

NATIVE IRON ASSEMBLAGES IN EARTH'S CRUSTAL ROCKS-MINERALOGICAL ANALOGUES OF IRON-RICH ASTEROIDS

Oleg S. Vereshchagin and Sergey N. Britvin

Saint Petersburg State University, Russia

Abstract Iron (Fe) is one of the most abundant elements on Earth. Its mineral form depends largely on oxidation conditions. The Earth's core contains native iron, while in the Earth's crust, almost all iron is oxidized. Processes in the Earth's core (and that of other planets) are inaccessible to direct observation. However, it is assumed that iron meteorites and iron-rich asteroids are fragments of planetary cores and provide direct information about their composition and mineralogy. Unfortunately, very little data is currently available on the origin of iron meteorites, and the only mission to the iron-rich asteroid Psyche will not reach it until 2029.

It is interesting to note that in some cases, native iron forms in the Earth's upper crust. Based on their locality, these processes can be divided into three groups: very local ($< 1 \text{ m}^3$; e.g., fulgurites), local ($1\text{-}50 \text{ m}^3$; e.g., high-temperature combustion metamorphic rocks), and large-scale ($> 50 \text{ m}^3$; e.g., magmatic rocks). In all three cases, under the influence of high temperatures (~ 1000 to $2500 \text{ }^\circ\text{C}$), native iron is reduced from primary Fe-bearing minerals through interaction with organic matter. It is important to note that native iron in Earth's upper crust rocks has been very well studied geologically, allowing one not only to obtain its mineral / material composition but also to identify the genetic features of its formation.

We studied anoxic mineral assemblages with native iron from fulgurites (Leningrad oblast and Kolyma region, Russia), high-temperature combustion metamorphic (pyrometamorphic) rocks (Hatrurim Comple, Israil and Jordan), and magmatic rocks (Disco island, Greenland; Krasnoyarsk region, Yakutia, Russia and Bühl, Germany). We also summarize data on the diversity of oxygen-free minerals in terrestrial native Fe-bearing crustal rocks and iron meteorites to further assess the formation conditions of metal-rich asteroids.

We listed 25 oxygen-free minerals as main constituents and accessory phases of iron. To the best of our knowledge, 10 minerals were unknown in terrestrial crustal rocks at the beginning of this study. Suprisingly, only 8 minerals (lonsdaleite, diamond, edscottite, carlsbergite, roaldite, perryite, joegoldsteinite, zolenskyite) of the 25 iron meteorite minerals have not yet been identified in native Fe terrestrial crustal rocks. However, the number of anoxic minerals specific for iron meteorites should be reduced to 4, given that (1) lonsdaleite, diamond and zolenskyite are formed from graphite and daubréelite, respectively by shock metamorphism atypical for iron meteorites, and (2) perryite is an aubrite rather than iron meteorite mineral.

Based on mineralogical and geological evidences we assume that the formation of metal-rich asteroids could have occurred at heating temperatures achievable in space ($\approx 1000\text{-}1100 \text{ }^\circ\text{C}$),

which easily lead to the formation of native iron melt from primary Fe-bearing silicate-rich matter. The chondrite substance contains a sufficient amount of organic molecules and carbon, which could act as a reducing agent. At the same time, the process does not require high pressures, which is consistent with data on iron meteorites. Depending on the primary composition of the bodies and their geological history, the resulting iron melts will have different geochemical and isotopic markers. At the same time, since the cooling of such melts occurs in space, it can be much slower than in terrestrial objects.

Key words : native iron, Fe, metal rich asteroid

Acknowledgements: The authors thank the Resource Center of X-ray diffraction studies, Geomodel Resource Centre, Center of Microscopy and Microanalysis and Nanophotonics Resource Centers of Saint-Petersburg State University for providing instrumental and computational resources.