SOME NOTES ON ORBICULAR ROCK

by

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(with 4 Text-figures)

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I

In the last one hundred years, a number of papers on the orbicular rocks have been published by many investigators. At the early stage of the research, orbicular rocks were classified by K. von CHRUSTCHOFF (1894) and later F. LOEWINSON-LESSING and O. VOROBJEVA (1929) as follows;

Classification of orbicular rock by K. von CHRUSTCHOFF
1. Assimilation of foreign inclusions
2. Portions of more basic or more acid segregations
3. Pudding granites
4. Endomorphic contact action

Classification of orbicular rock by F. LOEWINSON-LESSING and O. VOROBJEVA
1. Allothrausmatic orbicular rock (Allo = other, Thrausma = fragment)
2. Homeothrausmatic orbicular rock (Homeo = same)

Since the descriptions, classifications, comparisons and theories on the geneses of different kinds of orbicular rocks have been proposed by many authors, among them the descriptions done by Finnish geologists, J.J. SEDERHOLM, P. ESKOLA, and A. SIMONEN are quite excellent. As to Japanese orbicular rock, the summarization given by K. ISHIOKA (1953) is very useful. Though the knowledge on the orbicular rock have been accumulated, the general conclusive theory on the genesis of them is not given even now.

Recently, geneses of orbicular rocks are classified by D.J. LEVESON (1966) as follows:

1. Immiscible drop 2. Fluctuation of melt about eutectic or eutectoid 3. Reaction between magma and xenolith 4. Movement of core 5. High viscosity of magma 6. Excessive crystallization of feldspar 7. Rhythmic super-saturation 8 Granitization or diffusion 9. Influx of Na^{+} ions and outward diffusion of Ca^{2+}, Mg^{2+} and Fe^{2+} .

The fact that there is a lot of theories on the mode of origin of orbicular rocks seems to reflect the complexity of their geneses.

On the bases of field survey, observations of the polished slabs of orbicular rocks collected and preserved by the Geological Survey of Finland, microscopical observations have been done by the author in Finland, 1970 – 1971, in cooperation with A. SIMONEN and I. LAITAKARI. In this short article the author intends to mention some features of orbicular rock, which is considered to be important when the origin of them is investigated.

II

To understand the geologic condition of occurrence of orbicular rocks is necessary to consider the genesis of them, but many of the orbicular rocks have been found as boulder or erratic boulder at the place far from their original exposure, then it is very difficult to know their geological setting.

The volume ratio of orbicules to whole orbicular rock mass seems to be nearly the same in all orbicular rock. Orbicules occupy 60 – 70% of whole host rock in volume, independent from size and structure of orbucule. J.J. SEDERHOLM gave following ratio, 52% for Puutsaari orbicular rock, 60% for Espoo orbicular rock, 60% for Kangasala orbicular rock, 60% for Pöytyä orbicular rock, 61 – 68% for Virviik big orbicular rock, 62% for Virviik small orbicular rock, 66% for Hankasalmi orbicular rock and 70% for Kangasniemi orbicular rock and E.A. Kulish and Yu.K. Polin reported the ratio 60 – 70% for Burein Mountain orbicular rock.

This constancy of the ratio of orbicules to the whole host rock is not considered to be accidental.

The matrix of orbicular rock is usually heterogeneous, ranging from diorite to granite pegmatite or aplite. Coarse grained part, pegmatite and aplite are usually found in the form of vein (Kemijärvi and Kuru), and sometimes as pool (Virviik big orbicular rock, Kangasniemi and Kangasala) in the matrix.

In some cases two kinds of orbicules (Big multiple orbicule and small orbicule in Virviik, orbicule with thick microcline shell and orbicule with thin microcline shell in Kemijärvi and Kuru) are found together in an exposure. Two kinds of orbicules, however, don't occur in mixed condition, but have tendency to form separated independent colonies or groups respectively, as seen in Kemijärvi, Kuru and Virviik.

In some orbicules xenoliths are seen in the core (allothrausmatic orbicular rock after F. Loewinson-Lessing and O. Vorobjeva). Schistose rock is recognized in the core of orbicule from Kangasala, Kangasniemi, Mullaghderg. Metabasite and biotite clot are found in Espoo orbicule and various kinds of granulite occur in the orbicule from Taylor valley, South Victorialand, Antarctic.

Various kinds of xenoliths are seen in some orbicules frequently, but the presence of them seems not to be the primary cause for the formation of orbicule, because xenolithic core is not always found in every orbicule. Conversely, the occurrence of xenolith and reaction rim between xenolith and magma without orbicular structure are not unusual phenomena in the plutonic rock. Thus, orbicular structure is not necessarily developed under such consition. It is certainly assumed that special circumstance was prevailed when orbicule was formed.

III

We are able to know some characteristic features of orbicular rock by means of microscopical observation.

Texture, structure, size and mineral composition of orbicules are quite variable. Essential mafic minerals contained in orbucule, in general, are hydrous minerals as amphibole and biotite, except for the orbicular norite and gabbro. In Espoo orbicular rock, pyroxene is found in the basic schlieren in the matrix, on the other hand pyroxene is quite rare in orbicule (A. SIMONEN, 1938). Sillimanite bearing orbicule from Minedera-Yama, Japan, and granulite bearing orbicule from Taylor Valley, South Victorialand, Antarctic, are quite unique examples.

In the shell of an orbicule, we can find radially arranged plagioclases which are usually elongated parallel to the crystallographic axis *a*. Plagioclase of this type is seen in the orbicules from Corsica (P. ESKOLA,1938), Burein Mountain (E.A. KULISH and Yu.K. POLIN, 1966), Kangasala (J.J. SEDERHOLM, 1928), Espoo (J.J. SEDERHOLM, 1928), Hankasalmi (P. ESKOLA, 1938), Kangasniemi (B. FROSTERUS, 1896, J.J. SEDERHOLM 1928, P. ESKOLA, 1938), Lonesome Mountain (D.J. LEVESON, 1964), Mäntyharju (P. ESKOLA,1938), Mullaghderg (G.A.J. GOLE, 1916), Pampa de Los Altos (B.J. QUARTINO, and V. FABRE, 1966), Pöytyä (P. ESKOLA, 1938), Puutsaari (J.J. SEDERHOLM, 1928), Slättmossa (N.O. HORST and F. EICHSTADT, 1884), South Alaska (R.G. RAY, 1952), Spitzbergen (H. BACKSTROM, 1905), Tisselliline (J. GROLIER, 1961) and some Japanese orbicular rocks (K. ISHIOKA, 1953).

Radially arranged long crystals of plagioclase do not show compositional zoning and are poor in inclusion. The habit of crystals seems to suggest that they grew in a condition in which the material is able to move easily. These plagioclases are frequently replaced by granoblastic plagioclases and are occasionally remeined only as relictic form. As a rule, they have higher anorthite content than that of granoblastic plagioclases and are considered to be fundamental texture in the initial stage of formation of an orbicule.

Sometimes, potassium feldspar is also arranged radially and constructs the outermost shell as seen in the orbicule from Kemijärvi, Kuru and Kangasniemi.

Usually, core of an orbicule is rich in mafic mineral. It is noteworthy that the core of the orbicules occasionally contains anthophyllite or cummingtonite (Corsica, Laukaa and Mäntyharju).

The matrix and shell of orbicules usually have so conspicuous difference in texture, grain size and mineral composition that the boundary between shell and matrix is usually quite sharp, even if there is not the zone in which mafic minerals are arranged tangentially.

Judging from the petrographical characteristic of orbicule, it is assumed that orbicules were formed relatively independently from the matrix as a closed system rich in water.

IV

Up to now, a number of chemical analyses of orbicular rocks, the matrix, shell and core of an orbicule, and a whole orbicules have been reported. One of the important chemical characteristics of orbicule is, as pointed out by J.J. SEDERHOLM, that some kinds of orbicules have a peculiar composition of oligoclase diorite, esboite, named by J.J.SEDERHOLM.

The author considers that to know the composition of a whole orbicule is important when one investigates the origin of orbicule, but the composition of a whole orbicule is not always shown in the literatures. Therefore, the author recalculated the composition of whole orbicule from the analytical data of core and shell, referring their volume ratio, on the bases of the photographs and figures in the original papers.

The normative Ab-Or-Q and An-Ab-Or of the matrix, shell and a whole orbicule of the orbicular rocks already reported are plotted on the triangular diagrams (Figs. 1 and 2). The points representing the matrix of orbicular rocks are distributed in a wide area on these diagrams. On the other hand, generally speaking, the points of a whole orbicule occupy narrower area than those of the matrix. The points of the shells converge in two limited regions. One of which represents the composition of the esboite and the other one is represented by the shells with potassium feldspar zone as in the orbicule of Kemijärvi and Kuru.

In Figs. 3 and 4, matrixes and associated orbicules are plotted and joined by tie lines. From these diagrams, it is clear that, with some exception, the Or and Q component of the orbicule are less than that of the matrix. Regular relation between the composition of matrix and associated orbicule can be understood in these diagrams.

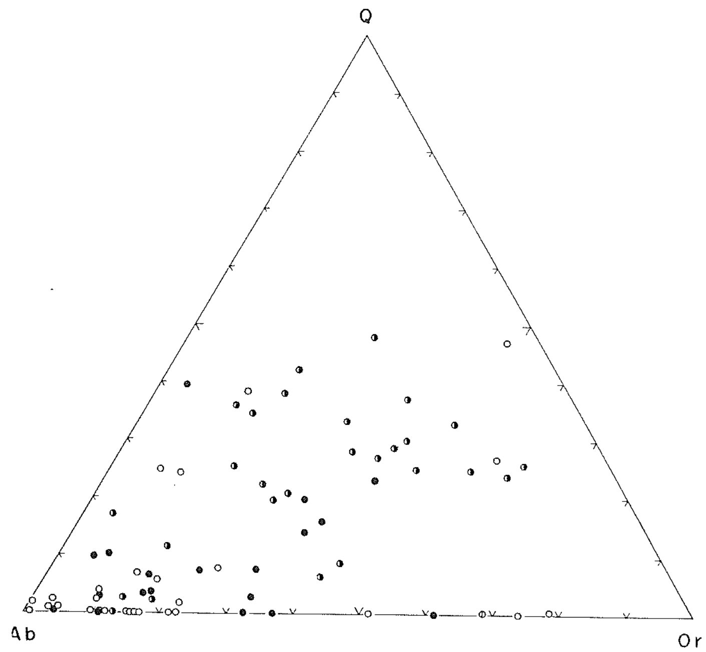

Fig. 1
Distribution of Normative Ab-Or-Q of the matrix, shell and a whole orbicule. Half black circle = matrix, circle = shell, dot = orbicule.

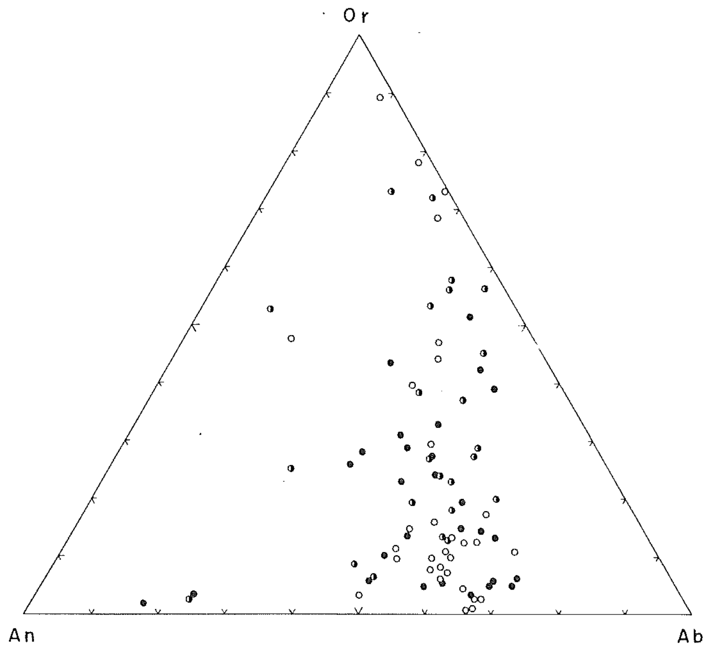

Fig. 2
Distribution of Normative An-Ab-Or of the matrix, shell and a whole orbicule. The designations are the same as in Fig. 1.

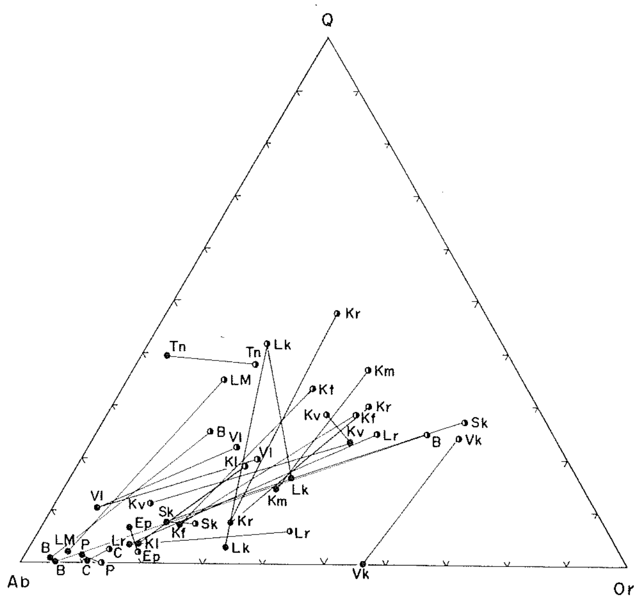

Fig. 3
Normative Ab-Or-Q diagram showing the relation between the matrix and orbicule.
B: Burein Mountain, C: Corsica, Ep: Espoo, Kf: Kortfors, Kl: Kangasala, Km: Kangasniemi, Kr: Kuru, Kv: Kemijärvi, Lk: Laukaa, LM: Lonesome Mountain, Lr: Lintusaari, P: Pöytyä, Sk: Skällefte, Tn: Tisselliline, Vk: Virviik, Vl: Vilppula.

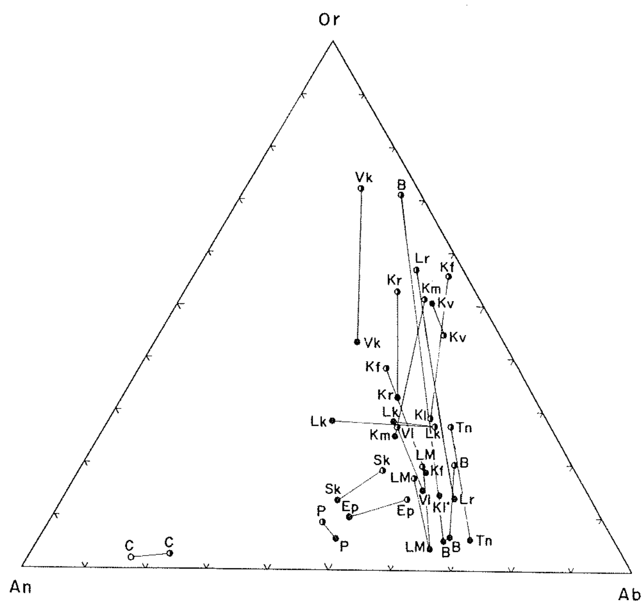

Fig. 4
Normative An-Ab-Or diagram showing the relation between the matrix and orbicule. The designations are the same as in Fig. 1 and Fig. 3.

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