Unveiling New Insights: Pre-Tertiary Tectonic Evolution and New Paleozoic-Mesozoic Intervals of the Penyu Basin and Arong Graben, Malaysia

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Abstract

A better understanding of the Pre-Tertiary interval and possible tectonic evolution during the Paleozoic-Mesozoic in the Penyu Basin and Arong Graben, Malaysia is proposed, partly for optimising the integration studies across offshore and onshore using geological and geophysical analysis. Field investigation, offshore key wells and reports, and seismic data coupled with U-Pb absolute dating analysis on the carbonates and siliciclastic rock samples from onshore Peninsular Malaysia and Mesozoic core and cuttings samples from offshore lead to interpretations of occurrences and distributions of Pre-Tertiary intervals within the study areas.

Considering the possible southward extension of the Sukhothai Back Arc basin into Peninsular Malaysia from previous work and the recent discovery of the back-arc suture zone across Penyu Basin from present work, four new conceptual models of Pre-Tertiary evolution and new stratigraphic interval for Penyu Basin are proposed: Back-Arc Opening during Carboniferous, Back-Arc Collapse during Permian, Main Collisional Event during Late Triassic, and Regional Continental Deposits during Jurassic-Cretaceous. These significant tectonic events during Paleozoic-Mesozoic are validated with the results obtained from U-Pb dating and observed seismic lines across the study areas. Late Triassic to Early Cretaceous and Early Jurassic to Middle Jurassic ages are assigned to the onshore siliciclastic and offshore well-cuttings of Rhu-3, Ara-1, and Janglau-1, respectively. Early Carboniferous to Late Triassic and Early Jurassic to Early Cretaceous ages are suggested for the carbonate occurrences in onshore Pahang-Johor areas and offshore Pari-1 core samples, respectively. The observed eastward thinning of carbonate deposits and westward thinning of Jurassic-Cretaceous sediments are linked to the proximity to the back-arc basin suture zone, defining the boundary between the back-arc basin and the Indochina hinterland. Carbonate build-ups prevail in the back-arc basin region due to opening-closing events. In contrast, the hinterland areas are characterized by Jurassic-Cretaceous sediments, reflecting their tectonic stability, distinct from the adjacent suture zone.

Regional seismic interpretations across 11 key wells provide new insights into Pre-Tertiary horizons, unconformities, and seismic units across the study areas. Four new horizons are proposed including Carboniferous basement, Permian-Triassic sediment, Triassic carbonate, and Jurassic-Cretaceous sediment, underlain or overlain by three new unconformities of Intra-Paleozoic, Intra-Mesozoic, and Base-Tertiary Unconformity, by their sediment ages. Deriving from these interpretations, three new Pre-Tertiary seismic units are introduced namely Penyu

Paleozoic 1 (PP1), Penyu Mesozoic 1 (PM1), and Penyu Mesozoic 2 (PM2). Low amplitude, low relief, low frequency, discontinuous to mainly chaotic features interval characterised the PP1.

PM1 showed more features with some isolated patches of strong reflectors (hydrocarbon trapping?). High amplitude, low frequency, semi-continuous to discontinuous reflectors, sub-parallel to chaotic with vertical fractures or tight foldings, and dominated by isolated carbonates characterised the PM2.

These significant findings have introduced new perspectives on opening up new exploration play potential in the Pre-Tertiary intervals of the Penyu Basin and Arong Graben, previously known as the “basement”, with undefined and doubted justifications.