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Four magnetite generations in the Precambrian Varena Iron Ore deposit, SE Lithuania, as a result of rock-fluid interactions

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Iron ores in Precambrian crystalline basement of the Varena area, SE Lithuania, were discovered during the detail geological-geophysical exploration in 1982-1992. They are covered with 210-500 m thick sediments. The Varena Iron Ore deposit (VIOD) may yield from 71 to 219.6 million tons of iron ore according to different economic evaluations (Marfin, 1996). They were assumed to be of metasomatic and hydrothermal origin, however several other hypotheses explaining the VIOZ origin, e.g. as a layered mafic or carbonatite intrusions were also suggested. Magnetites of the VIOD were thoroughly investigated by the Cameca SX100 microprobe at the Warsaw University and by the Quanta 250 Energy Dispersive Spectroscopy (EDS) at the Nature Research Centre in Vilnius, Lithuania. Four generations of magnetite were distinguished in the studied serpentine–magnetite ores (D8 drilling) and were compared with the earlier studied and reference magnetites. The earliest, spinel inclusion-rich magnetite cores (Mag-1) have the highest trace element contents (in wt%): Si (0.032), Al (0.167-0.248), Mg (0.340-0.405), Ti (0.215-0.254), V (0.090-0.138) etc. They might have formed during an early metamorphism and/or related skarn formation. Voluminous second magnetite (Mag-2) replacing olivine, pyroxenes, spinel and other skarn minerals at c. 540o C (Magnetite-Ilmenite geothermometer) has much lower trace element abundances, probably washed out by hydrothermal fluids. The latest magnetites (Mag-3 and Mag-4) overgrow the earlier ones and occur near or within the sulfide veins (Mag-4). As was observed from microtextures, the Mag-3 and Mag-4 have originated from the late thermal reworking by dissolution-reprecipitation processes.
To imply an origin of the studied magnetites, they were compared to the earlier studied magmatic-metamorphic (1058 drilling), presumably skarn (982 drilling) magnetites from the studied area and plotted in the major magnetite ore type fields according to Dupuis and Beaudoin (2011). They have similar trace element abundances as skarn magnetites, e.g. are in general Ti-poor. The Mag-1 is more than twice richer in Mg than the porphyry and Kiruna type iron ores. A slight enrichment in Al, Ti and V because of spinel and ilmenite inclusions may have caused the earliest Mag-1 to resemble the porphyry type ores, while the secondary Mag-2 has Al, Ca and Mn contents as low as the Kiruna type ores. Thus, we can consider that fluid-rock interactions have strongly affected chemical compositions of the studied magnetites. Even though there are no precise age constructions for the metamorphic, metasomatic and hydrothermal iron ore formation process, they likely started later than 1.80 Ga (metamorphism of the host rocks; Bogdanova et al., 2015) and lasted until c. 1.50 Ga, when the rocks were intruded by the within-plate AMCG magmatic bodies.

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