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The coupling between tectonic deformation and surface processes in thrust-related anticlines: The Montsec Thrust, Spanish Pyrenees

A.L., Whitchurch, P.A., Allen and A.C., Whittaker

Department of Earth Science and Engineering, Imperial College London, South Kensington, London SW7 2AZ, UK (amy.whitchurch02@imperial.ac.uk)

Advances in our understanding of the coupling between tectonics and surface processes has generated a number of modelling techniques to improve upon the structural and associated stratigraphic predictions of traditional fault-bend fold models. Erslev (1991) introduced the Trishear model, successfully reproducing fault propagation folds with smooth profiles and rounded hinges. Ellis and Densmore (2006) incorporate the influence of surface erosion on blind thrust evolution, with results suggesting that landscape development is controlled primarily by the competition between the geometry of the underlying thrust and base-levels flanking the emerging range. At present, the richness of the coupling between tectonics, erosion and sediment routing demonstrated by numerical models is not matched by the observational database. We aim to address this deficit in our understanding by comparing detailed field data from the Spanish Pyrenees with model predictions.

The Montsec anticline combines excellent exposure with comprehensive bio/magnetostratigraphic time constraints. Analysis of key stratigraphic units developed within the forelimb and backlimb of the structure allow reconstruction of topographic evolution in association with basin development, and reveal: 1) Maastrichtian sandstones, marking the first basin deposits, thicken basinward along the backlimb, yet are absent in the forelimb with onset of deposition here marked by Palaeocene units. This is indicative of an asymmetric distribution of accommodation during fault initiation, *ca.* 65 Ma, and later generation of forelimb subsidence;

2) Upper Palaeocene – Lower Eocene Units exhibit reworking of the Mesozoic succession and are themselves reworked into overlying deposits along the forelimb. In contrast, Palaeocene deposits pass via finely laminated sandstones into cyclical limestones along the forelimb with an absence of conglomeratic deposition. Clearly the Montsec existed as a bathymetric high *ca.* 58 Ma with steeper topography along its forelimb compared to its backlimb at this time; 3) Palaeocene – Eocene units, comparatively much thinner in the immediate forelimb than the backlimb, are thrust vertically in the footwall and pass into a small syncline indicating amplification of Montsec deformation *ca.* 60-55 Ma.

These key field observations are successfully reproduced by the Ellis and Densmore model of blind thrust evolution, which predicts initial asymmetric subsidence focused in the backlimb and the generation of tectonic topography in a sense opposite to that of the verging fault, reversing with fault propagation. Such features are shown to be associated with deep (>4 km), shallowly dipping faults (<45˚). Interestingly, these features are successfully reproduced without the need for significant crustal loading and foreland flexure. The Erslev Trishear model successfully predicts observations of tectonically thinned, steep forelimb strata folded into an anticline but cannot reproduce our observations of backlimb topographic evolution. Our results demonstrate that surface processes play a crucial role in the evolution of thrust-related topography and are closely coupled to tectonics.

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