Geometry and topology of fractures and faults affecting anticlines in the Zagros fold-and-thrust belt: a multiscale approach

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Faults and fractures play a key role in the permeability of the upper crust. Since anticlines represent very common structural traps for fluids, geometrical (i.e., orientation, length distribution) and topological (i.e., cross-cutting and abutting relationships, intensity) characterization of their fracture network is crucial to assess the migration and accumulation of fluids for CO$_2$ sequestration or hydrocarbon exploitation purposes. For this reason, many previous studies focused on anticlines worldwide, and in particular on the Zagros fold-and-thrust belt where they represent the outcropping analogs of oil fields in SW Iran.

The Zagros fold-and-thrust belt involve sediments of the pre-collisional Arabian plate passive margin, arranged in folds elongated in a NW-SE direction and tectonic transport toward SW. The belt is dissected by N-S dextral strike slip transfer faults reactivating former rift-related normal faults. Most of the studies on fracturing in the Zagros belt are based on fracture orientation data collected mainly in the field, or alternatively coming from satellite images, and deal with the origin of fracture sets (fold-related or not). Although two of the classical fold-related sets, oriented roughly parallel and perpendicular to fold axis (i.e., NW-SE and NE-SW striking respectively) can be generally recognized everywhere in the belt, other fracture orientation (e.g., N-S and E-W striking) are locally predominant and there is still no consensus on the nature of all fracture sets. For example, the role of the strike-slip reactivation of N-S and E-W striking inherited faults on fracture set distribution is still not clear.

In this study we leverage on high quality Bing Maps satellite images of the Zagros anticlines and on scanlines performed in the field to provide a multiscale investigation of geometry and topology of the fracture network affecting three anticlines, namely Sim, Kuh-e-Asmari, and Kuh-e-Sarbalesh. The three anticlines have similar dimensions and are variably affected by ~N-S striking dextral strike slip tectonic lineaments. In particular, Kuh-e-Asmari and Sim anticlines are located ~10km far from the Izeh and Sabz-Pushan faults respectively, whilst the Kuh-e-Sarbalesh anticline is characterized by an evident drag in map view against the Kazerun fault.

We manually interpreted the fracture network on satellite images at different scales (1:100 to 1:100,000), producing fracture maps with resolution ranging from 10m to 1km. Each fracture map was then analyzed using the NetworkGT plugin in QGIS. In particular, we were able to identify fracture sets, their spatial distribution and, were possible, the topology of the fracture network. In this framework, scanlines performed in the field represent punctual observations at furtherly
higher resolution (~1 cm). Following the same procedure for the three anticlines enables us to test the role of N-S faults on fracture set distribution at various scales.

With such a multiscale approach we provide a “big picture” that can help to shed light on the nature and distribution of the various fracture sets in the anticlines of the Zagros belt. Moreover, fracture sets identified at different scales in this study can be used to better interpret previous and future fracture data collected in the field.