CHARACTERISTICS OF THE RAMAN SPECTRUM OF GARNET-GROUP MINERALS FROM THE SARITAU DEPOSIT (SULTANUIZDAG MOUNTAINS, UZBEKISTAN)

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ABSTRACT

This article discusses the results of a study of garnet samples taken at the Saritau occurence. The obtained spectra of the samples were interpreted and correlated with the vibrational modes of the elements composing the garnet.

Keywords: Garnet, Pyrope, Almandine, Raman Spectrometry, Raman Spectra

INTRODUCTION

The Saritau occurence is located in the Beruniy district of the Republic of Karakalpakstan. The relief of the occurrence site is low-mountains with absolute elevations not exceeding 300 m.

The manifestation is represented by a near-latitude, steeply falling serpentinite body 3 km long and 5-8 m wide with amphibolized gabbro boudines. The rocks hosting the serpentinites are represented by various metamorphic shales of the Jamansai and Beshmazar formations of the Middle Devonian, which fall to the east-northeast at an angle of 50-65°. On the flanks, the serpentinite body is overlain by Quaternary sediments. Gabbro boudines have an elongated oval shape with a long axis elongated along the body stretch and measuring up to 7-4 x 1 x 2 m. Garnet mineralization in the form of dense inclusions of pink, crimson,



Figure 1: The location of the Saritau deposit

and cherry-colored almandine crystals is localized at the contact with serpentinites in the zone of schistosity and talcuming with a thickness of about 0.3 m. Garnet is translucent, with inclusions of serpentine and diopside. The samples selected during the development were studied using the non-destructive method of Raman spectrometry.

The main purpose of this article is to consider the Raman spectra of granet-group samples from the deposits of the Saritau deposit and the correlation of spectral characteristics with molecular and crystal structure.

MATERIALS AND METHODS

The studied garnet samples were taken from the Saritau deposit (Fig.1). Photos of the samples are shown in Figure 2. The samples were studied using the EnSpectr R532 Raman spectrometer equipped with a 532nm laser, filter and CCD detector (3648 pixels). The spectral range is 160 cm - 4000 cm⁻, the resolution is 4-6 cm⁻. The intensity difference in the same spectral regions of different samples is explained by small differences in the orientation of the crystals (Gardiner, 1989).

Spectrum processing (noise removal, correction) was performed in the original software of the EnSpectr GREEN spectrometer.



Figure 2: Photos of samples from Saritau garnet deposit

RESULTS AND DISCUSSION

The crystal structure of garnets consists of isolated [SiO4] groups located along a fourth-order helical axis with 6-coordinated octahedra of trivalent cations (Al^{3+} , Fe^{3+} and Mn^{3+}), and large gaps in the form of decahedra occupied by divalent cations (Ca^{2+} , Mg^{2+} , Fe^{2+} and Mn^{2+}) (Novak and Gibbs, 1971) (Fig.

1). When receiving the results of Raman spectrometry, the built-in comparison of the spectra showed a coincidence of the obtained spectra with the standards of pyropes and almandines from the international RRUFF database, which correlates with the results of visual inspection of the samples. The publications of other researchers were also considered in the processing of Raman spectra (Mingsheng et al., 1994; Koshlyakova et al., 2020).



Figure 3: The crystal structure of garnet-group minerals

In the crystal structure of garnet, the SiO₄ tetrahedra are connected with bivalent cation X polyhedra by sharing two edges, and connected with trivalent cation Y polyhedra by sharing apexes, different cations residing in the X sites naturally have more obvious effects on the distortion of SiO a tetrahedra and the connection strength of X polyhedra with the SiO₄. For the Fe-Al garnet series, the bivalent cations in the pyrope, almandite and spessarite are Mg²⁺, Fe²⁺ and Mn²⁺ respectively, then the stretch and rotatory motions of the SiO₄ tetrahedra

are obviously different, depending on the type, ionic radius, polarization force and atomic structure of the cations (Mingsheng et al., 1994; Liddicoat, 1948).

All the Raman spectra of the studied samples are shown in Figure 4. The spectrum reflects the length of the vibrational modes and their relative intensity (Koningstein, 1968). A fairly large part of the spectrum is occupied by areas with low and near-zero intensity of vibrations, so it makes sense to describe only areas with high intensity that characterize the constituent parts of the mineral. The studied peaks of the intensity of the Raman shift are very close to the peaks of the spectra of reference samples from the international online database of mineral spectra RRUFF.

All intensity peaks shown in the spectra are associated with vibrations of isolated [SiO₄] groups. The peak intensity at 219 cm⁻ is associated with translational vibrations of tetrahedra relative to cations, and at 349 cm⁻ is associated with rotational vibrations (Li Zhe, 1979). Three intensity peaks of 500, 557, and 630 cm⁻ are associated with asymmetric (v₄) and symmetric (v₂) bending vibrations (Moore, 1971). The intensity peaks in the region of 860, 911, and 1043 cm⁻ are associated with asymmetric (v₂)

tetrahedron stretching vibrations [SiO₄]. Additional intensity peaks can be observed in the spectrum of sample No. 2 in the region of 1209 cm⁻, and in the spectrum of sample No. 8 in the region of 4400 cm⁻, most likely, they are associated with inclusions in garnets.



Figure 4: The Raman spectrum of the garnet samples

CONCLUSION

During the study, the Raman spectrum of granite samples from the Saritau deposit was measured using an Enspectr R532 Raman spectrometer. Significant peaks in the intensity of the spectrograms were identified, which were associated with fluctuations in ions and molecules that make up almandine garnet, and data from the reference literature were used to correlate the ranges and fluctuations. The raman spectrum of turquoise is similar to the reference spectra from the RRUFF database.

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