Formation and later changes of the Staicele and Gārsene Proterozoic iron ore deposits: evidence from structure, mineralogical and chemical composition

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Previous drillcore mineralogical and petrographic studies, as well as geophysical and geochemical research of the Proterozoic iron-bearing rocks of Latvia were mainly carried out in the 1980-1990s and stopped afterwards. By the data of V. Vetrennikov the ores of the Staicele and Gārsene deposits contain Fe, Mn, Ti, Zn, Co and other metals in relatively high quantities, but due to their depth (0,7-1 km) the ores were supposed to be non-prospective in the nearest future. However, the situation changes. The list of the critical raw materials of the European Union (2023) includes Mn and Co found in the ores, but modern analytic methods allow to determine the ore composition more precisely. That supports the renewed interest on the Proterozoic ore mineralogical and geochemical studies. S. Bogdanova and co-authors suggest that the iron and other metal ores are related mainly to the Palaeoproterozoic metavolcanites and metasedimentary rocks of the Latvian-East Lithuanian domain. The Proterozoic plate tectonic settings and history of the study area is described in several publications. Nevertheless, the iron accumulation and concentration processes are poorly known. Metamorphism and other alteration processes of the ores are also not well-understood.

For this study 17 ore samples were taken from the Staicele-1 drillcores (Staicele deposit) and 18 from the Subate-2A drillcores (Gārsene deposit). Polished specimens and thin-sections were made and studied in microscope. Powder XRD, SEM with EDX spectroscopy, energy-dispersive XRF, ICP-MS, and laser-induced breakdown spectroscopy (LIBS) analyses were done.

This study indicates that magnetite from the Staicele deposit contains an average of 3.1 w% MnO, which means the existence of magnetite-jacobsite series. Manganese content in magnetite varies in depth. Manganese content to 22.10 w% was identified in the garnet (mainly almandine-spessartine series with dominant spessartine component) in the Staicele iron ore deposits. Contents of many other metals, including REE, were also determined in ore, as well as in such separate minerals as magnetite, sulphides and several silicates.

The rhythmically laminated structure indicates that the ores of both deposits belong to the banded iron ore formations (BIF). The ores of the Gārsene deposit were highly altered by metamorphic processes, when magnetite and quartz grains formed larger aggregates and enriched the ores. Following successive processes are suggested to have occurred in the Staicele deposit: metamorphism, which resulted in the simultaneous formation of silicates and second-generation magnetite; later granitization, mainly represented by quartz and albite; the transformation of earlier minerals (mainly pyroxenes) to secondary minerals. The nature and sequence of hematite mineralization indicate that earlier metamorphic processes are also possible.

The contents of metals in definite oxide, silicate, and sulphide minerals, quantities of these minerals in definite ore types, and the distribution of the ores in drillcores will be studies in further research works.

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