From banded iron formation to iron ore – Tiny crystals building huge iron ore deposits

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Banded iron formations (BIF) comprise alternating layers of iron oxides and jasper (i.e., microcrystalline quartz with abundant intragranular hematite nanoparticles). Selective removal of quartz from BIF leads to the residual formation of iron ore.

Current ore genesis models propose a series of mineral replacement reactions to remove quartz and to form new hematite. However, associated metasomatic alteration zones are rare and where present are not proportional to the required amount of fluid. Further, the silica sink and iron source remain the subject of debate. Although iron-bearing nanoparticles in BIF have provided new insights into the long-standing debate about the precursor minerals of BIF, their post-depositional fate during burial metamorphism and deformation as well as their role in the final upgrading to iron ore has not been investigated so far.

Here we investigate the role of hematite nanoparticles during metamorphism and ore genesis in BIF and iron ore samples from the Mount Tom Price deposit (Hamersley Province, Australia) via a combination of petrography, structural geology, scanning and transmission electron microscopy, and X-ray diffraction. We show that quartz dissolution leads to the residual enrichment of iron oxides. We interpret, that large quantities of hematite nanoparticles are liberated from jasper layers and aggregate to larger iron oxide crystals via nanoparticle attachment. This solid-state crystallisation mechanism is well-known in environmental science and crystal chemistry but it has not yet been applied to BIF or iron ores. Our results suggest that the iron oxide nanoparticles are the major building blocks of BIF and iron ore minerals. This offers new perspectives in understanding the geological evolution of BIF and iron ore genesis.