

Depositional architecture of the Quaternary succession in the southern Song Hong-Yinggehai Basin, offshore Vietnam: a seismostratigraphic and sequence stratigraphic approach

ABSTRACT

The Song Hong-Yinggehai Basin lies below the Gulf of Tonkin and is a pull apart basin that developed across the continental shelf of Vietnam and China between fault splaying off from the Red River Fault. The basin fill, 15–17 km thick, spans the Eocene–Holocene and contains gas reserves in both clastic and fractured basement-rock reservoirs. By integrating 2-D seismic reflection profiles, together with sediment cores, wireline log data and biostratigraphic constraints, the stratigraphic evolution of the Quaternary succession in the southern Song Hong-Yinggehai Basin, offshore Vietnam, is interpreted here for the first time through the seismostratigraphic and sequence stratigraphic approach. The studied succession, 1.85 km thick, onlaps onto the top-Pliocene unconformity (1.93 My), and reveals the shelf-platform to shelf-slope morphology.

Twenty-five erosional unconformities and their correlative conformity surfaces, together with the modern seabed surface, were mapped in the shelf topset and traced out basinwards into the shelf-margin clinoform toes. Sixteen biostratigraphically-constrained unconformities were identified in the lower Pleistocene deposits within an interval spanning 1.93–0.739 My and bound to the CNPL7, CNPL8, CNPL9 and lower CNPL10 calcareous nannofossils subbiozones. Nine seismic facies recognized in the study area record the occurrence of fluvial to shallow-marine transition in the muddy coastal plain (SF1), muddy shelf (SF2), shelf deltas (SF3), shelf-margin slope (SF4), incised-shelf valley fills (SF5), mass-flow deposits (SF6), deep-marine condensed mudstones (SF7), shallow-gas migration zones (SF8), and mud diapirs (SF9). Two main types of clinoforms were recognized in the seismic record, based on their scale and location. The shallow-water deltaic clinoforms are 20–115 m high and up to 2.37° in inclination. They tend to be scoured at top and pass distally into the shelf sediments. The shelf-margin clinoforms (SF4) are 200–649 m high and 2.86°–9.48° in inclination. They are commonly sigmoidal in

shape and show shelf-edge deltas grading basinwards into mass-flow deposits and basin-plain mudstones. Twenty-five 4th-order depositional sequences were distinguished and used for tracking the paleogeographic evolution of the Quaternary succession. The sequences are interpreted as the outcome of 4th-order sea-level fluctuations superposed on a high sediment flux (mean sediment accumulation 0.09 cm/a).

The shelf-topset to deep-water shelf-slope and basin-plain morphology is interpreted as the depositional product of sediment piling-up governed mainly by the basinward decreasing near-bed shear stress. The studied succession displays a concave-up, basinward-rising shelf-edge trajectory showing breaks, which define four stages in the shelf-margin growth. Stage 1 reflects vigorous progradation and little aggradation of the margin, while stages 2–4 record increased aggradational component associated with the enlargement and steepening of the slopes that extended downdip to bathyal depths. The slope steepening is thought to reflect the increased sediment storage on the shelf topset probably due to the increased amplitude of successive glacioeustatic rises superposed on a very high sediment delivery. Once established at ca. 1.1 My, the deep-water shelf margin had prograded for some 70 km axially towards the southeast until it reached its present-day position. The calculated progradation rate (<43 km/My) and average progradation/aggradation rate (103) are consistent with those known from moderately deep-water (<1000 m) margins associated with the common occurrence of slope and basin-floor mass-flow sands. Seismic evidence indicates sediment sources associated with both the longitudinal dispersal along the Red River trend and the lateral delivery by deltas sourced to the NE in the periodically emerged Hainan Island shelf and to the W in the Vietnamese mainland. The lateral delivery was augmented during forced regressions and lowstands when the basin assumed an embayed-coast configuration. Such proximity of source areas ensured copious sediment influx required to support the constant shelf-margin progradation. Seismic reflection evidence indicates also that the thick accumulations of sediment-gravity flow deposits tend to develop on the slopes and beyond of clinoforms that are ≥ 200 m in height and over 5.5 km in the downdip extent. These values may have some predictive significance in the hydrocarbon exploration focused on searching of deep-water sands in similar successions.