THE BALINGIAN SHEAR ZONE AND WEST BARAM LINE, SARAWAK AND THEIR IMPORTANCE IN THE EARLY CENOZOIC EVOLUTION OF NW BORNEO

ROBERT B. TATE
Department of Geology, University of Malaya, 59100 Kuala Lumpur

Intense shearing of the rocks at the Sibu-Bintulu road bridge site on the Sg. Balingian was recognised first in 1976 and the shearing then attributed to a NE-trending tectonic feature related to the Mulu Shear Zone (McManus & Tate, 1976). New roadside exposures in the middle-upper Eocene Belaga Formation in the neighbourhood of Sg. Balingian between Sibu and Bintulu now reveal a major zone of deformation which seems to trend approximately WNW. The zone appears to continue offshore where it is aligned with a positive gravity anomaly trending WNW (Hutchison,1991) indicating a major discontinuity at depth. The gravity anomaly coincides with the SW margin of the Balingian oil Province which has been described by Swinburn (1993) as the West Balingian Line.

The Balingian Shear zone is characterised by intensely folded turbidites belonging to the upper part of the Belaga Formation. Cleavage, quartz-filled jointing and ptygmatic folds, boudinage and small-scale thrusting are common within a belt about 5 km wide. Structural measurements obtained from the Balingian exposures indicate a general N-S compressional direction but more data are needed from a wider area before either the structural interpretation or lateral extent and direction of the shear zone, including whether there is any horizontal component, can be established satisfactorily. The timing of the deformation cannot be verified except that it is post upper Eocene. It is proposed to call this shear zone the Balingian Shear Zone and the main Sibu-Bintulu road crossing the Sg. Balingian designated as the type locality.

The Balingian Province sedimentary basins are bounded to the NE and SW by the West Balingian Line and the West Baram Line respectively (Swinburn,1993). The Lines are clearly of major tectonic importance in separating the oil-prone Baram Delta/Balingian and gas-prone Central Luconia Provinces and the barren areas of offshore SW Sarawak.

In a series of palinspastic maps, Agnostinelli *et al.* (1990) and Johnson *et al.* (1989), have shown conclusively that the Oligocene coastline trended approximately perpendicular to the present coast and that the Penian High formed the source of prograding deltas trending NE. In the Lower Miocene, shelf carbonates began to accumulate offshore on the SW side of the West Baram Line beyond the deltas. In Kalimantan, the extensive upper Oligocene-Lower Miocene Bayangkara Limestone is up to 300m total thickness (Lefévre *et al.*,1982) and formed in a similar position on the southeastward extension of the West Baram Line. In the present offshore area, Oligocene deposition to the NE of the West Baram Line was probably devoid of clastics except perhaps thin turbidites which may occur beneath the Baram delta. Onshore, the predominantly silty Setap Shale Formation accumulated in the Baram valley basin to the NE whereas the Oligocene deltas of the Nyalau Formation are terminated on the SW side of the West Baram Line. It seems likely therefore that the West Baram Line may extend across Borneo in a SE direction.

Both the West Baram Line and West Balingian Line seem to be of fundamental tectonic importance in the evolution of the early Cenozoic history of NW Sarawak. There is a marked change in heat flow across the West Baram Line (Rutherford & Qureshi,1981) indicating a fundamental fracture. Corroborative evidence includes tin-bearing Middle Miocene intrusives at Long Lai in central Kalimantan (Lefévre *et al.*,1982) located on a parallel fracture close to the SE projection of the West Baram Line. The Tinjar fault is also parallel and close to the West Baram Line and has Middle Miocene basalts intruded along its length (R.Mani, Pers. Comm.). The Kinabalu-type intrusion (?Middle Miocene) at Bukit Kalulong is probably also related.

The heat flow patterns suggest hotter crust beneath Luconia; the tin-bearing granodiorites at Long Lai point towards a continental source at depth and minor tin occurrences are known also in NW Kalimantan. Both heat flow and tin mineralisation suggest there is continental crust at depth beneath central and western Borneo.

The Arip Volcanics, Piring Granophyre and Bukit Mersing pillow basalts are sufficiently close to the Balingian Shear Zone to indicate that they are probably inter-related and they may perhaps represent igneous activity connected with upper Eocene-early Oligocene rifting. The igneous rocks are stratigraphically within the same upper Eocene-?early Oligocene range as the presumed age of the West Balingian Line and Balingian Shear Zone.

Oligocene limestones near the base of the Nyalau Formation at Bukit Lumut 80 km E of Balingian suggest they formed along the West Balingian Line in a similar fashion to the development of Miocene limestones to the SW of the West Baram Line. The West Baram Line appears to have been a major paleo-

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geomorphological shelf-edge feature in the Lower Miocene and the West Balingian Line also may have been so although the muddy nature of the limestones suggest that land was closer.

Questions arise concerning the nature of the two WNW-trending "lines" and the change in geology across them as well as the implications for the interpretation of another, more famous "Line", the Lupar Line. Do the Lines represent successive Cretaceous and Oligocene rifted margins of the eastern edge of continental Sundaland?