

# Close Link Between Sedimentary Facies, Folds and Fracture Zone Distribution in the Atlantic High-Atlas (Morocco): Flows Properties in the Folded and Fractured Zones

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## Abstract

In fractured reservoirs formed in shallow crust conditions, fracture clustering is expected to have a very strong dynamic impact. The Moroccan western High-Atlas exhibits numerous folded structures related to the atlasic orogenesis where fracturing can be easily observed due to favourable mechano-stratigraphical conditions.

In the cretaceous carbonates north of Agadir, studies on the relations between folding and fracturing allowed us to present a new aspect of localisation of fracturing during the development of curvature.

The folded series are characterized by intercalations of thick soft marly units and stiff (usually thinner) mechanical units of rather grainy carbonate facies (from wackestone-packstone to coarse grainstone). The main folds are EW trending and are large scale ( $\lambda > 5$  Km) affecting the whole sedimentary pile but smaller scale secondary structures (kinks, small scale folds with meter to decameter wavelength, etc.) are numerous all over the area and generally affect a single stiff mechanical unit.

There is a good correlation between the carbonate fractions, the stiffness and the fracture density of layers at the whole negative sequence scale. The upper sub-sequences, which are also the more marly ones, are less fractured than the lower ones, which contain higher carbonate proportions.

We propose mechanical scenarios aiming to describe the main stages of formation of articulations which are narrow zones of fracture concentration forming dip domain boundaries. This takes into account the role of preexisting Jurassic and cretaceous normal faults and more recent fractures of atlasic age in curvature accommodation.

Articulations can localize on inherited structures, or have a syn-folding origin, being created as instabilities during the fold initiation, in particular through small reverse faults. In both cases, early zones of weakness localize curvature. Because they most often imply opening mode fracturing and more generally vertically persistent zones of damage concentration across the whole thickness of the folded unit, fold articulations could play a major role in the axial permeability of folded and fractured reservoirs.

Keywords: Folding, fracturing, curvature accommodation, reservoirs, High-Atlas, Atlasic orogenesis.