Structural setting of iron oxide-apatite and Fe-Cu-sulphide occurrences in Kiruna, northern Sweden

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Kiruna in northern Sweden is one of the most productive mining areas in Europe. The area hosts the largest underground iron mine in the world and numerous exploration targets for iron and copper-gold are to be found in the area. Kiruna has a long tradition of geological research and the Kiirunavaara iron deposit forms the archetypal example for iron oxide-apatite (IOA) deposits, however, many fundamental questions remain unanswered. In this project, we focus on the structural setting and evolution in Kiruna and the relation to iron oxide-apatite, Fe-Cu-sulphides and their associated hydrothermal alteration footprint. Petrological and geochronological data from earlier studies together with our new stratigraphical and structural data and interpretations are in accordance with Orosirian basin development in an overall extensional (back-arc) setting synchronously with the emplacement of iron oxide-apatite bodies. The basin was inverted during subsequent compression (D1-D2) including movements along lithostructural boundaries and shear zones developed in sedimentary and volcanosedimentary rocks. D1 is dominantly ductile in character and the strain is distributed regionally, whereas D2 is associated to strong strain partitioning, brittle-ductile reactivations, and folding of D1 structures. Microstructures of shear zones indicate east-block-up kinematics in the central Kiruna area, whereas the areas east and west of central Kiruna indicate reverse kinematics (west-block-up). This causes juxtaposition of different crustal levels outcropping on either side of central Kiruna.

Regionally, D1 is associated to scapolite ± albite ± sulphide alteration formed coeval with magnetite ± amphibole alteration. The alteration styles associated to D2 are more diverse and potassic in character and associated to Fe-Cu-sulphides. A distinct D2 brittle Fe-Cu-sulphide overprint is recognized in the region. Primarily chalcopyrite, bornite, and pyrite are hosted by a wide range of D2-structures including fractures and brittle veins in competent volcanic units, and fold hinges and ductile shear bands in rheologically weak rocks. Competence contrast is assumed to be the most critical parameter controlling how and where Fe-Cu-sulphides were concentrated during D2 and are linked to the basin inversion phase of the geological evolution. This implies that IOA emplacement happened during a dominantly extensional setting whereas the Fe-Cu-sulphides were concentrated in an overall late compressive setting and the mineralized systems can be linked to different phases of the structural evolution.

Tectonic models presented by earlier workers contradict each other and the conclusions vary
depending on the geological discipline of the researchers. In general, models based on petrology/geochemistry include an extensional pre-tectonic phase whereas models focusing on geological structures include the development of a fold-thrust belt during D₁. In this project, we show that the structural configuration in Kiruna can be explained by basin inversion and we hope that our contribution will bridge geological disciplines by providing a structural framework in agreement with petrological results.