LAYERING IN RAPAKIVI GRANITE, SW FINLAND

CARL EHLERS

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Layering in rapakivi granite occurs locally in the islet Söderören, Åland, SW Finland.
The layering consists of 3—5 cm thick, rhythmically repeated layers with high concentrations of biotite, hornblende, allanite and olivine. Almost all layers are asymmetric with sharp lower contacts but gradually passing into the overlying light layers. Many layers show cross-cutting structures resembling current bedding in sedimentary rocks.
It is concluded that the layering is a gravity stratification probably due to convective magmatic currents in the roof zone of a granitic magma.

Carl Ehlers, Geologisk-Mineralogiska Institutionen, Åbo Akademi, Sf-20500 Åbo 50, Finland.

Introduction

Mineral layering in rapakivi granite was found on the islet Söderören in the Åland archipelago, SW Finland. Söderören is located about 85 km WSW of Turku (map sheet 1023 08 A), within the large Åland rapakivi massif (Fig. 1). The Åland rapakivi area covers about 4 000 km² and consists of different postorogenic granites ranging from coarse (wiborgitic), ovoidbearing types to fine-grained aplitic and quartz porphyric types (Sederholm 1934, Hausen 1964).

The layering was discovered in the summer of 1973 during regional mapping for the Geological Survey of Finland; it is exposed in only a few outcrops.

The existence of various kinds of schlieren and mafic parts in the Finnish postorogenic rapakivi massifs is known from earlier, although

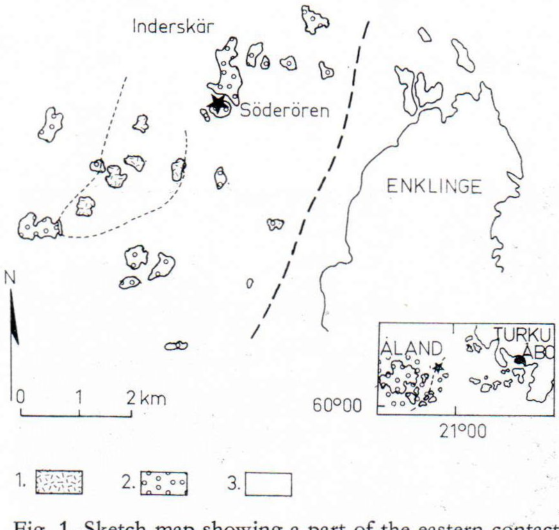

Fig. 1. Sketch map showing a part of the eastern contact of the Åland rapakivi massif, and the location of the little islet of Söderören.

1. Biotite rapakivi with feldspar megacrysts. 2. Medium grained wiborgitic rapakivi. (The area of Åland rapakivi in the inserted map). 3. Older granites and gneisses.

only passing reference is made to them in earlier literature (Wahl 1925, Simonen 1961, Vorma 1965).

Well-developed layering in rapakivi-type rocks in Greenland is described by Harry and Emeleus (1960) and Emeleus (1963).

The Layered Rapakivi

The dominating rock type in the eastern parts of the rapakivi granite area is a medium to coarse-grained »normal» rapakivi of wiborgitic type, but containing only few plagioclase-mantled microcline ovoids.

A rounded massif of biotite granite with potash feldspar megacrysts occurs some 2 km W of the contact (Fig. 1).

The layering is exposed in only a few outcrops on the shores of Söderören. The layered granite passes without sharp contacts into the surrounding rather homogeneous rapakivi which contains only a few dark schlieren. The best outcrop is on the NW shore of the island and is about 10 × 15 m in area.

The layered granite is characterised by rhythmically repeated banding which consists of 3—5 cm thick layers of more mafic rock (Fig. 2), separated by 5—15 cm thick bands of light

Fig. 2. Mineral layering in rapakivi, showing slightly curved and cross-cutting mafic layers. Söderören, NW shore.

Fig. 3. Asymmetric mafic layers with a sharp lower contact and an upper contact that gradually passes into granite. The size of the outcrop is about 2 × 2 m.

granitic rock which differs from the surrounding rapakivi granite in its porphyritic appearance.

The layering has a modest dip to NE and is locally almost horizontal. The individual mafic layers can be followed 4—6 m until they taper out and disappear. Most of the layers are slightly curved with their ends pointing upwards, and many are cross-cut by overlying curved layers in a manner that resembles current bedding in sediments (Fig. 2).

The dark layers are almost without exeption asymmetric, with clearly defined contacts against the underlying granitic layer but gradually passing into the overlying granitic layer (Fig. 3). The assymetric layers are consistently »young» upwards and they resemble gravity-stratified layers in mafic rocks as described by Wager and Brown (1967).

The grain size of the dark layers is clearly less than of the granitic layers. The feldspar megacrysts in the layered granite seem to be slightly oriented parallel to the layering (Fig. 4).

Mineralogy

The surrounding »normal» rapakivi granite consists of quartz, pertitic microcline, plagioclase, hornblende, biotite and some fluorite. Accessories include zircon in euhedral, zoned crystals and apatite. The amount of mafic minerals is about 5—6 per cent, and hornblende is the dominating mineral.

In the layered granite, the more mafic layers contain approx. 20 per cent biotite, hornblende, allanite and olivine. The mineral composition of the mafic and granitic layers in the layered rock is given below, each as a mean of 5 analyses using the point counter method.

	dark layers	light layers
quartz	35 %	40 %
microcline	30	38
plagioclase	12	15
biotite	13	4
hornblende	5	2
allanite	1—2.5	present
olivine	0.5	—
fluorite	1	0.7
zircon	0.3	present
apatite	present	—
opaque	present	—

The total amount of Fe in the dark layers is about 5.4 % (according to X-ray fluorescence analysis). The low content of opaque minerals points to a low degree of oxidisation. Biotite and hornblende often form clusters in which olivine, zircon and allanite usually are found. Olivine occurs as rounded inclusions in hornblende. Allanite, zircon and apatite are euhedral, the allanite crystals are metamict and are surrounded by a radial crack pattern. The lower parts of some of the dark layers are rich in allanite, nearly 3 per cent. The olivine grains are in many places replaced by a brownish or greenish mineral, probably iddingsite. According to Simonen (1961) the rapakivi olivines are fayalites containing only about 6 mol. per cent forsterite.

In the surrounding »normal» rapakivi the hornblende occurs in two generations. This is, however, not apparent in the layered rock, in which the hornblende contains rather few inclusions (quartz) and is partly euhedral. The colour of the hornblende is dark green, sometimes with a bluish tint which indicates a high

Fig. 4. Layering in rapakivi. In the light layers feldspar megacrysts showing weak orientation parallel to the direction of the layering. Note the difference in grain-size between mafic and granitic layers. Söderören, NW shcre.

alkalicontent. A detailed description of hornblendes and biotites in rapakivi is given by Simonen and Vorma (1969).

The biotite is completely anhedral and forms large aggregates sometimes crowded with inclusions. The inclusions are mostly quartz but also microline, plagioclase and fluorite occur. The biotite is very dark brown and rich in iron.

The quartz occurs in at least two generations, one older and one younger than the biotite. The younger quartz forms large, rounded megacrysts, principally in the granitic bands of the layered rock. In the fine-grained mafic layers the younger quartz is less represented.

Also the pertitic potash feldspars occur in several generations, for example, as fine-grained inclusions in biotite and as larger megacrysts probably younger than the biotite. The plagioclase seems to range from albitic to andesitic types. Partly it forms large, zoned euhedral phenocrysts of probably andesitic composition. In one case the plagioclase phenocrysts are enriched in the upper parts of one of the dark layers. More fine-grained oligoclase-albite occurs in the groundmass throughout the rock.

Compared with the dark layers, the light granitic layers are richer in quartz and potash feldspar and poorer in mafic minerals. They are clearly more coarse-grained than the dark layers, partly owing to the presence of young quartz and potash feldspar megacrysts. The granitic layers differ from the surrounding rapakivi in their porphyritic appearance.

Discussion

There is a close similarity between this layering in the rapakivi granite at Söderören and layering in the granite massifs of southern Greenland, described by Harry and Emeleus (1960) and Emeleus (1963).

The layering in the granites in Greenland is found at high levels close to the margins of the granites (Emeleus 1963). At Söderören the topographical differences are too small (less than 10 m) to enable long vertical sections through the granite to be made. However, in the Wiborg massif in eastern Finland and in the Laitila massif NE of the Åland rapakivi, dark schlieren and diffuse dark bands always occur near the margins of the rapakivi massifs or near the contacts between different rapakivi types (Vorma, pers. comm.).

Söderören is situated about 2 km W of the eastern margin of the Åland rapakivi massif, consequently it might be assumed that the horizontal layering indicates that this area once lay close to the roof, which has now been eroded away. Wager and Brown (1967) point out that all granites which show evidence of crystal sinking, also have structures suggesting flow, probably of the convection-current type. They find it possible that convection currents involving cooler and warmer parts of the granitic magma, may be a more frequent factor than the pure sinking of crystals, especially if viscosity is reduced by the presence of water, fluorine or other volatile constituents (Wager and Brown 1967).

Shaw points out that »natural convection must be reckoned with in any large granite pluton, at any rate in the early stages of crystallization» (Shaw 1965).

It seems possible that the Söderören layering in rapakivi is a result of gravity stratification in a granitic magma due to magmatic currents (or succesive magma pulses) against the overlying country rocks. The slight orientation of feldspars parallel to the layering indicates that almost all minerals were crystallized in a moving magma current, probably with the exception of some of the late quartz, which is enriched in the light layers.

It is possible that some of the not uncommon dark schlieren in other parts of the rapakivi might be of the same origin, and later remobilized and distorted by new currents.

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