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Analogue modeling of the kinematic evolution of fold-and-thrust belts under various syntectonic sedimentation rates, shallow *décollement* properties and basement inherited structure configurations

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Introduction

Structural deformation of fold-and-thrust belts is influenced by the properties of *décollements* (number, rheology, thickness, etc.), the presence of inherited structures in the basement as well as the amount of syntectonic sedimentation, among others. Although the effect of each of these parameters has been well constrained with a series of numerical and experimental works in the literature, few sandbox models consider all these parameters together, and particularly investigate the effect of their lateral variation.

To gain insight on this issue, we carried out several 3-D sandbox models and investigated the effect of increasing syntectonic sedimentation rate on the kinematic evolution of fold-and-thrust systems. Models contain a basal brittle detachment layer and a shallow detachment layer that changed from a brittle to a viscous domain along the model strike. The effect of basement high and syntectonic sedimentation are also considered meanwhile. Model results are compared with field data from the Wushi-Kuqa fold-and-thrust belt (FTB) in Southern Tianshan, Tarim basin, Central Asia.

Natural example

The Wushi-Kuqa is one of the south-vergent FTBs that developed in the southern Tian Shan orogen, within the Tarim basin (Fig. 1). The Wushi (W) and Kuqa (E) FTBs are separated by the Kalayuergun right-lateral strike-slip fault. According to geological maps and drilling data, the shallow *décollement* involved in the deformation of both FTBs changes laterally in rheological properties. The Neogene Jidike mudstones in the Wushi FTB (W) are considered as frictional, whereas the Paleogene evaporites in the Kuqa FTB (E) are viscous. This leads to different deformation styles along the strike, single fault and fold to the W, and salt nappe and folds to the E.

In both FTB, two basement high structures, the Wensu (to the W) and Xiqiu (to the E) basement high, have been interpreted from seismic profiles and affected the *décollement* continuity and thickness (Fig. 1.c). Thus, the Jidike mudstones in the Wushi FTB decreases in thickness toward the south (Line-1, Fig. 1.c). In the Kuqa FTB, the Xiqiu basement high is closer to the mountain front to the west than to the east. Its arcuate shape is likely responsible for the similar shape of the Qiulitage belt (Line-2 and 3, Fig. 1.c).

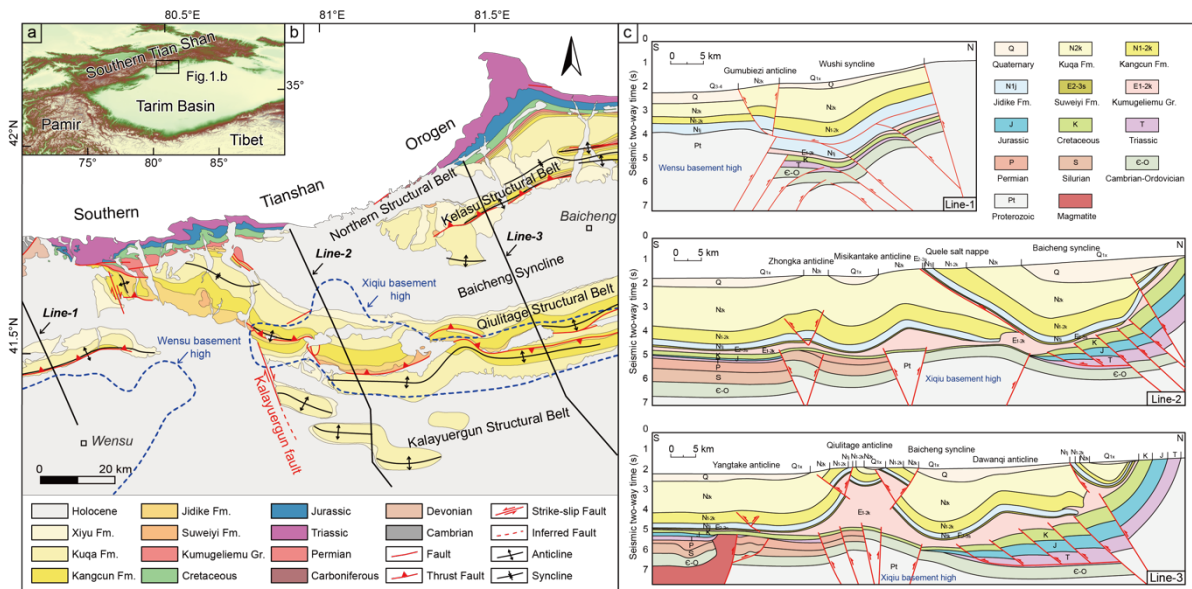


Figure 1: (a) Location of the Wushi-Kuqa FTB; (b) Geological map of the Wushi-Kuqa FTB; (c) Cross-sections in Wushi-Kuqa FTB.

Analogue modeling approach

We set up two series of experimental models at Lille University, France, to test the influence of syntectonic sedimentation rate magnitude and basement high configuration on FTB development. In Series 1, we test variable syntectonic sedimentation rates, including low (0.3 mm/h), medium (0.6 mm/h) and high (0.9 mm/h) rates. Then we combined basement high and syntectonic sedimentation together in Series 2, and we particularly tested the along-strike change in the width of the basement high.

The experimental models were typically made up of three materials that simulate different lithologies of rocks, including: (1) quartz sand, simulating the frictional behavior of brittle sedimentary rocks, (2) glass microbeads, simulating frictional brittle *décollement* and (3) silicone, simulating a viscous *décollement*, like salt layers.

Modeling results and conclusion

Modeling results of Series 1 show that the rate of syntectonic sedimentation exerts a first-order control on the kinematic evolution of fold-and-thrust belts which concentrates deformation along the mountain front and delays the propagation of both deep and shallow deformation in the brittle and viscous domains.

Modeling results of Series 2 (Fig. 2), indicate that: (1) syntectonic sedimentation reduced the number of fore-thrusts that nucleate between the basement high and the hinterland, in the viscous domain, and reduced the shallow thrust in the brittle domain; (2) basement high controlled the deformation process and distribution of deformation

only in the viscous domain. Besides, modeling results can be used to explain salt-influenced deformations on the Xiqiu basement high and in Wushi-Kuqa FTB, which shows that Xiqiu basement high acts as a weak stress zone in the deformation process resulting in localized deformation in the Qiulitage structural belt.

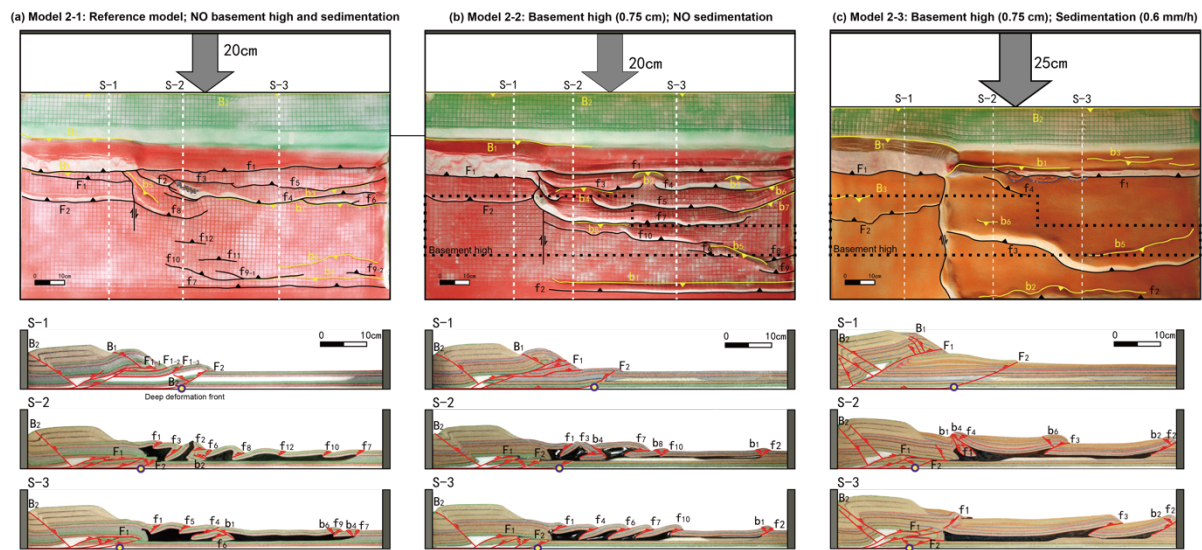


Figure 2: Modeling results of Series 2. (a) Reference model: Model 2-1; (b) Model 2-2 with basement high; (c) Model 2-3 with basement high and sedimentation.

Keywords

Syntectonic sedimentation, *décollement* properties, basement high, salt structure