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Rheology of large-scale Zagros folding

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Understanding better fold mechanics is of particular interest in the Zagros where several giant oil and gaz fields are trapped in carbonaceous reservoir rocks. The geometry of Zagros folding is characterized, in the central Fars area, by regular wavelengths of $\sim$16 km with axial lengths sometimes up to 100 km and relief that typically reaches 1000 m (Mouthereau et al., 2007). Few available seismic reflection profiles in the Fars region helped by outcrop-scale observations show that folding is hardly linked to measurable reverse faults. Elsewhere in the ZFB, folding is variably associated to thrust ramps. Shallow thrust-related folds can be caused by an intermediate level of decoupling in the evaporitic horizon of the Miocene Gashsaran Formation. Amplification of cover folding can also locally be produced by active basement thrusting, e.g. at the mountains front. In short, with exception of the particular group of multiple-detachment folds observed in the Dezful, the most typical set of symmetric or slightly asymmetric detachment folds is located in the central Fars arc. There, thrust faults when present are secondary features. The constant wavelength and symmetry of the folds support the insignificant deformation gradient across the folded belt, which is in agreement with the regionally constant peak differential stresses value (40 $\pm$ 15 MPa), determined from analyses of calcite twinning in folded carbonate rocks. This suggests that pure-shear deformation and buckling of the sedimentary rocks is the primary mode of fold development.

These types of folds to grow require significant thickness and competency contrasts. However, these parameters are rarely been quantitatively investigated. As already noticed the observed wavelengths are hardly compatible with simple elastic or viscous models of growing buckle fold instabilities. A key observation that may resolve these issues lies on the existence of mechanical stratigraphy, which defines a vertical rheological layering of the sediment cover. Indeed, the presence of intermediate weaker horizons of variable thicknesses, e.g. the Trias-Permian evaporitic layers (Dashtak, Kangan, Dalan or Faraghan Fms), the upper Jurassic evaporitic Hith Formation or the upper Cretaceous Kazhdumi shales together act to reduce the effective viscosity of the sediment cover. A more sophisticated set of visco-elasto-plastic numerical models (Yamato et al., submitted) found that the simple addition of these weak layers is sufficient to build the observed fold-dominated instead of fault-dominated style of deformation.

Cited references :

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