First find of nephrite in tremolitite body from Ograzhden Mountain, Southwestern Bulgaria

Първа находка на нефрит в тремолититово тяло от Огражден планина, ЮЗ България

Nikola Zidarov[1], Ruslan I. Kostov[2], Petar Zidarov[3]
Никола Зидаров[1], Руслан И. Костов[2], Петър Зидаров[3]

[1] Institute of Mineralogy and Crystallography, Bulgarian Academy of Sciences, 1113 Sofia; E-mail: nzidarov@interbgc.com
[2] University of Mining and Geology “St. Ivan Rilski”, 1700 Sofia, Bulgaria; E-mail: rikostov@yahoo.com
[3] New Bulgarian University, 1618 Sofia, Bulgaria; E-mail: petar.zidarov@yahoo.com

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Nephrite is a fiber cryptocrystalline massive variety with composition in the tremolite $Ca_2Mg_5Si_8O_{22}(OH)_2$ to ferroactinolite $Ca_2Fe_5Si_8O_{22}(OH)_2$ amphibole series (Hawthorne, 1981). Nephrite deposits are associated worldwide mainly with serpentinite units within ophiolite belts or with dolomite marbles as a product of metasomatic processes (Suturin, Zamaletdinov, 1984).

Nephrite takes a specific role in the history of human civilization. It is one of the first raw mineral materials used for prehistoric stone tools (axes, adzes and chisels), prestigious insignia, amulets and other juwellery artefacts. Nephrite artefacts are found on the Balkans with highest concentration on the territory of contemporary Bulgaria, from the Early Neolithic to the end of the Chalcolithic period (end of VII mill. BC – middle of V mill. BC), which is the reason for introducing a Balkan “nephrite culture”, probably one of the earliest in mankind, earlier and before the well known Chinese Neolithic nephrite yielding cultures (Kostov, 2007). On the territory of Bulgaria such nephrite artefacts are found mainly in the prehistoric sites along the Struma River valley, in Central Bulgaria, the Eastern Rhodopes and in Northeastern Bulgaria (Todorova, Vaisov, 1993). Despite the numerous nephrite archaeological finds on the Balkans, no *in situ* deposits or occurrences have been described in geological or mineralogical papers. The geological setting for such deposits and occurrences in Bulgaria and some other Balkan countries is favourable with a lot of serpentinized ultramafic rock outcrops.

The aim of this communication is the observation and description of an occurrence of nephrite bearing tremolitite body, which gives a hint for the idea that in SW Bulgaria there are conditions for the formation and future finding of nephrite deposits related to the rocks of the ultramafic genetic type.

Occurrence

Nephrite is found among the minerals of a small talc-tremolitic body included in metamorphic rocks cropping out in the Ograzhden Mountain, along the Lebnitsa River valley.

Geological setting

The investigated talc-tremolitic body is incorporated in non-uniformly migmatized biotite gneisses (metagranites with a protolith age ~ 460 Ma) constituting the metamorphic complex, building the Ograzhden unit of the Serbo-Macedonian Massif to the west of the Struma River (Zagorchev, 2001). They are metamorphosed in the amphibolite facies with a Variscan age (336±3.7 Ma according to data of the U-Pb method for xenotime), and in certain episods are related to the Alpine magmatic activity and change of the tectonic regime, with a lower in degree metamorphism (Zidarov et al., 2009). In some parts of the metamorphic complex are registered garnet-mica schists (Macheva et al., 2005), metamorphosed ultramafic and mafic rocks (serpentinized peridotites and/or harzburgites, clinopyroxenites and websterites, olivine gabbro-norites and leucocratic gabbros), which are metamorphosed to eclogites and latter on to amphibolites (Zidarov, Nenova, 1995). The Igralishte and Nikudin granitoid plutons with an age about 243 Ma (Peycheva et al., 2009) as well as volcanic dacitic bodies about 32 Ma old (Pecskay et al., 2001) are intruded in the metamorphic complex.

Description of the talc-tremolite body

The talc-tremolite body is elongated in a northwest-southeast direction with a lens shape form. Its length is about 10 m, width in the central part – 2–2.5 m and at the terminal parts – 0.5 m. It is subconcordant according the host biotite gneisses, which envelop it, and their crystallization schistosity is subparallel to the outline of the body and its schistosity, dipping to the north-east at a ~70° angle. At the lower contact of the body is observed an up to 10 mm thick biotite zone with striations, witnessing its tectonic transport, as well as small biotitized amphibolite lenses. The

body has a zonal composition with two main zones: *Talc zone* which is built by talc (about 90%), prismatic tremolite individuals, nestiform segregations of sericite, radiate margarite flake aggregates and muscovite flakes. *Chlorite-margarite-tremolite zone.* It constitutes the larger part of the body. The colour of the zone is green to yellow-green, with a radiated structure and a combination of nematoblastic, sheaf-like and fibroblastic texture. The tremolite (75–80%) is observed as long to fine prismatic aggregates. In the latter are observed fine fibers (nephrite). The margarite (about 20%) is distributed in nests as radiated aggregate flakes. Observed are also relict amphibole and Mg-Fe chlorite, as well as biotite flakes in the tremolite at the lower part of the body. According to the mineral composition, the described aggregate can be denoted as nephrite bearing tremolitite.

Mineralogical data

The tremolite and actinolite aggregates are heterograined, built by prismatic individuals. Most of the grains are elongated in one and the same direction, but there are also some which are orientated oblique or under an angle toward the elongation. They are cracked along and across their elongation. Needle like individuals with a length up to 1.5 cm are observed, as well as aggregates with radiated or sheaf-like texture. Under the microscope in thin sections the tremolite is transparent, colourless to pale green (in the richer to iron individuals), which causes a spotted distribution of the graygreen colour. The extinction angle c: Z varies from 15–18° in tremolite to 19–20° in actinolite.

Areas with a nephrite (nematoblastic, fibroblastic) texture are observed among the aggregates of tremolite, which are distributed in irregular forms or as small lenses with dimension of a few mm^2. They are composed by densely interlocked and twisted fibers, usually gathered in microfiber sheaves, with a cross section of about 2.5 μm and length up to 0.3 mm, and built up by subindividuals, each of which with a width under 1 μm – well observed at their free terminal part. Such curved and hair-like fine crystallites are known as trichites. Their genesis is related to the metasomatic replacement of the prismatic tremolite individuals by nephritic whiskers and aggregates. The front of metasomatic replacement is polycentric, in the form of nuclei, which transform into spots with the progress of the process. The nephritization process penetrates along the boundaries of the tremolite individuals and homoaxialy along their cleavage planes as well as along some transversely to the elongation cracks.

Chemical composition

The microprobe analyzed areas of the nephrite fibers correspond to a composition with empirical formulae $Ca_{1.936}K_{0.027}Mg_{4.318}Mn_{0.034}Fe_{0.711}Ti_{0.026}Si_{7.912}O_{22}(OH)_2$ and $Ca_{1.332}Na_{0.034}K_{0.010}Ba_{0.008}Mg_{4.470}Mn_{0.102}Fe_{1.079}Ti_{0.020}Si_{7.972}O_{22}(OH)_2$. According to the $Mg/(Mg+Fe^{2+})$ to Si (per formula unit) classification diagram (Hawthorn, 1981) the amphibole compositions are very close to tremolite-actinolite boundary of 0.9.

XRD data

The powder XRD analysis reveals that the studied mineral corresponds to tremolite (compared to PDF 850876). The strongest reflections in the powder diffraction pattern are (d in Å, I observed): 8.35, 100; 4.18, 15; 3.26, 10; 3.11, 60; 2.80, 16.

Mineral forming conditions

The genesis of the body is a result of replacement of amphibolites, formed on the basis of Precambrian ophiolites and Cadomian eclogites in the amphibolite facies during the Variscan metamorphism. The process of diaphtoresis is isochemical and has place under greenschist facies conditions, related to the activation of the fluid regime at the time of the intrusion of the nearby located Igralishte and Nikudin granite plutons. The nephritization of the tremolite is caused by modulation in its structure and heterogenic nucleation at the defect sites of its structure.

References

Hawthorne, F. C. 1981. Reviews in Mineralogy. 9A. Amphiboles and Other Hydrous Pyriboles. – In: Veblen, D. R. (Ed.). *Mineralogy*. Mineralogical Society of America, 1–102.

Kostov, R. I. 2007. *Archaeomineralogy of Neolithic and Chalcolithic Artefacts from Bulgaria and their Significance to Gemmology.* Sofia, Publishing House "St. Ivan Rilski", I-VIII, 126 p. (in Bulgarian with an English summary).

Macheva, L., R. Titorenkova, N. Zidarov. 2005. Kyanite-staurolite-garnet-bearing schists from Ograzhden moutain, SW Bulgaria - metapelites or orthoschists? – In: *Proc. of Jub. Inter. Conf. "80 Years Bulgarian Geological Society".* Sofia, 138–141.

Pecskay, Z., A. Harkovska, N. Zidarov, I. Zagorchev, M. Popov, V. Panteva. 2001. K-Ar dating of the tertiary volcanic rocks from Ograzden and Maleshevska mountains, SW Bulgaria. – *C. R. Acad. bulg. Sci., 54,* 4, 71–76.

Peycheva, I., A. von Quadt, M. Tarassov, N. Zidarov, E. Tarassova, V. Andreichev. 2009. Timing of Igralishte pluton in Ograzhden mountain, SW Bulgaria: implications for the tectono-magmatic evolution of the region. – *Geologica Balc., 37,* 3–4, 5–14.

Suturin, N. A., P. S. Zamaletdinov. 1984. *Nephrites.* Novosibirsk, Nauka, 150 p. (in Russian).

Todorova, H., I. Vaisov. 1993. *The New Stone Age in Bulgaria.* Sofia, Nauka i Izkustvo, 288 p. (in Bulgarian).

Zagorchev, I. 2001. Geology of SW Bulgaria: an overview. – *Geologica Balc., 21,* 1–2, 3–52.

Zidarov, N., P. Nenova. 1995. Basic and ultrabasic rocks and related eclogites from the Serbo-Macedonian massif (South-Western Bulgaria). – In: *Proc. of the XV Congr. of the CBGA, Spec. Publ., 4.* Geol. Soc. Greece, 619–626.

Zidarov, N., V. Andreichev, I. Peytcheva. 2009. Rb-Sr isotope data on Variscan and Alpine polymetamorphic evolution of the granitoids from the Ograzhden unit in SW Bulgaria. – In: *Proc. National Conference "Geosciences 2009".* Sofia, Bulg. Geol. Soc., 27–28 (in Bulgarian).