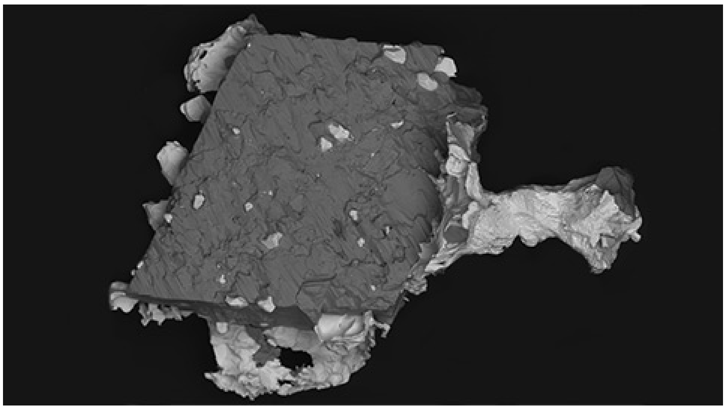
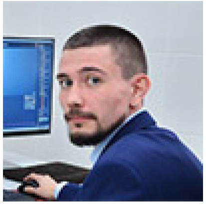
SibFU scientists study gold-bearing mineral arsenopyrite

Researchers from Krasnoyarsk and Tomsk have studied the microstructure of arsenopyrite (FeAsS), selected from the ores of deposits in the Yenisei Ridge (Krasnoyarsk Territory). It turned out that increased concentrations of gold (including invisible) are associated with unconventional arsenopyrites having different biases in their chemical composition and crystalline structure. The main results of the work are published in Minerals.



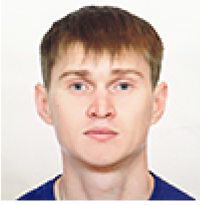
Arsenopyrite is widespread in nature. The mineral is fragile and, when blown strongly, gives out a sharp smell of garlic — this feature is due to the high content of arsenic, which is traditionally extracted from arsenopyrite raw materials. Another peculiarity of arsenopyrite is that it is found in significant quantities in gold deposits. And this close neighbourhood has long prompted geologists to think that gold can be sought where glittering needle- or diamond-shaped crystals of tin-white colour are found.



> *‘The linkage of gold and arsenopyrite can manifest in different ways. Visible gold (visible to the naked eye or through a microscope) can be found in crystals of arsenopyrite in the form of inclusions, in intergrowths with it, or can fill cracks in the mineral. But there is also this so-called "invisible" (or refractory) gold. It is not visible even under a microscope. This gold hides in the mineral under the guise of nanoinclusions of native metal, or in the form of single atoms. And the latter is the case with different possible options. An atom of gold can take the place of another atom in the structure of arsenopyrite, for example, can replace an atom of iron, or arsenic, or sulfur. In another case, atoms can be embedded in the voids of the crystal lattice of the mineral — a solid body seems dense to us and has no free space, nevertheless, there are many voids at the atomic level. And finally, gold atoms can occupy “defects” in the crystal lattice of a mineral (various kinds of vacancies, dislocations),’* explained **Sergey Siliyanov**, an engineer at the R&D centre of MMC Norilsk Nickel at Siberian Federal University, leading engineer at the Department of Geology, Mineralogy and Petrography.

The authors of the paper told that the study of arsenopyrite by Mössbauer spectroscopy made it possible to clarify the position of atoms of iron and their immediate environment in the mineral structure. It turned out that in contrast to the ideal arsenopyrite, where each iron atom in an octahedron is surrounded by three sulfur atoms and three arsenic atoms, in the natural version, iron atoms can have a different environment with a different ratio of sulfur and arsenic, for example, an iron surrounded by six sulfur atoms, or any other combinations. Such “errors” in the structure are associated with the physicochemical conditions of the mineral formation.

The scientists discovered another interesting fact: even with a large fraction of atoms of iron with an alternative, imperfect environment, arsenopyrite remains... arsenopyrite! That is, it completely retains its crystalline structure, which was confirmed by additional x-ray diffraction studies.

> 
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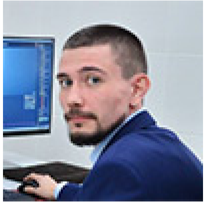
> *'We managed to advance in understanding the mechanism of formation of bound gold in arsenopyrites by studying the ligand environment of the atoms of iron. There have been no such detailed studies in arsenopyrites previously. In our case, the ligand environment of iron was studied on a large sampling of natural arsenopyrites, which allowed us to trace a number of interesting patterns,'* said the co-author of the study, an employee of L. V. Kirensky Institute of Physics of the SB RAS Federal Research centre, **Yuri Knyazev**.

> 
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> *'The issue of "invisible" gold has been very relevant lately, not only for fundamental science but also in terms of its applicability. Its large amount in ores complicates the process of metal extraction, this is why "invisible" gold and the ores containing it are also called "rebellious". There can be a lot of such gold in various deposits. Visible gold is easily concentrated by means of standard gravity concentration methods based on high density of the metal. In the case of invisible gold, such schemes do not work, and so more sophisticated methods have to be applied,'* continued **Sergey Siliyanov**.

So far, the team of Siberian scientists has been able to indirectly show that the proportion of gold in arsenopyrite increases with a decrease in its structural and chemical stoichiometry (the less "ideal" the mineral is the more chance it has to "shelter" gold inside). What's next? The researchers argue that arsenopyrite is not as simple as it seems at first sight. The features of its chemical composition and structure require careful study and explanation.

> *'In early December, we studied arsenopyrites at the Kurchatov synchrotron radiation source (at Kurchatov Center for Synchrotron Radiation and Nanotechnology). We are planning to investigate the state of gold in our samples — such studies are possible at the synchrotron in Grenoble. We hope that this work will let us understand how to extract "rebellious" gold with the least losses for domestic and world industry,'* summed up the Krasnoyarsk scientists.

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