Notes – *Notiser*

A Rb/Sr date from anorthosite-suite rocks of the Gloppen–Eikefjord area, western Norway

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Scattered data points from anorthosite-suite rocks of the Gneiss Region of western Norway indicate a minimum age of 1,511 ± 64 m.y. The scatter is believed to be related to retrograde metamorphism of >1,511 m.y. old original granulite-facies rocks, formation of mica foliation, and regional EW folding during a Sveconorwegian (Grenville) regeneration event previously defined by $^{40}Ar/^{39}Ar$ dating from the same suite.

Anorthosite-suite rocks of the Gneiss Region can be related to the 1,600 ± 200 m.y. old belt of anorthosite and rapakivi massifs of the north Atlantic shield.

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Extensive blastomylonitic and retrogradely metamorphosed granulite-facies gneisses occur with meta-anorthosites and quartz schists in the Fjordane Complex of western Norway (Figs. 1 and 2). It has been proposed that the granulites are genetically related to those which occur in the central nappe region of Norway (Kolderup 1952, Bryhni & Grimstad 1970), and the few radiometric dates now available do not contradict such a relation. Feldspars from pyroxene gneisses of the Jotun Nappe have yielded K/Ar dates at 1,280 ± 80 m.y., 1,020 ± 40 m.y. and in the range of 666–428 m.y. (Battey & McRitchie 1973), while a pyroxene from the Fjordane Complex has indicated metamorphic events at >1,550 m.y., 1,022 ± 18 m.y. and about 500 m.y. by the $^{40}Ar/^{39}Ar$ method (Bryhni et al. 1971). The present contribution gives results of Rb/Sr isotope data on the same suite of rocks in western Norway as studied by the $^{39}Ar/^{40}Ar$ method.

Sample description

Five samples were selected from anorthosite suite rocks which occur tectonically above quartz schists at Sande in Gloppen. Massive, coarse samples of anorthosite (Table 1, S-1) have relict grey or grey-violet plagioclase, much ilmenite with garnet rims, and small amounts of bioitit, amphibole, and zoisite. Schistose meta-anorthosites (Table 1, S-8) contain considerable white mica and epidote-minerals. The most common rocks of the area are fine-grained blastomylonitic dark grey gneisses (Table 1, S-2, S-3) with tight isoclinal folds (F_1) and upright, open F_2 folds. They often carry round porphyroclasts, suggesting derivation from massive, coarse-grained pyroxene and garnet bearing microperthite augen gneiss (Table 1, S-6), which can be found as relicts in the more severely altered gneisses.

Microperthite relicts are also found in augen gneiss from Eikefjord (Table 1, GN-2), although most of the anorthosite-bearing gneisses in this area are fine-grained blastomylonites (Table 1, GN-1), or completely recrystallized rocks in the amphibolite facies.

Table 1. Rb/Sr and Sr-isotopic composition data for rocks from Sande and Eikefjord, western Norway

Sample	Rb ppm	Sr ppm	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$
S-1	2.5	905	0.008	0.70388 ± 0.00003
S-2	23.2	595	0.113	0.70631 ± 0.00003
S-3	73.6	272	0.784	0.71917 ± 0.00003
S-6	52.8	378	0.404	0.71302 ± 0.00003
S-8	4.4	832	0.015	0.70465 ± 0.00003
GN-1	65.0	231	0.816	0.72144 ± 0.00002
GN-2	78.3	242	0.935	0.72390 ± 0.00003

Best fit isochron = 1.511 ± 64 m.y.
Best fit initial $^{87}Sr/^{86}Sr$ ratio = 0.70402 ± 0.00017

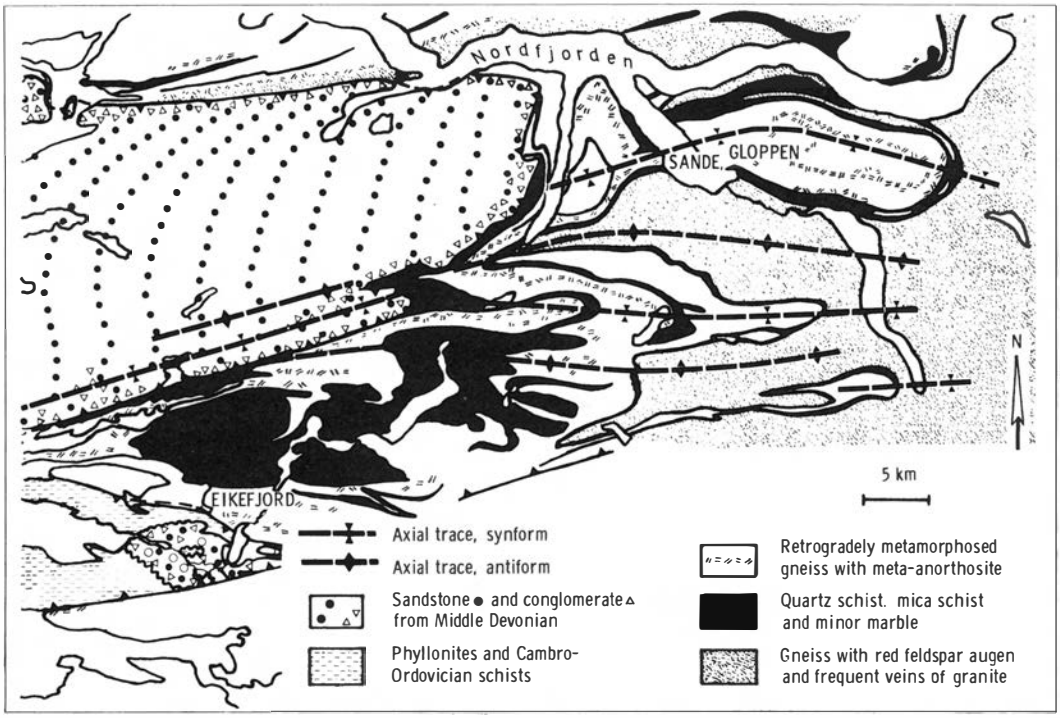

Fig. 1. Geological map of the Gloppen-Eikefjord area. Fjordane Complex indicated as retrogradely metamorphosed gneiss with meta-anorthosite, quartz schist, mica schist and minor marble.

Analytical techniques

The Rb and Sr contents were determined by X-ray fluorescence spectrography on pressed powder pellets using G-2 as primary standard. The error in the Rb/Sr ratio is taken as ± 1%. The isotopic composition of Sr was measured on an Aldermaston Micromass-30 mass spectrometer at Mineralogisk-geologisk museum. Our value for the $^{87}Sr/^{86}Sr$ ratio of the NBS-987 Sr standard is 0.71028 ± 0.00007 (2σ). The details of the above techniques are outlined in Jacobsen (1975). The ^{87}Rb decay constant utilized in the isochron calculations is $1.39 \cdot 10^{-11} y^{-1}$. Isochrons were calculated using the method described by York (1969).

Results

The Rb/Sr data obtained for the seven rock samples are given in Table 1. Five samples from Sande yield an apparent age of 1499 ± 121 m.y. with initial $^{87}Sr/^{86}Sr$ ratio at 0.7040 ± 0.0002. The two samples from Eikefjord can be fitted to a similar regression line, giving a combined 7 point 'isochron' of 1511 ± 64 m.y. with intercept at 0.7040 ± 0.0002.

The two least retrograded samples (S-1, S-6) give an apparent date about 1,660 m.y., while the three most retrograded samples yield an apparent date around 1,300. Fig. 3 shows the 'isochron' plot for the seven samples studied.

Discussion

Scatter of the data-points from the localities in Sande around the best line fit indicate some degree of open system behaviour during the history of the rock suite. This is to be expected, since the rocks are obviously polymetamorphic and in different states of transformation from original granulite-facies to amphibolite-facies assemblages. It is significant that the massive, least retrograded rocks yield a higher apparent age than those which are schistose and much altered. Thus the recorded 1,511 m.y. date is a minimum age. Retrogradation with production of a mica

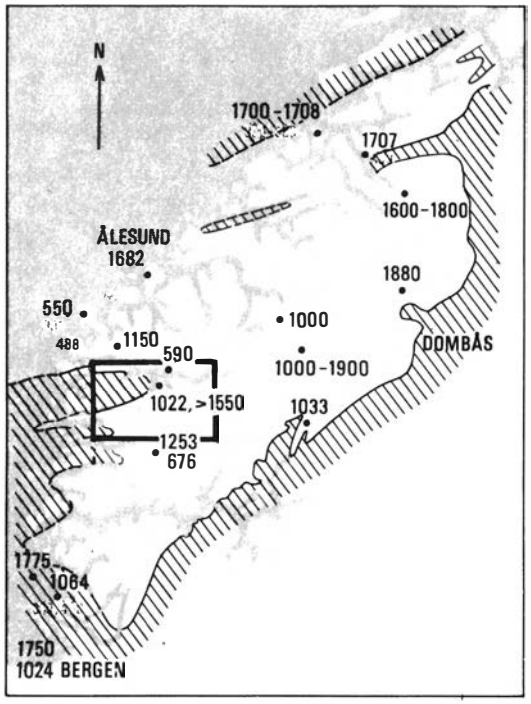

Fig. 2. Compiled radiometric dates from the Gneiss Region up to 1977. Data from Priem (1968), Brueckner et al. (1968), Bryhni et al. (1971), Mysen & Heier (1972), Pidgeon & Råheim (1972), Brueckner (1972), Råheim (1976) and Strand (pers. comm. 1973).

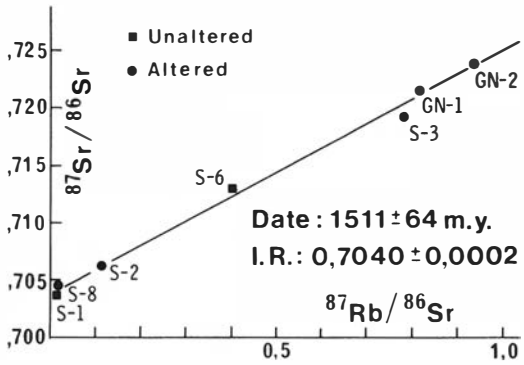

Fig. 3. Rb/Sr isochron plot for rocks from Sande and Eikefjord, western Norway.

foliation must be related to a later event, possibly to the 1,022 m.y. date recorded in the $^{39}Ar/^{40}Ar$ spectrum of pyroxene from the same rock suite.

Anorthosites north of the Grenville province in north-eastern North-America have given dates in the 1,400–1,480 m.y. range (review by De Waard 1974) and Bridgewater & Windley (1973) estimated the mean age for emplacement of anorthosites of the north Atlantic shield to be about 1,600 ± 200 m.y. Rapakivi is closely associated with these anorthosites, and it is very likely that some of the widely distributed augen gneisses also of the Gloppen-Eikefjord rocks represent altered rapakivi-type derivatives. Thus, our 1,511 m.y. minimum age may be valid and representative for an intrusive event within the anorthosite-rapakivi belt which extends across southern Norway to Finland and Russia.

Available radiometric data from the Gneiss Region (Fig. 2) indicate that the country rock gneisses of the northern part are about 1,700 m.y. old (Svecofennian) while those to the south give dates also around 1,000 m.y. (Sveconorwegian, Grenville). Only the southern part of this region has regional folds with E-W axial trend superposed on earlier structures (Fig. 1) and Barkey (1970) suggested that the 1,033 ± 37 m.y. old E-W elongated Hestbrepiggan granite (dated by Priem et al. 1973, recalculated by Sturt et al. 1975) intruded during or at late stages of this F_2 folding. Thus it is likely that Sveconorwegian (Grenville) regeneration took place in the southern part of the Gneiss Region. This regeneration was probably one of E-W folding, formation of a mica foliation, and retrograde metamorphism of original granulite facies rocks. Dates as high as 1,511 m.y. and higher have as yet been recorded only in the Fjordane Complex, while the structurally lower Jostedalen Complex has yielded dates around 1,000 m.y. This may be related to a much more thorough Sveconorwegian reworking and associated granitic plutonism in the most deep-seated part of the southern Gneiss Region.

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References

Barkey, H. 1970: Preliminary results of a geological investigation in West Jotunheimen, Norway. *Nor. Geol. Tidsskr. 50*, 269–270.

Battey, M. H. & McRitchie, W. D. 1973: A geological traverse

across the pyroxene granulites of Jotunheimen in the Norwegian Caledonides. *Nor. Geol. Tidsskr. 53,* 237–265.

Bridgewater, D. & Windley, B. F. 1973: Anorthosites, post-orogenic granites and crustal development in the north Atlantic shield during the mid-Proterozoic. *Geol. Soc. S. Africa Spec. Publ. 3,* 307–314.

Brueckner, H. K., Wheeler, R. L. & Armstrong, R. L. 1968: Rb-Sr isochron for older gneisses of the Tafjord area, basal gneiss region, southwestern Norway. *Nor. Geol. Tidsskr. 48,* 127–131.

Brueckner, H. K. 1972: Interpretation of Rb-Sr ages from the Precambrian and Paleozoic rocks of southern Norway. *Am. J. Sci. 272,* 334–358.

Bryhni, I. 1966: Reconnaissance studies of gneisses, ultrabasites, eclogites and anorthosites in outer Nordfjord, western Norway. *Nor. Geol. Unders. 241,* 68 p.

Bryhni, I. & Grimstad, E. 1970: Supracrustal and infracrustal rocks in the Gneiss region of the Caledonides west of Breimsvatn. *Nor. Geol. Unders. 266,* 105–140.

Bryhni, I., Fitch, F. J. & Miller, J. A. 1971: $^{40}Ar/^{39}Ar$ dates from recycled Precambrian rocks in the Gneiss region of the Norwegian Caledonides. *Nor. Geol. Tidsskr. 51,* 391–406.

De Waard, D. 1974: Petrology and structure of some north American anorthosite massifs. *Geol. Soc. Belgique Centenaire.* Géologie des domaines cristallines. Liège 1974, 324–332.

Jacobsen, S. B. 1975: Geochronological, geochemical and petrological investigations in the Kongsberg area. Unpublished cand. real. thesis, Universitetet i Oslo, 268 p.

Kolderup, N.-H. 1952: Gloppen-antiklinalen. *Univ. Bergen Årb. 1950, Naturvidensk. rekke 2,* 9 p.

Mysen, B. O. & Heier, K. S. 1972: Petrogenesis of eclogites in high grade metamorphic gneisses, exemplified by the Hareidland eclogite, western Norway. *Contr. Miner. Petrol. 36,* 73–94.

Pidgeon, R. T. & Råheim, A. 1972: Geochronological investigation of the gneisses and minor intrusive rocks from Kristiansund, west Norway. *Nor. Geol. Tidsskr. 52,* 241–256.

Priem, H. N. A. 1968: Second progress-report on the isotopic dating project in Norway, *Z. W. O. Laboratory for isotope geology.* Amsterdam, 42 p.

Priem, H. N. A., Boelrijk, N. A. I. M., Hebeda, E. H., Verdurmen, E. A. Th. & Verschure, R. H. 1973: A note on the geochronology of the Hestbrepiggan granite in West Jotunheimen. *Nor. Geol. Unders. 289,* 31–35.

Råheim, A. 1976: Aldersforhold mellom 'Bunngneiser' og overliggende bergarter av antatt 'Cambro Silur' alder i Møre-Trøndelagsregionen. *XII Nordiska Geologvintermøtet, Gøteborg 7–10 januari 1976.* Abstracts, 50.

Sturt, B. A., Skarpenes, O., Ohanian, A. T. & Pringle, I. R. 1975: Reconnaissance Rb/Sr isochron study in the Bergen Arc System and regional implications. *Nature No. 5493,* 595–599.

Versteeve, A. J. 1970: Whole-rock Rb-Sr isochron study of the charnockitic-granitic migmatites in Rogaland, south western Norway. *Annual progress report to the Netherlands organization for the advancement of pure research (Z.W.O.).* Laboratory for isotope geology, Amsterdam.

York, D. 1969: Least-squares fitting of a straight line with correlated errors. *Earth Planet. Sci. Lett. 5,* 320–324.