VARIETIES OF ENDOGENIC OPALS FROM MUTNOVSKY VOLCANIC AREA (SOUTH KAMCHATKA)

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Opals belong to the family of amorphous and weakly crystallized minerals of water silica (silica hydrated). Based on optical effects and mineral structure, opals can be divided into two groups: noble, with a bright diverse play-of-colour, and ordinary, without it. In this paper we consider two groups of opals from Mutnovsky volcanic area, their chemical and mineralogical composition, as well as the structure.

Under the conditions of formation opals are divided into three types: hypergenic (exogenous), sedimentary and endogenous. The main genetic type is hypergenic mineralization, which is formed in the weathering Cretaceous-Miocene crusts. It is common, for examples, in Central Australia (Vakin, et al, 1976; Deniskina, et al, 1987; Dowell, et al, 2002).

Large masses of opal are deposited as a layer due to coagulation of silica sols transported by rivers (Betekhtin, 1950).

The endogenous type of mineralization includes opals confined to folded system area and cases related to effusive volcanic rocks. They are known in the USA, Yellowstone national Park; Central America; Russia, far East, Kuril Islands (Tishkina, 2006). Opals are formed by deposition of silica from hydrothermal solutions at temperature of 50 to 200°C.

The opals studied by the authors belong to the third, less common type – endogenous. The conditions for the formation of these opals are presented in the article (Topchieva, 2017).

The opal mineralization is common to the Mutnovsky volcanic area. It is located 70 km south of Petropavlovsk-Kamchatsky, at the eastern and south-eastern slopes of the Dvugorbaya mountain. This area is belongs to the Eastern volcanic zone of Kamchatka. It is characterized by the long-term and intense volcanic and hydrothermal activities (Vakin, Kirsanov, 1976; Leonov, 1989).

The studied opals are represented by loose round shaped debris 20 cm in diameter. Two varieties of opals are distinguished: **ordinary** and **noble** (i. e. opal with opalescence) ones (Mostovaya et al., 2014).

In most cases, **noble opal** occurs in thin vein or film of different colours: gray, red, pink, yellow, beige shades. Almost in all samples purple films occur with a play-of-colour. Veins of noble opal are green, pink, red, blue, light blue and yellow.

The content of SiO_2 in noble opals is in the range of 85.2 – 94.5 wei. %. There is an increased content of TiO_2 0.81-2.11 wei. % compared to reference opals (Deniskina, 2006). Some samples show higher contents of Fe_2O_3 4.25 – 8.76 wei. %. The losses on ignition vary from 0.95 to 4.21 wei. %, which is the standard for opals (Deniskina, 2006).

Based on electron microscopic studies (Mostovaya, etc., 2014) and X-ray diffraction analysis, noble opal consists of α-cristobalite, α-tridymite. It relates to the cristobalite-tridymite structural type CT-Opal according to J. Jones and E. Segnit (1971).

Ordinary opals are fragile, loose and fractured rocks without opalescence. Both on theirs surface and on fresh chips. They are divided into the following sub-groups, according to colour: *cachalong* and *resin-red opals*.

Cahalong is opaque beige-white, porcelain or enamel-like opal. The content of SiO_2 is 75.9 – 87.3 wei. %; it is less than in the noble and other opals. The content of TiO_2 is 0.03 – 0.41 wei. % that is typical for ordinary opal (Deniskina, 2006), while the content of Al_2O_3 is higher, from 7.49 to 17.0 wei. %. The content of Fe_2O_3 and FeO is negligible. The loss on ignition is 1.18 – 7.63 wei. %.

The diffraction data cachalong show peaks of α-cristobalite and α-tridymite (structural type of CT-Opal) as well as some lines of clay minerals (kaolinite-montmorillonite). The last fact explains specific porcelain colour.

Resin-red opals have a variety of shades from maroon to bright resin-red. The amount of SiO_2 varies widely from 71.5 to 95.7 wei. %. The content of TiO_2 is higher 0.66 – 1.97 wei. %. The content of Al_2O_3 is from 0.61 to 15.2 wei. %. In some samples, higher contents of Fe_2O_3 is 2.48-3.04 wei. % were recorded. For ordinary opals the loss on ignition ranges from of 1.94 to 4.00 wei. %.

This subgroup of opals is characterized by the lines of α-cristobalite and α-tridymite on the X-ray diffraction pattern; it also belongs to the structural type Opal-CT.

On the microstructural level, the ordinary opal is characterized by chaotic fusion of crystals of cristobalite-tridymite opal with their uneven distribution (Mostovaya, etc., 2014).

Conclusion

Noble opals have high amount of TiO_2 and Fe_2O_3 that explains a wide variety of opal colours. The presence of violet veins propers to noble opal. Cahalongs are characterized by low content of TiO_2 and Fe_2O_3. Significant content of Al_2O_3 is due to the presence of aluminosilicates. The beige-white colour of caholongs is linked with the presence of clay minerals. Resin-red opals have rather colour spectra compared to the noble ones. Their colour indicates the presence of the following compounds: Fe_2O_3, TiO_2, Al_2O_3. All opals are characterized by standard losses on ignition; their content varies from 0.95 to 7.63 wei. %. The X-ray diffraction pattern of all investigated opals, show α-cristobalite and α-tridymite lines. All investigated opals belong to the Opal-CT structural type.

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