Annual Geological Conference '94
June 11-12, 1994, Kuala Terengganu, Malaysia

Reflection seismics case studies in Quaternary deposits of east coast Peninsular Malaysia

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Abstract: A high-frequency response seismograph together with a sledge hammer source was used to obtained reflection seismic data in Quaternary deposits from the east coast of Peninsular Malaysia. The thicknesses of individual subsurface layers as well as their internal structures were determined together with the depth to granite bedrock based on reflection seismic data. Correlation with borehole data supported the validity of the interpretation conducted.

INTRODUCTION

Recent modifications to the seismic reflection technique (Hunter *et al.*, 1984; Knapp and Steeples, 1986; Pullan and MacAulay, 1987; Ali and Hill, 1991) have contributed to the successful application of this technique for exploration at shallow depth. The modifications include the seismic source (Miller *et al.,* 1992; Meekes, 1992), seismic detectors (Gendzwill and Brehm, 1993) and field techniques (Frappa and Molinier, 1993). The main aim is to generate high-resolution seismic data and reduce noise to a minimum, especially low-frequency high amplitude ground roll.

The application of this technique in delineating the internal structure of Quaternary deposits and determination of the depth to granite bedrock in Pekan and Rompin areas is presented here. The study area in Pekan, Pahang (Fig. 1a) consists of Quaternary alluvium of Pleistocene to Holocene age (Saffen Baharudin, 1992) with thicknesses ranging from 18 m to 107 m overlying granite bedrock. Lithologically interlayers of clay/silt and sand/gravel are found in a number of boreholes (as marked in Fig. 1a). The Rompin area (Fig. 1b) consists of coastal sand mixed with continental clay of about 8 m thickness overlying a layer of marine clay. The marine clay with thickness ranging from 7 to 15 m overlies the granite bedrock.

METHOD OF INVESTIGATION

An ABEM 24 channel seismograph and an EG&G Geometrics 12 channel seismograph coupled with a data logging microcomputer were employed in the investigation, together with an approximately 5 kg sledgehammer as a seismic energy source. 14 Hz Mark geophones were used to receive the signals which were subsequently subjected to 100 Hz analogue low-cut filtering to enhance the high frequency content of the signal. Six-fold common mid-point (CMP) coverage was used for data acquisition, as outlined by Umar Hamzah and King (1988). Data processing included gain recovery, velocity analysis, normal move out correction and common mid point stacking. Stacking velocities were used for normal move out correction of the data. Static correction was not applied as the survey area was flat.

RESULTS AND DISCUSSION

Case 1: Pekan (locality P1)

The stacked seismic section for Profile P1 together with its geological interpretation is presented in Figure 2. Two distinct continuous and slightly undulating reflections are recognised together with two continuous to discontinuous reflections at a greater time, which are generally parallel to the earlier two reflections. Depth conversion was carried out by using the stacking velocity obtained from the velocity analysis with a value of 1,000 ms–1 for the conversion and production of stacked sections. Boreholes 7 and 13, respectively to the north and south of the profile (Fig. 1) were used for geological control. The 25 m thick layer above the first reflection correlates with a silty clay layer. Below this layer, a sand and gravel layer of variable thickness from 25 m to 75

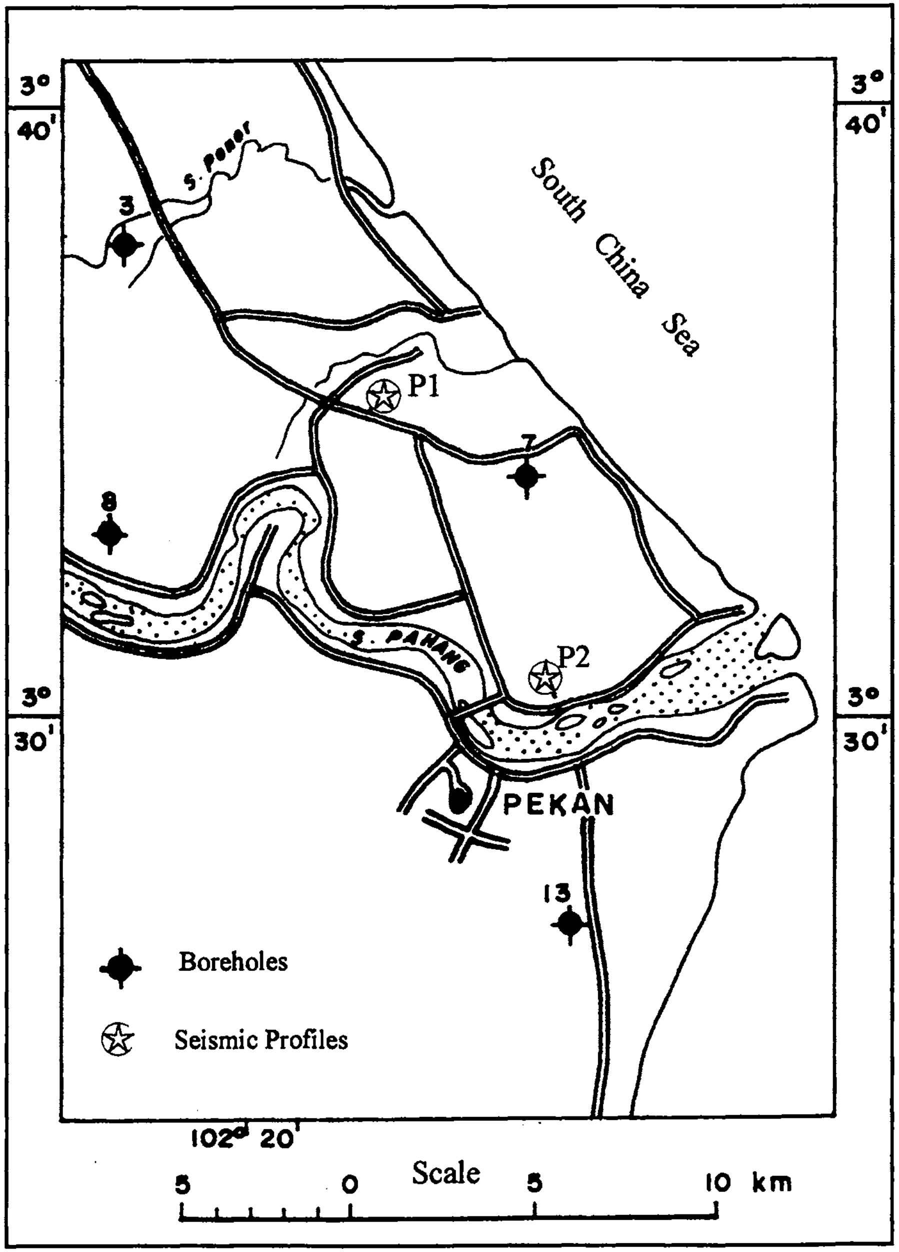

Figure 1a. Location of reflection seismic surveys and boreholes in Pekan, Pahang.

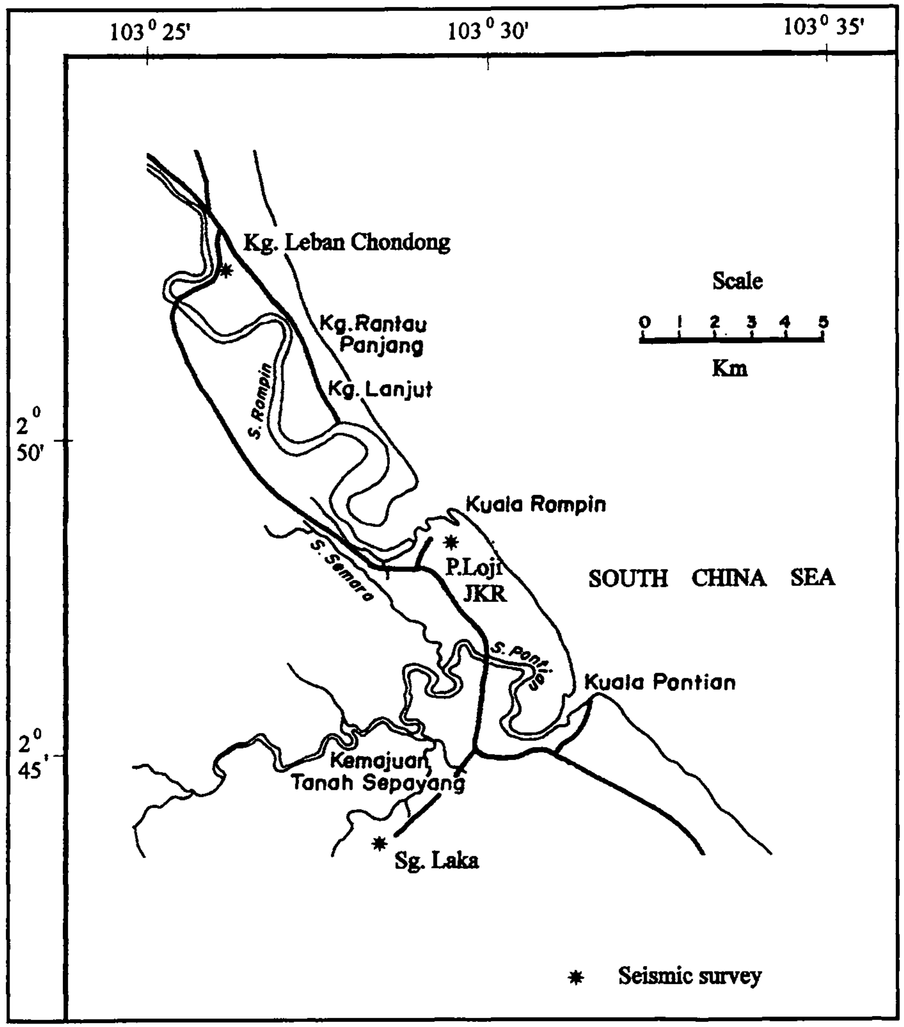

Figure 1b. Location of seismic surveys in Rompin, Pahang.

m below the ground surface is interpreted, with thin clay and silt layers within it. Granite bedrock occurs at a depth of 55 m to 60 m at the centre of the profile and deepening towards the north and south and is marked by a zone of poor reflection alignment as shown in Figure 2.

Case 2: Pekan (locality P2)

Figure 3 shows the reflection seismic section together with the interpreted geology. A dominant reflector, R1, at a depth of 28 m marks the interface between a silty clay layer (above it) and a sand and gravel layer. The reflector R2 is believed to be the top of a silty clay layer within the sand layer. Granite bedrock is interpreted at a depth of approximately 60 m as a poorly defined reflector below the R2 layer.

Case 3: Rompin (Sungai Laka)

The seismic reflection record as well as its interpreted geological section and borehole data are shown in Figure 4. The shallowest reflection is observed at a depth of 21 metres which correlates with sandy silt of 14 metres thickness. The reflector underneath is silty sand with gravel layer of about 28 metres thickness. This reflector overlies silty sand-gravel layer of 14 metres thickness. The granite bedrock is found at a depth of 105 metres from the surface.

Case 4: Rompin (Pantai Loji JKR)

The interpreted seismic section and borehole log (Fig. 5) indicate the first reflector is at 18.4 metres depth and correlates with grey silt and sand layer. This layer with about 8 metres thickness overlies gravel and gravelly silt layers of approximately 10 metres thickness respectively. Underneath is phyllite and metasiltstone which overlies granite bedrock at the depth of about 78.5 metres.

Case 5: Rompin (Kampong Leban Chondong)

The seismic section and borehole data at Kampong Leban Chondong are shown in Figure 6. The first sandy silt layer with thickness of 10 metres is shown by the first reflector at about 22.5 metres depth. It overlies silty sand mixed with gravel layer at depth of 45 to 52.5 metres. The granite bedrock is detected at 75 metres depth.

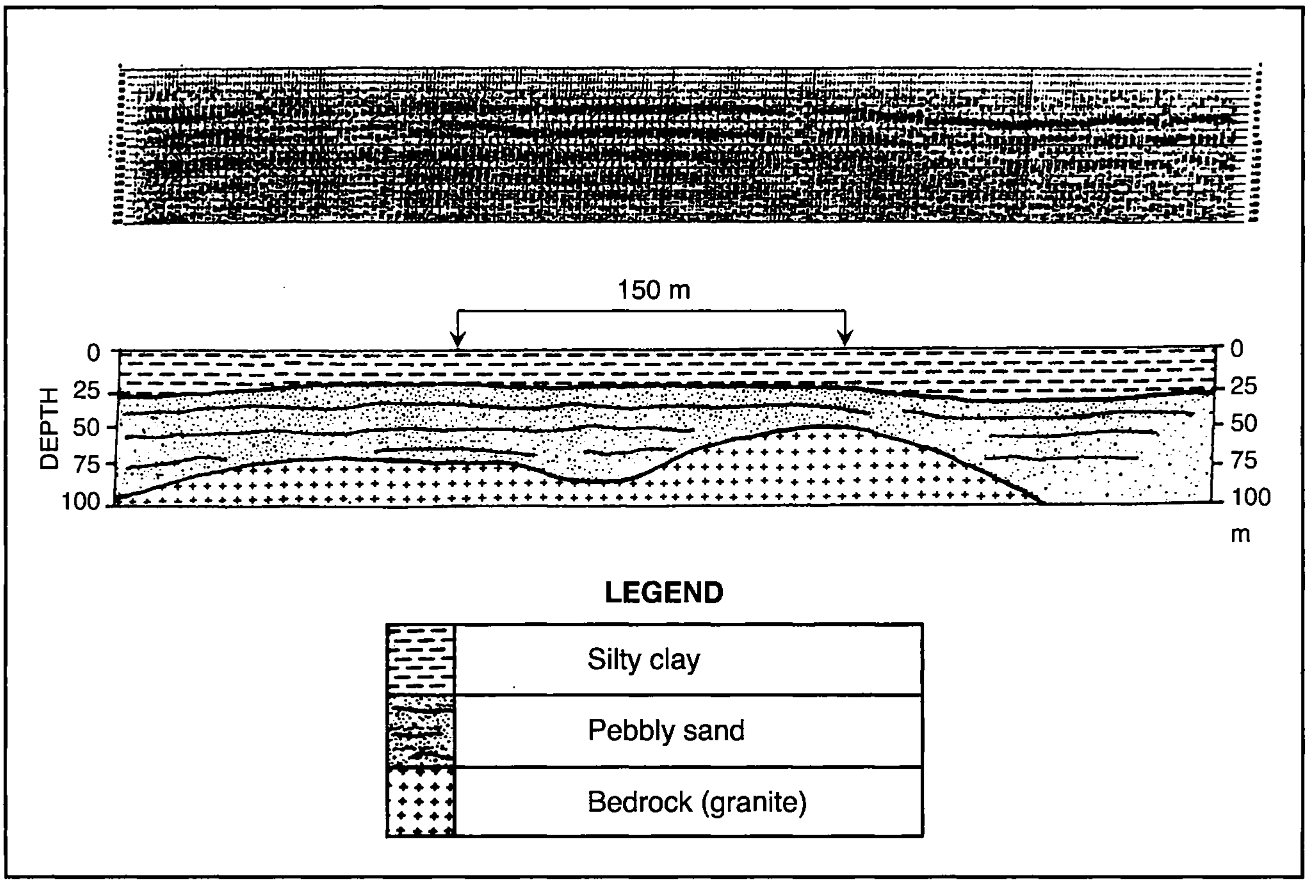

Figure 2. Reflection seismic section and geological interpretation of profile P1, Pekan, Pahang.

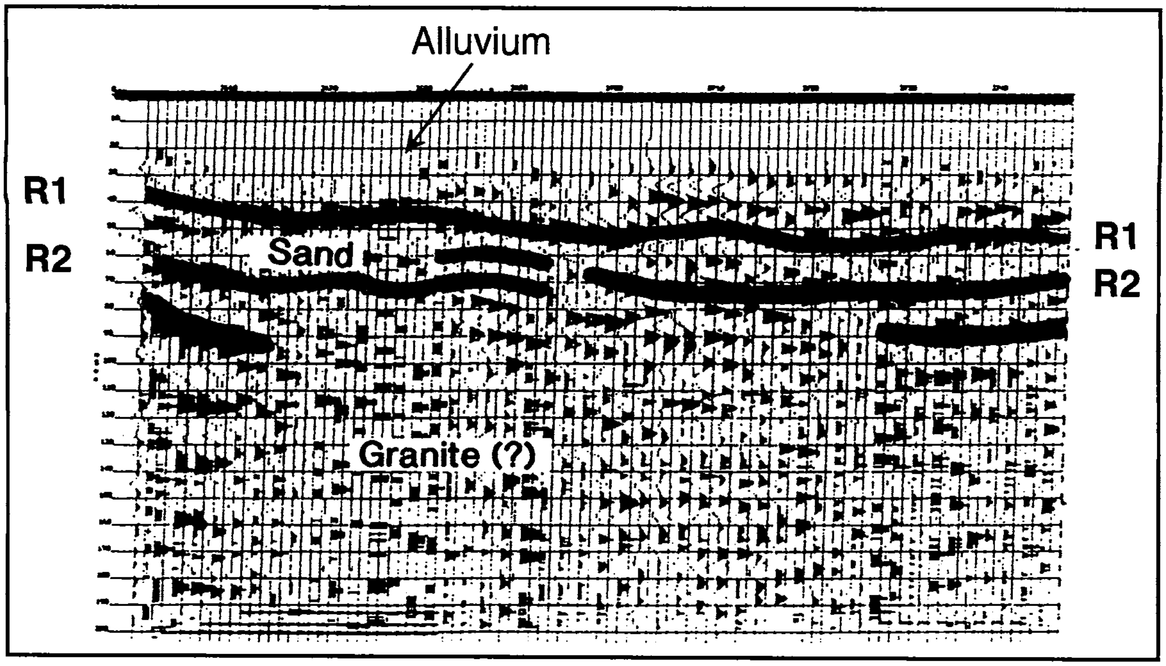

Figure 3. Reflection seismic section and geological interpretation of profile P2, Pekan, Pahang.

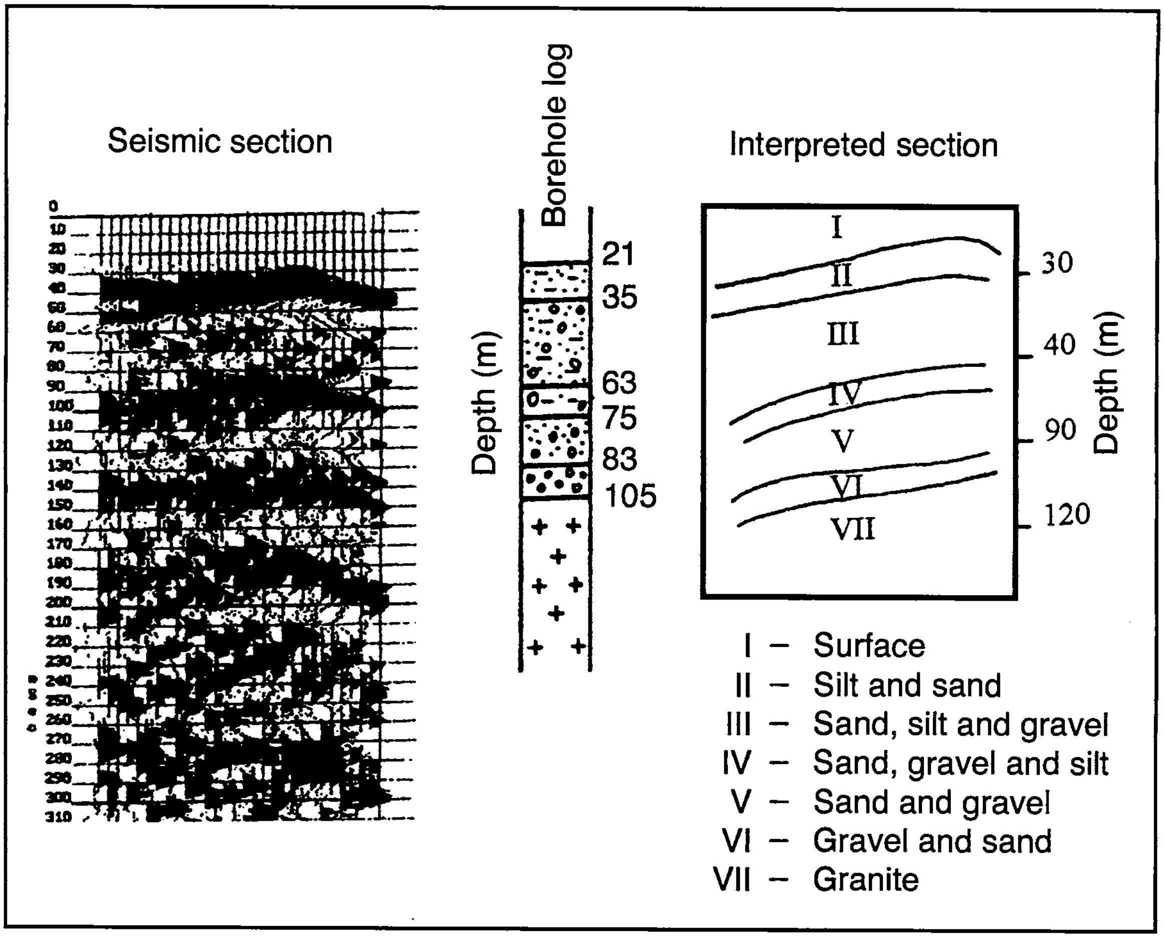

Figure 4. Subsurface structure based on reflection seismics at Sg. Laka, Rompin, Pahang.

CONCLUSION

The shallow seismic reflection results has successfully revealed the shallow subsurface strata (layers) below depth of about 20 m from surface. Interpretation of the layers has been possible with the help of borehole data made available for the study. The depths and thicknesses of the subsurface layers indicated by the seismic sections correlate well with the borehole logs. At Pekan, Pahang the granite bedrock is found at the depth of about 60–70 m below surface whereas in Rompin the granite bedrock occurs at slightly deeper level (approximately 75–100 m). This study demonstrates the usefulness of the seismic reflection technique in obtaining shallow depth subsurface information with considerable resolution and accuracy especially when correlated with borehole data.

ACKNOWLEDGEMENT

The authors record their appreciation to the Malaysian Government for the IRPA 4-07-03-03 research grant, JKR (IKRAM) for data processing software, as well as the field crew, drafting and general office of the Department of Geology, Universiti Kebangsaan Malaysia for the assistance rendered.

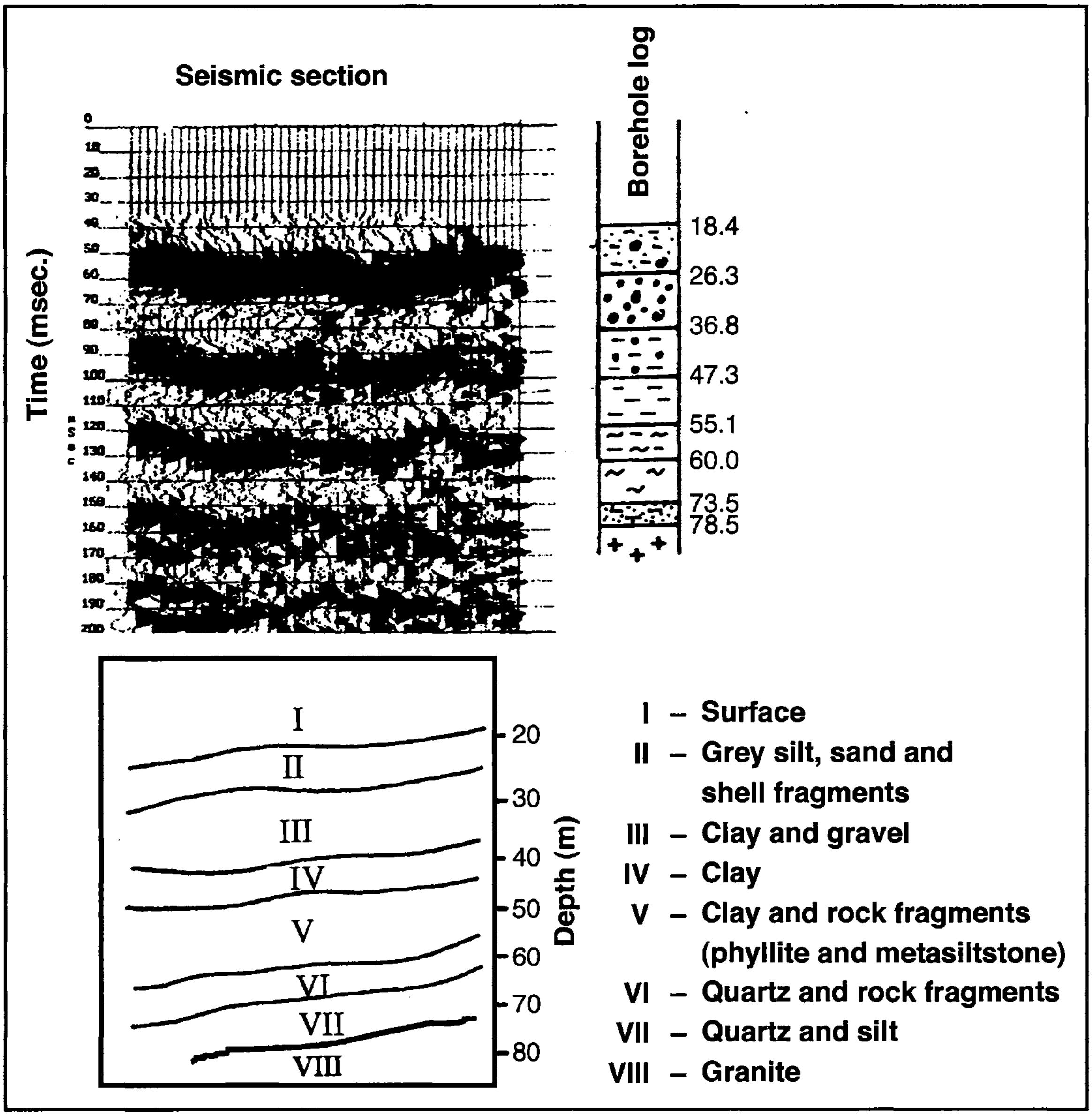

Figure 5. Subsurface structure based on reflection seismics at Pantai Loji JKR, Rompin, Pahang.

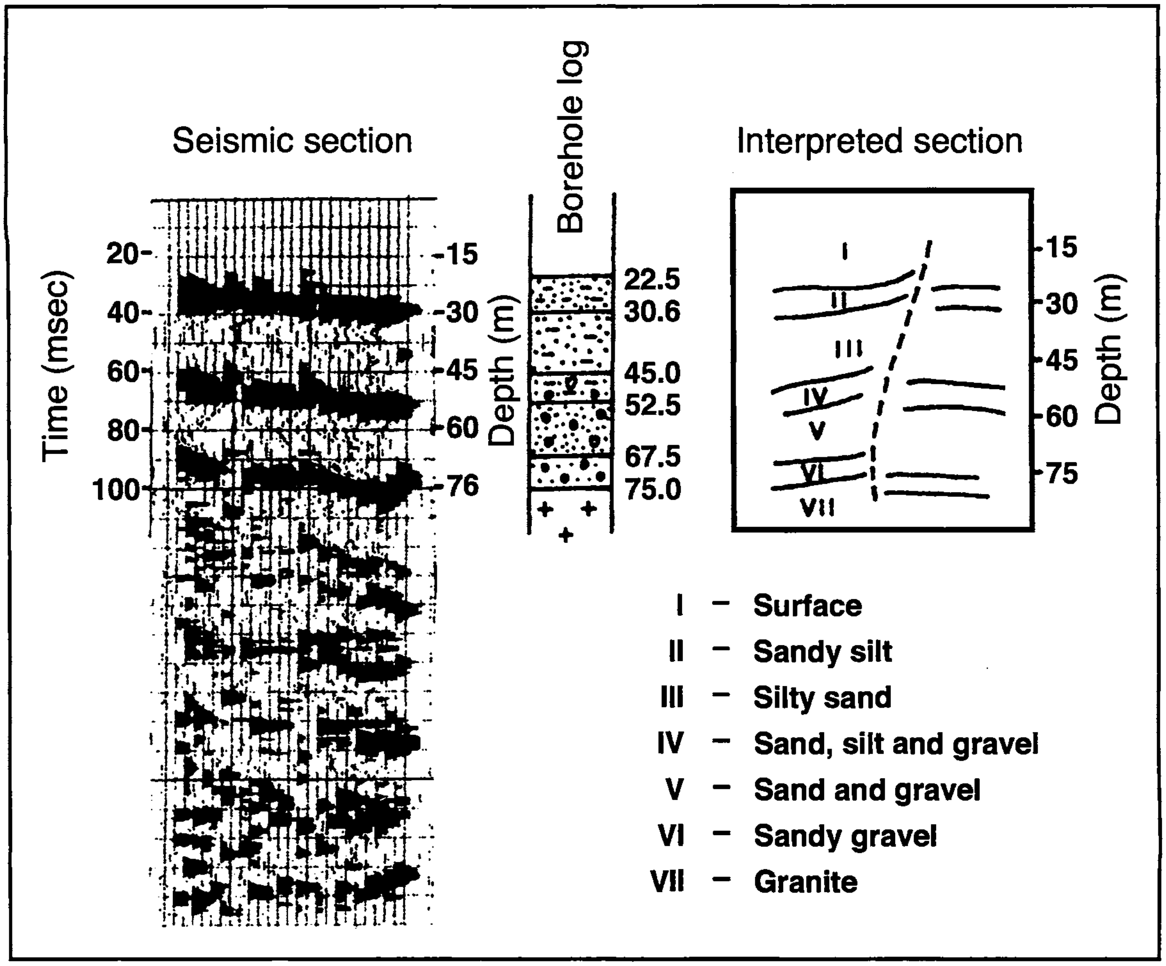

Figure 6. Subsurface structure based on reflection seismics, Kg. Leban Chondong, Rompin, Pahang.

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Manuscript received 26 October 1994