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Characterization of Anisotropic Deformation in Sandstones Using Micro-Computed Tomography Technique

Authors : Seyed Mehdi Seyed Alizadeh, Christoph Arns, Shane Latham

Abstract : Geomechanical characterization of rocks in detail and its possible implications on flow properties is an important aspect of reservoir characterization workflow. In order to gain more understanding of the microstructure evolution of reservoir rocks under stress a series of axisymmetric triaxial tests were performed on two different analogue rock samples. In-situ compression tests were coupled with high resolution micro-Computed Tomography to elucidate the changes in the pore/grain network of the rocks under pressurized conditions. Two outcrop sandstones were chosen in the current study representing a various cementation status of well-consolidated and weakly-consolidated granular system respectively. High resolution images were acquired while the rocks deformed in a purpose-built compression cell. A detailed analysis of the 3D images in each series of step-wise compression tests (up to the failure point) was conducted which includes the registration of the deformed specimen images with the reference pristine dry rock image. Digital Image Correlation (DIC) technique based on the intensity of the registered 3D subsets and particle tracking are utilized to map the displacement fields in each sample. The results suggest the complex architecture of the localized shear zone in well-cemented Bentheimer sandstone whereas for the weakly-consolidated Castlegate sandstone no discernible shear band could be observed even after macroscopic failure. Post-mortem imaging a sister plug from the friable rock upon undergoing continuous compression reveals signs of a shear band pattern. This suggests that for friable sandstones at small scales loading mode may affect the pattern of deformation. Prior to mechanical failure, the continuum digital image correlation approach can reasonably capture the kinematics of deformation. As failure occurs, however, discrete image correlation (i.e. particle tracking) reveals superiority in both tracking the grains as well as quantifying their kinematics (in terms of translations/rotations) with respect to any stage of compaction. An attempt was made to quantify the displacement field in compression using continuum Digital Image Correlation which is based on the reference and secondary image intensity correlation. Such approach has only been previously applied to unconsolidated granular systems under pressure. We are applying this technique to sandstones with various degrees of consolidation. Such element of novelty will set the results of this study apart from previous attempts to characterize the deformation pattern in consolidated sands.

Keywords : deformation mechanism, displacement field, shear behavior, triaxial compression, X-ray micro-CT
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