MELT AND FLUID INCLUSIONS IN MINERALS OF SCAPOLITE-BEARING GRANULITE (LOWER CRUSTAL XENOLITHS FROM THE PAMIR DIATREMES)

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Mantle and lower crustal rocks have been identified among the deep-seated xenoliths from the fergusite diatremes of Neogene age in Eastern Pamir (Dmitriev, 1976; Lutkov, 2000). The lower crustal rocks are represented by various granulites (Grt-Bt-Opx, Grt-Bt, Gr-Ky) and eclogite-like rocks (Grt-Cpx-Pl granulites). The reconstruction of the genesis of granulites has great importance for understanding the origin of the lower part of the abnormally thick (up to 70-75km) crust under Pamir. The magmatic origin of kyanite, garnet, orthopyroxene and some other minerals from all granulite varieties and eclogite-like rock of the P-5 sample has been determined earlier by primary melt inclusions evidence (Chupin et al., 1997; Chupin et al., 2001).

The paper presents the preliminary results of study of inclusions in minerals of the scapolite-bearing granulite (sample 1324), the first find among the Pamir deep-seated xenoliths. It is fine-, middle-grained rock with spotty texture, in which felsic areas are chaotically distributed in the aggregates of mafic minerals. Leucocratic minerals are nonuniformly distributed in different parts of xenolith (from 20 to 70 %). The rock is comprised of garnet ($Mg\#_{40\text{-}49}$; composition: $almandine_{41\text{-}44}$, $pyrope_{31\text{-}39}$, $grossular_{21\text{-}29}$), clinopyroxene (jadeite content 6-8 %), K-bearing plagioclase ($Ab_{38\text{-}49}$, $An_{43\text{-}52}$, $Or_{6\text{-}9}$), scapolite, quartz, sphene and negligible amounts of K-feldspar, apatite, ore phases, rutile and zircon. High-calcium scapolite ($meionite_{67\text{-}69}$ with 0,83-0,92 wt. % Cl) and sphene are rock-forming minerals (about 15 and 5 %, correspondingly). Small grains of quartz and opaque mineral commonly occur in garnet. The mafic minerals (particularly garnet) are strongly altered along the rims. Major rock-forming minerals from sample 1324 contain more CaO as compared to the minerals of the eclogite-like rock of sample P-5.

Primary melt inclusions occur in all rock-forming and accessory minerals from sample 1324. Inclusions of this type first have been found in scapolite, clinopyroxene and sphene from the Pamir xenoliths. The inclusions are distributed azonally. Groups of numerous inclusions occur in the central parts of scapolite grains. They are rare in other minerals. Inclusions are mostly 5-15 μm in size, although quartz and sphene contain vacuoles ranging in size from few μm to 40-60 μm. Almost all inclusions in garnet are partly decrepitated, but not in other minerals. Their phase composition at 20°C is as follows: glass+heterogenous fluid bubbles$\pm$several microcrystallites. Inclusions in plagioclase are more crystallized than in other minerals. Cryometric studies have determined that the fluid phase of melt inclusions in all minerals from studied rock has the same composition and is represented mainly by liquid CO_2.

Some garnet and scapolite contain primary fluid inclusions besides the syngenetic melt inclusions. According to freezing data, the composition of fluid inclusions is similar to the composition of the fluid phase of melt inclusions and it is represented by liquid CO_2 (with a density of about 0,75 g/cm^3 in scapolite). It means that early garnet and scapolite crystallized in the presence of CO_2-saturated melt and free CO_2-rich fluid. The estimated fluid pressure is up to 4 kbar at 1000 °C. This value is an underestimate due to the partial decrepitation of fluid inclusions in garnet or elastic increase of the volume of inclusions in scapolite, related to the pressure drop.

According to the microprobe analyses, the compositions of melts in heated and unheated inclusions in clinopyroxene and garnet (sample 1324) correspond to the subalkaline K-rich dacites (K_2O/Na_2O=4,0-2,7). The compositions of melts in unheated inclusions in scapolite, sphene and quartz from this sample correspond to the subalkaline K-rich rhyodacites (the average value of K_2O/Na_2O for inclusions in scapolite is 4,7; in quartz – 3,3 and in sphene – 2,5). The low contents of Cl (up to 0,09 wt. %) in the melt inclusions in scapolite and elevated contents of Cl (up to 0,8 wt. %) in the melt inclusions of other minerals are noted. The calculated CO_2 content in the melt inclusions exceeds 1,0 wt. %. Water and trace element contents are given in the table and in the figure (data of ionic microprobe analyses obtained on IMS-4f in Yaroslavl' by the method of A.Sobolev). Abnormally high contents of trace elements (Ce, Nd, Y, Dy, Yb, Er and other elements) reported for the melt inclusions in sphene are due to the "contamination" of the glass analyses by the material of the host mineral during analysis. The host sphene is enriched in these elements. The high LREE and Th contents and low contents of HREE and Y in melts contained in quartz from 1324 sample can be noted. The low HREE contents seem to be due to the crystallization of early garnet. According to the contents of water, CO_2, Cl, trace and rock-forming elements, the melts contained in quartz from sample 1324 are close to the melts in quartz from xenoliths of massive kyanite granulites of the same diatremes. The compositions of melt inclusions in garnet and clinopyroxene from sample 1324 are similar in general to the melts in garnet from the eclogite-like rock of sample P-5 (Chupin et al., 2001). Melts of sample 1324 are somewhat enriched in potassium.

The obtained data make it possible to conclude that low-water, subalkaline, K-rich acid melts with high CO_2 and Cl contents have played an important role in the formation of scapolite-bearing "granulite" of sample 1324. As was shown earlier for other granulites (Chupin et al., 2001), the appearance of these melts is best explained by the incongruent partial melting of K-bearing, high-calcium mafic substrates (at a pressure higher than 12 kbar and a temperature of about 1000°C). The incongruent melting has been accompanied by crystallization of Si-undersatureted and Ca-enriched minerals (garnet+clinopyroxene, probably, sphene and scapolite), and being the inclusions they have trapped micro portions of these melts. The HREE depletion of melts occurred during the crystallization of the early mafic minerals. Data on the composition of melt and fluid inclusions in scapolite and other minerals from sample 1324 make it possible to explain chemical peculiarities of the mineral-forming medium, wherein the formation of scapolite in the low crust at the elevated PT parameters becomes possible. Scapolite has likely started to form in the presence of the CO_2-rich fluid and when in melt high Cl content (up to 0,8 wt. %) and high CO_2 content were reached. At early stages, scapolite grew fast, which resulted in entrapment of abundant melt inclusions in the cores of crystals. At late stages, growth slowed down, resulting in formation of inclusion-free outer rims. Low Cl content in the inclusion melts can be explained by redistribution of Cl from the melt into the structure of scapolite. During the crystallization of higher calcium scapolite (instead of plagioclase), the excess of Na is taken up by the melt. This is supported by the fact that Na content in the melt inclusions in the late quartz is higher than that in inclusions in the scapolite.

Table. Water and trace element contents (SIMS) in glasses of unheated melt inclusions (MI) in garnet (Grt), sphene (Sph) and quartz (Qtz) from the Eastern Pamir xenoliths (Grt-Cpx-Pl granulites, samples P-5, 1324).

	P-5	1324		1324	
ppm	MI in Grt	MI in Sph		MI in Qtz	
Cr	236,31	93,82	13158	2,75	1,66
Sr	111,58	178	508	849	530
Zr	121,09	383	390	248	166
Ba	341	134			
Ce	38,67	3458	3210	166	141
Sm	1,69	392	383	5,39	3,65
Er	2,48	15,87	15,21	1,10	0,83
Th	22,26		230	35,00	46,88
Yb	2,98	19,49	18,25	0,58	0,44
Dy	3,98	63,75	59,83	1,73	1,07
Eu	0,68	20,49	12,35		2,10
Nd	6,73	2296	2249	41,08	30,26
La	29,58	891	818	122	100
Nb	0,47	45,73			
Y	24,63	123	95,31	5,21	3,20
Ti	1765	89372	76860	1365	1066
B	11,46	3,78	17,12	16,18	10,80
Li	150,86	76,77	60,75	6,18	8,64
Be	1,26	6,33	5,74	4,80	4,71
H_2O wt%	2,38	4,09	1,67	1,62	0,82

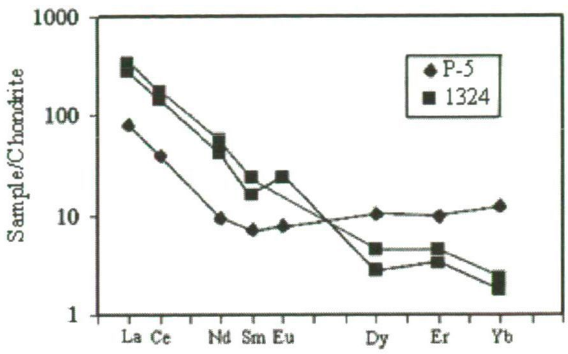

Fig. Chondrite-normalized REE pattern for glasses of unheated melt inclusions from the Eastern Pamir xenoliths (samples 1324, P-5).

P-5 –MI in garnet
1324 – MI in quartz

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