Paper 24

The timing and tectonic significance of mélange formation in Eastern Sabah, Malaysia

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Mélanges are an important, if poorly understood component of many orogenic belts. In the circum-Pacific region, mélange formation appears to be an almost ubiquitous accompaniment to subduction-accretion processes: so much so the presence of a melange belt has often been used to infer the presence of an ancient subduction zone. The definition of mélange depends on the scale of observation. Hamilton (1979) used the term almost interchangeably with subduction-accretion complex. This usage should be avoided, and here mélange is used to describe a chaotically-deformed assemblage of blocks of various lithologies in a more ductile matrix, which can be mapped at a scale of 1:25000 or less.

The aim of this paper is to show how the timing and processes of mélange formation can be used to distinguish, and in some cases reconcile, the various tectonic models proposed for the evolution of the Sabah region (e.g. Hutchison 1988, Rangin *et al.* 1990, Rangin, Silver *et al.* 1991, Daly *et al.* 1991, Tongkul 1992)

In western Sabah, small bodies of mélanges formed during the development of the Crocker accretionary complex. In the east of Sabah, a much larger mélange terrain is found, a composite of several units known variously as the Ayer, Kuamut and Garinono Formations. Together these East Sabah Mélanges cover an aggregate outcrop area of some 12000 km^2, making one of the largest melange terrains in the world. Importantly, these mélanges cannot be linked directly to subduction-accretion processes.

The East Sabah Melanges have been considered as a composite unit (Tahir and Tan 1986). New mapping and biostratigraphical data has generally confirmed this interpretation, but also shows the complexity of the processes of mélange formation (a combination of slumping, diapirism and tectonic disruption; Clennel 1992). The three-fold subdivision into Ayer, Kuamut and Garinono Units can be retained usefully in a modified form, because these names refer to geographical domains in which lithologically different, but stratigraphically equivalent, sedimentary units were disaggregated to form the melanges. The differences in melange block types, matrix types and structure reflect the differences in the bed thickness, mechanical competence and bulk composition of the sedimentary and igneous units which formed them. Examination of the mélanges, and the surrounding coherent rocks, shows that the mélanges formed in a composite basin (known as the Central Sabah Basin in Hutchison 1989) floored by faulted and deformed ophiolitic and magmatic arc basement.

New constraints on the biostratigraphy and lithostratigraphy of eastern Sabah have enabled the time of formation of the mélanges to be constrained more accurately than before. The time of formation correlates exactly with the Deep Regional Unconformity (sensu Levell 1987) offshore western Sabah, as suspected by Hutchison (1988). This unconformity is now believed to be a result of uplift as a consequence of collision of the Dangerous Grounds block with the Northwest Sabah margin (shown by seismic surveys of Hinz *et al.* 1989). These collision is too distant to explain all the features of the Sabah Mélanges, however, a consequence of the block collisions was to effect processes in the Sulu Sea. The direct trigger for the formation of the Sabah mélanges was accelerated spreading in the southeast Sulu Sea which led to rifting in Sabah. Indeed, eastern Sabah was a part of the Sulu Sea basin at the time the melanges formed (Hutchison, pers. comm., 1990). Since this time the Sabah Basin has become isolated, probably by the propagation strike-slip faults in the Upper Miocene (Hinz *et al.* 1991) and so has uplifted rapidly to its present position. The amount of burial and uplift is recorded in the geological structures, and in the organic matter and clay mineralogical maturity, of the eastern Sabah sediments.

During uplift the mélanges were remobilised, during diapirism and faulting, and as a result foundering of sandy Tanjong Formation sediments deposited in the so-called circular basins. This shows the inherent gravitational stability of large volumes of incomplete lithified, mud-rich sediments. The mélanges were also overthrust by, and imbricated with the upper levels of the Sabah ophiolite in a number of localities, and in the south of Sabah imbricated with a sequence of Neogene volcaniclastic sediments. These later deformations attest to Upper Miocene north-south compression in eastern Sabah, possibly as a result of rearrangement of subduction polarity beneath the Sulu Archipelago (Rangin, *et al.*, 1991).

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