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Offshore Gunung Jerai shallow seismic survey

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Abstract: A high resolution shallow seismic survey in the area immediately offshore from Gunung Jerai (Kedah Peak) has revealed extensive granites, and a deep bedrock channel which runs northwest past Pulau Songsong. Although scanty drilling has not uncovered detrital tin deposits, neither the margins of the newly found granite, nor the bedrock channel have yet been investigated.

INTRODUCTION

A regional shallow seismic study conducted in this vicinity in 1976 (Ryall *et al.*, 1978) has led to a recommendation to do more work in the shallow water area enclosed by a chain of islands offshore from Gunung Jerai, northwest Peninsular Malaysia, with a view to evaluating its tin potential. The area is about 8 × 20 km in size (Fig. 1).

PREVIOUS WORK

Onshore geology is very well described by Bradford (1972). Some seismic profiles from the 1976 survey run across our area (Fig. 1) but the survey parameters were such that the records are not of sufficient quality for detailed analysis. Pernas Charter Management drilled 13 reconnaissance boreholes (marked on Fig. 1) of which 10 reached bedrock and we are grateful to PCM to have the unpublished logs of some of these.

SURVEY OUTLINE

The survey vessel was a rented 35-ft wooden trawler. Our equipment is described in the Appendix. Over 3 days in December 1980, 145 km of seismic data were obtained, and about 100 km of usable coincident magnetic data. The latter was of limited value since there was no magnetic base station nearby. Even so, observatory records obtained from Kodaikanal, South India showed that magnetic activity was low during the survey period. Both seismic and magnetic coverage is poor in the south, due to equipment problems. Navigation was by twin sextants sighting on topographic features. This should have an accuracy of around ± 100 m. However the best base maps are only on a scale of 1:63,360 and the grid systems of two overlapping maps were found to be inconsistent by 300 m. Hence we think we have a relative accuracy of 150 m, but an absolute accuracy of only 300 m. Line spacing was 1–2 km, with cross ties at 3–4 km.

RESULTS

Previous work has suggested that the entire Sunda Shelf has acted as a unit, without tilting, in late Cainozoic times. A similar Quaternary stratigraphy has been recognized off Bank Island (Aleva, 1973, Batchelor, 1979), off Lumut-Dinding, Perak (Batchelor, 1979, Ringis, 1976), off Southwest Thailand (Ringis, 1979) and off Kedah

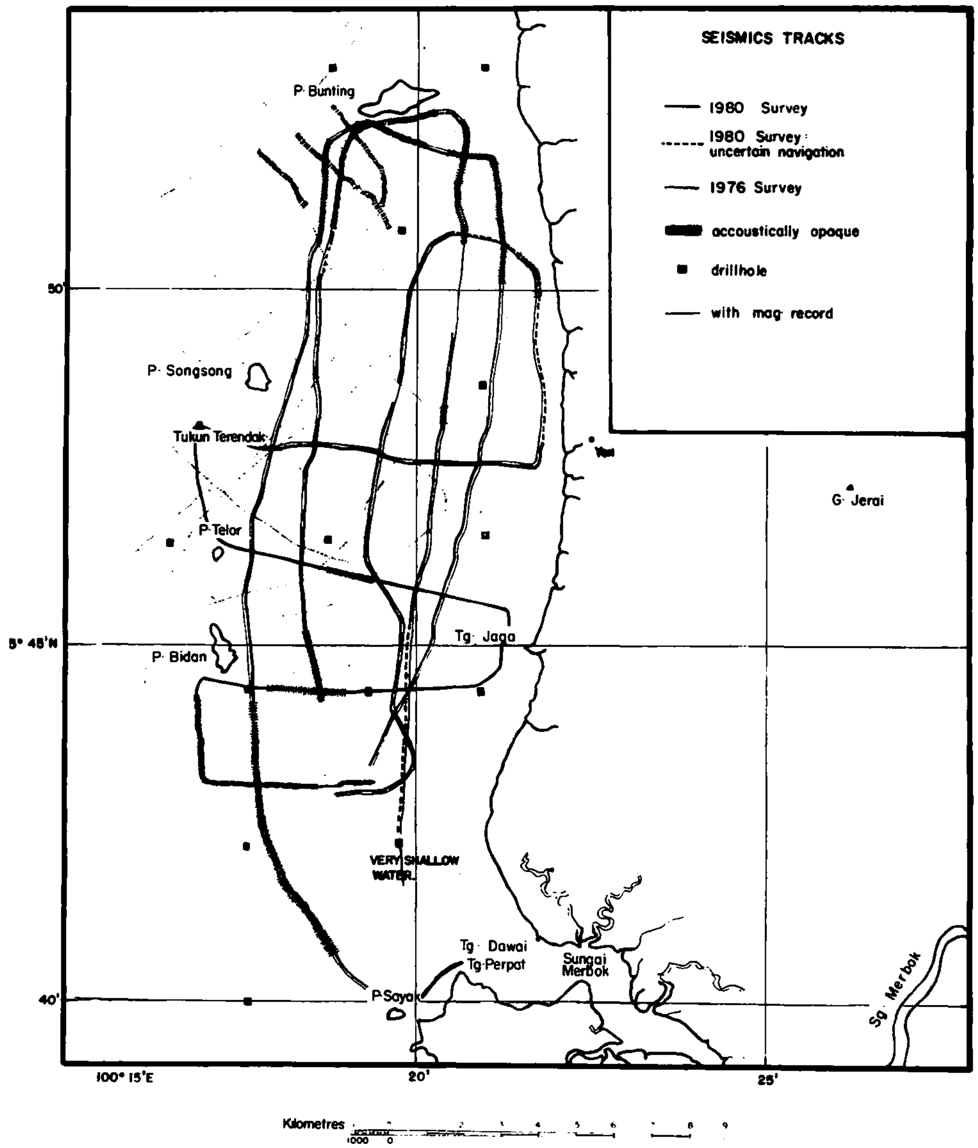

Fig. 1. Information base and location map.

(Ryall *et al.*, 1978, Lew, 1979). The stratigraphic scheme is an environmental one. Figure 2 is a generalized sequence proposed by Ringis (1979), which may be compared with a typical seismic section from the middle of our area (Figure 3). Due to the shallow water here, the seafloor reflection is obscured by the direct wave. Between the seafloor and horizon A is a layer of soft, recent marine mud. It has a thickness of 5–10 m in this nearshore area. The confused sequence from A to B was deposited in a fluviomarine

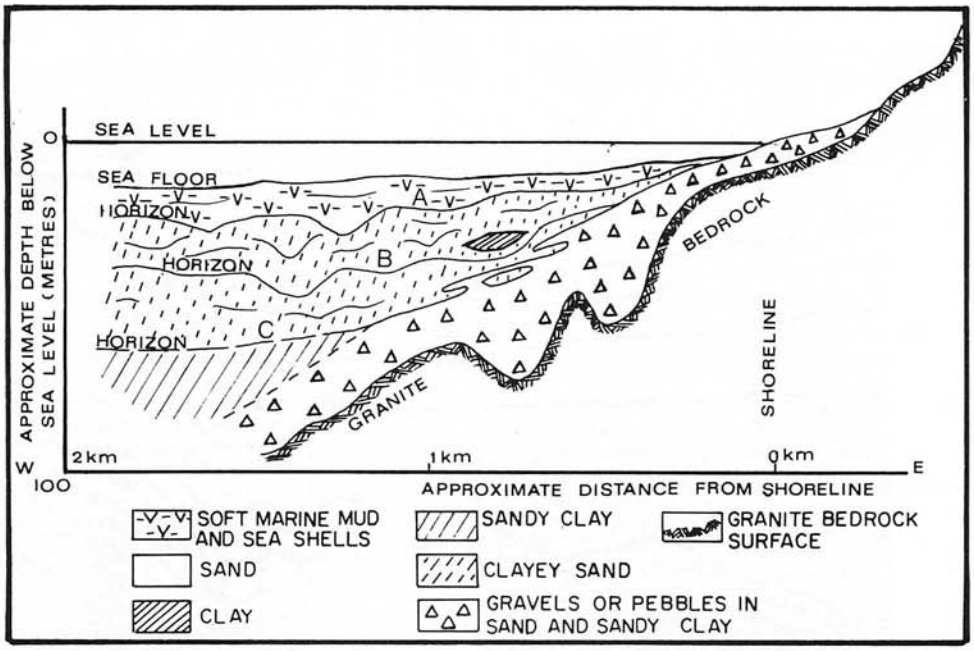

Fig. 2. Generalized stratigraphic sequence off west coast of Peninsular Malaysia (from Ringis, 1979).

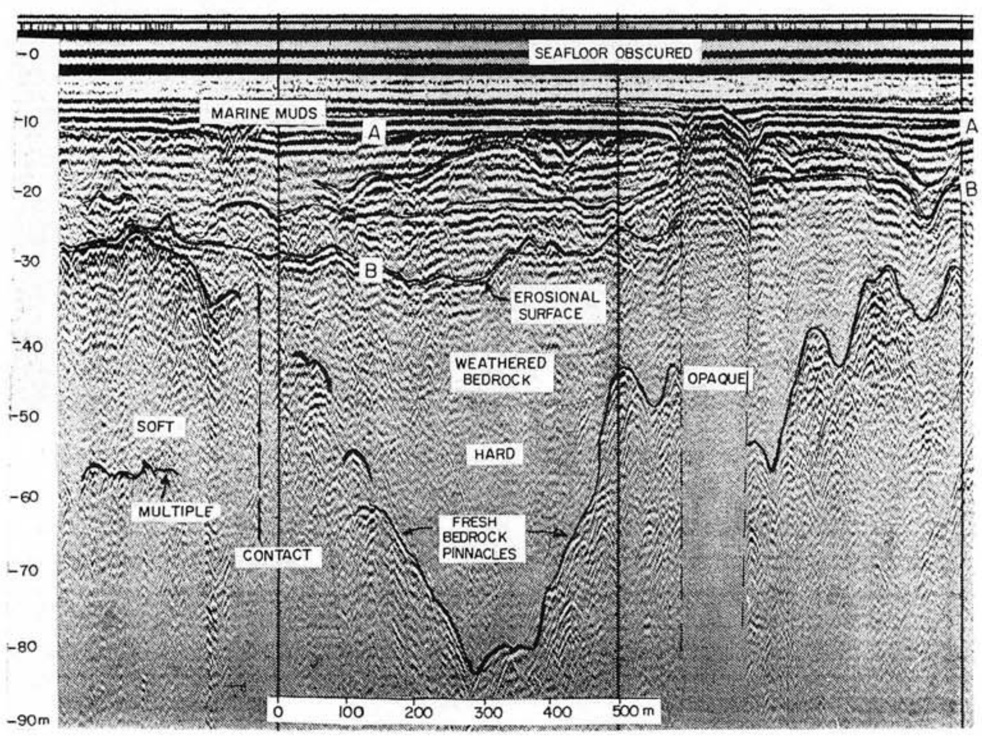

Fig. 3. Typical seismic section, 2 km from shore, ENE of Pulau Songsong.

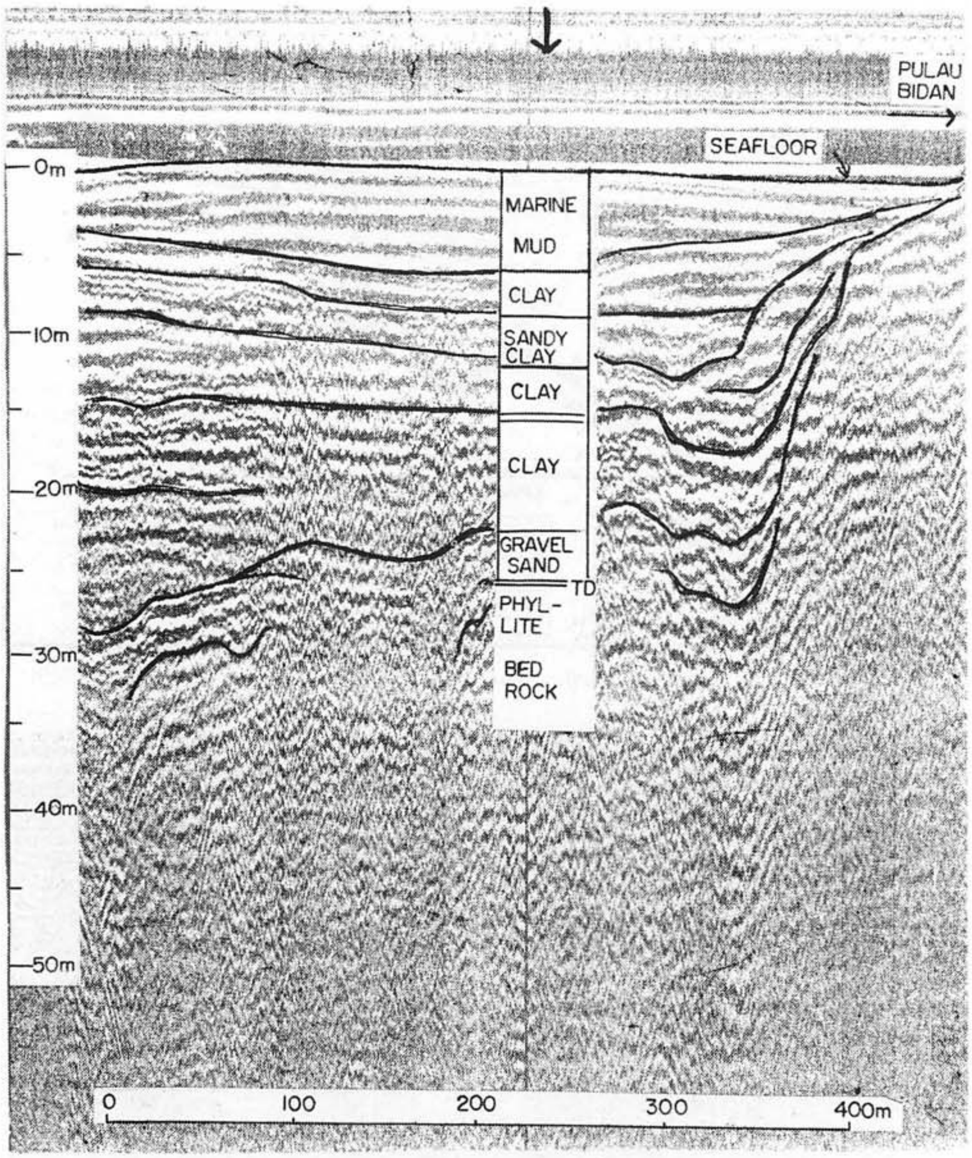

Fig. 4. Drilling log correlation, 1 km SE of Pulau Bidan. Bedrock reflection not clear.

environment at a time of alternating sea level. At the bottom of this sequence we find mostly terrestrial sediments (with a good proportion of sand) and at the top mostly marine (predominantly clay). On Figure 3, an erosional surface, is not apparent in areas close to shore, as noted also by Ryall and his co-workers. The corresponding erosional surface here, however, turns out to be the top of weathered bedrock—this is clear from the drilling logs. In the case of granite bedrock, fresh

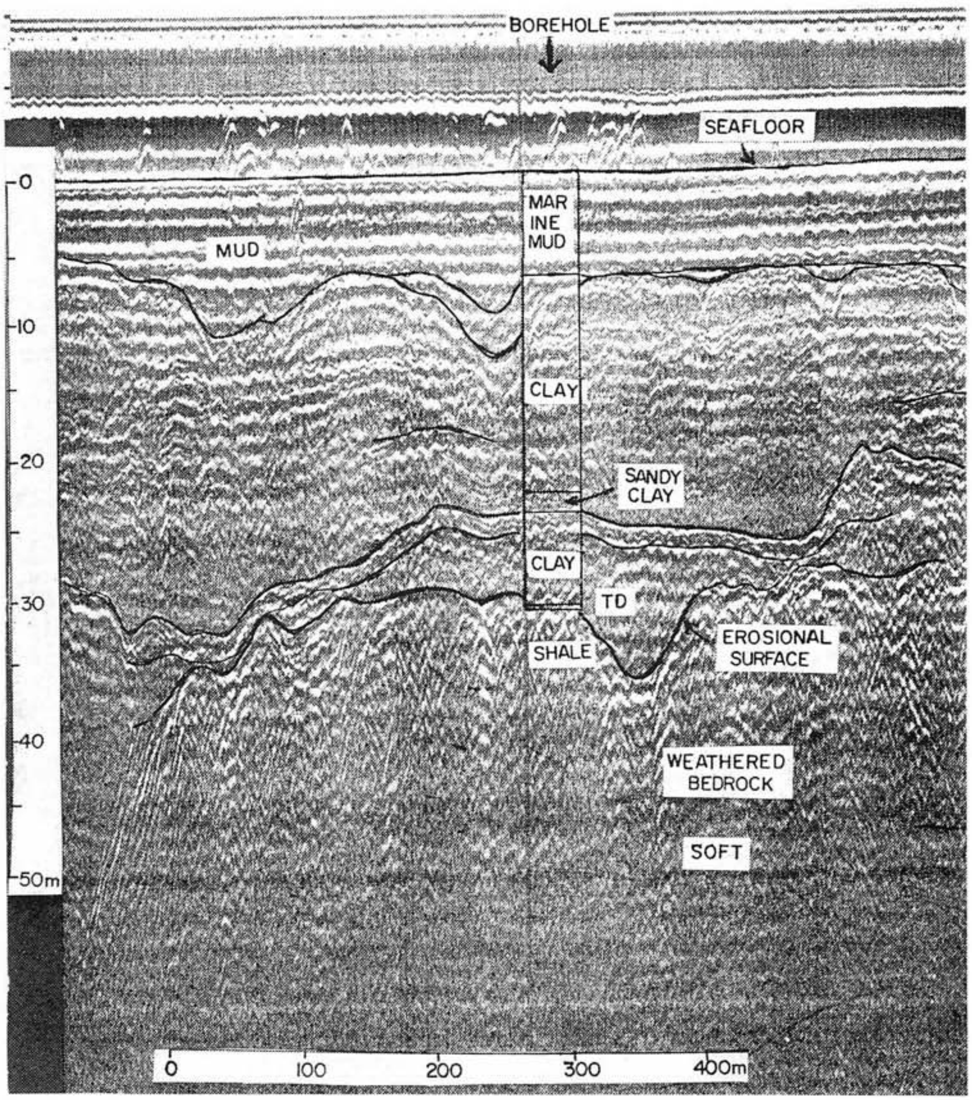

Fig. 5. Drilling log, taken 3 km south of Pulau Bunting, correlated with seismic section 1 km to SE of drilling location.

granite can be seen at greater depth. Correlation between drilling logs and seismic sections is good locally (Figures 4,5), but the sequence is too confused to extrapolate the correlation any distance. Sand–clay boundaries often show a very strong accoustic contrast. Topography of the erosional surface on bedrock (Figure 6) has been obtained by converting seismic two-way travel times to depths for a water velocity of 1520 m/sec. and an average velocity in sediments of 1740 m/sec. as used by Lew (1979). A number of Lew's depth values were also incorporated. All these depths correlate reasonably

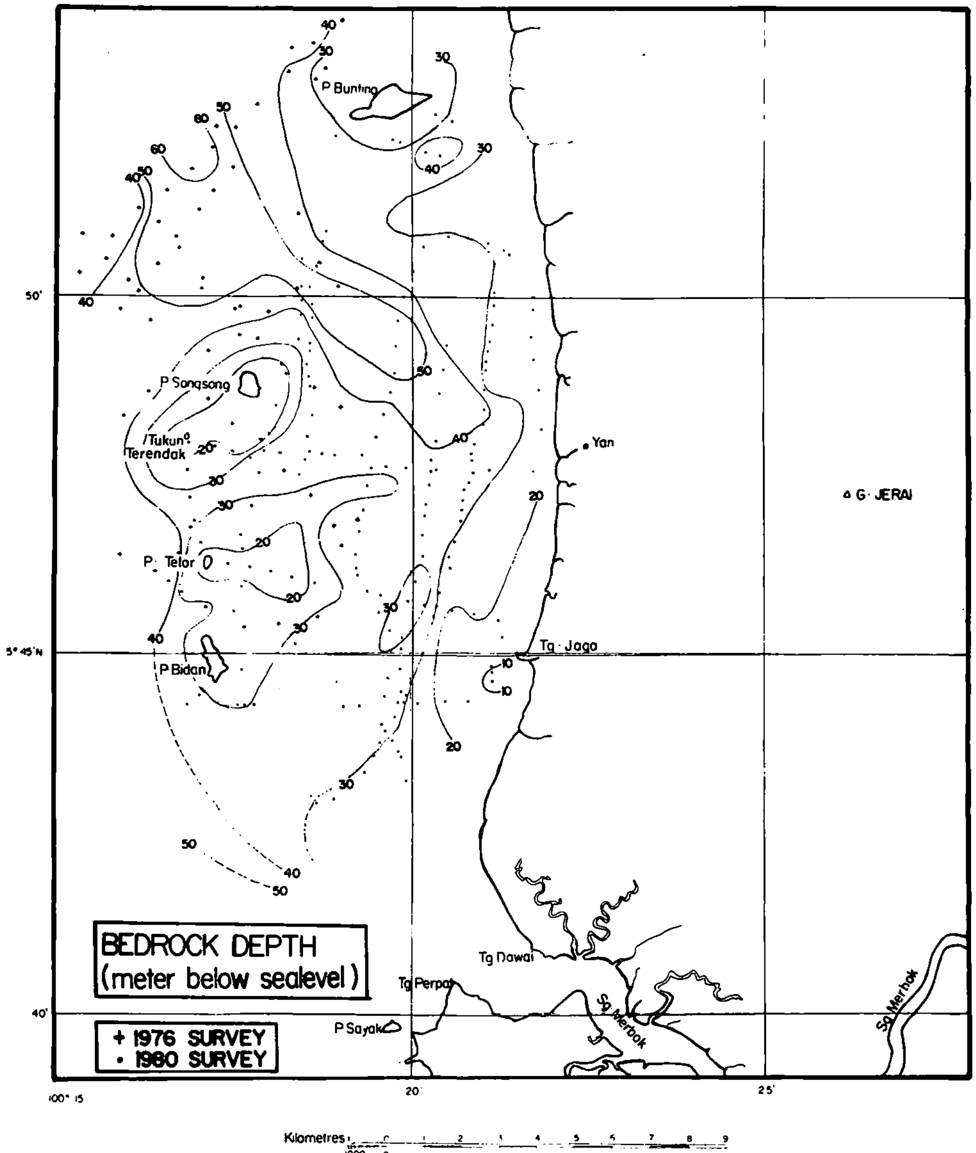

Fig. 6. Bedrock depth offshore Gunung Jerai.

well with the drilling data. The major feature on Figure 6 is a 2 km wide channel running NW directly away from Gunung Jerai. This is support for Bradford's postulate of a river which once ran along the northern flanks of the mountain (Bradford, p.6). The channel has been traced further west another 30 km by Lew. It may have served as a concentrator for alluvial tin deposits, but has not been drilled. Another channel of the same river may have been broken through between Pulau

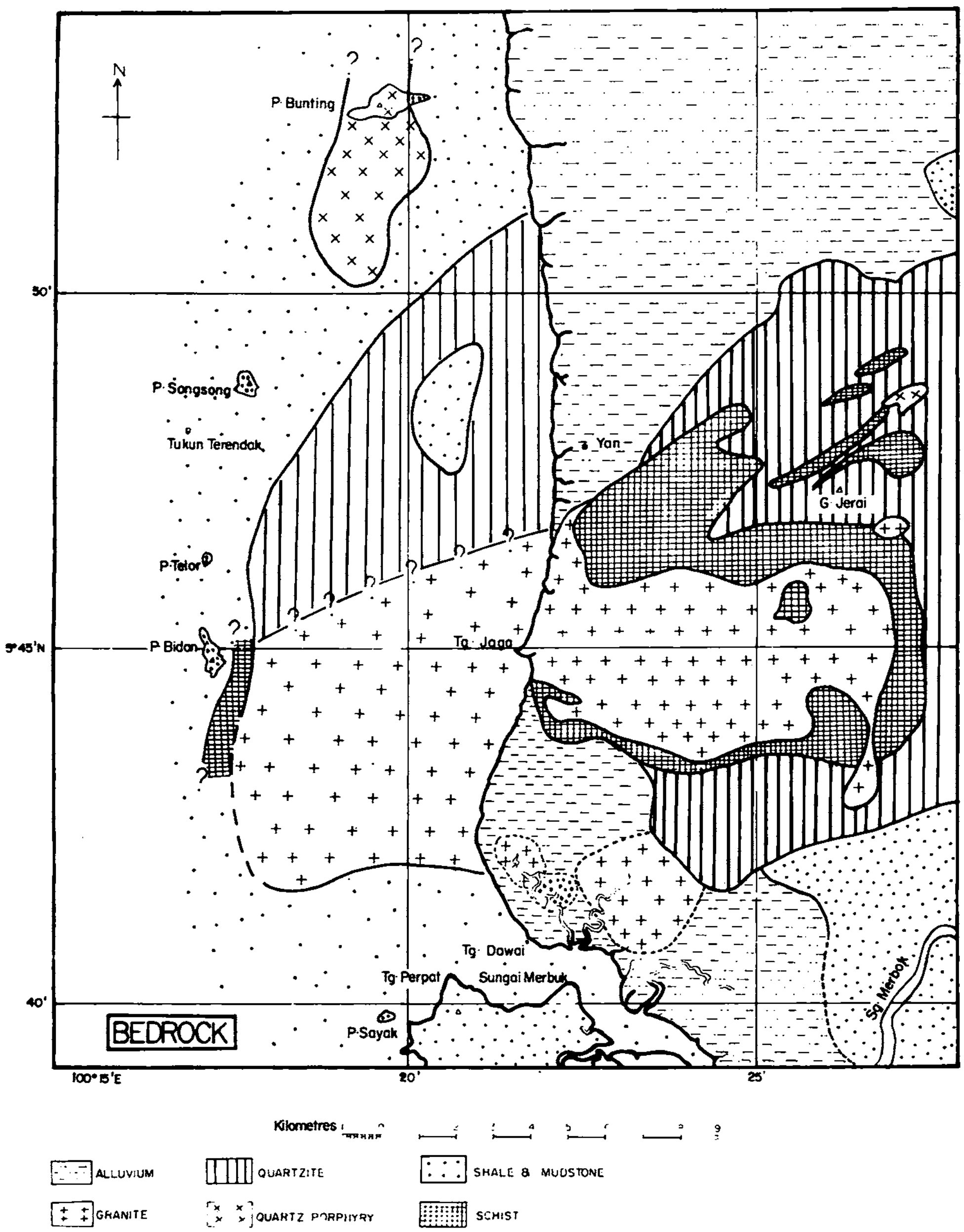

Fig. 7. Bedrock type offshore Gunung Jerai.

Songsong and Pulau Telor, leaving these two areas as bedrock highs. In between Pulau Bidan and Tanjong Jaga, bedrock lies uniformly at a depth around 30 m.

On the basis of seismic data alone, bedrock can be divided into only two types: hard (igneous or metamorphic) and soft (sedimentary). Onshore geology and drilling shows that the "hard" bedrock may be granite, or quartzite (possibly belonging to the Gunung Jerai Formation), or quartz porphyry. Since these are seismically indistinguishable, the granite-quartzite boundary in Figure 7 is poorly controlled.

"Soft" bedrock may be either shale or mudstone (which is predominant in the area) or its metamorphosed equivalent phyllite (encountered in a drillhole just southeast of Pulau Bidan). Magnetics provide an additional discriminator—the "hard" bedrock has a flat magnetic signature, but the "soft" shows some variability (Fig. 8). It is the magnetic record alone which provides control on the southern boundary of the granite. The sediments here are almost entirely opaque to seismic energy, probably due to organic gas trapped at the base of the recent marine mud section.

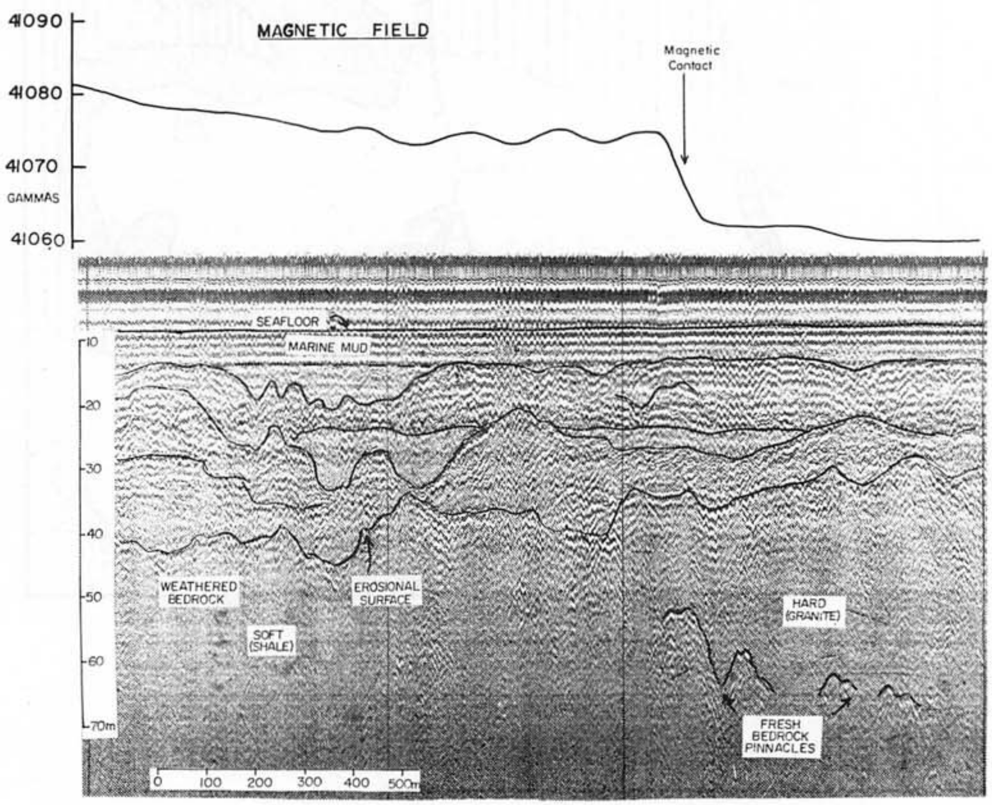

Fig. 8. Magnetic record correlated with seismic section to locate granite-shale boundary. About 2 km SE of Pulau Songsong.

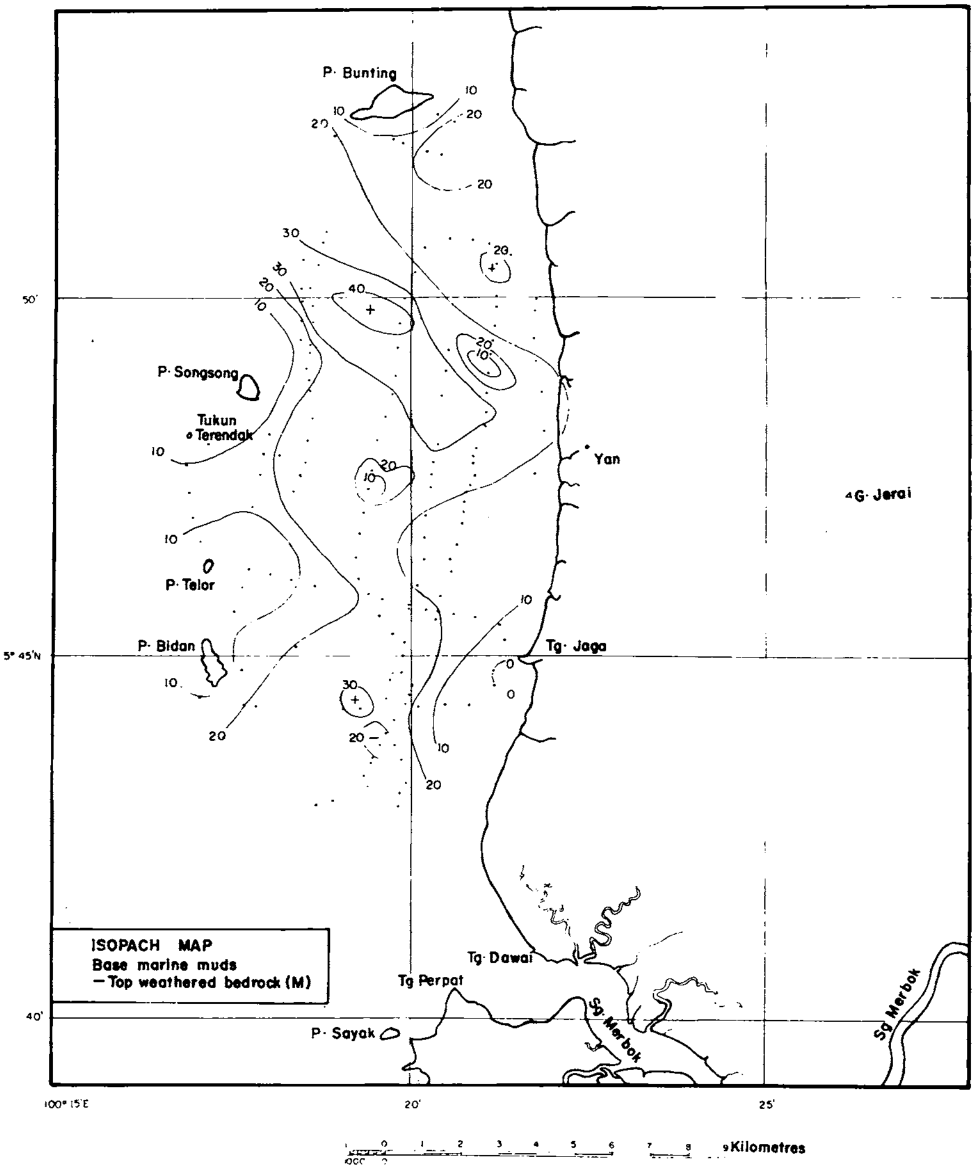

Fig. 9. Thickness of sediments below marine muds offshore G. Jerai.

Our bedrock map more than double the area of granite shown by Bradford and suggests a second granite pluton which has not been recognized before. This could provide an explanation for the indurated character of the rocks of the western chain of islands, and of the quartz veining seen on Pulau Telur. The quartz porphyry found on Pulau Bunting in the north may be analogous to that found near the top of Gunung Jerai, which is considered an intrusive by Lim (1980). A couple of strong (500 gamma) magnetic anomalies found near the eastern end of the island confirm that magnetic veining occurs at the contact with the shale there.

It is possible also to compute sediment thicknesses. The marine muds are known to be invariably barren. However the material between the base of these muds (horizon A) and the top of weathered bedrock is of interest—its thickness is shown on Figure 9. Water depth throughout the area is shallow—Admiralty chart no. 3943 shows the seafloor sloping westward evenly to a depth of 10 m around the western islands. A shallow mudbank extends to about 4 km offshore from the northern bank of Kuala Merbok, making movement difficult there.

ECONOMIC IMPLICATIONS

None of the drill-holes in the area encountered more than traces of tin and this does not encourage optimism about finding economic deposits offshore. The fact that no colluvial or eluvial tin was found actually on the granite suggests either that the upper portions of the intrusive have already been removed entirely, or that the sea level changes have deposited a new blanket of sediment over the bedrock which was derived from elsewhere. Also more significantly, the granites are not sufficiently mineralised to give rise to placer tin deposits. Alternatively of course, the granite may never have been mineralised. However, the reconnaissance drilling pattern was extremely sparse (spaced at 3–4 km), incomplete, and not guided by seismic information. Several proposed holes around Pulau Songsong, covering part of the newly discovered channel, could not be drilled as the area within the 3.2 km limit of Pulau Songsong was restricted to target practice by the Air Force. The marine muds (from the seafloor to horizon A) are not prospective (Ryall *et al.* 1978). Below this, between horizon A and the top of weathered bedrock is a variable sequence of mixed prospects, the thickness of which is shown on Figure 9. Drilling records suggest that the upper portions are mostly clayey, and not prospective. The bottom section, say below 20 m depth, contains more abundant sand and gravel layers. These are probably of terrestrial origin, and the coarser sediments are prospective. Over most of the area this more sandy section is only about 5 m thick and immediately overlies the bedrock. But it will be considerably thicker in the channel which runs past the northern edge of the granite, and in the Sungei Merbok channel running past the southern side. Unfortunately the seismic data alone is inadequate to define the nature of the sediments in these areas unambiguously. The large northern channel, running between Pulau Songsong and Pulau Bunting, and the smaller one between Pulau Songsong and Pulau Telur have not been drilled and these may contain alluvial placers derived either from Gunung Jerai or the second pluton buried between Tanjung Jaga and Pulau Bidan. The accumulation of economic tin deposits, however, is also dependent on mineralised source(s). The margins of the buried granite body should also be investigated for possible placers. Sediments drape off the southern margin into the Sungei Merbok bedrock channel. Unfortunately neither the southern nor the northern margins are well defined by the present survey. Further seismic work in the south would be hampered by the accoustically opaque sediments.

CONCLUSIONS

A short, shallow depth, high resolution seismic survey has revealed an extensive granite suboutcropping just offshore from Gunung Jerai. The margins of this intrusive body may be prospective of tin. A major bedrock channel runs northwestwards from Gunung Jerai.

ACKNOWLEDGEMENTS

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APPENDIX

Our high resolution shallow seismic system was manufactured by EG & G and consists of a power supply (232A), capacitor bank (231), Uniboom transducer (230-1), 8 element hydrophone streamer (265), with a Krohn band-pass filter (model 3700) and EPC graphic recorder (model 4600). The system was powered with two 7HP Briggs and Stratton generators. We found an optimal repetition rate to be 0.375 sec., and achieved an actual power output of about 160 J per pulse under these circumstances. A bandpass filter setting of 200–1500 Hz was effective. Surveying speed was kept around 6km/hr (3.2 knots) for best results. We were unable to use the Motorola Miniranger radio navigation gear offered by CCOP because of difficulties in obtaining a licence from Telekom. Our marine magnetometer was made by Geometrics (model G-801).