Unique “meteoritic” minerals in pyrometamorphic rocks

The International Mineralogical Association declared 2022 the Year of Mineralogy. These activities highlight the important role of mineralogy as basic science. “Mineralogy 2022” will take place under the patronage of the International Year of the Basic Science for Sustainable Development which has been approved by UNESCO.

For more than 15 years, our research group has been working on extending general scientific knowledge on the mineral composition of the Earth. We discover, investigate and describe new minerals from pyrometamorphic rocks, which form at very high temperatures and very low pressures at the Earth's surface or in near-surface conditions. One of the amazing objects of our research is the rocks of the Hatrurim Complex, which form areas up to several hundred kilometers along the Dead Sea Fault in the territories of Israel, Palestine, and Jordan. For the few last years, scientists from our research group have discovered more than 30 new minerals from pyrometamorphic rocks of the Hatrurim Complex. Most of the newly discovered minerals were formed under oxidizing conditions characteristic of pyrometamorphic processes having a place in zones of atmospheric oxygen effect.

In 2019 an explosive channel, filled by phosphide-bearing gehlenite breccia, was found in the Negev Desert of Israel, within pyrometamorphic rocks of the Hatrurim Complex. The breccia contains minerals characteristic for meteorites such as schreibersite, Fe_3P; andreyivanovite, FeCrP; allabogdanite, Fe_2P (orth.); barringerite, Fe_2P (hex.); murashkoite, FeP; osbornite, TiN; caswellsilverite, $NaCrS_2$; cronusite, $Ca_{0.2}CrS_2 \cdot 2H2O$; merrillite, $NaMgCa_9(PO_4)_7$; paqueite, $Ca_3TiSi_2(Al_2Ti)O_{14}$ and others. A small explosive channel about 4-5 meters wide, filled with phosphide-bearing breccia, is an unique geological object and has no analogs on the Earth.

The main goal of this project is to reconstruct the conditions and mechanisms of the formation of "meteoritic" minerals of terrestrial origin, the formation of which took place under reduced conditions. Osbornite is an indicator of super-reduced conditions characteristic for meteorites, and is very rarely found in terrestrial conditions. A find of this mineral allows a completely different look at the hypotheses of the Hatrurim Complex rocks formation. Interestingly, all previously described finds of osbornite on the Earth are most likely related to anthropogenic pollution of samples with synthetic TiN. The find of osbornite in pyrometamorphic rocks may be the first detection of terrestrial osbornite - a mineral characteristic for meteorites. The discovery of paqueite in phosphide-bearing breccia (reduced mineral associations), which has a structure of the synthetic langasite type and was previously known only in meteorites, suggested that the Fe^{3+} - analog of paqueite can be found in oxidized gehlenite paralava. Preliminary studies indicate the presence of a number of Fe^{3+} - bearing natural langasites, some of which contain Ba, Nb, and Sb. We consider that a comparative study of reduced and oxidized associations of gehlenite paralavas will bring more discoveries of new minerals and help solve a number of genetic problems of the Hatrurim Complex.

The successful implementation of this project will be provided using a comprehensive study, including field works and laboratory investigations combined traditional and modern methods of investigation such as optical microscopy, scanning electron microscopy, electron probe microanalysis, Raman and IR spectroscopy, powder X-ray diffraction, single-crystal X-ray diffraction, partly, using synchrotron radiation.

The proposed project belongs to the area of fundamental mineralogy. The discovery of a new mineral is a concrete achievement in Earth Sciences, which also influences the ranking of Polish mineralogy in the world. The study of new minerals expands our knowledge of the mineral and chemical composition of the Earth. Some of the new minerals have a practical application. The new minerals investigation results are used in geological sciences, solid-state physics and chemistry, and materials science. Minerals as solids can be used as model objects and prototypes of advanced materials. The fundamental information obtained on new minerals will impact on various mineralogical, physical and chemical databases.