

Formation kinetics of Iron-Oxide-Apatite deposits: Examples from Kiirunavaara and El Laco

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The contentious debate on Iron-Oxide-Apatite (IOA) formation continues to this day (Reich et al. 2022, Tornos et al. 2023). The historically most investigated and debated IOA localities are the Kiirunavaara deposit in northernmost Sweden and the El Laco deposit in northeastern Chile. However, detailed ore deposition characteristics are still not well understood, and characterization of deposition mechanisms are complicated to study due to the isometric crystal symmetry of magnetite. Advanced analytical techniques such as electron back scattered diffraction (EBSD) analysis enables, among other features, the study of crystal orientations and crystal alignments regardless of crystal symmetry and can therefore be applied to understand formation kinetics in IOA deposits. Here, we report the first EBSD analyses on massive magnetite samples from the Kiirunavaara and El Laco IOA deposits.

The applied rationale is based on fluid dynamic experiments of rigid bodies in flows (Zitoun & Sastry, 2004). For magnetite crystals in a flow environment, this suggests that the crystals align one of its crystallographic axes {111} along the principal flow direction. On the contrary, magnetite crystals in a stagnant environment will instead accumulate without any preferred alignment. By evaluating the relative distribution of {001} and {111} we can better understand the different depositional mechanisms and kinetics that form giant Kiruna-type deposits.

EBSD analysis was performed at the Swedish Museum of Natural History using an Oxford Instruments Nordlys detector attached to a FEI Quanta FEG 650 SEM, based on the procedure in Kenny et al. (2020), using magnetite match units from Wechsler et al. (1984). The Oxford Instruments software's Aztec and Channel 5 were used during data collection and post-acquisition processing.

Two clear trends are revealed in the EBSD data from the massive magnetite samples when comparing the relative distribution of {001} and {111}. The magnetite samples from Kiirunavaara show no preferred alignment and suggest a calm crystal settling environment, concordant with crystal settling of magnetite crystals from crystal fractionation or within an immiscible melt (Troll et al. 2019; Zhang et al. 2020). Oppositely, the magnetite samples from El Laco exhibits extreme crystal alignment along {111}, consistent with previous interpretations of massive magnetite lava flows at El Laco.

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