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The rheological behavior of fracture-filling cherts: example from Barite Valley dikes, Barberton greenstone Belt, South Africa.

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A 100m-thick complex of black carbonaceous chert dikes marks the transition from the Mendon to Mapepe Formations (3260 Ma) in the Barberton Greenstone Belt, South Africa. Fracturing was intense in this area, as shown by the profusion and width of the chert dikes (ca. 1m on average) and by the abundance of completely shattered rocks. Similar structures occur in many greenstones worldwide. Here we investigate (1) the origin of the dikes and (2) the nature of the material that precipitated to form the fracture-filling chert.

The dike-and-sill organization of the plumbing system and the upward narrowing of some of the large veins indicate that at least part of the fluid originated at depth and migrated upward. Abundant angular fragments of silicified country rock are suspended and uniformly distributed within the larger dikes. Jigsaw-fit structures and confined bursting textures indicate that hydraulic fracturing was at the origin of the fractures, a particularity attributed to the confinement of the hydrothermal system below an impermeable cape of chert. The location of the dikes beneath an impact spherule bed leads us to propose that the hydrothermal circulation was related to the impact. The present site may have been located at the external margin of a large crater.

The geometry of the dikes and the petrography of the cherts indicate that the fluid that invaded the fractures was thixotropic. The injection of black chert into extremely fine fractures is evidence oflow viscosity at the time of injection while the lack of closure of larger veins below eroded country blocks and the suspension of fragments in a chert matrix provides evidence of high viscosity soon thereafter. The inference is that the viscosity of the injected fluid increased from low to high as the fluid velocity decreased.

Such rheological behavior is characteristic of media composed of solid and colloidal particles suspended in a fluid. The presence of abundant clay-sized particles of silica, carbonaceous matter and phyllosilicates, the high proportion of siliceous matrix and the capacity of colloidal silica to form cohesive 3D networks, accounts for the viscosity increase and thixotropic behavior of the fluid that filled the veins. Stirring and shearing of the fluid as it was injected imparted a low viscosity by decreasing internal particle interactions; then, as the flow rate declined, the fluid became highly viscous as the inter-particulate bonds were reconstituted. The gelation of the chert was rapid, probably within a day after it was injected, and the structure persisted for several months to years under low temperature conditions (T<200°C) before fractures were sealed and the chert indurated.