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# 3D Geometrical and Numerical Modelling of Folding in the Taznakht Area, Morocco

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The Variscan Orogeny in the Anti-Atlas has led to a peculiar relationship between polyharmonically folded Palaeozoic sedimentary cover and its underlying Precambrian basement, which appears to be undeformed on a macroscopic scale. This is not explained by a basal decollement. Instead the Anti-Atlas appears to behave in a thick-skinned fashion, with inverted late Proterozoic to early Cambrian extensional faults uplifting basement inliers (structural domes). The folding of the Palaeozoic sediments is locally influenced by these inliers. In the central Anti-Atlas, Palaeozoic sediments show a unique folding pattern near the Zenaga inlier, with rapid lateral changes in folding amplitudes and wavelengths. This study examines how the proximity to the Zenaga inlier influences the folding style of sediments in the Taznakht area. Three major possibilities are considered: (1) unusually large thickness irregularities in sedimentary layers due to synsedimentary slump folds in the SW near the Zenaga inlier or lenticular volcanic layers (rhyolite) of the Ouarzazate Supergroup creating a palaeotopography, (2) thinning of competent sedimentary layers, such as sandstones and carbonates, towards the SW, due to an onlap geometry, and (3) a half-graben geometry in the basement with intervening accommodation space for incompetent shales, allowing the competent layers to buckle with variable intensity and wavelength.

Three different approaches are used in this study to investigate local deformation in the Taznakht area. First, field data, microstructural analysis, and illite crystallinity measurements show that deformation occurred under low-grade metamorphic conditions and that pressure solution and solution transfer are the governing deformation mechanisms in dolomite and shale units. Associated syntectonic mineral growth of fibrous chlorite in the pressure shadows of pre-existing quartz and dolomite grains produced a strong CPO, with the development of a clear slaty cleavage in the shale units. A detailed geological and structural map was made and measurements of veins, en échelon structures and fold axes were used to reconstruct the local deformation history. Second, a 3D geometrical model was developed using the Geomodeller software package provided by Intrepid Geophysiscs, to obtain a better understanding of the sub-surface and present-day geometry in the Taznakht area. Using this model, cross-sections were constructed with a SW-NE orientation to reveal variations in layer thickness and shortening on the map scale. Finally, numerical experiments were carried out to systematically investigate potential models for fold development. The finite-element method was employed to model compression and folding of a multilayer stack, with linear viscous rheology in 2D and 3D. The numerical results indicate that thinning of competent layers, as well as initial thickness irregularities of 10% of each layer thickness, can promote the development of lateral variations in fold amplitude and wavelength similar to those in the natural model. The present-day geometry could not be reproduced in detail, but the simplified numerical models demonstrate that stiff-layer thinning and large variations in layer thickness may play an important role as initial irregularities that determine the variability in the final fold geometry.