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Is the banding in iron formations controlled by water transparency?

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Banded Iron Formations (BIF's) show a typical layering of Fe minerals and quartz that is observed at various scales ranging from micrometers to meters. Millimeter sized micro bands are commonly interpreted as annual layers so larger bands require decades or millennia to form, whereas micrometer sized nano bands have been interpreted to represents sub annual and even diurnal cycles. Because the mineralogical composition of BIF's is not primary and because single-phase Fe(III) silica gel forms when Fe(III) (oxyhydr-)oxide precipitates in Si rich water, secondary processes are often invoked to explain the banding. However, trace element and isotope data point towards distinct sources for the Fe and Si rich bands, which is difficult to reconcile with a single phase starting material. In addition, the correlation of banding over long distances is inconsistent with most secondary models. Both primary and secondary models struggle to explain the versatile nature of the banding. I will present a conceptual model that could explain BIF layering at all scales and the more widespread formation of granular iron formations (GIF's) in the Paleoproterozoic.

The concept builds on primary precipitation models postulating that banding forms due to some form of periodicity such as cyclic Fe or nutrient supply to the shelf. Fe(III) is mainly produced by phototrophic iron oxidizing bacteria. These photoferrotrophs are adapted to very low light levels corresponding to about 1% of the light level required by oxygen producing phototrophs allowing them to thrive deep down in the water column. The depth of Fe(III) production is mainly controlled by water turbidity which controls how deep photosynthetically available radiation (PAR) penetrates into the water column. Eutrophic conditions result in turbidity induced by the biomass itself resulting in shallow Fe(III) production depth and the formation of Fe rich bands. During oligotrophic stages, Fe(III) is only produced deep down in the water column, so that silica rich bands can form. In this case, Fe(III)-silica co-precipitation is not an issue because silica precipitates in the Fe(III) free upper water column. Reactive transport modelling shows that besides upwelling and nutrient supply, alternating Fe(III) production depth are mainly associated with changing light conditions. Hence the model predicts annual layering, but also local occurrences of diurnal cycles. Larger periodicities could be associated with: 1) nutrient supply patterns; 2) formation and clearing of atmospheric haze; or 3) additional sources of turbidity in the water column such as silicate particles, MnO_2 particles or metal sulfides. These additional sources of turbidity become more important in the Paleoproterozoic and could be responsible for the more widespread occurrences of GIF's, indicative of Fe(III) production above storm wave base. The additional factor light, is quite versatile in producing periodicities at variable scales.