Magnetism at Depth: Magnetic properties of granulite-facies rocks and rocks exhumed from the eclogite facies (> 120km). What do their properties tell us about magnetization in the deep crust?

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Abstract: The magnetic response of crustal rocks is directly related to the type and abundance of oxides in rock bodies. Many eclogites, formed in the deep lithosphere during Early Devonian subduction, are paramagnetic, while adjacent gabbros preserved significant magnetic oxides from their Proterozoic protoliths, only partly modified during the subduction and exhumation processes.

A collection of >1300 samples from mafic bodies in the Western Gneiss Region (WGR), Norway were studied for their magnetic properties and oxide mineralogy. The collection shows strong variations in petrophysical properties, oxide mineralogy and mineral assemblages. Four groups of samples were studied, representing different crustal depths and metamorphic conditions: 1) Corona gabbros generally considered to require 600-750^{o}C and 1-1.5 Gpa equivalent to depths approaching 60 km; 2) Eclogite-facies rocks that reached 700-750^{o}C and 1.5 -2.5 Gpa corresponding to depths of 60-90 km; 3) Ultrahigh-pressure eclogite-facies rocks that reached 750-850^{o}C and pressures from 2.5-4 Gpa; 4) Garnet peridotites that may have reached 850-900^{o}C and up to 6.5 GPa.

In the corona gabbros magnetite is the dominant magnetic oxide and the primary controlling feature is the abundance of oxide, mainly because the magnetite is commonly of multi-domain size, close to end-member, and lack small microstructures. With few features to stabilize the NRM, the magnetic response is dominated by induced magnetization. In contrast, in the ultrahigh-pressure rocks discrete magnetite grains commonly have lamellae of ilmenite, spinel and rutile and have higher ratios of NRM to induced magnetization (Q value) than the lower-pressure garnet corona samples. When exsolved members of the ilmenite-hematite series are present, the response is dominated by the NRM. The intensity of the NRM is more complicated than in rocks with only magnetite as the oxide. In addition to the amount of oxide in the rock, the orientation of the oxide grains to the magnetizing field, and amount of exsolution lamellae are important. If there is no coexisting magnetite, then these rocks will have very high Q values because of low induced magnetization. In these more oxidized rocks remanent anomalies are more common than in the more reduced magnetite-bearing rocks from the same pressure and temperature conditions. The WGR rocks are compared to the mafic rocks from the Swedish Granulite Region (SGR). These contain high-pressure granulites-facies assemblages with peak temperatures of 770°C and pressure of 0.75-1.05 GPa. Overall the NRM dominates the magnetic properties and the resultant magnetic vector is dominated by the NRM vector. Here the NRM is nearly opposite to the Earth's present magnetic field. There is a very strong contrast in magnetic properties between the two regions, due to different prevailing oxidation states. Both regions offer insights and shows strong variations in the magnetic properties of lower crustal rocks. It is also interesting to note that except for the corona gabbros the entire WGR collection yields susceptibility values much lower than values commonly used in modeling lower crust.

Keywords: (up to five)

Eclogite, lower crust, magnetic anomalies, magnetic oxides