Accretionary wedge dynamics: A numerical approach

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Subduction accretion is a viable mechanism that adds material to the front of a convergent margin by thrusting and stacking sediment on the subducting plate. Accretionary wedges have been the focus of many investigations because they provide key information on sediment deformation in a (submarine) tectonically active environment. Because most of the modern accretionary wedges are not exposed on land (Barbados, Costa Rica, Nankai, Gulf of Cadiz, Eastern Mediterranean), their large-scale characteristics are interpreted from seismic profiles (e.g. *Grando and McClay*, 2007), and their bulk behaviour and growth is commonly simulated in analogue experiments (e.g. *Smit et al.*, 2003). Based on a wealth of data, much from Deep Sea Drilling, we know that accretionary wedges lay over a major décollement. Off-scraping removes material from the subducting plate and the wedge grows both vertically and horizontally by addition of oceanic sediment and shallow crustal material.

An important characteristic of accretionary wedges is the contemporaneous activity of deformation and sedimentation, which leads to the formation of growth structures (Fig. 1).

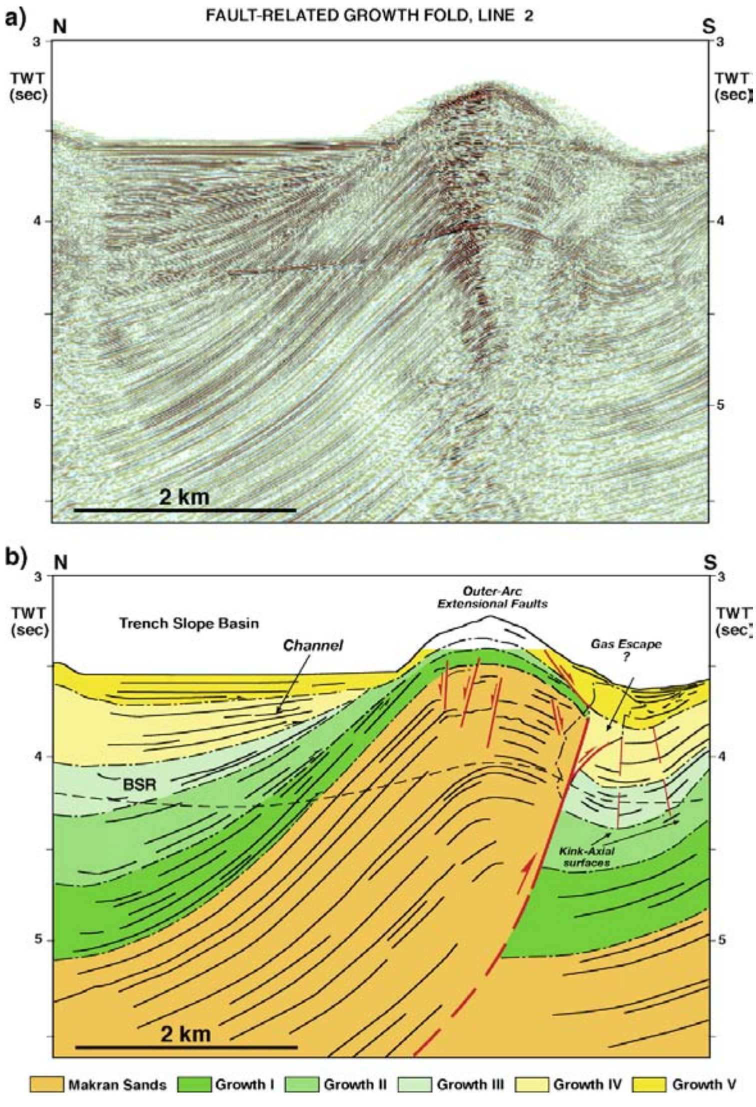

Fig. 1 Interpreted seismic profile of an imbricated fan segment offshore Makran from Grando and McClay (2007) indicating progressive unconformity development on the back limb of growing fault-propagation folds.

One of the biggest and still active accretionary complexes is the Makran, SE Iran, situated in the zone of convergence active since at least the Late Cretaceous between the Arabian and Eurasian plates. The essentially Eocene–Holocene wedge results from the still on-going subduction of the oceanic lithosphere flooring the Gulf of Oman. A north-dipping thrust near the present shoreline separates an active and frontal southern half from a less active northern half. Water provided by dewatering of the accreting sediments apparently lubricates the basal décollement and the major thrusts between imbricate thrust sheets in the accretionary wedge.

The influence of surface processes on thrust wedges has drawn increasing attention only during recent years: Experimental studies have tested the effects of syntectonic erosion and sedimentation on the mass distribution in the wedge and thus its geometry and evolution (e.g. *Barrier et al.*, 2002). However, these models do not satisfactorily explain the geometries of growth strata cropping out in Makran, their relation to thrusting, and the influence growing structures exert on wedge dynamics. Indeed, most current models of thrust wedges are derived from purely frictional experimental studies in which syntectonic erosion and sedimentation are included either as a predefined temporal or continuous mass redistribution or as a static system of evolving thrusts and growing folds.

Fieldwork on the Iranian Makran led us to identify several types of growth structures in the Miocene-Pliocene sequences, documenting complex relationships between sedimentation and the development of thrusts and related folds. From our field observations we noticed that these growth structures and the related thrusts and folds are also not satisfactorily explained by existing numerical models.

We present results of new numerical models in which we test the influence of erosion and sedimentation in thrust wedges and the interplay between thrusts, folds and growth strata both at wedge scales and at the scale of single structures (Fig. 2). We use a visco-elastoplastic finite element code to simultaneously take the brittle overburden and the ductile substratum into account, which in the Makran is formed by shale-rich (at least initially) water-saturated olistostromes and other comparably soft units like marls.

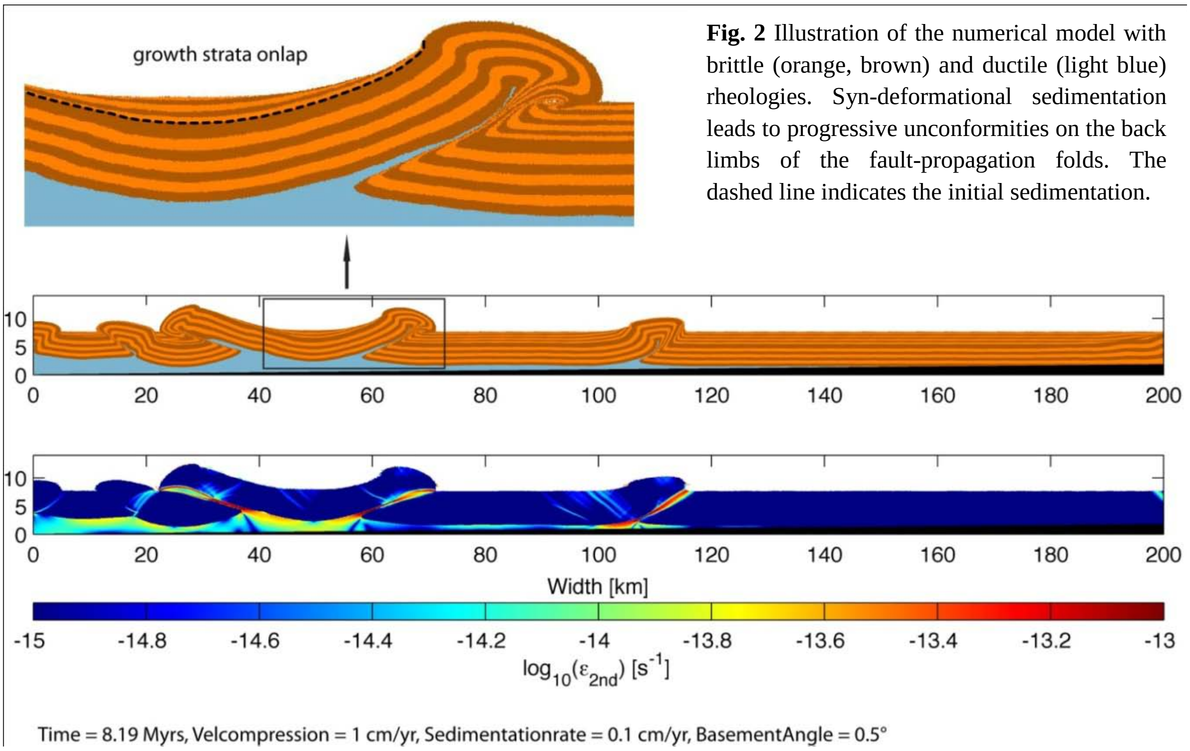

Fig. 2 Illustration of the numerical model with brittle (orange, brown) and ductile (light blue) rheologies. Syn-deformational sedimentation leads to progressive unconformities on the back limbs of the fault-propagation folds. The dashed line indicates the initial sedimentation.

<u>References</u>

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