Dala and Fellingsbro Groups, 1.74-1.64 Ga. Reliable age data from from the Malingsbo-type granites in the Kopparberg area are still lacking, however, so it is uncertain whether they can be included in the Fellingsbro Group of Younger Granites.

Introduction

The Younger Granites which intruded the 1.9-1.8 Ga old Bergslagen Supracrustal Series in the Filipstad-Grythyttan-Kopparberg region, West Bergslagen, comprise three groups; the Värmland-Småland Group granites of the Filipstad area in the western part of the region, the Dala Group granites N of Grythyttan, and the Fellingsbro Group granites of the Kopparberg area in the eastern part of the region (Oen & Verschure 1982). The Younger Granites of the Värmland-Småland and Dala Groups are commonly designated as 'post-orogenic' with ages between 1.7 and 1.6 Ga, contrary to the 'ser-orogenic' or 'late-orogenic' granites of the Fellingsbro Group with ages between 1.8 and 1.73 Ga (Magnusson 1940, 1970; Wilson 1980; Lundström 1983). Recent work on Fellingsbro Group granites in the Grängen area, SW of Kopparberg, however, indicates Rb-Sr whole-rock ages in the 1.7-1.6 Ga range; suggesting that all three groups of Younger Granites are synchronous (Oen 1983). This suggestion is reinforced by the results presented in this paper of a Rb-Sr investigation of a Fellingsbro Group granite E of Kopparberg.

The huge, complex massif of Fellingsbro Group granites about 8 km E of Kopparberg consist of the Malingsbo-type granite, intruded by a small body of the Fellingsbro-type granite (Fig. 1). This paper reports the results of a Rb-Sr whole rock investigation of the latter granite. The locations of the investigated samples are shown on the map of Fig. 1.

The fine- to medium-grained Malingsbo-type granite has pegmatite-rich border zones and abundant roof prendants and wall rock inclusions. The Fellingsbro-type granite is a coarse porphyritic

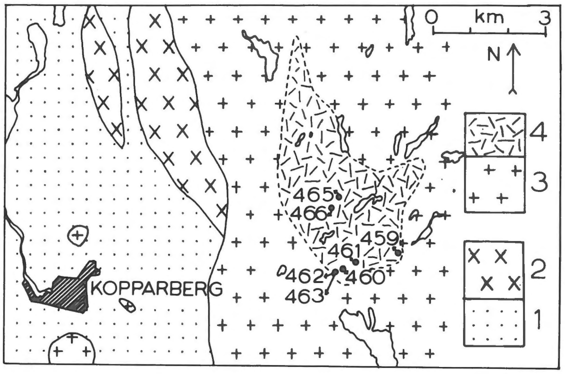

Fig. 1. Geological sketch map of the area E of Kopparberg (Magnusson, 1940). 1. Leptites (felsic metavolcanics) of the Bergslagen Supracrustal Series; 2. Older Granites; 3. Malingsbo-type granites; 4. Fellingsbro-type granites. Numbers indicate sampling sites.

biotite granite. It is generally assumed that the Fellingsbro-type granites represent later intrusions than the Malingsbo-type granites, but that they are closely associated and belong to the same period of intrusion of the Younger Granites (Magnusson 1970). Similar relations exist in the Grängen area, where pegmatite-rich Tallåsberget granite of Malingsbo-type are cut off by the coarse porphyritic Grängen granite of Fellingsbro-type (Oen 1983).

Petrography

The investigated Fellingsbro-type coarse porphyritic granite contains quartz, microcline, oligoclase (An_{20}), hornblende and biotite as major constituent. Accessories are sphene, fluorite, allanite, apatite, zircon, magnetite and pyrite. The rocks show incipient tectonization (gneissose zones in the field; granulation and microshear zones in thin section). A low-grade pumpellyite-prehnite facies retrogradation is indicated by an assemblage of secondary and late minerals, including chlorite, sericite, epidote, albite, microcline, fluorite, pumpellyite, prehnite and stilpnomelane.

Quartz is present as HT-pseudomorphs within and as anhedral grains between cm-size megacrysts of plagioclase and microcline. Subhedral oligoclase is often rimmed by albite and altered in aggregates of sericite-epidote (saussurite)-albite. Euhedral oligoclase is occasionally enclosed in microcline, whereas antiperthitic microcline occurs as patches in oligoclase. Subhedral microcline with veinperthite show patchy sericitization and replacement by myrmekitic albite. Fine-grained, recrystallized clear microcline locally occurs along grain boundaries. The hornblende is anhedral, green to bluish green, and encloses grains of sphene. It shows alteration into chlorite and stilpnomelane. The biotite is brown to greenish brown. Along the cleavage it shows replacements by chlorite and by lenticles of pumpellyite, prehnite, albite, microcline and sphene. Bushels of acicular, gold-brown ferristilpnomelane, often associated with yellow serpentinous minerals, are found along biotite boundaries. The stilpnomelane is surrounded by zones of radiation damage, which are observed as pleochroic haloes in hornblende and biotite (Verschure, in prep.). Pleochroic haloes are also observed in biotite around inclusions of apatite, allanite and zircon. The biotite also often shows 'border pleochroism' by radiation damage due to intergranular, microcrystalline mineral matter. The euhedral, partly metamict allanite is mostly rimmed by epidote. The euhedral, zoned zircons often show rounded cores. Colourless to purple fluorite occurs in patches and veinlets, usually in aggregates of the dark minerals.

Table 1. Rb-Sr whole rock data of the Fellingsbro-type Kopparberg granite

Sample nr	Rb (ppm Wt)	Sr (ppm Wt)	Rb/Sr (Wt/Wt)	87Sr/86Sr	87Rb/86Sr
81 Brl 459	203	165	1.230	0.79451	3.588
81 Brl 460	222	160	1.392	0.80424	4.067
81 Brl 461	185	105	1.753	0.83198	5.134
81 Brl 462	194	217	0.8933	0.76895	2.600
81 Brl 463	156	218	0.7148	0.75545	2.078
81 Brl 465	187	92.1	2.030	0.85215	5.957
81 Brl 466	198	87.1	2.2692	0.86672	6.668

Experimental procedures and constants

The procedures and accuracies for the XRF analysis of Rb, Sr and Rb-Sr and the Sr isotope analysis are given in a previous paper (Oen 1982), along with the methods used for the calculation of the best-fit line and the Mean Squares Weighted Deviation (MSWD). The ^{87}Rb decay constant used for the age calculation is $1.42 \times 10^{-11}a^{-1}$.

Results and discussion

The Rb-Sr whole-rock data of the samples of Fellingsbro-type Kopparberg granite are presented in Table 1 and Fig. 2. A good linear correlation is shown by the data-points (MSWD = 1.1). The best-fit line corresponds to an age of 1715 ± 50 Ma with an initial $^{87}Sr/^{86}Sr$ ratio of 0.7046 ± 0.0026 (errors 95% confidence level as computed from the scatter of the data-points about the regression line).

In Table 2 the published Rb-Sr whole-rock ages of the Värmland-Småland, Dala and Fellingsbro Groups of Younger granites are listed. They all fall in the range between 1.74 and 1.64 Ga, somewhat older that the range of 1.7-1.6 Ga previously assumed (Oen & Verschure 1982) for the Younger Granites. The three groups of Younger Granites and associated porphyrites show a wide range of initial $^{87}Sr/^{86}Sr$ ratios, between 0.702 and 0.710, but

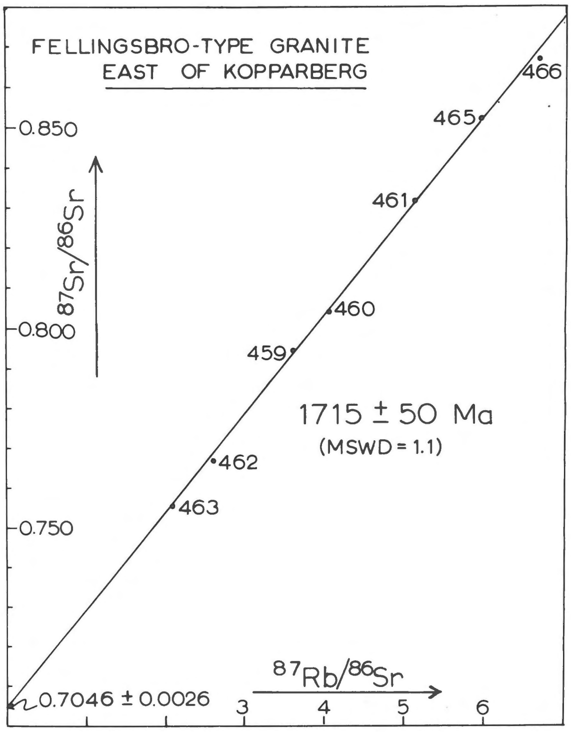

Fig. 2. Plot of Rb-Sr whole-rock data of the Fellingsbro-type granite East of Kopparberg.

Table 2. Rb-Sr whole-rock ages of Younger Granites and associated porphyries in Bergslagen and adjoingin regions*

	Age in Ma	Initial 87Sr/86Sr	n	MSWD
Värmland-Småland Group:				
Småland granite (Larsen & Springer 1976)	1713			
Småland granite, Stralnäs (Åberg 1978)	1693 ± 65	0.7040 ± 0.003	6	0.13
Småland porphyries (Ibid.)	1645 ± 20	0.7081 ± 0.0014	14	1.72
Filipstad granite (Welin et al. 1977)	1664 ± 37	0.7068 ± 0.0021	5	
Hagfors-Kristinehamn granites (Ibid.)	1653 ± 30	0.7021 ± 0.0006	8	
Rockesholm granite (Oen 1982)	1694 ± 191	0.7098 ± 0.0153	12	34
Dala Group:				
Dala porphyries, Garberg granite (Welin & Lundqvist 1970)	1634 ± 38	0.705	10	
Rätan granite (Welin & Lundqvist 1977)	1649 ± 25	0.703 ± 0.003	9	
Järna E granite (Åberg & Frederiksson 1984)	1675 ± 12	0.7039 ± 0.0006	6	0.03
Järna W granite (Ibid.)	1734 ± 14	0.7027 ± 0.0006	4	0.02
Fellingsbro Group:				
Grängen granite (Oen 1983)	1663 ± 51	0.7084 ± 0.0058	10	9
Tallåsberget granit (Ibid.)	1639 ± 185	0.7019 ± 0.0424	4	4
Kopparberg granite (this paper)	1715 ± 50	0.7046 ± 0.0026	7	1.1

*Data deviating from those given in the original publications are recalculated data given by Wilson & Sundin (1979) with preponderance of ratios below 0.705. This suggests a contribution of mantle-derived material to the Younger Granite magma.

The Younger Granites comprise succesive intrusions of distinct types of granite. In the Fellingsbro Group the Fellingsbro-type granites presumably belong to the youngest, and the Malingsbo-type granites to the oldest intrusives. Unfortunately, reliable age data on the Malingsbo-type granites are still lacking. The Malingsbo-Type Tallåsberget granite in the Grängen area has provided a Rb-Sr whole-rock age of 1639 ± 185 Ma, but this error is far too large to confirm the assumption that the Malingsbo- and Fellingsbro-type granites belong to the same intrusion period. It remains thus possible that the Malingsbo-type granites form part of the Older Granites (Oen & Verschure 1982); the results of further age studies have to be awaited.

The low-grade pumpellyite-prehnite facies metamorphism that has also affected the Fellingsbro-type Kopparberg granite is of wide regional extent in the SW Baltic Shield (e.g., Zeck et al. 1971; Nystrom & Levi 1980). It has been related to the Sveconorwegian and/or the Caledonian episode (Verschure 1981, Verschure et al. 1980; Sauter et al. 1983).

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References

Åberg, G. 1978 Precambrian geochronology of southeastern Sweden – Geol. För. Stockholm Förh. 100: 125-154

Åberg, G. & G. Frederiksson 1984 Radiometric dating of the postorogenic Järna granite, South Central Sweden – Geol. För. Stockholm Förh. 106: 171-174

Larsen, O. & N. Springer 1976 Radiometrisk datering af granitoider i Blekinge og på Bornholm – Abstract, 12 Nordiska Geologvintermötet

Lundström, I. 1983 Beskrivning till Berggrundskartan Lindesberg SV – Sver. Geol. Unders. Ser. Af nr 126: 140 pp

Magnusson, N.H. 1940 Ljusnarbergs malmtrakt – Sver. Geol. Unders. Ser. Ca nr 30: 188 pp

Magnusson, N.H. 1970 The origin of the iron ores in Central Sweden and the history of their alterations – Sver. Geol. Unders. Ser. C nr 643: 364 pp

Nyström, J.O. & B. Levi 1980 Pumpellyite-bearing Precambrianrocksandpost-Svecokarelianregionalmetamorphismin central Sweden – Geol. För. Stockholm Förh. 102: 37-39

Oen, I.S. 1982 Isotopic age determinations in Bergslagen, Sweden: II. The Filipstad-type granite of Rockesholm, Grythyttan area – Geol. Mijnbouw 61: 305-307

Oen, I.S. 1983 Isotopic age determinations in Bergslagen, Sweden: IV. Granites of the Grängen area, East of Hjulsjö – Geol. Mijnbouw 62: 301-303

Oen, I.S. & R.H. Verschure 1982 Isotopic age determinations in Bergslagen, Sweden: I. Introduction – Geol. Mijnbouw 61: 301-304

Sauter, P.C.C., Hermans, G.A.E.M., Jansen, J.B.H., Maijer, C., Spits, P. & Wegelin, A. 1983 Polyphase Caledonian metamorphism in the Precambrian basement of Rogaland/ Vest Agder, S.W. Norway-Norges Geol. Unders. 38: 7-22

Verschure, R.H. 1981 The extent of Sveconorwegian and Caledonian metamorphic imprints in Norway and Sweden – Abstract lecture on Seventh European Colloquium on Geochronology, Cosmochornology and Isotope Geology, Jerusalem 1981 (also in Terra Cognita 1982, 2, 64-65)

Verschure, R.H. Andriessen, P.A.M., Boelrijk N.A.I.M., Hebeda E.H., Maijer, C., Priem, H.N.A. & Verdurmen E.A.Th. 1980 On the thermal stability of Rb-Sr and K-Ar biotite systems: Evidence from coexisting Sveconorwegian (Ca 870 Ma) and Caledonian (Ca 400 Ma) biotites in S.W. Norway – Contrib. Mineral. Petrol. 74: 245-252

Welin, E., R. Gorbatschev & P.H. Lundegårdh 1977 Rb-Sr dating in the Värmland granite group in Sweden – Geol. För. Stockholm Förh. 99: 363-367

Welin, E. & T. Lundqvist 1970 New Rb-Sr age data for the Sub-Jotnian volcanics (Dala porphyries) in the Los-Hamra region,centralSweden–Geol.För.StockholmFörh.92:35-39

Welin, E. & T. Lundqvist 1977 Rb-Sr dating of Ratan granite, central Sweden – Geol För. Stockholm Förh. 99: 417-420

Wilson, M.R. 1980 Granite types in Sweden – Geol. För. Stockholm Förh. 102: 167-176

Wilson, M.R. & N.O. Sundin 1979 Isotopic age determinations on rocks and minerals from Sweden 1960-1978 – Sver. Geol. Unders. Rapporter och Meddelanden nr 16: 42 pp

Zeck, H.P., C. Andersen & E. Leonardsen 1971 Pumpellyite in quartzofeldspathic gneisses from SW Sweden – N. Jb. Miner. Mh: 256-262