Stress domains in the Sarawak and NW Sabah basins

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At the northern side of Borneo from the Lupar suture in the west towards the Balabac fault off northern Sabah, the Tertiary structural grain swings in broad waves from ESE becoming NE (Fig. 1). Northwesterly faults and sutures clearly control and at certain places drastically alter the regional flow of strike-change. Such changes occur in Brunei by the northerly trending Belait belt (6) and the Jerudong-Morris fault (5). In central Sarawak, the Dulit triangle is a distinct kink in the structural trendlines. The triangular outline probably developed through detachment of the upper Neogene strata from the underlying older rock mass along the mobile Setap shale interval combined with "frame-folding" provided by the major faults Tinjar (7), Dengan (8) and Tubau (9). In Sabah the Mulu Shear (4) seems associated with sharp bends of structures striking NE into easterly directions. In central Sabah, arcuate structural strikes centre about the Trusmadi Range. The nature of this Trusmadi centre is not known.

Borehole breakout data, published and unpublished structural information of onshore outcrops and from offshore hydrocarbon exploration, and newly interpreted radar images were integrated to determine the stress domains of the Sarawak and NW Sabah basins, and that of the Baram delta petroleum province. The stress trajectories were determined to strike normal to reverse faults and general fold trends, and/or were compatible with the pattern of wrench-fault movements. The stratigraphy of the region indicates strong tectonic disturbance in late Early Miocene through early Middle Miocene. Possible changes in stress domains were examined by separating pre-Mid Miocene structures from those of younger geological age. In the Sarawak basin the pre-Mid Miocene structures are those in the post-Rajang group through Cycle I/II sequences; in Sabah this older group of strata are pre-Stage IV sedimentary rocks.

The pre-Mid Miocene stress domains of the region consist of four compression axes: NW, North, NNE, and ENE (Fig. 2). The domain boundaries mainly follow recognised limits or major faults illustrated in recent publications with several notable exceptions. Roughly along 112°30' E. longitude the Balingian province is separated into an western stress domain characterised by N-S compression and eastern stress domain with NW-SE compression. The SEATAR Crustal Transect VII that incorporates this part of Sarawak has also shown evidence for both compression orientations. No published explanation is available. N-S compression also dominates an area marked by Kidurung in the Tinjar province. The N-S compression in this Kidurung "enclave" could be associated with sinistral wrenching on the NE-SW Anau-Nyalau fault striking parallel to the coast line. The ENE compression in the eastern Baram delta is roughly normal to the compression axes in the rest of the delta province (Fig. 2). Tentatively, the ENE compression in the eastern Baram is interpreted as an expression of a stress field induced by growth-faulting towards NNW at the delta foot. It should be noted that this non-tectonic structural event occurred in post-Mid Miocene. The fourth anomalous stress domain is off northwestern Sabah. The stress trajectories in that domain is based on the pattern of wrench-fault senses in the offshore and are also normal to the east-west structural grain onshore. All its boundaries seem to be major faults.

The post-Mid Miocene stress domains are fewer in number. In the SW Luconia province from west to east, compression orientation changes from NW to N (Fig. 3). In the Tatau Half-graben province, NW compression seems to change into NE orientation. A possible explanation is that the NE compression resulted from sinistral strike-slip on the SW Luconia - Mukah line. Another anomalous stress domain is the northern part of the eastern Baram Delta, where NE-SW compression is approximately perpendicular to compression directions in the rest of the province. Apparently, growth-faulting at the delta foot towards north altered the principal stress orientations in the eastern Baram, where as result, the regional NW maximum stress axis and NE minimum stress axis exchanged orientations. The area to the west of the Kudat peninsula that contain pre-Mid Miocene anomalous stress trajectories has now been subjected to NW-SE compression as indicated by the orientation of the thrust fault bordering the so called "Lower Tertiary Thrust Sheet".

Detailed, repeated GPS measurements (3 stations on Borneo island: Brunei; Tanjung Bajau, W. Kalimantan; Batu Baja, S. Kalimantan) show that the island and adjacent offshore areas belong to the Sunda Block and is moving at 20 mm/yr NE-ward with respect to the Eurasian Plate. No obvious relationship is indicated to the fragmented appearance of stress domains of the Sarawak and Sabah basins. This implies complex origins probably associated with accreted terranes, influence of older structures, major fault movements, diapiric mass emplacements, and non-tectonic events. Refinement of stress domain characteristics should prove useful in planning deviated wells and contribute to a better understanding of structuration scenarios.