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The Implications of Detachment Unit Deformation on Fold and Thrust Belt Evolution: Examples from the Deepwater Niger Delta

Dominic Maloney*[1], Richard Davies[1], Jonathan Imber[1], Simon Higgins[2] and Steve King[3]

[1]Department of Earth Sciences, Durham University, Science Labs, Durham, DH1 3LE, United Kingdom
[2]Forusbeen 50, N-4035 Stavanger, Norway
[3]BG Group plc, Thames Valley Park, Reading, Berkshire, RG6 1PT, United Kingdom
*Corresponding author, email address: d.p.maloney@durham.ac.uk

Kinematic models for fault propagation, fault bend, and detachment folding have long been applied to deepwater fold and thrust belts. The geometry and kinematics of these structures are well understood and hence are regularly used to constrain the various thin-skinned mechanisms of fold growth within an overlying cover sequence. In contract, basal detachment units have received little attention primarily due poor resolution issues highlighted in seismic reflection data. As a consequence the role played by a basal detachment unit in accommodating strain and controlling deformation styles remains poorly constrained. It is possible that some of the deformation observed within an overlying cover sequence is controlled by an entirely separate phase of deformation that occurs within a basal detachment unit which is unrelated to shortening mechanisms in the overburden.

The basal detachment unit of the Niger Delta is composed marine, 'mobile' shales, known as the Akata Formation. 2D and 3D seismic reflection data used in conjunction with interval velocities identify the Akata shale by a lack of reflectivity coupled with an inversion in acoustic velocities that occurs at the top of the Formation. This indicates that the Akata shale is mechanically weak and overpressured. We consider the processes that occur within the Akata shale with the aim of providing alternative hypotheses forwards the nature of deformation that occurs in this typically poorly seismically imaged succession.

We present 2D and 3D seismic reflection data from the contractional domain of the Niger Delta to image growth, and/or stratal packages that document deformation in a basal detachment unit. This deformation continues later, or occurs post-faulting, with respect to shortening mechanisms in the overburden. Older growth packages record the kinematic development of fold and thrust structures and younger growth, or stratal packages, record a later phase of deformation manifest in the overburden which is driven by deformation within the underlying Akata shale. We document two examples involving a late stage of detachment unit deformation. Firstly, a post-kinematic redistribution of shale leading to tilting of the fold and thrust belt coupled with formation of a shale weld; and secondly, amplification of a large detachment fold which continued to grow after the main episode of contractional faulting.

Insights into the internal deformation mechanisms that may occur within detachment units can be derived from the rate that shale deforms (moves). Weld formation was instantaneous with respect to the rate of sedimentation and ~160 km^3 of shale moved. In contrast, detachment fold growth occurred over a time interval of 4 to 5 million years and ~590 km^3 of shale moved We put forward that the so called ‘mobile shale’ does not deform solely by ductile failure mechanisms as traditional interpretations on shale tectonic provinces have previously suggested, but in fact, also deforms in a brittle manner. The identification of two discrete, separate deformation episodes using growth and stratal packages has important implications for types, integrity and timing of hydrocarbon traps within contractional petroleum plays.