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Structural controls on the formation and transposition of the Malmberget apatite iron ore deposit, northern Sweden

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The Malmberget mine is the World's second largest underground iron ore operation. It is composed of approximately 20 apatite iron ore bodies, whereas 13 ore bodies with 5-245 Mt each are presently mined. The massive magnetite ore is hosted within volcanic and volcaniclastic rocks. Host rocks within the entire area were subject to intense hydrothermal alteration. The ore reserves at beginning of 2012 totalled 290 Mt at 44 percent iron. Together with Kiruna and Svappavaara these three deposits stands for more than 90 percent of the iron ore production in Europe. An on-going collaborative research project aims at unravelling the structural geometries, relationships and control on ore formation and ore body transposition at different scales in the Gällivare district in general and in the Malmberget mine in particular.

Recent results show the three-dimensional crustal architecture of the Malmberget deposit which has undergone at least two separate deformation events. The first deformation event (D1) resulted in the formation of a strong and penetrative cleavage (S1) forming a varyingly intense banding within the volcanic rocks. The D1-event coincides with the amphibolite facies peak metamorphism in the area. Distinct, biotite-rich D1 shear zones are spatially related to the majority of the S1-parallel massive magnetite bodies. These D1 shear zones seem to be responsible for a strong strain partitioning during D1. A second compressional event (D2) resulted in open to close folding of the S1 fabric, the D1 shear zones and the related ore bodies. The result is an asymmetric F2-synform with moderately south-west-plunging fold axis. Furthermore, distinct D2 high strain zones are responsible for local transposition of S1 fabrics, tight to isoclinal folding and channeling or re-mobilization of hydrothermal alteration minerals. Both deformation events are accompanied by syn- and late-tectonic granitic intrusions forming both foliated and unfoliated and commonly boudinaged granitic sheets and dikes. Strong hydrothermal alteration occurred during several phases and is spatially and temporally related to D1 and D2 structures.

Based on the structural observations a robust three-dimensional framework model is currently constructed using MOVE by Midland Valley Exploration. The resulting 3D-model visualizes the F2 folding pattern, the spatial distribution of D1 and D2 high strain zones and the structural controls on both primary and remobilized ore minerals. This framework model can act as a base for further modelling actions as well as for production and near mine exploration purposes.