Zeolitized inclusions in trachyrhyolitic spheruloids from Oligocene Studen Kladenets volcano, Eastern Rhodopes

Зеолитизирани включения в трахириолитовите сферолоиди от олигоценския вулкан Студен кладенец, Източни Родопи

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Резюме. В някои сферолоиди от преходната перлит-трахириолитова зона на вулканските куполи са наблюдавани, наред с ахатите, розови или зелени включения от зеолитизирани перлити и туфи. Стъклото е заместено от клиноптилолит-Са, опал-СТ, смектит и K-Na фелдшпати с променлив състав. Генезисът на тези включения се свързва с „инжектиране“ на все още пластична лава в централната кухина на вече кристализиралите и разпукали се сферолоиди.

Key words: Studen Kladenets volcano, spheruloids, perlite inclusions, clinoptilolite, anorthoclase.

Studen Kladenets volcano (6.5×3.5 km) belongs to the 2-nd Rupelian acid phase of the Eastern Rhodopes volcanic area (Ivanov, 1960). It is located in Arda River valley, 25 km east of the town of Kardzhali. The volcano consists of 15–20 domes (dimension up to 3×1 km), 2 flows (up to 1 km long) and 1 sill (Yanev, 2003). Both domes and sill are composed of a central core of massive red-brown trachyrhyolite (average SiO_2 74.92, Na_2O 3.38, K_2O 5.23 wt.%) and gray to black perlite (average SiO_2 70.32, Na_2O 2.98, K_2O 6.02, H_2O 4.06 wt.%) periphery; the flows are of brecciated perlite. A transition zone exists between the trachyrhyolitic core and perlite periphery. It is presented by an alternation of decimetric perlite and trachyrhyolite bands on which trachyrhyolitic spheruloids are “adhered”. Also, many spheruloids (diameter from some mm to 10–15 cm) “float” in perlite. Their texture is porphyric (with sanidine, oligoclase, biotite and rarely augite or amphibole phenocrysts). The groundmass is spherulitic consisting of cristobalite and Na-K feldspar ($Or_{57.5–63.2}Ab_{42.5–33.3}$) fibers.

Except agates, zeolitized perlite inclusions (Fig. 1), rose or green in colour, with relicts of typical perlite cracks and crystallites flows were found in the central voids of some spheruloids from the domes of the NE part of the volcano (Cholderen massive). Note, that the perlites from Studen Kladenets volcano are not affected by any zeolitization. Some inclusions are brecciated, consisting of zeolitized perlitic “pearl”, trachyrhyolitic clasts, cemented also by zeolite. The zeolite is clinoptilolite-Ca $(Si_{28.97}Al_{6.71}Fe^{3+}_{0.071}Mg_{0.48}Ca_{2.21}Na_{0.45}K_{0.81})O_{72}.24H_2O$, associated with opal-CT, green smectite and feldspars of variable composition. The central parts of the feldspar aggregates have high Na content, reaching to anorthoclase ($Ab_{53.8}Or_{40.6}An_{5.7}$) or albite, while the periphery is rich in K (Na-sanidine to sanidine or even adularia). We presume that the anorthoclase, as a low-temperature phase, is probably a nanoscale intergrowth of Na and K feldspars (Harlow, 1982).

There are two hypotheses explaining the origin of the spheruloids (Yanev, 2003 and references therein): (i) incomplete crystallization of viscous acid lava or partial crystallization of already solidified glass (partial devitrification); (ii) immiscibility, probably subliquidus – separating of a super-cooled water-bearing lava into two melts: one, rich in H_2O and K, producing perlite after solidification, and second, dry melt, rich in Na, that crystallizes to form both trachyrhyolitic bands and spheruloids. Only the second hypothesis can explain the deformations of the crystallites flow bands around the spheruloids, the meniscus of the spheruloids on the trachyrhyolitic bands, the deformation of their bottom surface like pillow-lava, the opposite distribution of Na and K between perlites and spheruloids, as well as the existence of felsitic spheruloids (f.i. Bryan, 1954).

The simplest explanation of the occurrence of zeolitised perlite inclusions in the spheruloids would be that they are xenoliths derived from the volcanic basement. Indeed, in some spheruloids there are latite or

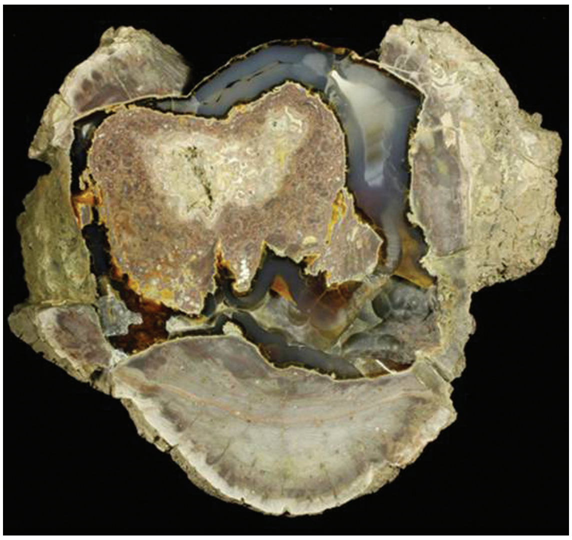

Fig. 1. *Left:* polished section of spheroloid (museum sample No 6098) from Studen Kladenets volcano with central void, filled with agate and zeolitized perlite inclusion (pink). *Right*: microphotograph (plane-polarized light) of the zeolitized perlite inclusion with relicts of typical perlite cracks.

greenish (rarely pink) tuff xenoliths; the last containing relicts of glass shards or pumices fragments that are also completely zeolitized. However, the morphology of the perlite inclusions does not resemble those of a xenolith. And since there is no earlier acid phase under Studen Kladenets volcano, which could provide perlite xenoliths (the 1st acid volcanic phase is only explosive – Ivanov, 1960), we suppose another way of their formation.

After the implantation of the acid lava bodies on/or near the surface their periphery cools rapidly without crystallization and falls into subliquidus area where an immiscibility field is presumed. The melt splits into 2 liquids (see above) and dispersion phase (water poor globules) crystallizes in form the trachyrhyolite spheruloids. The crystallization of water-free minerals provokes liberation of fluids and formation a central void. The increasing pressure of these fluids and the release of specific heat of crystallization lead to cracking of already crystallized spheruloids. Also, according to Swanson et al. (1989) the volume of the crystallized material is about 10% lesser than those of the liquid. According to the model of Bryan (1954) still plastic dispersion media is injected through these cracks in the voids. It solidifies in the spheruloid voids into perlite. The last is replaced by zeolites, feldspars and clay by the action of the fluid that fills the voids.

Bryan (1954) described this phenomenon in the rhyolites of Binna Burra, Queensland (Australia) where a metric "ribbon" of still plastic lava is injected in the central void of 1 meter felsitic spheruloid.

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