



Archean cherts: field, petrographic and geochemical criteria to determine their origin

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Archean cherts provide valuable information about conditions on the sea floor during the early history of Earth. We conducted field, petrological and geochemical studies on examples from different environments in the Barberton Greenstone Belt (3.2-3.5 Ga), South Africa, with the aim of improving our understanding of these enigmatic rocks. We distinguish three different origins for cherts: direct precipitation from seawater (C-cherts); precipitation in fractures from silica-rich fluids (F-cherts); and replacement of preexisting rocks (silicification) either at or near the surface (S-cherts). The three types were distinguished using a combination of sedimentary and deformation structures, petrological observations (RAMAN, electron microprobe, X-Ray microfluorescence, cathodoluminescence) and geochemical data.

C-cherts best record the composition and physical conditions in primitive oceans and the depositional environment because they precipitated from seawater. Based on sedimentary structures, we show that the silica was deposited as a siliceous ooze or amorphous gel on the seafloor, with variable precipitation rates that depend on the amount and nature of co-precipitated phases (called here the “contaminant”), such as detrital grains, carbonates, carbonaceous matter and oxides. We observe a complex rheology of C-cherts, which show both ductile to brittle deformation structures, sometimes in the same layer. We infer that the cherts underwent extremely rapid diagenetic induration at or near the surface, a process that proceeded faster when contaminants are lacking. Geochemical data (ICP-MS/ICP-AES) indicate that whole rock chemistries are dominated by the contaminant phases. Detrital grains with continental signatures dominate the compositions of cherts in the turbidite sequence of the Komati River whereas carbonates preserving modern, seawater-like compositions control the compositions of cherts of Fig Tree Fm in the Barite Valley. The silica minerals do not contribute significantly to the trace-element composition, but acts as a diluent. Buck Reef cherts have extremely low contents of most trace elements due to low contents of detrital minerals and carbonates.

S-cherts result from the silicification of preexisting rocks: under the action of circulating fluids, primary minerals are replaced by silica minerals and the porosity of the protolith is significantly reduced. Such process occurs even at the surface and persist downward the sedimentary units until after the rocks are indurated.

F-cherts were observed in the Barite Valley, where chert dykes cross-cut surrounding units at high angle. The fractures often display jigsaw-puzzle textures, suggesting hydraulic fracturation, and their near-vertical orientation points to emplacement at shallow levels in the sediment pile. The dykes are filled with a black chert that contains variable amounts of host rock fragments that vary in shape (angular to rounded) and size (dm to μm). They control the whole-rock chemistry of cherts, and obscure the chemical composition of the primary, precipitating fluid. We believe that this fluid had a thixotropic behavior, i.e. it was fluid enough during the intrusion to fill very fine <1mm fractures but viscous enough when the velocity decreased to suspend decimetric host rock fragments.

Based on our observations, we conclude that (1) field and petrological studies are more reliable than geochemical analyses for the recognition of various chert types; (2) the composition of cherts strongly depends on the type and amount of mineral phases other than silica, especially clays and carbonates; (3) C-cherts might be more abundant than previously thought and deposited as an amorphous, siliceous gel onto the seafloor before being rapidly indurated.