PERGAMON

Journal of Structural Geology 21 (1999) 689–690

JOURNAL OF STRUCTURAL GEOLOGY

Kinematics of large scale tip line folds from the High Atlas thrust belt, Morocco: Discussion

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Received 14 November 1998; accepted 22 February 1999

Saint Bezar et al. (1998) describe two large scale thrust tip folds in the High Atlas thrust belt, in Morocco, and propose a kinematic forward model for their evolution. The authors describe a large recumbent syncline at the front of the Jebel Ta'bbast anticline as a puzzling structure, and propose a 'caterpillar' delamination model for its development.

We do not question the kinematic model they propose which, as the authors say, is consistent with the field data but it is not unique. We emphasize how the presence of recumbent synclines at the front of thrust-related anticlines may provide a key feature to infer the kinematic mechanism of folding, rather than being a puzzling feature.

Regionally sized recumbent folds have been described in many thrust–fold belts such as the Apennines (e.g. Storti and Salvini, 1996), the external Alps (e.g. Rowan, 1993), the Montana thrust belt (e.g. Boyer, 1986), and the Eastern Subbetic Zone of southern Spain (e.g. Allerton, 1994). Storti and Salvini (1996) proposed the progressive rollover fault-propagation folding model, to account for the presence of recumbent folds in foreland belts (Fig. 1a). In this model, line length and area balancing are coupled with mechanical constraints to simulate development of thrust-tip folds at very shallow crustal levels, where tectonic and surface processes interact directly. Recumbent folds develop when the ratio between tectonic uplift rate and syntectonic sedimentation rate (*U*/*S* ratio in Storti and Salvini, 1996) is greater than 1, causing the mechanical instability of the forelimb of overturned, thrust-related anticlines (both fault-propagation and décollement anticlines).

We agree with Saint Bezar et al. (1998) that fault-propagation folding (Suppe and Medwedeff, 1984) provides a suitable kinematics to explain the evolution of the Jebel Ta'bbast and Tadighoust anticlines. However, the presence of a large recumbent syncline at the front of the Jebel Ta'bbast anticline may provide an additional constraint to support the progressive rollover kinematics. To test this hypothesis, we have

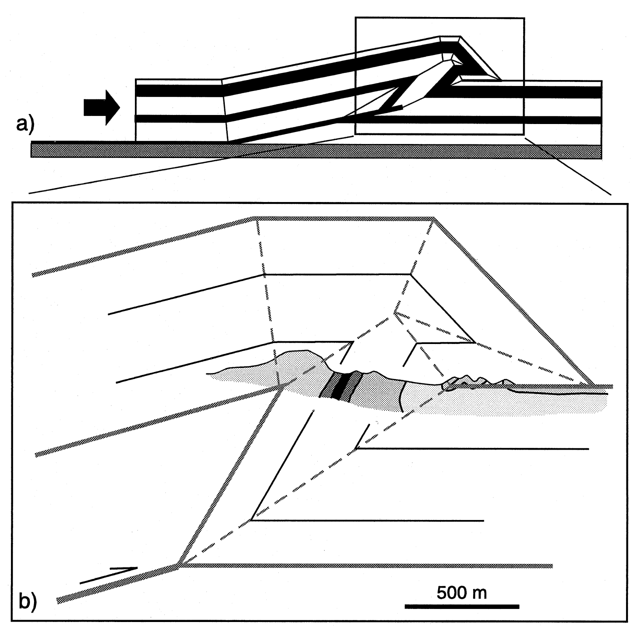

Fig. 1. (a) Geometric model of a progressive rollover fault-propagation anticline (after Storti and Salvini, 1996). (b) Application of progressive rollover fault-propagation folding to the Jebel Ta'bbast anticline (cross-section after Saint Bezar et al., 1998). A detail of the crestal region of the fold is illustrated.

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PII: S0191-8141(99)00087-5

applied the progressive rollover fault-propagation folding model to the Jebel Ta'bbast anticline using dip domain and displacement data in fig. 5 of Saint Bezar et al. (1998) (Fig. 1b). The model optimally fits field data for a step up angle of 15° and predicts the presence of a recumbent syncline at the front of the Jebel Ta'bbast anticline. The triangular shape of the recumbent rock panel implies the upward decrease of the recumbent limb length.

In conclusion, we suggest that the use of the progressive rollover kinematics may provide a further improvement in the forward modelling process of Saint Bezar et al. (1998) by predicting the presence of the large recumbent syncline at the front of the Jebel Ta'bbast anticline. In progressive rollover fault-propagation folding, a recumbent syncline develops from the onset of deformation as part of the thrust-tip folding process, and provides the necessary mechanical stability to the structure.

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