Diagenetic Modeling to Assess the Relative Timing of Quartz Cementation and Brittle Grain Processes During Compaction

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This study describes porosity reduction by brittle deformation and the application of TouchstoneTM sandstone diagenesis modeling software to assess the relative timing and interactions between grain fracturing and cement formation during burial compaction. Two examples from a previous study of compactional fracturing are used: the Oligocene Frio Formation, Gulf of Mexico Basin, and the Cambrian Mount Simon Formation, Illinois Basin, USA. Grain fracturing during compaction creates intragranular fracture surfaces that are favorable sites for quartz nucleation compared to external grain surfaces that may bear coatings that inhibit the nucleation and growth of quartz cement. Thus, the progress of brittle fracture processes during diagenesis affects quartz cementation. In turn, modeling of the quartz cementation process can serve to place fracturing into its proper context in burial history.

In the Mount Simon Formation, the extent of brittle deformation of quartz grains correlates with reconstructed effective stress at the onset of quartz cementation. For Frio Formation samples, however, the extent of brittle deformation does not correlate well with reconstructed effective stress obtained using a 1D basin model that uses compaction disequilibrium (Bethke, 1986) as the dominant mechanism for overpressure generation. Judging from the observed degree of grain fracturing, significant fluid overpressures in the Frio may not have developed at the shallow depths indicated by our basin models. The degree of compactional fracturing in sandstones constitutes observable evidence that can be used to decipher the complexities of pressure history.