Ichinsky volcano: two types of melts in the minerals of 4200 14C eruption.

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Magmatic mixing processes are very important for the petrogenesis of the acid and intermediate rocks. Disequilibrium paragenesises and textural heterogeneity are usually considered as markers of such processes. Melt inclusions study allows one to get direct evidence of the coexistence of the several agents in the magmatic reservoir system. One of the examples of such evidence is the thermobarogeochemical data on melt inclusions of Ichinsky volcanic massif.

Ichinsky volcanic massif is located in Sredinny Range of Kamchatka – the largest volcanic structure of the peninsula, composed by Cretaceous-Paleogene metamorphic massif and N-Q volcanic belt; Quaternary period of its evolution is described as post-subduction geodynamic environment. Ichinsky is the largest volcano in Sredinny Range. It is a complex polygenetic volcano of Somma-Vesuvius type. Holocene deposits of the volcano are represented mainly by tephra, sometimes by andesite-dacitic middle-K lava flows. It is surrounded by a large monogenetic volcanic field, which produced in Holocene at least one volumnious eruption, called Southern Cherpouk; lavas of this center (Ol-Pl basaltic) formed spatial lava field and are dated 6500 years BP (Pevzner, 2004, Volynets, 2006).

We studied melt inclusions in Pl, Px, Amph and micas of the several horizons of volcanic tephra (Tolstykh, 2018) erupted from 6500 to 4100 years BP (hereafter we use 14C age). The whole rock tephra compositions of these eruptions are very similar (table 2, 1-3).

Table 1. Averaged composition of rocks (1 -3) and melts (4 – 7) of Ichinsky volcanic massif

	1	**2**	**3**	**4**	**5**	**6**	**7**
SiO_2	65.23	65.08	67.65	72.55	75.12	74.87	74.1
TiO_2	0.60	0.61	0.63	0.42	0.21	0.23	0.2
Al_2O_3	15.51	15.51	15.52	13.06	12.39	12.51	11.51
Fe_2O_3	5.43	5.74	4.2	2.19*	0.92*	0.95*	0.93*
MnO	0.10	0.10	0.1	0.07	0.04	0.04	0.03
MgO	1.88	2.14	1.1	0.39	0.16	0.19	0.14
CaO	3.87	3.66	3.1	1.69	0.69	0.7	0.6
Na_2O	4.04	4.04	4.15	3.82	3.38	2.98	2.67
K_2O	2.83	2.81	3.32	2.45	3.72	4.14	4.64
P_2O_5	0.21	0.17	0	-	-	-	-
Total	99.83	99.81	99.8	96.64	96.63	96.61	94.82
Age	6500	4200	4100	4200	4200	6500	4100
n	3	3	1	24	36	47	20

*Note: * - FeO in the glasses of melt inclusions; Age – 14C age of the eruptions, years BP; N – amount of analyses; 4, 5 – averaged compositions of glasses of two types of inclusions in the tephra of the same eruption.*

One of the last eruptions of Ichinsky volcano, dated as 4200 y. (table 1, N 2) has two contrast melts composition in its phenocrysts (table 1, columns 4, 5, Fig. 1). This eruption was first after the large-scale activization of this center, happened 6500 y BP. It was so-called “triplex” eruption (Volynets, Pevzner, 2018), which started from the large basic monogenetic edifice formation (Southern Cherpouk) and finished by the dacite tephra eruption from the main polygenetic edifice – Ichnisky volcano (table 1, column 1).

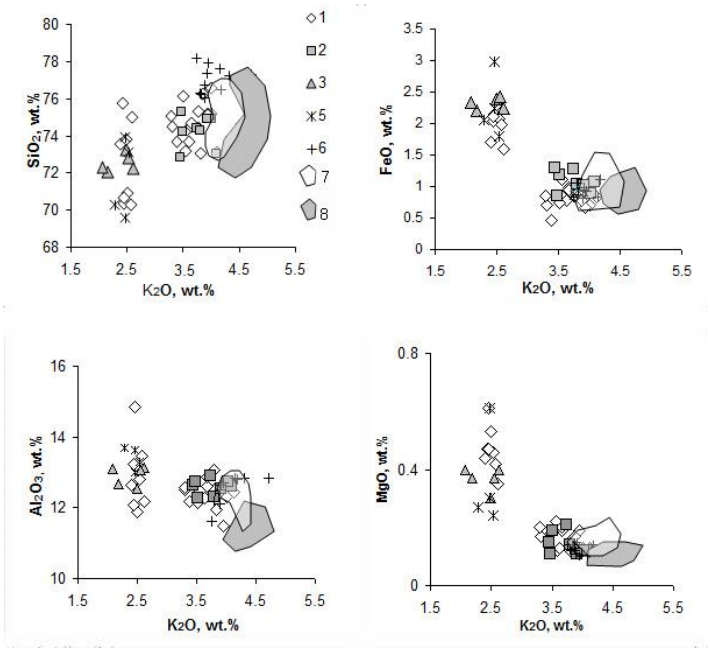

Fig. 1. Harker diagrams for melt inclusions in minerals from tephras of Ichinsky volcanic massif.
1-6 – melts of 4200 C eruption:
1 – melt inclusions in Pl,
2 – melt inclusions in Amph and micas,
3, 5 – melt inclusions in Cpx and Opx
6 – groundmass glasses.
7 – melts inclusions in Pl, Amph, micas in 6500 C eruptions
8 – melts inclusions in Pl, Amph, micas in 4100 C eruption.

Melts of the first type (fig. 1) are found in Cpx and Opx, and in An 57-61 as well. Minerals of this parageneris are frequently form joints; Px are sometimes surrounded by the reaction rims, composed by the spheroidal Amp crystals. Another interesting feature of Pl of this paragenesis is the abundance of the crystalline inclusions of the more acid spar – An 45-57 Ort 3-4. These melts, acid by composition (SiO_2 69-76 wt.%) are also characterized by the low K2O content (around 2.5 wt. %) and increased Fe and Mg content (1.5 – 3 and 0.3 – 0.6 wt. %, respectively).

Melts of the second type (fig. 1) are found in Pl (An 47-41 Ort 2 – 3), Amph and hydrobiotite, as well as in the groundmass glasses of the dacitic tephra of 4200 14C eruption and in both preceding and following eruptions (shown as fields at Fig. 1). Composition of these glassesare localized in more acid area, belong to the high-K series (K_2O 3-4.5 wt. % in most of the inclusions), have lower Fe, Mg, Ti concentrations.

Incompatible elements concentrations are different in these two types of the melts as well (fig. 2). Low-K melts (fig. 2, line 3) are characterized by the maximally high for Ichinsky center melts (Fig. 2, field 2) HREE concentrations, average MREE and lowered LREE, Th and U. Besides, acid high-K melts have higher water content (up to 5 wt. % H_2O) compared to the low-K type (up to 3 wt. %).

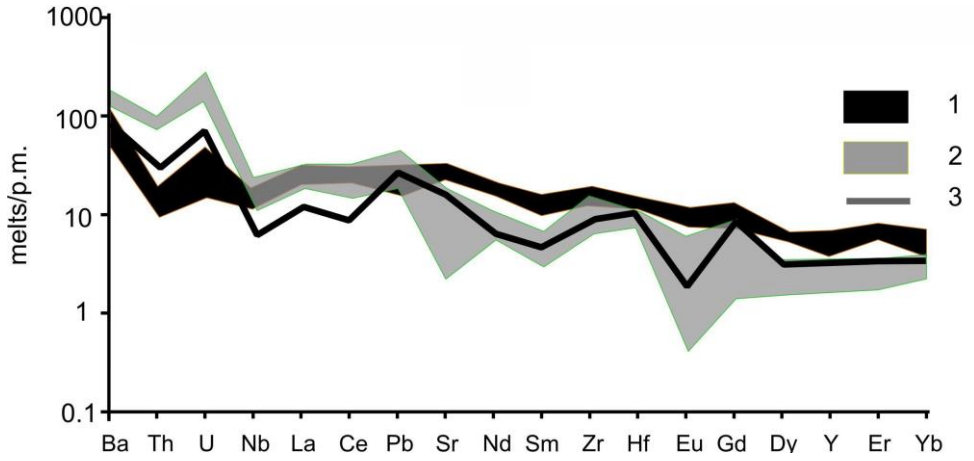

Fig. 2. Incompatible elements distribution in the melts of Ichinsky volcanic massif (normalized to primitive mantle by Sun and McDonough, 1989).
1 – melt inclusions in Ol of Southern Cherpouk monogenetic center (Volynets, 2006)
2 – melt inclusions of high-K type in minerals of all eruptions
3 – melt inclusions of low-K type in 4200 y BP eruption

It is interesting that acid high-K melts are rock-forming for the rocks of both preceding and following eruptions with respect to 4200 14C y BP event, and the later eruptions melts show a tendency of K2O accumulation (fig. 1). This might be caused by the Amph-Pl paragenesis fractionation.

Nevertheless there is no such a fractionation trend which could combine low- and high-K varieties of melts. It is possible to explain the low-K component in the system if we involve a basic Mg component (Southern Cherpouk center, 6500 y). Melts which form inclusions in the olivines of these rocks (Volynets, 2006) are middle-K basalts. Fig. 2 shows similarity of the REE and fluid-mobile element distribution in the basic cone melts (fig. 2, field 1) and low-K type of the acid melts. Unfortunately petrological modeling is impossible in the systems with water-containing mineral phases, therefore we do not have a qualitative assessments of such relationship.

Conclusions

Products of the 4200 14C y BP eruptions of Ichinsky volcano are hybdid. Part of the phenocrysts is formed from the high-K water-saturated melt of the main crustal chamber, feeding the volcanic center throughout the Holocene times. According to the relationships of the melts compositions, described in this research, we can reconstruct the Holocene part of Ichinsky volcano history.

Intrusion of the deep basic magmas into the volcanic center during 6500 y. BP episode, together with monogenetic center formation might trigger the eruptions of the acid magmas of the main chamber. Reasonably small portions of the evolved parts of the basic magmas might join the acid material of the main magmatic chamber of Ichinsky stratovolcano, and formed hybrid rocks of the 4200 y BP eruption. During this event, all “hybrid” material was expended, and the following 4100 y BP eruption shows only high-K acid rocks, which are typical for the whole Holocene stage of the main Icninsky edifice activity.

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