Diapirism and basin development in Sabah

LEE CHAI PENG & S.P. SIVAM
University of Malaya

The absence of suitable volcanic arc associations and any significant island-wide fold trends in the post-Eocene suggest that existing subduction-related tectonic models are inadequate to elucidate the geology of Sabah.

In the search for a more satisfactory explanation for these anomalies a plot of the strike ridges in Sabah reveals a pattern of concentric ridges between which are present in many places broken chaotic formations. Such distributions suggest an origin based on gravity tectonics where diapiric deformations resulted in broad synclinal depressions fringed by squeezed-up anticlinal ridges. This, however, does not negate interpretations that the concentric basins are related to basement faulting and tectonics because the latter may predetermine zones of pressure release and also enhance the effectiveness of differential loading. An assumed thin lithosphere in Borneo, would favour rapid response to vertical movement and loading because the zone of isostatic adjustment is at very shallow depths due to the shallow occurrence of low viscosity layer(s). In thick sediment piles over such thin lithosphere with high heat flow, the lower layers are more metamorphosed and tend to become overpressured in the early stages. Metamorphic convection could be set up aided by the influx of mantle fluids. Granitization could occur in siliciclastic sequences with attendant volume increase, thus destablising the vertical stress system and aid diapirism. In areas of high heat flow with significant uplift, major areas of tension are created in the lithosphere which give rise to horsts and grabens for the accumulation of thick sedimentary piles suitable for the development of diapiric structures.

The prime requirement for vertical diapiric tectonics is for density inversion to occur within the sedimentary pile and/or in the basement. Such a density inversion occurs where denser sandy sediments are deposited rapidly over less dense overpressured

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clayey sediments. It is further enhanced where great differences in thickness exist causing significant uneven loading. This is common in Sabah where equal-aged sediment piles of variable thicknesses are found in an active margin setting as deltas and turbidite fans. The overriding of Borneo over the South China Sea caused massive uplift of Sabah in a warm humid climate condusive to rapid weathering and erosion. This provided large quantities of rapidly sedimented, undercompacted and overpressured clay layers for the development of basinal load structures where they were overlain by denser sandy sediments. Such depocentres once created are self-sustaining in growth as they attract the further deposition of sand in the depressions created by loading. This occurs until most of the underlying clay is diapirically squeezed out following which the basins will rapidly fill with sands till they overflow the edges of the basins and create new depocentres downslope.

The significance of this model to petroleum exploration in Borneo is twofold. Firstly, rapid and uneven changes can occur in the thermal maturity of a sequence in a rapidly subsiding basin. The same bed or formation can be overmature, mature or immature depending on its location in the basin. It can be overmature at the centre and become progressively less mature at the edges due to different depths of burial. The same source rock which is overcooked or undercooked in places might be suitable in other instances. Secondly, if the anticlinal structures are of diapiric origin, they would tend to be more clay-rich and tectonized than the basin interiors and thus are less suitable as prospects for drilling.