NEOPROTEROZOIC (TONIAN) STRATIFORM IRON FORMATIONS ASSOCIATED GLACIOGENIC DEPOSITS IN THE SCANDINAVIAN CALEDONIDES

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Stratiform iron formations (IFs) occurring within mica schist-marble sequences over a distance of ca. 550 km between latitudes 65˚20' and 69˚40' in the Scandinavian Caledonides of Northern and North-Central Norway are known as Dunderland type deposits. In the Rana district this ore type constitutes important economic deposits which have been mined for nearly a century. The other iron formations comprise several historical iron mines and prospects worked intermittently during the last century.

Neoproterozoic IFs were formed worldwide after a paucity of one billion years (Cox et al. 2013). The depositional age of the sediment-hosted Dunderland type ore deposits has been discussed, and recent chemostratigraphic studies of associated calcite and dolomite marbles demonstrate a common Mid-LateTonian (800-735 Ma) depositional age for those associated with the IFs (Melezhik et al., 2015, in prep.).

Dunderland type IFs occur with few exceptions within the Uppermost Allochton of the Norwegian Caledonides. The amphibolite facies IFs and associated schist-marble sequences were originally formed outside Baltica, and were subsequently thrust upon the Baltoscandian margin during the Scandian continent-continent collision during the Silurian.

The iron formations vary in thickness from a few centimetres up to 30 metres. However, most of them are in the range 5-10 metres when measured outside areas with isoclinal hinge zones where the ore horizons may become multiplied in thickness. They can be traced for several tens of km as linear aeromagnetic anomalies that locally become disrupted into smaller segments due to tectonically dismembering of the IFs by detached isoclinal folds and imbrication. Both banded and disseminated ore types occur. The banded structure is assumed to be primary layering later metamorphosed to alternating bands (mm-dm scale) with various ratios of fine grained hematite and/or magnetite as well as quartz, amphibole, garnet, apatite, augite, epidote, carbonates, and/or biotite in order of decreasing abundance. The disseminated Fe-oxides occur commonly in several-metre-thick zones and/or diffusely delineated bands and stringers in quartz-rich biotite and/or hornblende schist. Magnetite is the only Fe-oxide in the northern part of the study area, whereas both hematite and magnetite occur in the southern part. Apatite appears preferentially in quartz- and amphibole-banded ores, whereas spessartine-rich zones most commonly occurs as discrete Mn-rich beds along one of the borders of the IFs. Nearly 400 samples of iron ores yield average grades in the range 15-40 % Fe_{tot}. The Dunderland type iron formations can be subdivided into low-P and high-P ore. The former which is the ore type presently being exploited in the Rana area contains less than 0.9 wt. % P_2O_5. The high-P ores commonly contain 1-3 wt. % P_2O_5 and have low content of manganese, whereas the MnO rich ores (up to 20-30 % MnO) are low in P_2O_5.

The IFs along the length of the Caledonides in northern Norway are all interlayered with different amphibolite facies meta-sedimentary rocks like mica schists (often calcareous) and calcite and/or dolomite marbles. However, additionally there exists some lateral variations in the composition of the wall rocks. The IFs occurring in the northernmost areas are also characterised by the presence of abundant interlayered amphibolites and intermediate to felsic gneisses assumed to represent extrusive and intrusive rocks. In the southern parts of the area, the IFs are often associated with units of diamictites which occur in contact with the IFs in the Rana district (Melezhik et al. 2015). The diamictite consists mainly of scattered and non-sorted clasts (cm-dm-scale) of fine grained carbonate rocks. Locally, the diamictite contain abundant Fe-oxides as dissemination and/or massive lenses in a matrix of quartz, carbonate, amphibole and/or biotite. These diamictites are assumed to represent glaciogenic deposits.

The Fe, Si, Mn and P enriched iron formations in the Scandinavian Caledonides shear many common features with Neoproterozoic IFs worldwide. Several models have been advocated for the global reappearance of IFs in the Neoproterozoic (reviewed in Melezhik et al., 2015). Anoxic basins are required, and in addition rifting, mafic volcanism and glaciation are assumed to be of various importance. These models, differing in details, share one major feature in common: they link directly or indirectly the global re-appearance of IFs in the Neoproterozoic to the onset of global icehouse conditions of Sturtian age. The global scale icehouse event might have triggered a widespread shift in marine redox conditions causing the iron accumulation and precipitation of iron oxyhydroxides. The accumulation of ferrous (Fe^{2+}) iron in the ocean implies anoxic conditions that could have evolved in an ice-capped basin, while hydrothermal flux of iron could have played a more important role in the northern part of the studied area. Phosphorous have been scavenged from P-rich seawater and co-precipitated with the iron oxyhydroxides.

References

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