Mafic underplating as a possible source for iron oxide-apatite deposits in Norrbotten, Sweden

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The Norrbotten region in northern Sweden is one of the most active mining areas in Europe and the hub of Europe's iron production. The northern Norrbotten ore district hosts a rather unique cluster of iron oxide-apatite (IOA) deposits, including the Kiruna and Malmberget iron mines as the most prominent examples. Genetic models for Kiruna-type IOA deposits are controversial and range from a magmatic origin to a purely hydrothermal origin. Martinsson et al. (2016) suggested a combination of both models for Malmberget and Kiruna. IOA mineralization processes are assigned to a phase of back-arc extension at the onset of the Svecokarelian orogeny (ca. 1.88 Ga; e.g. Andersson et al. 2022). Despite the formation processes, a major question remains regarding the source of iron needed for the formation of these large systems. Several potential sources have been suggested, ranging from greenstone rocks to Svecofennian volcanic rocks to mafic intrusions.

A common feature that all IOA deposits in northern Norrbotten share is the existence of ultramafic and coeval felsic intrusions close by. These intrusions are typically magnetite-rich and have a similar age as the related IOA deposits. Drex project has recently acquired dense regional scale (~ 100x100km) magnetotelluric (MT) data array consisting of more than 400 sites around in the area. Data were inverted to obtain a full 3D conductivity model of entire crust. The 3D conductivity model contains extensive enhanced conductivity structure in the upper, middle crust at depth range from about 10 to 30 km. The resolution of the 3D model is sufficient to map pipe-like features that partly reach the surface in the close vicinity of known IOA deposits. Those deep feeders are also mapped in more details with deposit scale MT arrays in Nautanen and Malmberget areas. Enhanced conductivities in the crust can be explained by the presence of sulfides (grain boundary sulfides), iron oxides (magnetite), graphite or iron-rich ultramafic rocks (e.g. Hill 2021). Based on a combination of MT 3D model with field observations and potential fields 3D models we suggest that the crustal conductor under northern Norrbotten represents a large volume of ultramafic rocks emplaced by underplating during the back-arc extension. Tornos et al. (2023) recently showed that assimilation of crustal rocks can promote separation of silicate magma from iron-rich ultramafic melts and is interpreted as the formational process for IOA deposits. The data presented here suggests a comparable model where ultramafic intrusions intrude into the upper crust sourcing from a larger volume of ultramafic rocks caused by mafic underplating. Assimilation of crustal rocks during uprise of these intrusions can subsequently trigger separation and formation of iron rich melts.

References

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