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FREEZING METHOD IN MINERALOGICAL STUDIES

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To solve the problems of possible extraction of rare, trace elements from coals or ash dumps, samples of sulfides were taken from coal mines of the Donetsk coal basin and frozen, as a result of which the surface of the sample was covered with a significant amount of minerals such as arsenosalts, copyapites, zeolites and their varieties, which are much easier to explore. The freezing method can be used for stage analysis. A qualitative pattern has been established - the higher the degree of coalification of coals, the less the yield of zeolites, arsenosalts, copiapites and similar minerals to the surface.

Keywords: coal, microelements, arsenosalts, zeolites, copyapites, stage analysis

The Donetsk coal basin of Ukraine, like other coal basins, was formed in low areas of the earth's surface. Not only organic materials in the form of dead plants were carried there, but also a fairly large amount of rare, trace elements in various forms of minerals, rock fragments, and dust particles. Thus, coal matter consists of organic matter, consisting of gases and inorganic impurities. These impurities enter the sedimentation basin in two main ways - with plant remains, into which they enter in dissolved form with moisture, during plant growth and independently of plants, with temporary flows, dust, glaciers, flood waters and other similar ways [1–2].

The study of such processes and formation conditions, with the subsequent transformation of coal deposits, is relevant for us due to the presence of significant impurities of rare and trace elements in coal matter, which are extracted at different stages of mining of coal deposits - during the production of coke, from fly ash and coal slag, from coal matter. Suffice it to say that the coal basin in question actually provided the industrial enterprises of the former Soviet Union with germanium [2–4].

Since all coal deposits were studied in detail during their geological exploration and subsequent mining, we know about the presence and content of useful elements in coal seams of different mines and coal regions. The specified data is publicly available on the Internet on the website Geoinform of Ukraine (State Information Geological Fund of Ukraine - https://geoinf.kiev.ua/wp/index.html).

The increased volumes of rare and trace elements in the coals of the Donetsk coal basin are due to the fact that sedimentary deposits were removed from a crystalline shield rich in deposits of various metals and elements, which formed about 2 billion years ago.

The coal basin under consideration is located in the north and northeast of the crystalline shield, and during the formation of the DDV (Dnieper-Donets Depression), sediments were transported from the south and southeast into this depression to the north and northeast. This is an important point, since we can highlight in more detail the areas from which demolition took place.

This brief publication will discuss the possibility of using the freezing method as an additional mineralogical analysis, as well as the possibility of adjusting the stage analysis of the formation of sedimentary and metamorphic rocks.

Lithology, the science of the formation and transformation of sedimentary rocks, originated in the 19th century, but received wide spread development and recognition only in the 20th century, in parallel with the widespread use of oil and coal-type caustobiolites.

Since specific mineral resources are associated with different stages and sub stages of lithogenesis, primary lyproviding energy for most countries - coal, oil, gas – studies of sedimentary deposits and stage analysis are important.

Carboniferous deposits of the Paleozoic are distinguished by the presence of significant volumes of caustobiolites of the coal series, but their quality can vary significantly. It all depends on the conditions in which the organic matter was formed and transformed. The conditions of the coal basin under consideration are characterized by the entire range of thermobaric conditions, and the coals mined there vary from brown to anthracite.

Selected and polished sulfide nodules from this basin (Krasnolimanskaya mine) were frozen, after which a complex of

various mineral formations of different shapes, sizes, composition and colors appeared on the surface of the nodule (Fig. 1–2).

An important point here is to obtain a unique enrichment of impurities of rare and trace elements, which are rich in both coals and rock layers, nodules, rocks in the soil and the roof of coal seams. Such elements may include magnesium, calcium, copper, iron, aluminum, tungsten, cadmium, cobalt, gold and other elements that are not profitable to extract due to their low contents. The above germanium was extracted from lipids, which are released in the form of liquid tar from coals during the production of coke.

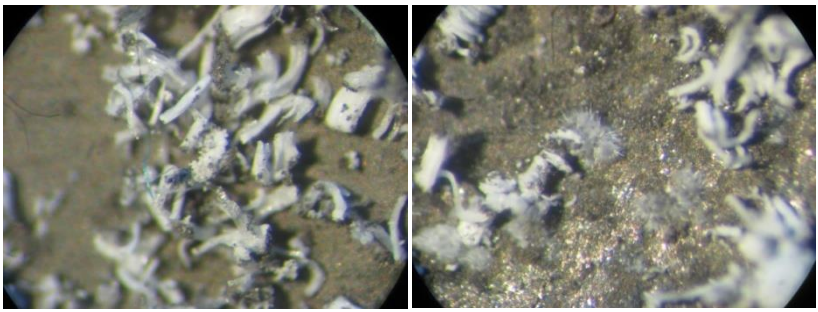

Fig. 1. Arseno salts of silvery-white color on the surface of a sulfide nodule after freezing (synonym – arsenic pyrite) – a; isolation of copiapite (synonym – ileite) from cracks of pyrite nodules from coal seam l3 in the form of needle – shaped hemispheres–b

Other rare and trace elements can be extracted from fly ash after combustion of coal in thermal power plants. In the ash, the specified minerals and elements are enriched to contents that can be extracted using currently existing methods.

In addition, there are a large number of waste heaps containing significant volumes of rare elements, but their use for extracting minerals is problematic, since waste heaps of different mines and geological regions differ in the properties and content of different components.

In addition to problems with enrichment, there is also the problem of geological exploration of waste heaps, which are not homogeneous in composition. Perhaps they will be of interest in the future, because they have already been extracted from the ground.

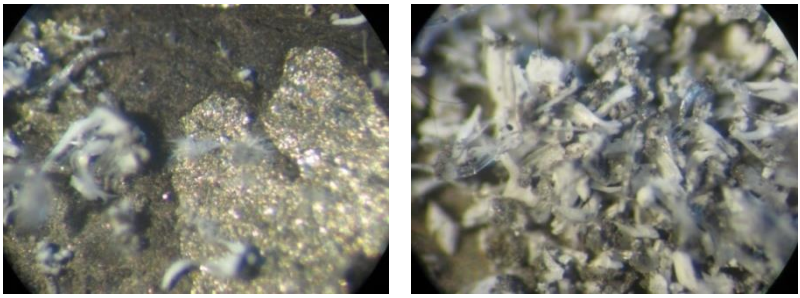

Fig. 2 Radial-fibrous segregations of copiapite (somolnokite) from cracks in a pyrite nodule from a coal seam l3 – a; Arsenosalts on the surface of a sulfide nodule after freezing – b

The next area where the freezing method can be used is stage analysis. There is a lot of different literature on this topic and, unfortunately, there is no consensus among researchers, both in our republic and in other countries.

I would like to remind you that different stages and substages of lithogenesis have their own temperature limits. Each grade of coal has its own temperature and this can be used in any sedimentary rock to solve various scientific and practical problems.

The method for determining the temperature of formation of coal and sedimentary rocks under No. 124536 is patented in accordance with the established procedure. It is interesting that the early substage of catagenesis has a small temperature range, about 60–100^{0}C. The middle substage of catagenesis is characterized by a wider range, about 100–160^{0}C. The late substage of catagenesis has the most significant range, about 160–300^{0}C.

Freezing of sulfide nodules from the late substage of catagenesis showed a significantly smaller amount of release of zeolites and salts of various minerals. In other words, the higher the degree of catagenesis, the lower the moisture content of sediments and the less various salts, zeolites and similar minerals in the pores of rocks and nodules, which is natural.

The work [3] describes the process of removal, transfer and transformation of lipids and, along with them, various salts, rare and dispersed minerals and elements. I called this process “swings”, since it is characteristic precisely of the middle substage of catagenesis at temperatures from 100 to 160^{0}C. The meaning of the “swings” is the

movement up and down. Reservoir water turns into steam, which rises, and after cooling, it is already in the form of a liquid and falls down. At the same time, lipids with highly soluble elements, salts, and minerals are washed out and transferred to disturbed areas.

Depending on the temperatures that existed during the formation of coal, the coal interlayers, soil and roof of coal seams were enriched with these elements and minerals. At elevated temperatures, these substances were transported over longer distances and accumulated in disturbed zones.

Thus, the freezing method can be used to solve various scientific and applied problems, such as studying the content of rare and trace elements; determination of substages of catagenesis; determination of quantitative and qualitative characteristics of zeolites, mineral salts and similar easily soluble minerals.

Analysis of the above listed factual data allows us to transfer the zeolite stage (more often called facies) to the stage of catagenesis. It is clear that this requires a complex of analyzes of samples taken from different sedimentary basins, sufficient statistical sampling performed by different researchers in different laboratories. But now we can say that the stage of metamorphism follows the stage of catagenesis, and the boundary of the transition of sedimentary rocks into metamorphic rocks lies in the region of 300^0C, which in general has long been known and determined by other methods.

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