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HYDROTHERMAL REGIME OF QUARTZ VEINS FORMATION AT THE EPITHERMAL DEPOSITS

Cathodoluminescence is a convenient method in studying the evolution of mineral formations. We used it to study quartz veins from three hydrothermal deposits of the epithermal type: Berehivske ore field (Ukraine), deposit of Kavnyk (Romania) and Banská Štiavnica ore field (Slovakia). Cathodoluminescence in quartz occurs due to the presence of alkali metal impurities. The nature of the detected cathodoluminescence indicates the accumulation of trace elements in the stagnant sections of the veins. At the same time, flow zones do not have a cathodoluminescence, which is proof of the infiltration regime of these zones in the veins.

Key words: cathodoluminescence, vein quartz, trace elements, hydrothermal deposit, Neogene.

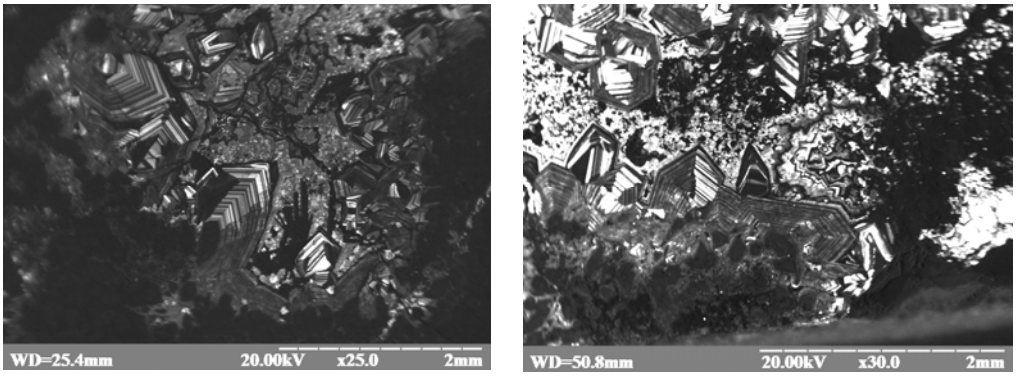
Introduction. The study of ores and mineral aggregates structures and textures is a prerequisite for any mineralogical studies. Regardless of the tasks set for researchers, nowadays the cathodoluminescence image analysis is widely used. We consider the possibilities of the cathodoluminescence method on the quartz vein samples of three different objects: Berehivske ore field (Ukraine), Kavnik deposit (Romania) and Banská Štiavnica ore field (Slovakia). They are in the Neogene volcanic belt of the Carpathians and belong to the epithermal type of hydrothermal deposits [2, 4, 5].

Formulation of the problem and the relevance of its solution. Cathodoluminescent image analysis has won its place among other mineralogical research methods long ago [1, 3]. This method allows us to consider the structures and textures of the mineral aggregates, invisible under an optical microscope, to establish the crystallization history of the mineral bodies. A necessary condition for the experiment is that the studied minerals belong to the dielectrics. A disclosure of the internal structure, growth zoning and defects of the crystal lattice, impossible in the case of other analytical methods, – the most important applied value of the cathodoluminescence.

Factual material and research methodology. Cathodoluminescent analysis was performed using an electron scanning microscope REMMA 120-02 in the Scientific, Technical

and Training Centre for Low Temperature Research (Ivan Franko National University of Lviv), using a cathodoluminescent detector with a wavelength of 400 to 650 nm. Samples in the form of polished plates were sprayed with carbon to prevent the accumulation of electric charge during the study. Beam scanning speed is 20 s, resolution – 1024 × 860 pixels, 256 shades of gray; U = 30 kV and I = 200 nA.

Obtained results and their discussion. The cathodoluminescent glow was able to identify areas in which there is no cathodoluminescence in the quartz, directly bordering on areas where it is present. For example, examine vein quartz of the Berehivske ore field (Fig. 1, *a*), the microcrystalline quartz shows a clear oscillatory zoning, due to which the direction of growth is observed. Right here, fine-crystalline quartz has spotted luminescence (see Fig. 1, *b*). Beyond the zones of the druse fine crystalline quartz are areas where there is no cathodoluminescent glow.



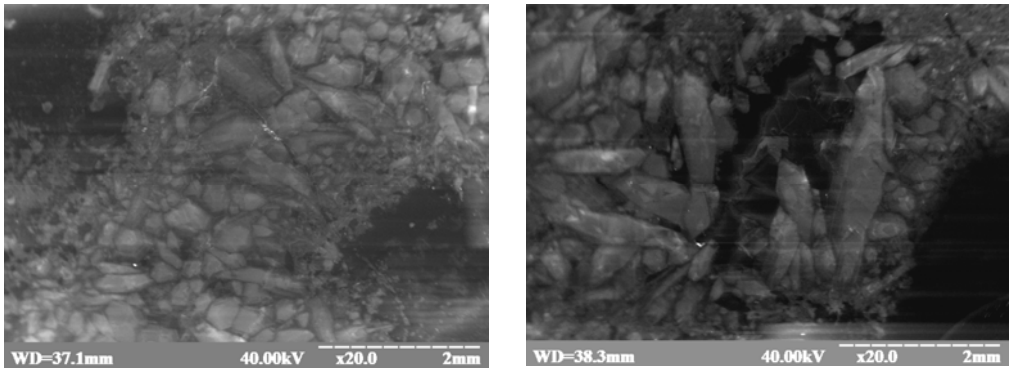
a *b*

Fig. 1. Cathodoluminescence of the vein quartz of the Berehivske ore field.

Consider cathodoluminescence of the vein quartz from the Cavnic deposit (Romania) (Fig. 2). As can be seen, the present cathodoluminescence is extremely indistinct and weak. It mainly delineates the nuclei of the crystalline individuals in quartz. The elongated individuals are oriented in different directions.

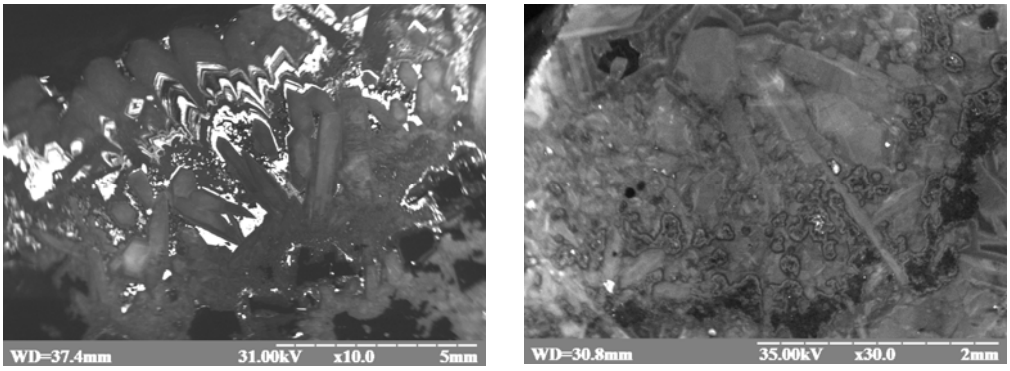
Analysis of cathodoluminescence imaging of the vein quartz from the Banská Štiavnica (Slovakia) (Fig. 3) shows that quartz prisms and intersections of hexagonal prisms have a very weak vague cathodoluminescent glow. Along with these areas, zones of the very bright oscillatory cathodoluminescence are observed (see Fig. 3, *a*). They, in turn, are overlapped by the growth zones, in which the vague cathodoluminescent glow is developed. The image shows crusting fine-grained whorls of quartz overgrowth in some places.

The causes of this luminescence are defects in the crystal structure or impurities hosted in the crystal lattice. The reason for the cathodoluminescence emission in quartz is the entry of aluminium, alkali metals and hydrogen into the quartz crystal lattice [3]. The stagnant sections of the quartz veins have a bright cathodoluminescence. At the same time, the areas in which there was an infiltration of the solution do not show luminescence in the cathode rays. The impurity alkali metals, which are responsible for the occurrence of the cathodoluminescence, did not accumulate in the quartz under the dynamic regime of a solution movement. As a result, there are areas in such places where there is no cathodoluminescent glow.



a *b*

Fig. 2. Cathodoluminescence of the vein quartz from the Cavnic deposit (Romania).



a *b*

Fig. 3. Cathodoluminescence of the vein quartz from Banská Štiavnica ore field, vein Theresia.

Conclusions. Thus, the quartz under study from different deposits shows not only the morphology, the internal anatomy of individuals, the boundaries between them, but also the history of a nucleation, the development evolution of the vein aggregates. A similar situation of the accumulation of the quartz impurities is noticeable for all deposits: in the stagnant regime, areas with the bright cathodoluminescent glow appear, and in the infiltration zones, there is no cathodoluminescence at all.

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ГІДРОТЕРМАЛЬНИЙ РЕЖИМ ФОРМУВАННЯ КВАРЦОВИХ ЖИЛ ЕПІТЕРМАЛЬНИХ РОДОВИЩ

Катодолюмінесценція є зручним інструментом під час вивчення еволюції розвитку мінеральних утворень. Ми використали цей метод для дослідження кварцових жил з трьох гідротермальних об'єктів епітермального типу: Берегівського рудного поля (Україна), родовища Кавник (Румунія) та рудного поля Банська Штявниця (Словаччина).

Катодолюмінесценція в кварці виникає внаслідок наявності домішок лужного металу. Характер виявленої катодолюмінесценції в дослідженому кварці свідчить про нагромадження домішок у стоячих ділянках жил. Водночас зони інфільтрації не мають катодолюмінесцентного світіння, що є доказом відповідного режиму цих зон у жилах.

Ключові слова: катодолюмінесценція, жильний кварц, елементи-домішки, гідротермальне родовище, неоген.