Marekanitic-rhyolitic Complex of the Okhotsk Coast (North-East of the USSR) *

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Up to the present time the problem of lavas of acid effusives is to a certain extent disputable: some people think the effusion of acid melts possible, while others deny such a possibility. Factual material indicates that an effusion of lavas of an acid composition does take place. One of generally known examples is the effusion of acid lavas on Lipari Island, which gave the name to the most acid rocks — liparites. However, even at the present time the eruption of relatively acid material continues to take place before the eyes of man. An example is a recent eruption of Karimsk volcano on Kamchatka, where flows of a relatively acid composition are distinctly recorded. If we revert to effusives of an older age (Mesozoic), we can find such examples in many places and over vast territories (CHUKOTKA, YAKUTIA *et al.*).

A rather striking evidence of the effusion of acid lavas are the effusives of Okhotsk coast widely known in literature under the term « marekanite ». These rocks are developed on the coast of the Sea of Okhotsk in the basin of the river Marekan. Beginning with the end of the 18th century these rocks attracted the attention of mineralogists and petrographers by their peculiar outlook (fluidal-puckered structure), the ability to heave and to disintegrate into separate spheroids at an impact.

Chemical analyses of rocks of the marekanitic-rhyolitic complex indicate a certain instability in the composition of some components. In particular this refers to the content of silica, alkalies and alumina. By the average content of silica the rocks of this complex belong to typical liparites (74.6 % with variations from 68 to 81). They are

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also characterized by a high content of alkalies (about 8 %), which indicates their trachytic tendency with nearly general predominance everywhere of sodium over potassium. As to the content of water, its summary amount reaches 1.5 % only in single cases, including marekanite-rhyolites with a perlitic jointing. By the amount of contained water these rocks occupy an intermediate position between unhydrous and water-bearing volcanic glasses. Mention should also be made of considerable variations in losses during ignition of the rocks. This loss varies from 0.08 to 5.12 %. The last figure refers to rocks in K. I. BOGDANOVICH's collection, an analysis of which was made as early as in 1905. All the other analyses made later (1962) indicate a maximum content of 1.75 %.

Components	Marekanite-rhyolites (an average of 14 analyses)	Granites and granosyenites (an average of 4 analyses)
SiO_2	74.60	73.20
TiO_2	0.14	0.28
Al_2O_3	13.76	13.58
Fe_2O_3	0.71	1.87
FeO	0.49	0.57
MnO	0.04	0.06
MgO	0.11	1.03
CaO	0.76	0.98
Na_2O	4.60	4.34
K_2O	3.21	3.47
H_2O^+	0.91	0.46
H_2O^-	0.80	0.26
Σ	100.13	100.10

The table below gives average results of a chemical analysis of the rocks of the marekanitic-rhyolitic complex. They are accompanied for comparison by the results of chemical analyses for the final stage of intrusive activity represented by granites and granosyenites.

A very characteristic feature of the marekanitic-rhyolitic complex is the structure of the rocks indicating a lack of uniformity in the character of eruptions. Three horizons are distinctly distinguished, each of them having its own typical texture.

The most complicated puckered-flow structure of glassy lavas with an extremely great variety of forms is characteristic of the lowest and most widely developed horizon in this complex. Under a microscope one can see distinctly that the lavas of this type represent slightly devitrified glass of an acid composition with a very pronounced fluidity. The fluidity is stressed both by an alternation of dark and light bands of glass contrasting in colour and by a somewhat different degree of devitrification.

The width of the bands is not great and in the majority of cases amounts to several millimeters. The formation of this horizon is a consequence of a squeezing of the melt into the fissures. Its rocks by their character are close to an extrusive.

The middle part of this complex consists of tuffs and partly of agglomerate lavas formed as result of a strong explosive process that interrupted the squeezing out of the viscous acid melt. In the tuffs rare fragments of lavas are distinguished with a flow structure and small patches and fragments of light-coloured pumices. The agglomerate lavas are of an indistinct occurrence, in which both the fragments and the cement are of the same composition.

After that followed a relatively quiet eruption of glassy lavas, which form the upper part of the marekanite-rhyolites. They are characterized by a flow flatly-parallel structure. In a general case their banding coincides with the outlines of the underlining surface of the tuff horizon.

As compared with the lavas of the first horizon, the lavas of this horizon are characterized by a somewhat greater crystallization of the volcanic glass and by a more noticeable porosity. The last factor is the reason of an easy divisibility of these lavas into layers, which makes them disintegrate into thin lamellae.

Special mention should be made of lavas with a perlitic jointing or true marekanites. This is a semi-transparent glassy rock. A most characteristic feature of these lavas is the presence in them of spheroids. They do not form an independent horizon, being mostly associated with the fluidal-banded lavas of the lowest horizon and are represented by lenses and separate spheroids pressed into loops of fluctuation. The spheroids are of varying sizes and have from several millimeters to 2-3 cm in diameter.

By their outer appearance the spheroids are characterized by the same shades of colouring as the enclosing slightly devitrified glassy lavas.

Under a microscope one can see that devitrification is either absent in the spheroids or exhibits its initial signs. This is either a lightly coloured isotropic structureless glass or the same glass with a distinct fluidity. Fluidal bands, usually, cross the entire spheroid, not displaying any morphological relation to its boundaries. This fact can indicate that these fluidal bands are a part of the general structural pattern of the lava and reflect the fluctuation that preceeded the solidification of the melt. On this basis one can deduct that the perlitic structure and the formation of marekanitic spheroids belong to the postvolcanic stage in the existence of the rock. However, the lesser degree of devitrification of the spheroids as compard with the enclosing mass of banded-fluidal lava indicates that the perlitic fracturing preceeded devitrification. Marekanitic spheroids squeezed in the loops of the flow structure withstood the postvolcanic processes longer than their surrounding mass of the fissured and physically unbalanced glass.

The crystallization character of the marekanitic-rhyolitic complex is also peculiar. As already mentioned, the most characteristic feature of these rocks is their banding. The latter does not depend upon the post-eruptive contractional fracturing and is due to the original heterogeneity of the melt, though these differences in their composition are not very great. In the process of eruption the viscous lava became extended into a heterogeneous mass with a very complex alternation of bands, which determines the structural pattern in the lavas of the majority of sequences. This original heterogeneity in the composition of the bands is the reason of their different relation to postvolcanic processes and, first of all, to the most important of them — devitrification. The initial stage of devitrification is more noticeable in darker bands and finds its expression in an absence of isotropy in small patches. Later the devitrification process develops somewhat further, when it becomes possible to distinguish the appearance of crystallites and crystallite bundles, mostly extending along the fluidity. The final stage of devitrification is expressed in the formation of spectacular radial-ray spherulites, in which locally it is possible to distinguish fibrous rays of quartz-feldspar composition. At an even later stage the intervals between the spherocrystals become filled out mostly by opal and chalcedony. Sometimes the latter form some entire bands. Cristobalite and tridymite are found in minor pores of crystallizing glasses. In the central part of larger cavities it is possible to discern granular aggregates of quartz.

In addition to the recorded modification of silica there are also sporadic grains of minerals of the pre-effusive stage. They include: broadly tabular twinned plagioclase of an oligoclase composition, short prismatic transparent crystals of sanidine, rounded corroded quartz grains, elongated strongly pleochroic brown biotite flakes, prismatic and acicular little crystals of pyroxene of a greenish colour, single crystallites of zircon found in a groundmass, relatively large magnetite crystals of an octahedral habit.

The mineralogical composition of pre-effusive components, both qualitatively and quantitatively, in a general case corresponds to the rocks of a liparitic or trachyliparitic composition, which brings them close to the granite-granosyenitic assemblage of the plutonic rocks occurring here.

Let us revert to the formation character of the marekanitic-rhyolitic complex. The age position of this rock mass is determined within a relatively wide range, but, anyway, its formation took place during the Pre-Neogene time. Absolute age determinations indicate the Eocene time (42 $\pm$ 3 million years).

Important is the question regarding the age and genetic relations with the rocks of plutonic character (Lonzhinsk intrusion). As to the age relations, this question is solved simply: the marekanite-rhyolites are younger than the granitoid intrusion.

The following can be said regarding the genetic relations. The formation of the granitoid intrusion is associated with a triple intrusion, the final stages of which were granites and granosyenites. The geological position of this intrusion indicates its hypabyssal character and some fine-grained porphyric varieties of granites and granosyenites are nearly analogous to the intrusive liparites and trachyliparites.

The marekanitic-rhyolitic complex was formed during the same time interval as the granitoid intrusion and its final stage — the granites and granosyenites are petrochemically analogous to the marekanite-rhyolites, which are already truly volcanic forms. Their similarity increases also by a high content of sodium in the composition of alkalies.

Geological, petrographic and petrochemical analogies between the rocks of the final stage of intrusive activity — granites and granosyenites and the later volcanic rocks — marekanite-rhyolites warrant an assumption that there is also a genetic dependence between them. As is generally known now, interrelations exist between plutonic and volcanic forms in many places of the world.

The marekanitic-rhyolitic complex is a characteristic element in the development of volcanicity in the Okhotsk belt during the Late Mesozoic - Early Cenozoic time. These rocks exhibit many features indicating an inheritance of their properties, which are characteristic for the granitoids of this area.

A study of such peculiar volcanic rocks as the marekanite-rhyolites is of a great geological interest. Such rocks are also of a great practical value owing to their ability to heave repeatedly.