A New Tectonostratigraphic Model For The Evolution Of The South China Sea

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The present configuration of the South China Sea (SCS) is the result of a complex succession of tectonic processes involving rifting, subduction and collision phases (see Pubellier et al., 2014). Magnetic anomaly data suggest that the opening of the SCS occurred from North to South in several phases between 32 Ma and 15.5 Ma (Fig. 1). A major collisional episode along the NW Borneo margin took place around the Mid-Miocene and is recorded onshore and offshore by a succession of major unconformities of similar age to the regional Mid-Miocene Unconformity (MMU).

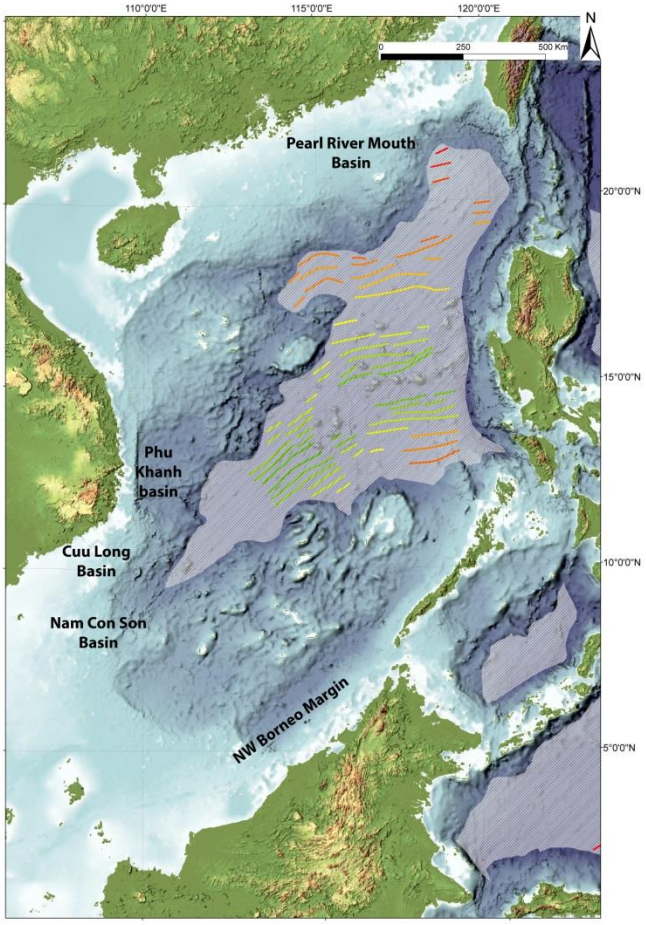

Figure 1: Bathymetric map of the South China Sea. Oceanic crust is shaded and magnetic anomalies (from Briais et al., 1993) are shown in colour (green for the youngest magnetic anomaly and red for the oldest magnetic anomaly).

We have used seismic reflection and well data along the Vietnamese margin of the SCS (Phu Khanh and Nam Con Son basins) as well as published data along the southern and eastern margins of the SCS to design a new tectonostratigraphic model of the region. Five seismic stratigraphic megasequences and bounding unconformities have been identified on the Vietnamese side of the SCS and interpreted in terms of depositional environments (Fig. 2). Each of these seismic

stratigraphic intervals records a tectonic phase related to the opening of the SCS and is not related to collisional events recorded along the NW Borneo margin.

The first unit (M0) identified above the acoustic basement is characterised by discontinuous, low-amplitudes seismic reflections associated with intrusions or by relatively continuous and folded reflections. This unit has not been drilled as far as we are aware but clearly pre-dates the main rifting phase, which is characterised by relatively rare horsts and half grabens filled by sediments with typical synrift geometries (M1). Unit M1 has been drilled in the Nam Con Son Basin where Late Eocene to Early Oligocene lacustrine sediments have been intersected. Similar lacustrine settings are the primary source for oil and gas accumulations in the Cuu Long and Pearl River Mouth basins. The overlying M2 unit onlaps previous topographies and is characterised by faulted yet relatively parallel seismic reflections that are truncated by a regional unconformity often interpreted as the MMU. M2 has never been drilled in the Phu Khanh Basin but is characterised by coastal plain sandstone, mudstone and coal of the Oligocene Cau and Early to Middle Miocene Dua formations in the Nam Con Son Basin. Comparable shallow environments are described in the northern part of the SCS (Pearl River Mouth basin) but their age is restricted to the Oligocene suggesting that the unconformity at the top of M2 propagates from North to South and is not a synchronous Mid-Miocene event as suggested by the name of the MMU. We interpret the M2 unit as a sag basin precursor to the final marine inundation, the unconformity at the top representing the propagating break-up unconformity. Unit M3 corresponds to the depositional counterpart of the break-up unconformity and is only observed in small basins preserved from erosion. M4 is deposited after the SCS break-up and is characterised by a carbonate ramp facies followed by shelf progradation and major sediment transfers from the uplifted periphery of the SCS to the central subsiding area.

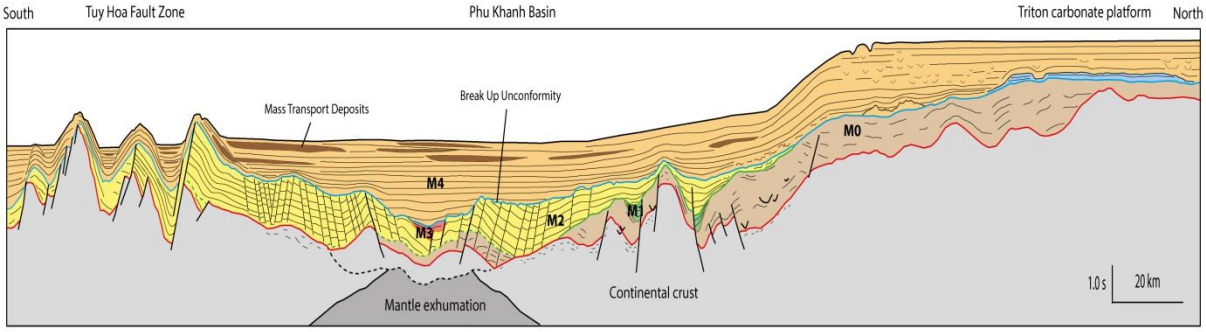

Figure 2: Cross section across the Phu Khanh Basin showing the five tectonostratigraphic units M0 to M4.

This tectonostratigraphic model involving a sag phase (M2) that postdates the main rifting phase and predates the propagating break-up of the SCS, explains several critical observations similar to those intensely debated in Atlantic-type passive margins (Aslanian et al., 2009; Unternehr et al., 2010): 1/ the presence of a thick shallow marine sequence (M2) overlying thinned continental crust, 2/ the diachronous nature of the break-up unconformity, 3/ the rare occurrence of high-angle faults and well-defined tilted blocks in seismic sections and 4/ mantle exhumation observed in the Phu Khanh Basin. Finally, this tectonostratigraphic model opens new perspectives for the hydrocarbon exploration of the SCS. The interpretation of the timing and depositional setting of the megasequences permits improved understanding of hydrocarbon plays, their risks and uncertainties and enables a systematic assessment of future potential utilising play-based exploration methods.

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