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Diagenetic Processes and Porosity Evolution within Deformation Bands in the Eolian Navajo Sandstone (Early Jurassic), Southern Utah

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The relative role that compaction and cementation plays in porosity loss within deformation bands in wind-ripple deposits of the Early Jurassic Navajo Sandstone is greatly variable, affecting the amount and distribution of the remaining porosity. Quantitative data on grain, cements, and porosity types were obtained by point counting of combined secondary electron (SE) and scanned-cathodoluminescence (SEM-CL) image photomosaics from randomly selected portions of both host rock and deformation bands (400 points each mosaic) in three samples (NaKa13, NaKa14 and NaKa15) from the Zion Canyon area (47 km north of Kanab, southern Utah). A depositional porosity value of 39% was assumed for these sandstones.

Results for undeformed host rock sandstones indicate that quartz cement as overgrowths (9.5 to 11.6% of rock volume) leaves large amounts of intergranular macroporosity (15.3 to 15.9%), with intergranular volumes (IGV) relatively constant between 29.6 to 33%. Within deformation bands, macroporosity has been destroyed by grain crushing and precipitation of authigenic silica on the fresh, clean, and angular surfaces of fractured grains, resulting in high values for intragranular quartz cement (14.1 to 18.7%), less common quartz overgrowths (3.3 to 3.5%), and variable amounts of microporosity (0 to 11%).

Significant variations of intergranular volumes (IGV) computed for deformation bands (22 to 34%) suggest differences in the relative timing of grain breakage and quartz cementation. The intergranular macroporosity originally present in the host rocks followed different paths of evolution during deformation band development in the three analyzed samples; macroporosity was almost completely destroyed due to a sub-equal participation of mechanical compaction and quartz cementation (NaKa13), mostly reduced by mechanical compaction (NaKa14), or it is redistributed as microporosity within the comminuted grain debris (NaKa15) (Fig. 1).

The amount of microporosity hosted within deformation bands correlates directly with the intergranular volume (IGV), and inversely with the amount of intragranular quartz cement. The increasing degree of grain crushing during progressive deformation would enlarge the available surface area of grains, probably favoring precipitation of intragranular quartz that prevented further compaction. Preservation of microporosity within the highly comminuted grain debris as opposed to the healing of fractures that is commonly observed in less severely broken grains (Fig. 2) may be related to slow growth rates of the microquartz crystals due to the presence of multiple nucleation sites, or to low circulation velocities of cementing fluids associated to relatively lower permeabilities due to pore size decrease.

The larger values of Q_{cem}/Q_{detr} ratio computed for deformation bands (0.25 to 0.33) compared to host rocks (0.22 to 0.24) point to an unusual increase of authigenic quartz precipitation that explains the typical resistance of these deformational features to weathering observed in many outcrops. Chemical analyses carried out in two samples confirm this relative enrichment in silica content within the deformation band ($SiO_{2\ def}$ = 94.2-95.2%) with respect to the host undeformed rock ($SiO_{2\ host}$ = 93.6% in both samples).

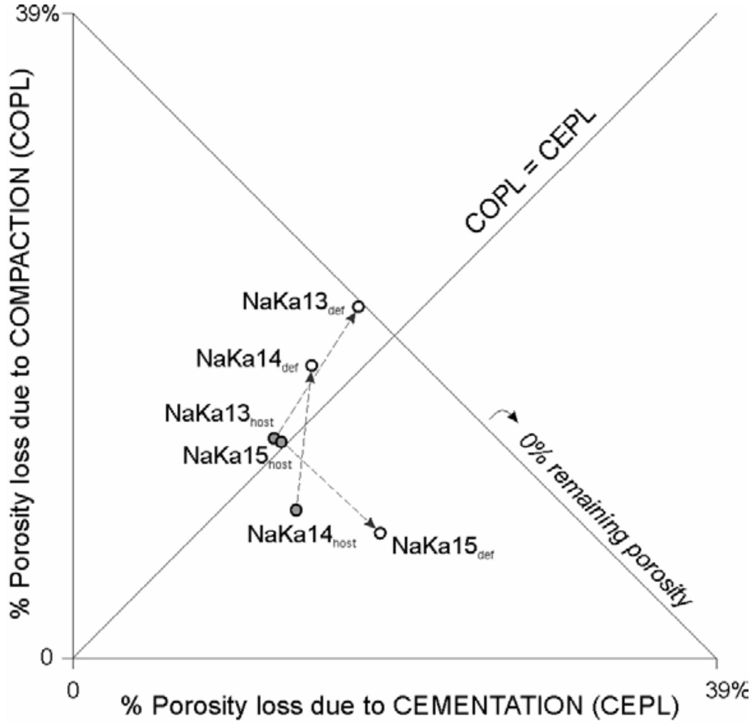

Figure 1 – Porosity loss due to compaction (COPL) and cementation (CEPL) for host sandstones (grey circles) and their correspondent deformation bands (white circles). Arrows indicate paths of porosity evolution.

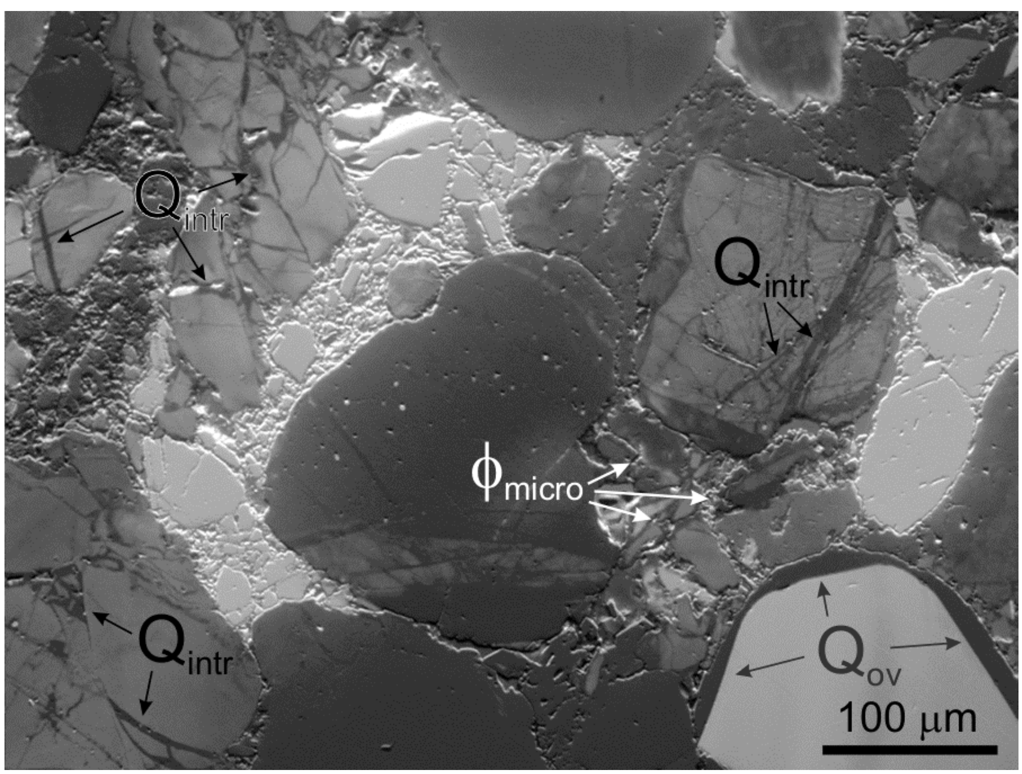

Figure 2 – Combined SE-CL photomicrograph showing how intragranular quartz cement (Qintr) completely heals fractures within less severely broken quartz grains, whereas microporosity (ϕmicro) is present among pieces of more extremely deformed grains. Notice quartz overgrowths (Qov) on the grain at lower right. Sample NaKa14, X200.