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Influence of pore space heterogeneity on compaction localization: X-ray CT imaging and mercury porosimetry data

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In the last decade compaction localization in high porosity sandstones has been observed in numerous studies both in the field and in the laboratory. In laboratory experiments compaction localization involving a whole complexity of failure modes was shown to develop at the brittle ductile transition. Despite an increasing number of experimental data, the parameters controlling the nucleation and propagation of localized compaction features as well the associated spatial distribution of damage remained however unclear. Part of the difficulty lies in finding an appropriate way of describing the phenomenon since compacted areas may be associated with limited density changes and compacted features may not form as a single object but often appear at multiple locations within the sample. Pilot studies involving X ray CT imaging suggested that pore space heterogeneity, porosity and composition play a role in the development of compaction localization.

In this study we performed mercury porosimetry experiments and X-ray CT image analysis on five high porosity sandstones in which compaction localization had been observed in laboratory experiments. In order to evaluate the influence of pore space heterogeneity on compactive failure mode, we compared mercury porosimetry data acquired in undeformed samples with compaction features that had developed during triaxial tests. While distributions of X-ray attenuation values at 50 μm resolution are

close to normal, the coefficient of variation (ratio of standard deviation over the mean) calculated over a sliding window of 3*3*3 voxels provide a set of values that are distributed in the same manner as the pore size. Overall, we observed a good qualitative correlation between pore space statistics and failure mode. In two sandstones, mercury porosimetry experiments were also performed post compaction tests in order to observe associated changes in the distribution of the pore entry radii. These data are very conclusive in showing that larger pores were preferentially destroyed and pore space was redistributed toward smaller pore entry radii values.