PETROLOGY OF THE GRIMSTAD GRANITE

I. Progress Report 1964

By

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Abstract. From chemical data and field observations it is concluded that the Precambrian Grimstad granite moved upwards in the crust by the action of chemical attack and buoyancy. Assimilation of overlying rocks led to the formation of different sub-types of the granite.

The red, coarse-grained Grimstad microcline granite is situated in the Precambrian of the South Coast of Norway, 300 km southwest of Oslo. I. OFTEDAL (1938, 1945), referring to the sharp granite contacts and the occurrence of some intrusion breccias near the borders, considered the Grimstad granite to be magmatic. J. A. W. BUGGE (1940) objected to Oftedal's suggestion that dark granite types inside the intrusive body represent earlier stages of crystalline differentiation, he maintained that the dark granite types were remnants of amphibolites assimilated by the granite. K. S. HEIER (1962, Fig. 2) gave diagrams of K, Rb, Ba/Rb, and K/Rb of K-feldspars of a series of seven samples taken at the main road traversing the Grimstad granite. Heier's diagrams may be taken as a support of a magmatic viewpoint and an indication of concentric chemical structures in the granite body.

For the present study nearly 300 samples of the Grimstad granite were collected, about 180 of them serve as the basis for a scheduled partial trend surface analysis (Fig. 1), and the following statements can be made from the data on hand at the end of 1964.

The chemical analyses show that the variation of the concentrations of the main elements is large. The modal data (Table 1) display variations even larger than those suggested by OFTEDAL (1945).

There seems to be a systematic relation between areal chemical variations within the granite and chemical composition of the sur-

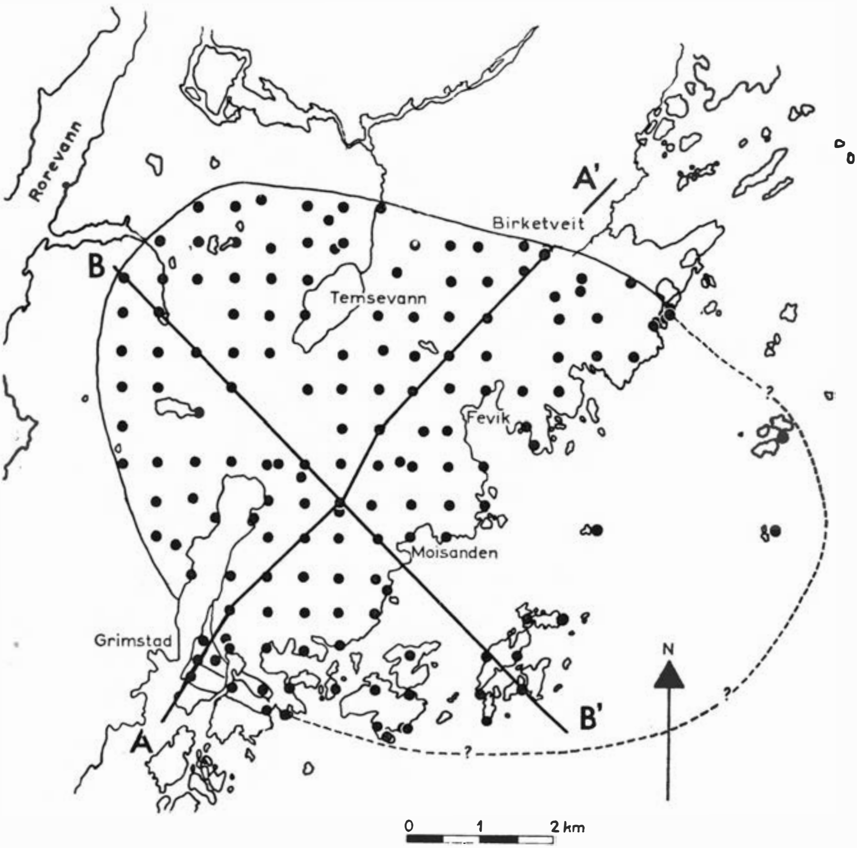

Fig. 1. Locations of samples for partial trend surface analysis of the Grimstad granite are shown by black points. Another 100 selected samples are not marked on the map. Sections AA′ and BB′ refer to the Rb and Sr profiles of Fig. 5.

rounding rocks, as seen from the schematic SiO_2 diagram of Fig. 2.

The numerous inclusions in the granite appear to be unsystematically distributed over the present granite surface. The chemical data of a selected series of samples display a continuous variation of concentrations of elements from host rock amphibolites through dark inclusions and dark granite sub-types to pink coarse-grained granite (marked Grimstad granite in the diagram of Fig. 3) and support the idea that the dark granite sub-types are assimilated host rock amphibolites.

Table 1. *Modal properties of red Grimstad granite samples. In grey and dark granite sub-types the content of biotite + amphibole increases to 10–25 0/0 and plagioclase to 40 0/0 on account of quartz and sometimes K-feldspar.*

	Geometric mean*	Variation
Quartz	26	13.3–40.4
K-feldspar	40	19.9–52.3
Plagioclase	28	13.6–36.8
Biotite	5	1.0–10.0
Accessories	1	

* Geometric mean = most prevalent concentration (AHRENS 1954).

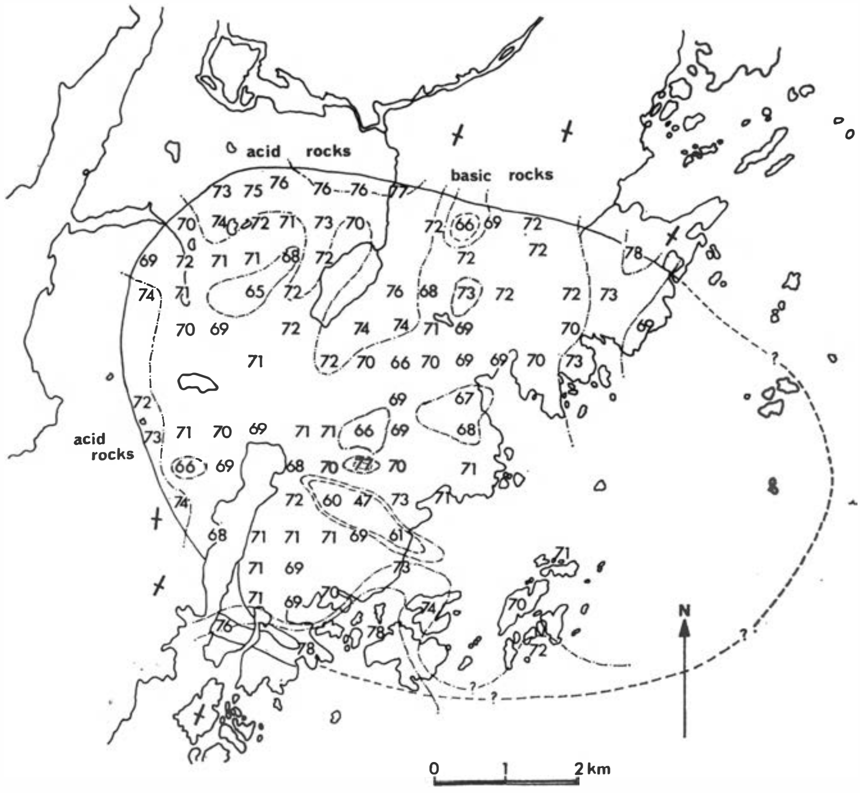

Fig. 2. Schematic SiO_2 map of the Grimstad granite, contours based on values with one decimal. At the contact towards acid rocks the granite has higher SiO_2 values than at contact towards amphibolitic host rocks.

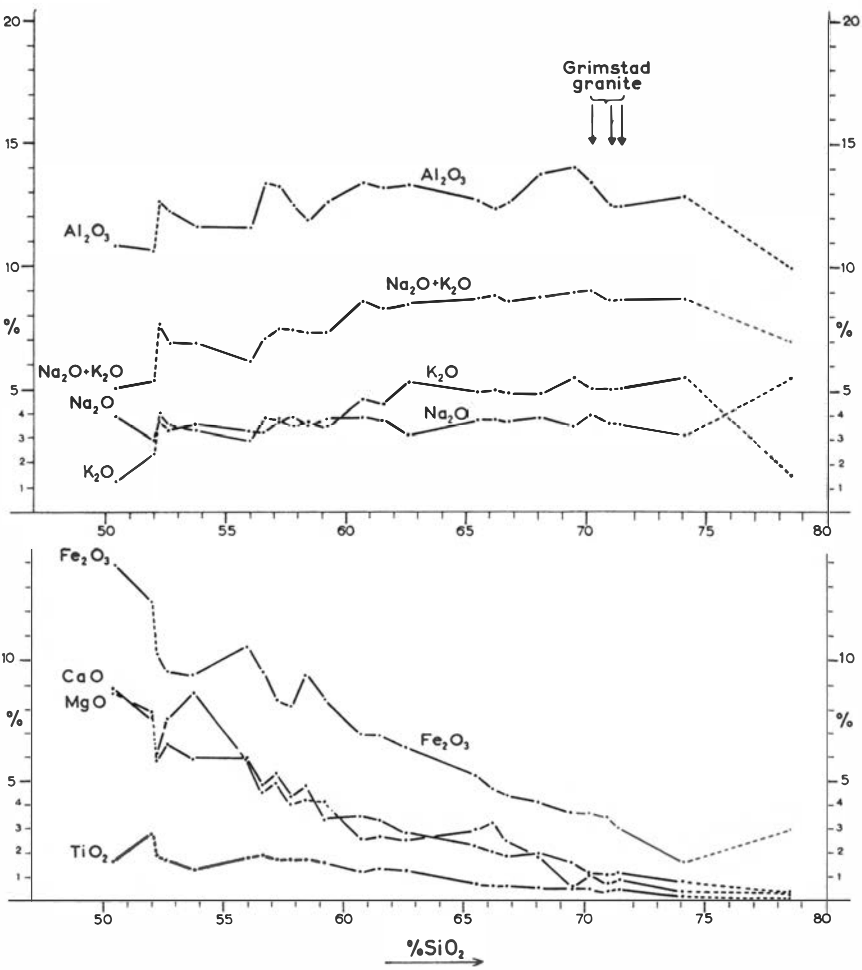

Fig. 3. Variation of main elements in a selected series representing the wide range of compositional variation of rocks in the Grimstad granite, supplemented by two host rock amphibolites and one quartzite (50% and 52%, and 78.5% SiO_2 respectively). Three samples marked Grimstad granite represent the common red and coarse-grained granite, the samples lower in SiO_2 are darker granite sub-types and inclusions (FALKUM 1964).

From the Na_2O/K_2O ratio (Fig. 4) it is seen that the dark granite sub-types represent intermediate steps in the amphibolite-granite transformation which is characterized by formation of biotite and

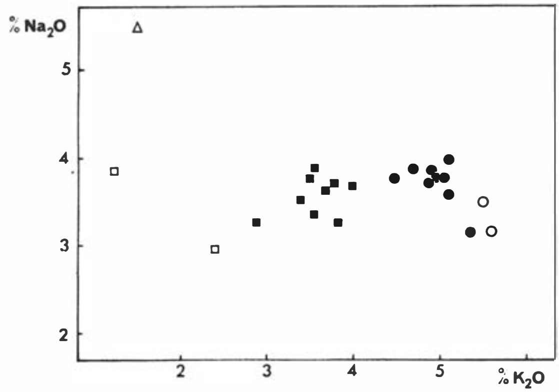

Fig. 4. Relation between Na_2O and K_2O in samples of Grimstad granite and host rocks. Dark circles and squares: pink and dark granite sub-types respectively, open circles: host rock gneisses, open squares: amphibolites, open triangle: quartzite. This diagram indicates that the dark granite sub-types are derived from host rock amphibolites rather than from gneisses (FALKUM 1964).

groundmass K-feldspar in the earlier stages of assimilation and by K-feldspar porphyroblast growth in the later stages.

In the section studied by Heier the distribution pattern of Rb, Ba, and K corresponds fairly well with the distribution of the main elements analysed by us. However, the distribution pattern given by Heier is a result of the incidental distribution of different granite subtypes in that section. Other sections give different patterns and, therefore, Heier's results are not representative of the variation pattern of the granite as a whole (Fig. 5).

The Rb and Sr concentrations of the feldspars are markedly different in the various sub-types of the granite (Table 2). BARTH (1961) suggested a geothermometer based upon the partition of Sr between alkali feldspar and plagioclase. This thermometer gives higher apparent temperatures of formation for the dark granite types than for the main granite. We believe, however, that the structural state of the feldspars of the dark granite types represent thermal disequilibrium. They exhibit RD structures and these Si-Al disordered states, typical of growing feldspars, are likely to give too high temperatures of formation. Therefore, the higher temperature of formation of the dark granite types indicated by the Sr distribution in coexisting feldspars is not necessarily real.

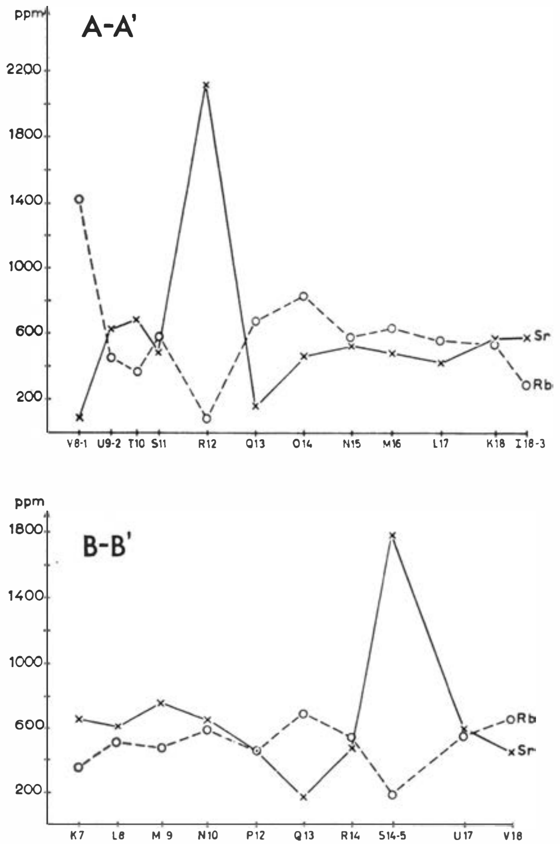

Fig. 5. Sr (full line) and Rb (broken line) concentrations of K-feldspars of two profiles through the Grimstad granite (THORESEN 1964). Letters AA′ and BB′ refer to Fig. 1. The profile AA′ is near to the one of Heier's analysed rocks, and by eliminating every second Rb observation and starting with U 9–2 a curve almost identical to that of Heier's is obtained. The complete set of data, however, gives a picture different from that of Heier's.

There is a tendency towards lower triclinicities of the K-feldspars of the darker granite types. This may also be taken as a result of higher temperatures of formation, but again the frequent occurrence of RD feldspar structures in rocks of lower K-feldspar triclinicity values indicates that the lower triclinicities may be ascribed to an interplay of growth and ordering kinetics rather than to thermal differences within the granite.

Table 2. *Concentrations in ppm of Rb and Sr in feldspars of 23 Grimstad granite samples given as mean values of the three main granite types*

	Q-rich	Normal	Dark
Sr in K-feldspar	125	550	1950
Sr in plagioclase	230	850	2450
Rb in K-feldspar	1050	530	130
Rb in plagioclase	75	100	81

The data at hand suggest the following hypothesis for the formation of the Grimstad granite: The Grimstad granite was emplaced at a post-kinematic stage. Acid 'fluids' concentrated at the top of the granite and corroded the roof of host rocks. We consider the ascending granite as a viscous body moving upward through an even more viscous matrix of amphibolites, gneisses, and quartzites. There need not have been any temperature difference between the granite and the host rocks since the granite was emplaced by the action of chemical attack. The different granite sub-types represent different stages towards complete assimilation of host rocks.

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