

## **Close Link Between Sedimentary Facies, Folds and Fracture Zone Distribution in the Atlantic High-Atlas (Morocco)**

**Mostafa Amrhar<sup>1</sup>, Hassan Ouanaimi<sup>2</sup>, Loïc Bazalgette<sup>3,4</sup>, and Jean Pierre Petit<sup>3</sup>**

<sup>1</sup> Laboratoire GEOHYD, Département de Géologie, Faculté des Sciences de Marrakech, B.P. 3502, Amerchich, Marrakech 40000, Morocco

<sup>2</sup> Département de Géologie, Ecole Normale Supérieure, B.P. S2400, Marrakech. 40000, Morocco

<sup>3</sup> GéofracNet, Laboratoire Dynamique de la Lithosphère, (UMR 5573), c.c. 060, Université Montpellier II, Place EugèneBataillon, 34095 Montpellier, cedex 5, France

<sup>4</sup> Now at Shell International Exploration and Production, Carbonate Team, Kessler Park 1, Postbus 60, 2288GS, Rijswijk, The Netherlands

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 mechanostratigraphical conditions.

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

The folded series are characterized by intercalations of thick soft marly units and stiff mechanical units of rather grainy carbonate facies. The main folds are EW trending and are large scale (>5 Km) affecting the whole sedimentary pile but smaller scale secondary structures (kinks, small scale folds) 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. Smaller-scale heterogeneities of sedimentary origin as channels or bed amalgamations have also shown a strong influence on the initiation of intensely fractured zones.

We propose mechanical scenarii aiming to describe the main stages of formation of articulations which are narrow zone of fracture concentration forming dip domain boundaries. This takes into account the role of inherited 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.

Key words: Folding, fracturing, accommodation, reservoirs, High-Atlas, Morocco.