Quantitative 3D strain analysis in analogue experiments simulating tectonic deformation: Integration of X-ray computed tomography and digital volume correlation techniques

J. Adam M. (1), Klinkmüller (2), G. Schreurs (2), and B. Wieneke (3)

(1) Department of Earth Sciences, Royal Holloway University of London, Egham, TW20 0EX, Surrey, United Kingdom
(2) Institute of Geological Sciences, University Bern, Baltzerstrasse 1+3, 3012 Bern, Switzerland
(3) LaVision GmbH, Anna-Vandenhoeck-Ring 19, D-37081 Göttingen, Germany

Abstract

The combination of scaled analogue experiments, material mechanics, X-ray computed tomography (XRCT) and Digital Volume Correlation techniques (DVC) is a powerful new tool not only to examine the 3 dimensional structure and kinematic evolution of complex deformation structures in scaled analogue experiments, but also to fully quantify their spatial strain distribution and complete strain history.

Digital image correlation (DIC) is an important advance in quantitative physical modelling and helps to understand non-linear deformation processes. Optical non-intrusive (DIC) techniques enables the quantification of localised and distributed deformation in analogue experiments based either on images taken through transparent sidewalls (2D DIC) or on surface views (3D DIC). X-ray computed tomography (XRCT) analysis permits the non-destructive visualisation of the internal structure and kinematic evolution of scaled analogue experiments simulating tectonic evolution of complex geological structures. The combination of XRCT sectional image data of analogue experiments with 2D DIC only allows quantification of 2D displacement and strain components in section direction. This completely omits the potential of CT experiments for full 3D strain analysis of complex, non-cylindrical deformation structures.

In this study, we apply digital volume correlation (DVC) techniques on XRCT scan data of “solid” analogue experiments to fully quantify the internal displacement and strain in 3 dimensions over time. Our first results indicate that the application of DVC techniques on XRCT volume data can successfully be used to quantify the 3D spatial and temporal strain patterns inside analogue experiments. We demonstrate the potential of combining DVC techniques and XRCT volume imaging for 3D strain analysis of a contractional experiment simulating the development of a non-cylindrical pop-up structure. Furthermore, we discuss various options for optimisation of granular materials, pattern generation, and data acquisition for increased resolution and accuracy of the strain results.

Three-dimensional strain analysis of analogue models is of particular interest for geological and seismic interpretations of complex, non-cylindrical geological structures. The volume strain data enable the analysis of the large-scale and small-scale strain history of geological structures.