ESTMATE OF CONDITIONS OF PHENOCRYST PLAGIOCLASE FORMATION IN THE SHIVELUCH ERUPTION PRODUCTS ON THE BASIS OF THE EXPERIMENTAL DATA

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The results of the experimental study of the conditions of plagioclase crystallization from water saturated andesite melt of volcano Shiveluch at pressure 1-2 kbar and different oxygen fugacity with the use of the express technique based on the application of plagioclase seeding have been first represented in the paper. Observing the contact of a seeding with the melt, we determine a character of interaction: dissolution or growing, thus, indicating a temperature of a metastable mineral liquidus. All the runs were done at a high gas pressure vessel with a slow quenching. So, there were many quenching phases among the products of the runs. Plagioclase crystals of Ab_{50} composition were chosen for the experiments as seeds.

Experimental results. Fig. 1 represents the results of the experiments at 2 kbar and temperatures 1000, 980, 950, 950°C. Crystal compositions grown most closely to the boundary of the seeding are shown on the diagram within the coordinates 1000, 980, 950, 930°C.In the run at 1000°C dissolution took place completely, but at quenching plagioclase grew. At 950°C epitaxic overgrowing of the seeding by plagioclase crystals occurred, which continued growing at quenching (fig. 2).

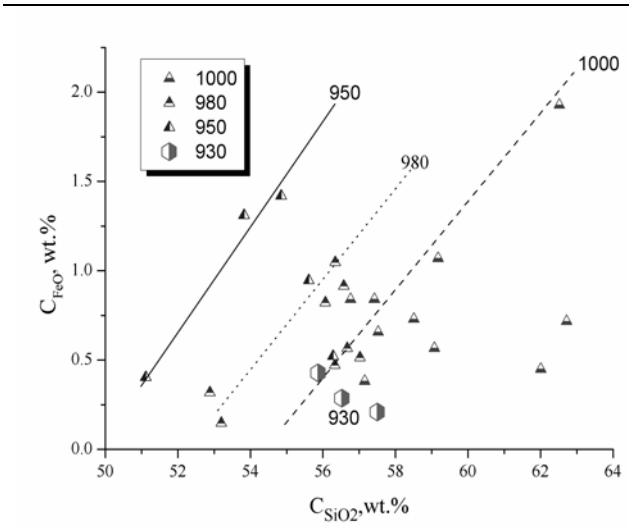

Fig.1. Plagioclase compositions grown at 2kbar

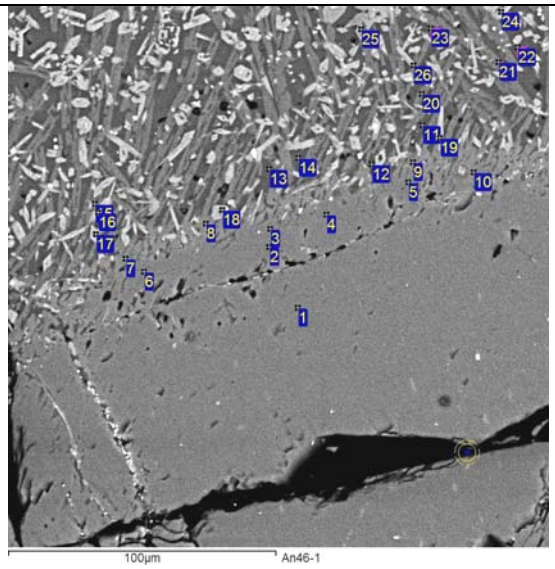

Fig.2. Epitaxial overgrowing of the seeding T=950°C, P=2 kbar

The most basic plagioclases with silica content of 51-54 mass. % and FeO mass. % are observed among crystals grown at 950°C. The most acidic plagioclases (to 62 mass. % of silica) were grown in the run at 1000°C. The highest iron content mass to 2 mass. % FeO can be seen among them. A high content of iron and albite seems to be related to the fact that a considerable overheating suppressed growth centers on the surface of the seeding and crystals began growing with a considerable delay, i.e. at a low temperature. It is a remarkable fact that both plagioclases grown at quenching in the run at T=980°C and those grown at overcooling at T=930°C are more acidic than those being formed at 950°C. Thus, both morphological observations and a study of crystal compositions testify to the fact that plagioclase liquidus temperature at P =2 kbar is between 950°C and 980° C. Judging by the intensity of plagioclase dissolution at T=980°C liquidus temperature is about 960°C.

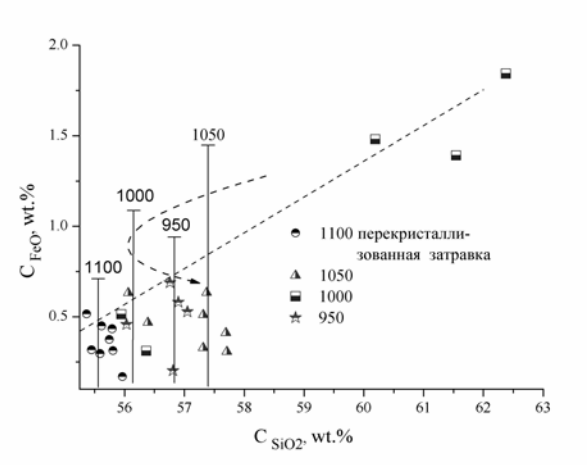

Fig.3. Plagioclase compositions grown a P=1 kbar

Fig.3 gives the results of the runs at water pressure of 1kbar and temperatures 1100, 1050, 1000, 950^{0}C shown on the diagram within the coordinates $C_{SiO2} - C_{FeO}$. The epitaxial overgrowing of the seeding took place at T 1000^{0}C. In the overheated melt at T=1100^{0}C the suppression of the growth centers (actually heterogeneous nucleation) of plagioclase was so effective that at quenching there was no overgrowing and the external crystal boundary corresponds to the recrystallized seeding. Its composition is somewhat more basic (C =55.5 mass. %) than overgrowing at T=1000°C. (C =56.5mass. %). Overgrowing at overcooling (T=950^{0}C) and quenching (T=1050^{0}C) has a more acidic composition. The maximum iron content as well as in the runs at P =2 kbar is 2mass. %FeO. The iron content of both recrystlalized plagioclases and those grown at minimum overcooling is about 0.5 mass. %FeO plagioclase liquids temperature at P=1 kbar is about 1000^{0}C.

The obtained information makes it possible to estimate iron distribution coefficient between crystals and a melt. According to the data of microprobe analyses a total content of ferrous oxide in andesite melt was 4.5-5.2 mass. %.These data correspond to the distribution coefficient 0.1 0.01. We estimated the degree of melt oxidation by the relationship of iron forms found on the data of the Mössbauer analysis according to [1] and it is about NNO 1.5-2.0. It is determined that the distribution coefficient of the ferric iron is approximately by an order higher than that of the ferrous oxide [2]. Considering that all the iron in plagioclase is three-valent and taking into account the content of the ferrous oxide in the melt (according to our data it is about 3.3mass%) we get distribution coefficient for three-valent iron of about 0.21 (the correction is made to recalculate FeO in Fe_2O_3 in the crystal).By the way, the value of the distribution coefficient weakly depends on plagioclase composition and water content in the melt, since about 0,5 mass.% FeO enter the crystal at minimum overcooling at P=2 kbar and P=1kbar.

The analysis of the experimental data. We compared our experimental data with the estimates of plagioclase liquidus temperature according to the model of Putirka [3], connecting melt composition, plagioclase composition, temperature and pressure. As a result of the calculations we got very close values for P =2 kbar T=956^{0}C and P=1kbar T =1006^{0}C. It means that this model describes well variations of plagioclase liquidus temperature depending on the content of water and pressure. Our data were obtained at rather large contents of water in the melt (3-5 mass. %). It is known that the maximum effect of melt properties (diffusional mobility of the components, viscosity, mineral liquidus temperatures) dissolve the first 2-2.5 mass.% of water. The first portions of water dissolve mostly due to the formation of hydroxyl groups, at larger contents molecular water becomes important. So, it is rather interesting to estimate variations of liquidus plagioclase composition in the region of small contents of water. Liquidus slope in grade/mass. % of water becomes a principal parameter. As a result of using the Putirka model [1] we got multi-valued dependence of the anorthite content in liquidus plagioclase on water content in the melt. At water content less than 2.7 mass.% anorthite content increases approximately from 39 up to 80 mol. % with temperature rise and water content drop from 2.7 down to 0.2 mass. %. On the other hand, the similar growth of anorthite also occurs (from 39 to 80 mol.%) at the increase of water content from 2.7 up to 6.5mass.%.

Characterization of volcano Shiveluch plagioclases. On the basis of the experimental data we tried to interpret the conditions of formation of some zonal crystals of plagioclase from the catastrophic eruption of 1964 of volcano Shiveluch (fig. 4).

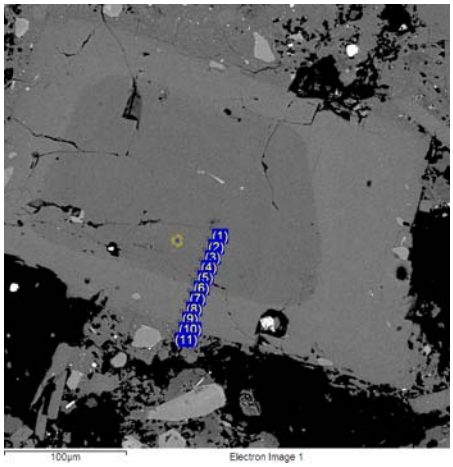

Fig.4. Zonal plagioclase from the eruption of 1964 of volcano Shiveluch

Plagioclase crystals have a markedly reverse zoning. Crystal nuclei have a composition of about $An_{37\pm5}$, and a rim $An_{65\pm2}$. The analysis of amphiboles from the samples of this eruption testifies to the fact that they were mainly formed by means of replacement of orthopyroxenes (probably of the basic cumulates formed at magma crystallization of the mantle genesis) and that from the acidic melt. This interpretation agrees with a rather acidic composition of plagioclase nuclei. The basic plagioclase of the rim seems to correspond to the low branch of the dependence of plagioclase composition on water content, i.e. the rim was formed from a low-aqueous (about 1.5 mass. % H_2O) and hot (about 1080^0C) melt. The majority of anhydrous mafic phases (orthopyroxenes) in the basic mass of the rock testifies to such an interpretation. Amphibole crystals are surrounded by the thin ompacite zone: they decomposed in the medium with high T°C and low fugacity of water. Presumably, high-aqueous hot adakite magma reacted with the changed cumulate and was subjected to depth degasation with the transition of a considerable part of water into a fluid phase. The composition of amphibole phenocrystals formed before the mixing corresponds to low oxygen fugacity of the order of NNO-0.5. The equal low content of iron of about 0.2-0.15 mass. % in the core of plagioclase crystals increases markedly up to 0.6-0.65 in the rim. Such a change can be explained by growth of oxygen fugacity from NNO-0.5 to NNO (1-1.5). The products of depth degassing and conjugated oxidation seem to have caused the catastrophic eruption of 1964.

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