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# Transformation of titanomagnetite to titanomaghemite: A slow, two-step, oxidation-ordering process in MORB

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## ABSTRACT

Magnetic iron oxides in a sequence of pillow basalts that were dredged from the Atlantic Ocean floor have been studied to characterize titanomaghemite and to define the processes of maghemitization. Distances from the spreading ridge and ages (in parentheses) of the samples are 0–10 (0–1), 160 (9), 450 (26), and 900 km (70 Ma).

Iron titanium oxides occur as 1 to 10 μm-sized dendritic and cruciform-shaped crystals with identical appearances in all samples and with no signs of change or significant heterogeneity in composition or structure as observed by TEM and AEM. Parameters change progressively from the youngest to the oldest, e.g., Curie temperature = 180 to 360 °C; lattice parameter = 8.466 to 8.361 Å; number of octahedral cations per cell from Rietveld refinement = 14.8 to 12.1; mean hyperfine (internal) fields at 300 K from Mössbauer data = 37 to 45 T. The large Ti contents ($Uv_{60}$ to $Uv_{70}$) are nearly constant. SAED patterns show superstructure reflections only for the oldest sample.

The youngest sample has parameters corresponding to nearly unoxidized titanomagnetite, whereas the oldest is near-end-member titanomaghemite. Intermediate samples are partially altered but display no superstructure reflections, implying a lack of significant ordering of vacancies. The data therefore show that the process of (titano)maghemitization has two distinctly different components: (1) oxidation and loss of Fe, with creation of disordered vacancies, and (2) ordering of vacancies. The data collectively imply a process dominated by solid state diffusion of Fe from the crystals, oxidation of Fe, and creation of vacancies wherein the O closest-packed framework is preserved, in sharp contrast to a model of addition of O or to dissolution and neocrystallization.