

BOULDER OF ORBICULAR RAPAKIVI, IN TAIVASSALO, SOUTHWESTERN FINLAND

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A boulder of an orbicular rapakivi was found in Taivassalo, close to the southern contact of the Vehmaa rapakivi area in southwestern Finland. Many features, *e.g.* the fluorite content, the lack of signs of orogenic stress, the miarolitic cavities and the finding-place all point to a rapakivi. The spheroids are nearly spherical, indicating that after they had finished growing in the magma, they sank and were piled upon the bottom of the magma chamber. When the interstitial magma between the spheroids crystallized, the volatiles were confined and concentrated, causing pegmatitic growth or miarolitic cavities.

Key words: Orbicular granite, rapakivi, magma.

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Introduction

During a visit in August 1976 to Kräänä, Taivassalo, in southwestern Finland, Mr. Mikael Holmberg showed me an erratic boulder of an unusual rock which seemed to be a strange orbicular granite, probably an orbicular rapakivi because it was found on the southern contact of the Vehmaa rapakivi area. It aroused special interest because orbicular rapakivi granites have not been found earlier, at least not from Finland. The boulder has been sawed into plates, and several series of thin sections have been made through the spheroids. This paper is a brief description of the rock, giving only some superficial ideas of the origin.

Megascopic description

The boulder consists of a medium-grained reddish granite in which the spheroids are so closely spaced that they often touch one another. The granite is markedly coarser or pegmatitic in the interstices between the spheroids (Fig. 1). Miarolitic cavities are also found in these coarser parts. The granite does not show any kind of parallel structure or other signs of stress.

The spheroids are about 20 centimetres across (Fig. 1). They deviate insignificantly from the spherical and are concentrically built with a rather coarse core surrounded by a simple or double biotite-rich seam against the mantle. The mantle, which forms the

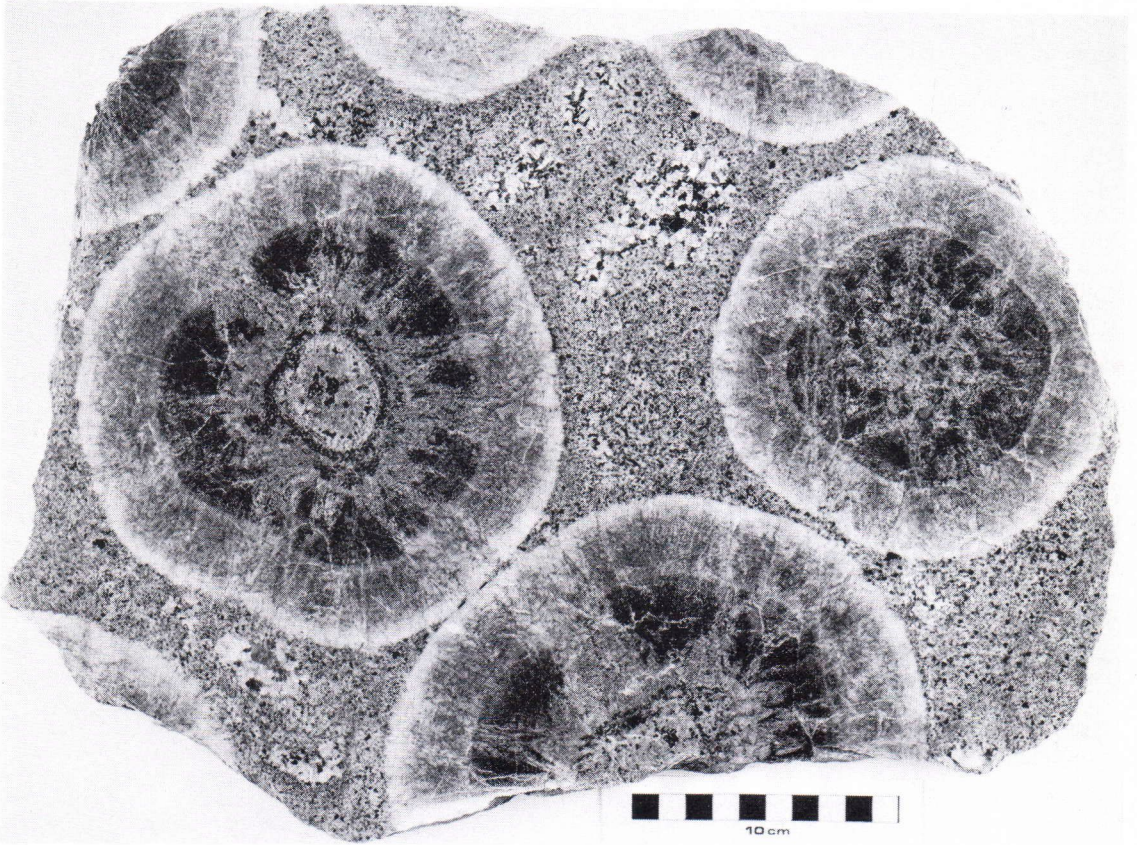


Fig. 1. Polished plate of the orbicular rapakivi. Coarse-grained parts sometimes with miarolitic cavities between the spheroids.

main part of the spheroid, consists of two shells with faint radial and concentric structures. The inner shell is darker and has a sharp contact with the outer, lighter shell. The inner shell contains indistinct, light parts forming radiating beams or networks from which the concentric structure is absent. The outer shell is lighter but also patchy and its outer margin is very light.

Microscopic description

Core

The cores of the spheroids consist of plagioclase, quartz, biotite and potassium

feldspar. The alteration products are sericite, chlorite and ore pigment. Accessory minerals are muscovite, apatite, fluorite, zircon and ore minerals. The texture is hypidiomorphic with quartz filling the interstices between the idiomorphic plagioclase grains (Fig. 2).

The plagioclase, an oligoclase with about An_{15} , is strongly sericitized or pigmented in places, the clear parts often showing anti-perthite patches of twinned microcline. Grains of untwinned potassium feldspar are occasionally found in the core. Quartz occurs as clear, xenomorphic grains. Undulating extinction is weak or absent. There are two types of biotite: one forms big laths that are pleochroic from light brownish

to blackbrown, the other is pleochroic from brownish to blackgreen and form small scales in the outer part of the core. The brown biotite is often greenish along the margins, indicating incipient chloritization. Chlorite also occurs as separate green grains. It is difficult to distinguish the small grains of green biotite from chlorite because the interference colours are masked by the strong colour of the minerals. Apatite forms small needles, and zircon small grains. One grain of fluorite has been found in the sections of the cores.

Mantle

Between the core and the mantle there are one or two thin shells rich in biotite of the green type. The inner one, which may be absent, consists of rather big isolated grains, whereas the outer one is continuous and consists of small grains.

Although, megascopically, the mantle can easily be divided into two shells, microscopically, the differences in the shells are not so obvious. The dark parts of the inner shell are richer in green biotite than the outer shell. The light parts of the inner shell



Fig. 2. Photomicrograph of the core. The interstice between the plagioclase crystal is filled with quartz.

are, as seen in one section, medium-grained areas without any radial structure.

The main minerals of the mantle are potassium feldspar, quartz and plagioclase. Small grains of green biotite are common in the inner shell. Sericite and chlorite are alteration products, and fluorite, apatite, zircon, opaques and epidote are accessory minerals.

The mantle is composed of large radiating grains of potassium feldspar with abundant inclusions of other minerals (Fig. 3). This feldspar generally has only Carlsbad twins, but a few grains show the cross hatching of microcline, too. Perthite flames are common.

Quartz is the dominant mineral in the inclusions and occurs as grains of different size and shape. Some of the quartz occurs as long grains with tapering ends. They are oriented radially but they have not grown in a specific crystallographic direction as they have both positive and negative optical elongation (Fig. 3). They do not show simultaneous extinction and hence are separate grains. All the other quartz grains are isometric. Some have plane boundaries pointing to crystal faces but many are drop shaped.

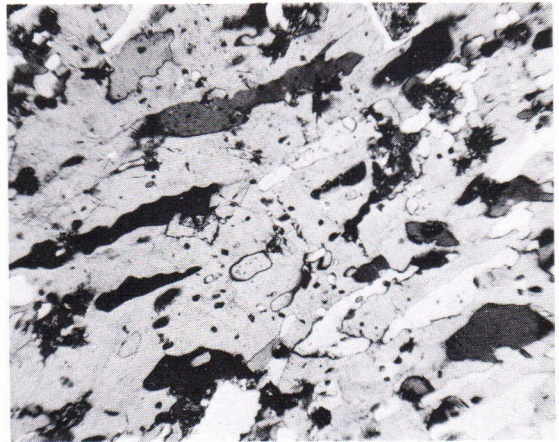


Fig. 3. Photomicrograph of the mantle. Two large grains of potassium feldspar. Inclusions of elongated and isometric quartz grains and small plagioclase grains.

The undulating extinction is weak, if present at all.

Although plagioclase occurs rather seldom as inclusions in the potassium feldspar, it is common in the light, medium-grained parts of the mantle. As a rule the plagioclase grains exhibit rather good crystal shapes, with strongly pigmented cores but clear margins. Some of the plagioclase grains are clear throughout, implying that there are two generations of plagioclase.

Biotite is common in the inner shell but rare or absent in the outer shell of the mantle. It occurs as small scales preferably oriented in two directions, radially and tangentially. They also form bundles of minute scales. The biotite of the mantle is exclusively of the green type. Some of the biotite grains have a myrmekite-like intergrowth with quartz along their margins.

Fluorite, which is present in many of the sections, is irregularly distributed as small xenomorphic grains often adjacent to biotite. Other accessories are less important. Apatite has the shape of small needles. The presence of hematite is indicated by the commonly redbrown colour of the ore minerals along the margins. A few of the hematite grains are surrounded by a very fine-grained corona, the composition of which has not been examined.

Granite

The granite between the spheroids is medium-grained with the exception of the coarser spots mentioned above (Fig. 1). The main minerals of the granite are potassium feldspar, plagioclase, quartz and brown biotite. All the minerals except brown biotite seem to occur in equal proportions. The amount of biotite is subordinate. Alteration products are chlorite, epidote and sericite. Accessories are fluorite, zircon, apatite and

ore minerals. Topaz and monazite have been met with.

The granite is equigranular, even if the potassium feldspar is somewhat coarser than the other minerals. Plagioclase generally has a rather good crystal shape. The quartz grains often have straight boundaries suggesting of crystal faces, but regular, hexagonal cross sections have not been found.

Plagioclase occurs as two types, pigmented and clear grains. The pigmented grains often have clear border zones and some show weak zoning. The pigmented and sericitized cores are oligoclase with An_{10-15} , whereas the clear borders are albite. Small grains of potassium feldspar occur in the plagioclase, as a result of either exsolution or replacement. Potassium feldspar forms more or less xenomorphic grains somewhat larger than the other minerals. Carlsbad twinning is common but cross hatching is rare. Perthite is common and sericitization occurs. The quartz grains are isometric. Undulating extinction is weak or absent. The biotite grains, which are of the same size as the other mineral grains, are of the brown type; only close to the spheroids is the biotite of the green type. Chloritization occurs. Fluorite is present in every section as small or medium-sized grains that tend to be fairly xenomorphic. One section shows a single grain with optical properties suggesting topaz. There is also one grain that appears to be monazite.

Discussion

This superficial description is no basis for any far-reaching inferences about the origin of the orbicular granite of Taivassalo. Nevertheless, some comments are called for. The granite does not show any signs of orogenic deformations and is therefore

considered to be postorogenic. The mineral composition and especially the regular content of fluorite, the questionable topaz and monazite grains, the somewhat obscure idiomorphy of quartz and the miarolitic cavities all point to the rapakivi group, an interpretation born out by the fact that the boulder was found on the southern contact of the rapakivi massif of Vehmaa.

The peculiar structure of the mantle is identical to that of the thin reddish shells of the orbicular granite of Kemijärvi (Simonen 1941, Fig. 7). In Kemijärvi only some of the spheroids have such shells; the other orbicular rocks have quite different structures (Sederholm 1928).

The present observations permit only a few suggestions to be made about the origin. In composition and texture the cores of the spheroids diverge strikingly from the mantle and the granite. The hypidiomorphic texture with dominant plagioclase points to crystallization from a melt rich in sodium. The biotite-rich boundaries between the core and the mantle mark the transition from the sodium-dominated crystallization of the core to the potassium-dominated one of the mantle. This is the exact opposite of the rapakivi ovoids with potassium feldspar surrounded by an oligoclase shell. At the boundary between the core and the mantle the biotite changes colour from brown to green, indicating a drop in the Ti content of the biotite and the magma. Potassium feldspar has grown radially around the core forming the mantle, and quartz and plagioclase grains have been enclosed in the rapidly growing grains of potassium feldspar. For some reason, about half of the quartz grains have been able to keep pace with the growth of the potassium feldspar and have developed into radially oriented elongated grains. The equigranular parts of the mantle may represent enclosed magma which crystallized in a regular way.

The texture of the core suggests crystallization from a magma, whereas the mantle could have crystallized from a magma as well as from a gel. When the magma between the spheroids crystallized, the volatiles were enclosed and concentrated causing formation of pegmatites and miarolitic cavities. Similar pegmatitic granites between spheroids have been described from Kangasniemi orbicular granite (Sederholm 1928, pp. 38–39 and Fig. 3, Plate VI).

We cannot yet say for sure how the spheroids were formed, but we can make some suggestions. The regular shape of the spheroids and the fact that they touch one another implies that they were formed elsewhere and then heaped up in the final place. If they had been formed in situ one would wonder why the crystallization should have been initiated at evenly spaced points and stopped as soon as the spheroids came in contact with one another. The chemical and mineralogical differences between the core and the mantle present another problem. Such a differentiation within spheroids is difficult to understand. It is therefore conceivable that small fragments of a plagioclase-rich older differentiate entered the rapakivi magma offering crystallization nuclei for the mantles of the spheroids. If the fragments were very cold, they could cool the magma around them into colloidal or glassy mantles, which would then crystallize later into the present structure.

The orbicular granite of Taivassalo differs in many respects from most orbicular rocks, which commonly consist of spheroids with alternating light and dark shells. We can therefore suppose that not all orbicular rocks originate in the same way. The formation of orbicular rocks certainly depends on a number of coincident conditions and on several co-operating processes which were active partly concurrently and partly in sequence.

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