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The acquisition of thermochemical remanent magnetization by oxidation of titanomagnetite at temperature

Valera Shcherbakov (1,2,3) and Karl Fabian (4,5)

(1) Institute of Physics of the Earth of RAS, Moscow Russia, (2) GO Borok IPE RAS, Nekouzskiy region, Yaroslavskaya oblast, Russia, (3) Institute of Geology and Petroleum Technologies, Kazan Federal University, Kazan, Russia, (4) Geological Survey of Norway, Trondheim, Norway, (5) CAGE - Centre for Arctic Gas Hydrate, Environment and Climate; Department of Geology, University of Tromsø, 9037 Tromsø, Norway

The oxidation of titanomagnetite is a ubiquitous process in ocean floor basalt and has been studied in details since the earliest beginnings of rock magnetism, even before the dramatic importance of ocean floor magnetization became evident (Nagata, 1963). In spite of these decades of investigation, a quantitative model for the acquisition of the NRM by oxidation of titanomagnetite at temperature is missing. Here we develop a detailed physical framework to model this NRM acquisition process. It includes first the solution of the diffusion equation in a spherical grain which describes the oxidation of titanomagnetite. The model is based on experimental results of Gapeev and Gribov (1990) that provide concentration dependent diffusion constants for titanomaghemite. Based on the work of Nishitani and Kono (1983) the corresponding change of the lattice parameters is used to calculate the internal stress evolution due to progressive diffusion, and the evolution of the radial distribution of Curie-temperatures and stresses. Combining these results provides a time and size dependent blocking scenario for the thermochemical remanent magnetization in ocean basalts that takes into account the complexities of stress the dependent anisotropy energy. Using basic energy principles of fracture mechanics and the fact that oxidation occurs via Fe expulsion, we can derive that fractures in oceanic titanomaghemite particles should not form below grain sizes of 5-6 [U+F06D]m what agrees with observations (Gapeev and Tsel'movich, 1983; Petersen and Vali, 1987).