

Coupling of Thrusting and Shale Detachment within the Thrust-Related Intraslope Minibasins: New Insights Into Gravity-Driven Structural Styles in the Deep-Water Niger Delta

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Abstract

Compared to the extensive studies on traditional salt-withdrawn intraslope minibasins, the thrust-related intraslope minibasins are still poorly studied. The deep-water Niger Delta Basin is a classical shale tectonic province where prominent fold-thrust belts are largely developed above the basal overpressured shales as a result of the regional gravity detachment, forming a series of thrust-related minibasins near the seabed. This paper focuses on the minibasins at tectonic translational zone of the Niger slope where thrusting and shale detachment coexisted with some special structural styles generated. High-quality 3-D seismic dataset (~70 Hz) and well data are integrated to characterize static structural styles of the studied minibasins. Dynamic evolution process is further revealed through detailed mapping of sequence stratigraphy (8 sequences) within the syn-growth strata interval. Eventually, the forming mechanism is discussed in respects of thrusting activity and shale deformation. Results show that both strike-oriented thrust-propagation fold and dip-oriented detachment fold (DODF) are developed in the tectonic translational zone, which collectively confine the distribution of piggy-back minibasins. The DODF, featuring dip-oriented shale-thickening cores at the basal detachment unit, is a newly found structural style that distinguishes from the traditional strike-oriented detachment fold and cannot be explained by the regional gravity-driven compressive stress along slope. According to the spatial distribution of syn-growth

sequences, such DODF had developed throughout the evolution of minibasins with continuously changed morphology and scale, indicative of continuous activity of shale detachment as the slope-parallel thrusting happened at the same time. The varied syn-growth sequence architecture implies three tectonic stages: 1) coupling stage of thrusting and shale detachment when both tectonic mechanisms are strongly active and the DODF rotated asymmetrically. 2) continued shale detachment stage when thrusting activity weakened greatly with the DODF uplifting apparently, and 3) weak shale detachment stage when thrusting activity ceased with slightly uplifted DODF. Deep analysis suggests that differential thrusting activity between laterally adjacent fold-thrust belts could generate dip-oriented shear stress that may have triggered the formation of the DODF, and subsequent shale detachment process induced by differential loading had caused the DODF to rotate and uplift asymmetrically. Both brittle and ductile deformation are evidenced to have coexisted within the shale core as it thickened gradually. This study provides new insights into the structural styles within the poorly studied tectonic translational zone and helps to explain the origin of the shale-cored thrust fold identified by Maloney et al. (2010) at neighboring area.