Analysis of static stress variations in the 2013 Valencia Gulf (NE Spain) seismic sequence

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In this study we assess the role of static stress transfer during the earthquakes that struck the Valencia Gulf in September and October, 2013, some 20-30 km offshore, while and after gas injections in the area to develop an Underground Gas Storage (UGS) were conducted. The events built-up to reach a maximum of M_L 4.3 on October 2nd and some were felt by the nearby population.

We use the Coulomb Failure Function criterion ($\Delta CS = \Delta\tau \pm \mu'\Delta\sigma$) to quantify Coulomb stress change (ΔCS), and so determine whether failure is promoted or inhibited on mapped faults as a result of static stress change. First, source faults (slip $\neq$ 0) are derived from Focal Mechanism (FM) information of the 8 strongest events in the sequence (M_L 3.5-4.3); FMs are calculated using full waveform inversion and compared with solutions shown in the available references. To assess ΔCS, we build a first-stage 3D fault model of the area both with source faults and known faults derived from geological studies, the latter acting only as receiver faults (no slip) due to FM solutions having been resolved at greater depths (Fig. 1).

Based on the studied physical mechanism, the three main findings of the study are: 1) static stress transfer is revealed as a potentially destabilizing mechanism in the sequence; 2) The East 4 structure is the one with higher probability of having been activated, should one of the mapped faults have slipped; 3) The seismic cycle concerning the Main Fault's characteristic earthquake (M_w 6.0) was not (remarkably) shortened by the experienced events.
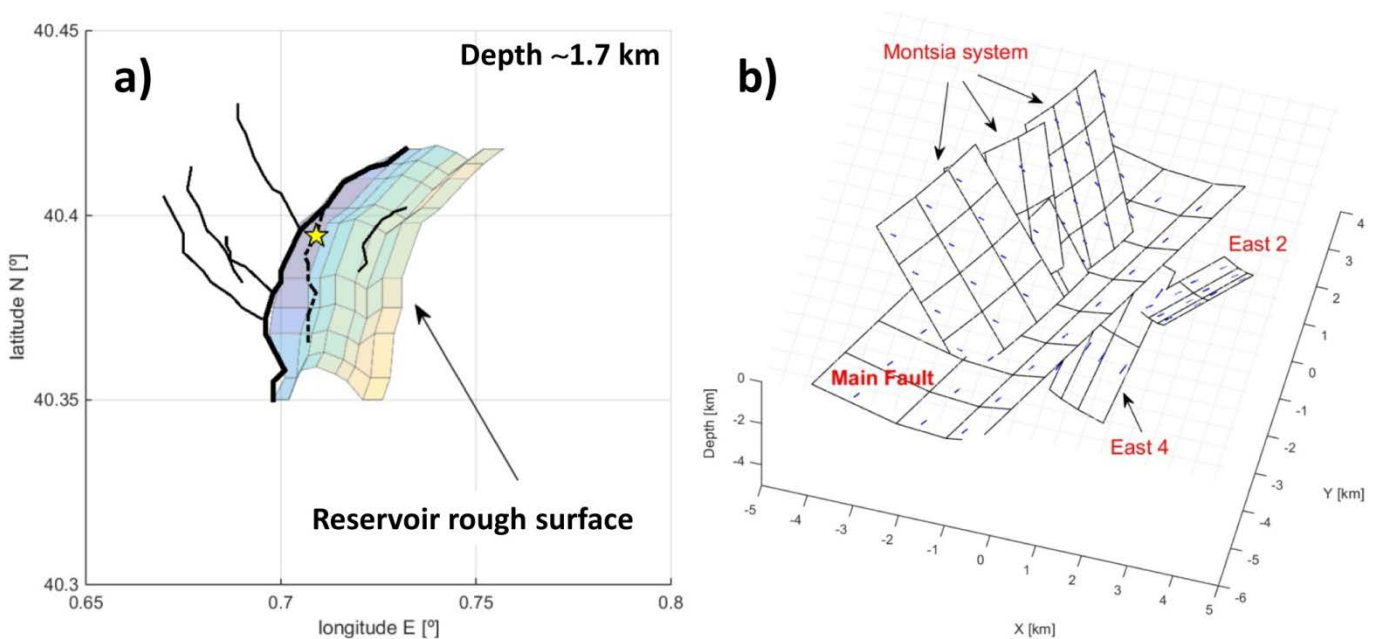

Fig. 1 a) Horizontal slice of the geometrical 3D model of known faults, near reservoir top, derived from existing references. Fault traces are shown as black lines, continuous if dipping to the west and discontinuous otherwise (East 4). The yellow star shows the UGS platform location. **b)** Fault model used in COULOMB calculations, generated using a) as an input. Just receiver (mapped faults) are shown, source faults being smaller and deeper. The Montsia system and the Main Fault reach depths near surface, while the East faults' shallowest point is about reservoir top depth.