

Seismic stratigraphy of Quaternary sediments offshore northwest Peninsular Malaysia

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Several shallow high-resolution marine seismic surveys have been conducted in the Strait of Malacca offshore Kedah, Pulau Pinang (including the Penang Channel between the island and the mainland) and Perak since the mid-1970s. These have been carried out for a variety of

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purposes such as reconnaissance mineral exploration, geological mapping, stratigraphic correlation and geotechnical investigations. The surveys were conducted by, among others, Pernas Mining, Geological Survey Department, Universiti Sains Malaysia (separately by Lew, Ryall, van Klinken, Lee and their co-investigators) and private firms (for reclamation works, cable and pipe laying and bridge construction). These studies have yielded a wealth of data on the offshore sediments, their environments of deposition and paleodrainage in the area.

The stratigraphic framework of the sediments in the area is well established. Onshore, Quaternary alluvium covers the coastal plains and valleys. According to Suntharalingam and others, this alluvium consists of marine, fluviomarine and fluvial unconsolidated to semi-consolidated muds, clays, sands and gravels. They can be grouped into four major formations. The Gula Formation of Holocene age consists of clay, silt, sand, gravel and peat deposited in a mainly fluvial environment during the Holocene. The Simpang Formation consists of clay, silt, sand, gravel and peat deposited in a terrestrial environment before the most recent major low sea-level, in the Late Pliocene to Pleistocene. The Kempadang Formation is made up of clay, silt and sand laid down in a marine environment in the Pleistocene. Sea-level fluctuations in the Holocene have played a major role in the depositional history of the whole region.

Seismic sections acquired in the various surveys in the offshore areas under discussion are remarkably consistent even though they are of differing data quality, resolution and penetration. Water depths vary from a few metres to over 50 m. Penetration up to approximately 160 m below the seabed was achieved in the survey offshore Perak and Pulau Pinang. Closer to shore, significant portions of the sections are acoustically opaque due to the presence of biogenic gas from decaying organic debris, in the uppermost layers of sediment, discharged by the many rivers draining into the area.

In general, four major regional seismic reflectors can be identified. From top to bottom they have been designated Reflectors A, B, C and D. Reflector A is generally continuous throughout the area. Reflectors B and C are more discontinuous but can still be correlated through most of the area. The deep Reflector D was detected only in limited localities in the deep-penetration survey offshore Perak and Pulau Pinang. Nevertheless it appears to be regional in character. Various minor reflectors of more local extent are seen in the seismic sections, especially in the upper portions.

The sediments between the seabed and Reflector A consist mainly of fine sand and clayey sand with marine mud on top. Shells are abundant in certain localities. The thickness varies between 0 and 25 m. Cut-and-fill structures evident in most parts of the seismic sections indicate an active erosional regime before this layer was deposited. This sequence is interpreted to be marine in origin and can be correlated with the Holocene Gula Formation. In the nearshore areas around major river mouths, this layer tends to be gas-charged in the upper portions. The top surface of this layer, the seabed, is generally flat on gently undulating. Locally however, sedimentary structures such as sand waves have been detected.

Between Reflectors A and B are found complex sequences of clay and sand, in varying proportions, about 10 m to 45 m thick. Prominent and complex channels are seen in this layer, suggesting a very active fluvial environment. Channel-fills of coarse sand and gravel are evident. Locally, there are indications of a more fluviomarine environment. This layer can be correlated with the Beruas Formation.

Located between Reflectors B and C is another complex sequence of clay and sand, though more compact and homogeneous than the layer immediately above.

Its thickness varies between 5 m and 60 m. Below this layer, between Reflectors C and D is a sequence of semi-homogeneous sediments, predominantly sandy clay with locally coarser materials. This layer is of the order of 100 m in thickness. Stratigraphically, these two layers

of probable terrestrial origin are equivalent to the Simpang Formation of Pliocene-Pleistocene age. Below Reflector D not many details are evident but the sediments appear to be compact, semi-consolidated terrestrial deposits of clay with local sand and gravel, of probable Tertiary age.

Offshore Kedah, bedrock of mainly granite and metasediments was encountered from a few metres to about 60 m below sea-level. Offshore Perak, no bedrock was detected in the seismic sections because the profiles were a considerable distance from shore. In the Penang Channel granite bedrock was detected between 30 m and 70 m below sea-level near both shores.

This integration of the various seismic data sets acquired in this wide area presents an overall picture which is generally consistent with the known geology of the adjacent onshore areas.