Geophysical Research Abstracts
Vol. 17, EGU2015-7658, 2015
EGU General Assembly 2015

Detecting and estimating errors in 3D restoration methods using analog models.

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Some geological scenarios may be important for a number of socio-economic reasons, such as water or energy resources, but the available underground information is often limited, scarce and heterogeneous. A truly 3D reconstruction, which is still necessary during the decision-making process, may have important social and economic implications. For this reason, restoration methods were developed. By honoring some geometric or mechanical laws, they help build a reliable image of the subsurface. Pioneer methods were firstly applied in 2D (balanced and restored cross-sections) during the sixties and seventies. Later on, and due to the improvements of computational capabilities, they were extended to 3D. Currently, there are some academic and commercial restoration solutions; Unfold by the Université de Grenoble, Move by Midland Valley Exploration, Kine3D (on gOcad code) by Paradigm, Dynel3D by igeoss-Schlumberger. We have developed our own restoration method, Pmag3Drest (IGME-Universidad de Zaragoza), which is designed to tackle complex geometrical scenarios using paleomagnetic vectors as a pseudo-3D indicator of deformation. However, all these methods have limitations based on the assumptions they need to establish. For this reason, detecting and estimating uncertainty in 3D restoration methods is of key importance to trust the reconstructions. Checking the reliability and the internal consistency of every method, as well as to compare the results among restoration tools, is a critical issue never tackled so far because of the impossibility to test out the results in Nature.

To overcome this problem we have developed a technique using analog models. We built complex geometric models inspired in real cases of superposed and/or conical folding at laboratory scale. The stratigraphic volumes were modeled using EVA sheets (ethylene vinyl acetate). Their rheology (tensile and tear strength, elongation, density etc) and thickness can be chosen among a large number of values, allowing to simulate many geologic settings. Besides, we also developed a novel technique to reconstruct the deformation ellipsoid. It consists in the screen-printing of an orthogonal net in every single EVA plate. The CT scan of the stack of plates allows the numbering of the nodes in 3D. Then, the geologic geometry is simulated and scanned again. The comparison of the nets before and after the deformation allows computing the distribution of strain ellipsoids in 3D. After extracting the principal axes, we can calculate dilation, total anisotropy etc. with a density proportional to the mesh size. The resultant geometry is perfectly known and thus, the expected result if we apply any restoration method. In this contribution we will show the first results obtained after testing some restoration methods with this stress test.