EXTREMELY LARGE MOLDAVITE FROM BYŇOV NEAR NOVÉ HRADY (SOUTHERN BOHEMIA): IMPORTANCE OF SOURCE ROCK CHEMICAL COMPOSITION IN THE FORMATION OF MUONG NONG-TYPE MOLDAVITES. M. Trnka[1], R. Skála[2], E. Pecková[2], S. Venclová[3] [1] Lithos Co., Ltd., Durďákova 41, CZ-61300 Brno, Czech Republic, e-mail: trnka@lithos.cz, [2]Institute of Geology of the Academy of Sciences, Rozvojová 269, CZ-16500 Praha 6, Czech Republic, [3]South Bohemian Museum in České Budějovice, Dukelská 1, CZ-37001 České Budějovice, Czech Republic.

Introduction: A very unusual moldavite was found close to the village of Byňov near Nové Hrady in South Bohemia recently. Its appearance was so atypical that even many experienced collectors doubted whether it is a real moldavite. Doubts were raised by its extraordinarily high weight, almost complete opacity, distinct layering and unusually finely abraded surface. A chemical study was used to the confirmation of its belongings to moldavites. This study could only be non-destructive because of the uniqueness of the sample. Recently, the moldavite is on display in the South Bohemian Museum in České Budějovice.

Description of the moldavite: The moldavite from Byňov is morphologically similar to the typical blocky tektites of the Muong Nong type of the Australasian strewn field. It is an irregular flat fragment, which is bounded by two surfaces roughly parallel to its layering, and by a system of transverse concavely curved fracture surfaces. Its overall dimensions are 90×59×33 mm.

The weight of the moldavite is 211.8 g. Therefore, it is the heaviest South Bohemian moldavite discovered so far. Based on the shape of the transverse fracture surfaces and the overall fabric, the original weight of the piece before fragmentation can be roughly estimated at 1 kg or more.

All edges of the moldavite are slightly rounded by abrasion. Its almost flat surface is covered with incompletely worn, shallow pitted sculpture. Deeper linear furrows on the transverse breaks indicate layering highlighted by corrosion and abrasion. The uniformly matte appearance of the moldavite surface is caused by arc-shaped cracks of microscopic size with a length of tens of micrometers, which cover its entire surface. The orientation of the cracks is random, only rarely they are arranged in chatter marks. The accentuation of cracks due to subsequent chemical corrosion is only weak. The character of the surface demonstrates that the abrasion of the moldavite occurred during slow transport, most likely by solifluction during glacial period.

The color of the moldavite in transmitted light is brown-green, extremely dark for a moldavite. However, due to its overall thickness, the color can only be observed at the edges when using a strong light source.

The place of find: The place of Byňov locality is located at the southeastern margin of South Bohemian moldavite region. The locality is often referred to by collectors and in publications after the nearest settlement as Jakule. It has been known since the seventies of the last century as a relatively rich locality. The geographic coordinates of the place where the moldavite has been discovered are 48.836 N and 14.805 W, its altitude is about 500 m above sea level.

Moldavites occurring in this area are found there in denudation relicts of Tertiary sediments. Among them, feldspar sandy gravels dominate. Thin bed of sandy clays occurs locally at their base. These sediments correspond to the oldest deposits hosting moldavites (Vrábče Layers and Koroseky Sandy Gravels) that formed shortly after the fall of the moldavites. Atop these Tertiary relics and in their surroundings, moldavites redeposited into Quaternary sediments were found sometimes. The described moldavite represents find from sediments of such age.

Moldavites from the Tertiary sediments near Byňov are typically small angular fragments weighing up to 3 g (approx. 75 % pieces). Such appearance indicates their short transport from the places of their original fall. The locality is characterized by a high proportion of dark brown and brown-green moldavites (approx. 25 % - [1]) which are rare within the South Bohemian region. Moldavites with linear structure, caused by frequent, strongly elongated bubbles (channels), as well as moldavites visually resembling the Muong Nong type tektites are common. Muong Nong-type moldavites from this locality have already been described and studied in the past [2-4].

Chemical composition: The chemical composition of the moldavite was determined by an energy-dispersive X-ray spectrometer Oxford Instruments Ultim Max 65 attached to a scanning electron microscope Tescan Vega 3XM in a low vacuum. The sample was attached to the sample stage with a Leit-C-Plast conductive mounting plastic and aluminum foil to keep it in the desired position yet it was not carbon-coated. The accelerating voltage of the SEM was 20 kV, the beam current was optimized for analytical data collection, and the working distance was ~13 mm. The elements were quantified with the standardless procedure implemented in the EDS control software.

The bulk composition as the average from 20 randomly selected analytical spots (in wt.% with respective ranges and relative standard deviations given

in brackets) is as follows: SiO_2: 79.42 [(78.7-80.39)/0.58]; TiO_2: 0.37 [(0.29-0.47)/11.31]; Al_2O_3: 11.31 [(10.6-11.82)/2.62]; FeO: 1.93 [(1.64-2.12)/6.74]; MgO: 1.08 [(0.98-1.16)/4.12]; CaO: 1.19 [(0.86-1.48)/17.81]; Na_2O: 0.94 [(0.77-1.06)/8.46]; K_2O: 3.77 [(3.39-4.16)/4.77]. It should be taken into account, however, that the analytical data were collected from uncoated irregularly shaped specimen under low vacuum conditions. Consequently, oxides whose contents are ~1 wt.% or less (Na_2O and TiO_2) may be subject to relatively higher errors.

Discussion: When compared to the published averages for South Bohemian moldavites [5,6], the described moldavite shows lower contents (in rel.%) of CaO (–60), MgO (–50), and conversely higher TiO_2 (+30), FeO (+20), Al_2O_3 (+15), Na_2O (+120) and K_2O (+10). The contents of CaO, MgO and Na_2O lie on the margins of their ranges found in South Bohemian splash forms and are not common even among all moldavites.

Similar compositional differences, in comparison to the moldavite splash forms, were found in other analyzed Muong Nong type moldavites from Byňov (Jakule) [2,4] and from several other localities in the South Bohemian region [3,7-9]. Regardless of finding places, the Muong Nong-type moldavites are in comparison to splash forms from the same region always depleted in CaO and MgO and simultaneously enriched in Na_2O, K_2O, FeO, TiO_2 and Al_2O_3. Strikingly, their composition is close to Moravian moldavites [2, 8].

It is generally assumed that the different properties of Muong Nong-type tektites when compared to splash form tektites (irregular blocky appearance, layered structure, higher content of volatiles, crystalline inclusions, etc.) resulted from lower temperature of their formation [10-12 etc.]. However, such an explanation is oversimplified and does not provide an unequivocal clue to all the features. It is much more feasible that splash forms were formed from a melt of lower viscosity than was that of the Muong Nong type tektites while melt viscosity is influenced not only by temperature itself, but also by chemistry, particularly SiO_2 content, and the amount of volatiles released from the source rocks. The coexistence of splash form and Muong Nong-type moldavites of different chemical compositions at localities at the distance of 260–310 km from the Ries source crater raises the question of whether temperature is the only or even the main reason for their differences in this case.

The chemistry of the studied moldavite as well as other Muong Nong type moldavites from the South Bohemian region can most likely be explained by the formation from relatively less mature sediments with a lower content of carbonates and on the contrary with a higher content of unweathered feldspars (especially albitic plagioclase), chlorites, or biotite. Sediments with such a mineral composition would contain a lower content of bound volatile components (H_2O and CO_2) compared to more mature sediments, which in dehydration melting results in higher viscosity of the melt at comparable temperatures. That is, to the same effect as could theoretically be caused by a different temperature of their formation. However, there is no obvious reason to consider different temperatures in the formation of moldavites found on a single spot.

However, a comparison of the South Bohemian Muong Nong type moldavites with the Moravian splash form moldavites offers a different perspective. The chemistry is often very close in both cases. Moravian moldavites, however, lack any layering indicative of the Muong Nong-type tektites [5]. Therefore, it seems likely that the reason for the textural differences between the Moravian moldavites and the South Bohemian moldavites of the Muong Nong type is primarily the different temperature of their formation. This is also consistent with occurrence of Moravian moldavites at a distance of 380 to 455 km from Ries impact crater.

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References: [1] Vamberová O., & Ševčík J. (1990) Proceedings of 5th Conference on Moldavites. Jihočeské muzeum, České Budějovice, 106-124. [2] Glass B.P., et al. (1990) 20th Lunar & Planet. Sci. Conf. Proceedings, 341-342. [3] Meisel T., et al. (1993) Meteoritics, 28, 397-398. [4] Molnár G. (2012) BSc. Thesis, Faculty of Science, Charles University, Prague. [5] Trnka M., & Houzar S. (2002) Bull. Czech Geol. Survey, 77, 283-302. [6] Trnka M., et al. (2015) Bull. mineral.-petrolog. odd. Nár. Muz. (Praha) 23, 1, 34-38. [7] Fehr K.T., & Preuss E. (1999) Schr. Staatl. Mus. Mineral. Geol. Dresden 10, 27-29. [8] Trnka M. (2003) Přírodovědný sborník Západomoravského muzea, 41, 31-44. [9] Švardalová L. (2008) Minerál, 15, 2, 136-140. [10] Barnes V.E. (1989) The Texas Journal of Science, 41, 1, 5-33. [11] Koeberl C. (1992) Geochim. Cosmochim. Acta, 56, 3, 1033-1064. [12] McCall G.J.H. (2001) Tektites in the Geological record. The Geological Society, 256 pp.