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Roughness is the key: a compared performance analysis of 3D restoration methods, coupled with low-pass filtering in spatial and frequence domain

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3D restoration is an effective tool in complex tectonic settings (e.g., salt or polyphase tectonics) where a 2D approach is not fully informative or where material moves out of the main tectonic transport plane. Following assumptions on balancing constraints, deformation kinematics and boundary conditions, an effective 3D restoration allows to inspect the undeformed geometry of subsurface horizons. The 3D restoration is thus a helpful methodology to figure out and extract the structural evolution of a region, in terms of tectonic motion of the geological structures and as a key point in understanding fundamental deformation processes: the growth of folds or faults in three dimensions, the interactions between faults (Rouby et al. 2000) and the spatial relationships between salt tectonic and sedimentation.

Restored horizons must be geologically viable and geometrically consistent, the latter usually referring to area and volumes conservation. Currently, the validation of 3D restoration is usually achieved by jigsaw balancing of restored surfaces, trying to minimize gaps or overlapping sectors. This procedure can be greatly helped by the correlation of piercing points of pre-deformation linear markers (e.g., erosive channels) recorded on the horizons as high frequency and relatively low amplitude features.

Since the different restoration procedures work in order to unfold the deformed horizon to an original geometry (usually horizontal) by flattening the horizon and preserving its surface area, it is vital that pre-deformation must be preserved from flattening, through an adequate filtering approach. In this work we applied filtering techniques in both spatial (Wiener's filter – "average filter" with increasing size convolution windows) and frequency domain (fast Fourier transform filter) to a deformed surface of know initial geometry and validated results through standard jigsaw restoration.

The dataset used is 20 m DEM of the Po Valley, characterized by fluvial channels with variable frequency width and depth. Firstly, we induced a 3D dome-like deformation to the surface, by moving differently oriented faults through a trishear algorithm. Then, we filtered the surface and performed the restoration on the filtered surface, moving passively the original one. We adopted both a flexural slip restoring tool by Midland Valley and an innovative 3D-unbfolding tool, developed by the TOTAL in-house software SismageTM. The 3D restoration tool of SismageTM is based on the combination of flexural slip and conformal flattening that allows to preserve the surface angles in all the directions (Frambati et al. 2018).

Our preliminary results show that SismageTM tool works properly and the filtering preserve the pre-deformational features. Assumptions on the geometry and dimensions of pre-deformation features are required by spatial-domain filtering. Furthermore, we notice that SismageTM provide good results even for out of plane deformation requiring few structural assumptions.