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Quantitative strain analysis in analogue modelling experiments: insights from X-ray computed tomography and tomographic image correlation

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The combination of scaled analogue modelling experiments, advanced research in analogue material mechanics (Lohrmann et al. 2003, Panien et al. 2006), X-ray computed tomography and new high-resolution deformation monitoring techniques (2D/3D Digital Image Correlation) is a new powerful tool not only to examine the evolution and interaction of faulting in analogue models, but also to evaluate relevant controlling factors such as mechanics, sedimentation, erosion and climate. This is of particular interest for applied problems in the energy sector (e.g., structurally complex reservoirs, LG & CO2 underground storage) because the results are essential for geological and seismic interpretation as well as for more realistically constrained fault/fracture simulations and reservoir characterisation.

X-ray computed tomography (CT) analysis has been successfully applied to analogue models since the late 1980s. This technique permits visualisation of the interior of an analogue model without destroying it. Technological improvements have resulted in more powerful X-ray CT scanners that allow periodic acquisition of volumetric data sets thus making it possible to follow the 3-D evolution of the model structures with time (e.g. Schreurs et al., 2002, 2003).

Optical strain monitoring (Digital Image Correlation, DIC) in analogue experiments (Adam et al., 2005) represents an important advance in quantitative physical modelling and in helping to understand non-linear rock deformation processes. Optical non-intrusive 2D/3D strain and surface flow analysis by DIC is a new methodology in physical modelling that enables the complete quantification of localised and distributed model deformation. The increase in spatial/temporal strain data resolution of several orders of magnitude makes physical modelling - used for decades to visualize the kinematic processes of geological deformation processes - a unique research tool to determine what fundamental physical processes control tectonic deformation.

We have adapted our analogue modelling setups for optimal analysis of complex deformation processes using leading-edge volumetric strain monitoring techniques (3D volume DIC, Tomographic DIC). In this study, we apply DIC on X-ray CT images of analogue models. Our first results indicate that DIC can successfully be applied to quantify the 2D and 3D spatial and temporal patterns of strain accumulation.

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