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Quantifying Brittle Deformation During Burial Compaction of Sandstones: A Comparison of Values from the Frio and Mount Simon Formations

Sandstone samples of different ages and compositions, taken from two basins with contrasting burial histories are used to examine the relationship between brittle deformation and quartz cementation in the context of burial compaction. During burial, brittle deformation (microfracturing) of quartz grains increases exponentially as sandstones are subjected to increasing overburden pressure (effective stress). The exponential trend is observed in both the lithic-rich Frio Formation from the Gulf of Mexico basin (R2=0.8122) and the quartz-rich Mount Simon Formation from the Illinois Basin (R2=0.7764). Differences in the trends lie in the degree of fracturing at a given depth. A larger number of quartz grains in the Mount Simon Formation undergo fracturing at shallow burial (< 2 km) compared to the Frio Formation, whereas at intermediate to deep depths of burial a larger number of quartz grains are fractured in the Frio sandstones.

Plotting the ratio of the number of particles in fractured grains versus depth (R2=0.2063 for Frio and 0.0346 for Mount Simon) illustrates that the intensity of brittle deformation for a single fractured grain is independent of depth. Lack of statistically significant trends for individual grain behavior suggests that fracturing commences very early during burial and that individual grains may become severely comminuted even at relatively shallow depths. It also suggests that grain fracturing initiates throughout burial.

Combining information on the degree of brittle deformation and the amount of quartz cement localized within microfractures (intragranular cement) allows calculation of the amount that brittle deformation influences compaction. Porosity loss values attributed to brittle deformation range from 0.12 to 8.37% and 0.25 to 2.16% for the Frio Formation and Mount Simon Formation, respectively. Larger values are affiliated with deeper samples in which a majority of quartz grains manifest fractures.