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Oceanic lithosphere subducting beneath the Sunda Trench: the Wharton Basin revisited

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The disastrous earthquakes and tsunamis of Dec. 26th, 2004 and March 21, 2005 off Northern Sumatra have initiated a large international scientific effort including up to ten oceanographic cruises in the last two years. Multibeam bathymetry, gravity, magnetics, seismic profiles (including three high-quality deep seismic lines shot by Western Geco) and seismological (OBS) data have been acquired; sediment cores have been collected; pictures of the seafloor have been taken by a ROV. Most of this effort has focussed on the accretionary prism and the subducted slab. However, in order to understand the physics of large earthquakes and the processes of subduction, it is of tremendous importance to characterize the subducting plate and therefore to describe the structure, age and evolution of the Wharton Basin.

From a recent version of the free-air gravity anomaly deduced from satellite altimetry, we delineate tectonic elements such as the Sunda Trench and the fracture zones of the Wharton Basin. The latter exercise is made difficult by the presence of seamounts, compressive deformation patterns, the flexure of the plate approaching the subduction zone, and the Ninetyeast Ridge. When available, multibeam bathymetric data are also considered to improve the position of the fracture zones.

We use all magnetic data available to us, including the compilation of a joint cooperative programme between French and US Institutions known as the “Alliance Exotique” in the 90s, supplemented by published Russian and Indian data, a German map presented at meetings, and French data acquired by R/V Marion Dufresne in 2005 and 2006. The magnetic anomalies are interpreted by comparing observed and synthetic profiles, and magnetic linéations are drawn in order to build a tectonic map of the Wharton Basin.

This new tectonic map shows more refinements than previous ones, as expected from a larger data set. The fossil ridge is clearly defined; spreading ceased at anomaly 18 young (38.5 Ma), and, perhaps, as late as anomaly 15 (35 Ma). Symmetric anomalies are observed on both flanks of the fossil ridge up to anomaly 24 (54 Ma), preceded by a slight reorganization of the spreading compartments between anomalies 28 and 25 (64 - 56 Ma) and a more stable phase of spreading between anomalies 34 and 29 (83 - 64 Ma). Earlier, a major change of spreading direction is clearly seen in the bending fracture zones; interpolating in the Cretaceous Quiet Zone between anomaly 34 in the Wharton Basin and anomaly M0 in the Cuvier and Gascoyne abyssal plains off Australia leads to an estimate of ˜100 Ma for this reorganization.

The tectonic map provides an accurate determination of the age of the subducting lithosphere along Sumatra. Some identifiable anomalies associated to subducted lithosphere are observed as far as 50 km landward from the trench. Spreading rates have been determined and range from 20 km/Ma before anomalies 33r (79 Ma) and after anomaly 18r (41 Ma) to more than 70 km/Ma between anomalies 22 and 30 (49 - 68 Ma). Because the structure and the composition of the oceanic crust varies significantly with spreading rate, this parameter may be important in implying the existence of a thick and brittle layer of magmatic crust (at fast spreading rate and/or magmatic ridge) or the outcrop of much more ductile altered mantle rocks (at a slow rate and/or magma-starved ridge) in different areas of the subducting slab.