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Applying Seismic Refraction Method in Depicting Geological Contact at Bukit Bunuh, Lenggong, Perak, Malaysia

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Abstract. The study objective is to delineate geological contact for subsurface geological structure. The study area situated at Bukit Bunuh, Lenggong, Perak, Malaysia, covered 8km long with West-East direction. A combination of 62 seismic spread with 115m each spread, data acquisition conducted using 20kg weight drop as the wave source, 24 units of 24Hz geophones and a seismograph. Time-travel of the seismic wave is used for interpretation using computer software. The geological contact is determined by distinct changes of the seismic velocity as this indicates that the wave has entered a new earth material with different elastic property. Result shows that the study area basically consist of two main zones which are alluvium mix with boulders with seismic velocity of 400-1400m/s and granite bedrock with velocity of 2100-6000m/s. Correlation made with borehole data has confirmed that the earth materials are alluvium and granite. The thickness of the first layer which also indicates depth to bedrock was 4.1-28.7m.

Keywords: Bukit Bunuh, geological contact, seismic refraction.

1. Introduction

The boundary between different rock bodies is known as geologic contacts [1]. Depicting geological contact has its own benefits such as producing geological map [2], determination of deep crustal structural [3], and mapping geological boundaries for engineering purpose [4]. Common geophysical techniques applied for delineating geological contacts are gravity method [5], resistivity method [6] and seismic refraction method [7]. Gravity and 2-D electrical method were used to determine the dip angle of the geological contacts. However, gravity survey has its own limitations such as time consumption especially for a wide study area. Thus, seismic refraction survey is applied for outlining geophysical contact in this study as it gives depth profile of the geological contact by interpreting the lateral velocity change of the seismic wave.

The survey area is situated at Bukit Bunuh, Lenggong, Perak, Malaysia. Generally the Lenggong valley consists of few lithology which are alluvium, tephra dust and granitic rock. Most of alluvium unit are situated along river area where the quaternary sediment consist of alluvium and tephra dust, while the granitic rock which is from Jurassic end-Carbonaceous low era being dominated the whole of Lenggong valley and originated from Bintang Range at the west of Lenggong [8]. Previous work done using the same method has obtained almost similar result [9].

Seismic refraction method makes use of waves travelling along the ground surface and of waves in the underlying more compact layers where the velocities are higher (Fig. 1) [10]. They return to the surface as refracted waves which are sometimes called head waves [11].

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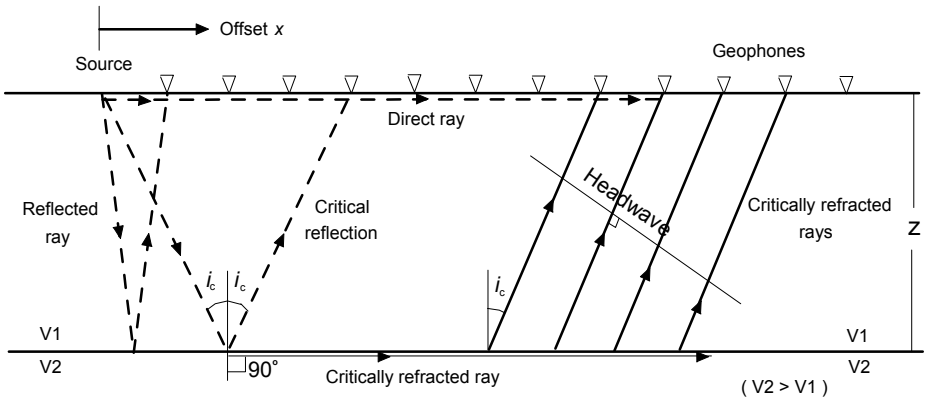

Fig. 1: Direct wave, reflection and refraction ray.

Determining times for direct and refracted arrivals from seismic section, thickness and velocity of material above and below an interface can be calculated [12]. Table 1 shows seismic P-wave velocity of Earth materials [13]. The type of rock or earth material is interpreted based on the table. The geological contact is determined by the sudden change of the seismic refraction velocity. The depth of the contact is where the velocity changes abruptly.

Table 1: The P wave velocities of various earth materials.

Material	P wave Velocity (m/s)
Air	332
Water	1400-1500
Granite	5500-5900
Sandstone	1400-4300
Limestone	5900-6100
Sand (Unsaturated)	200-1000
Sand (Saturated)	800-2200
Clay	1000-2500

2. Methodology

2.1. Data acquisition

The seismic survey line (Fig. 2) start from West with coordinate 5° 4'22.80"N and 100°56'43.50"E toward East with coordinate 5° 4'10.90"N and 101° 0'53.60"E. The total length of the survey line is 8km. 20kg weight drop was used for seismic source, 24 units of 24Hz geophones and ABEM MK6 seismograph. The length of each seismic spread is 115m with 5m geophones spacing. Thus, there are 62 seismic spreads in total. Two boreholes D1 and BH1 located a few meters away from the survey line.

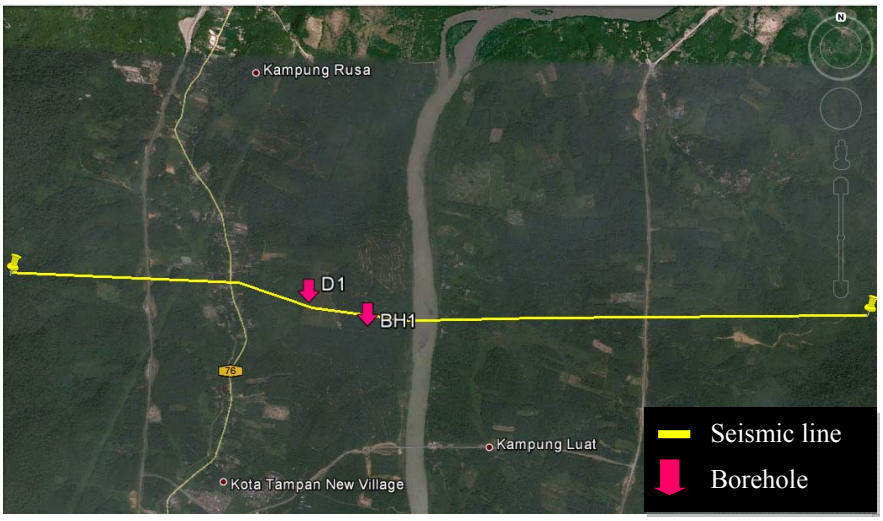

Fig. 2: Seismic survey line at study area.

The interpretation of seismic refraction survey has considered few borehole data as guideline. As seismic refraction method does not require gridding data point, less time is needed in data acquisition compared to potential field survey.

2.2. Data processing

Seismic data, recorded by seismograph were processed using software FIRSTPIX for picking first arrival time and plotting travel time curve. GREMIX15 software was used for velocity analysis to produce seismic cross section. Microsoft Excel was used to produce the seismic cross section and Surfer 8 was used for producing borehole data cross section.

3. Results and Discussion

The data used in interpretation of geologic contact are seismic refraction depth profile and two borehole data.

3.1. Seismic refraction

Seismic cross section of the survey line (Fig. 3) show the study area generally consists of two main layers. The first layer predominantly consist of alluvium mix with boulders with velocity of 400-1400 m/s while the second layer with velocity of 2100-6000 m/s and depth of 4.1-28.7 m is interpreted as bedrock. The second layer, marked by red lines in the seismic cross section also indicates the geological contact of granite bedrock with overburden. Seismic section shows steep slopes identified at a distance of ~ 450 - 1250 m.

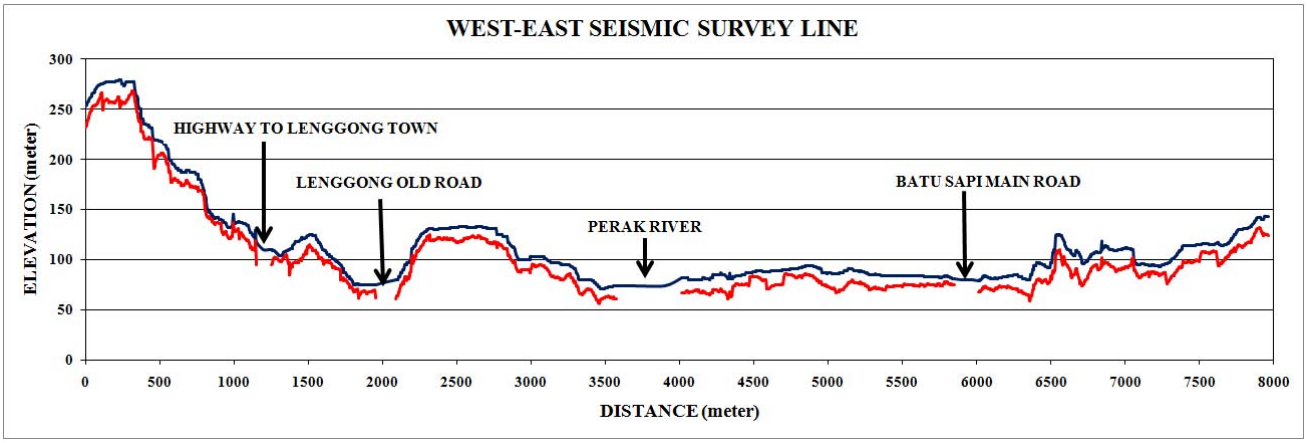

Fig. 3: Seismic cross section of West-East survey line.

3.2. Borehole record

Borehole data, D1 and BH1 (Fig. 4) shows that the study area was covered by alluvium, mostly sand mix with clay. Granite bedrock in borehole D1 was at depth 9.50 m. The borehole data match with seismic velocity record of seismic spread no. 42 specifically at geophones 20 and 21 which situated nearest to D1 gives the velocity of 3916-4485 ms^{-1} at depth about 9.7-9.8 m.

Granite bedrock for borehole BH1 found at depth 12.50 m and the borehole data fit with seismic velocity data of seismic spread no. 37 at geophones 23 and 24 which indicate the geological contact at depth 11.6-13.3 m. Boulder found nearby the borehole shows that the area has undergoes igneous rock intrusion (Fig. 5).

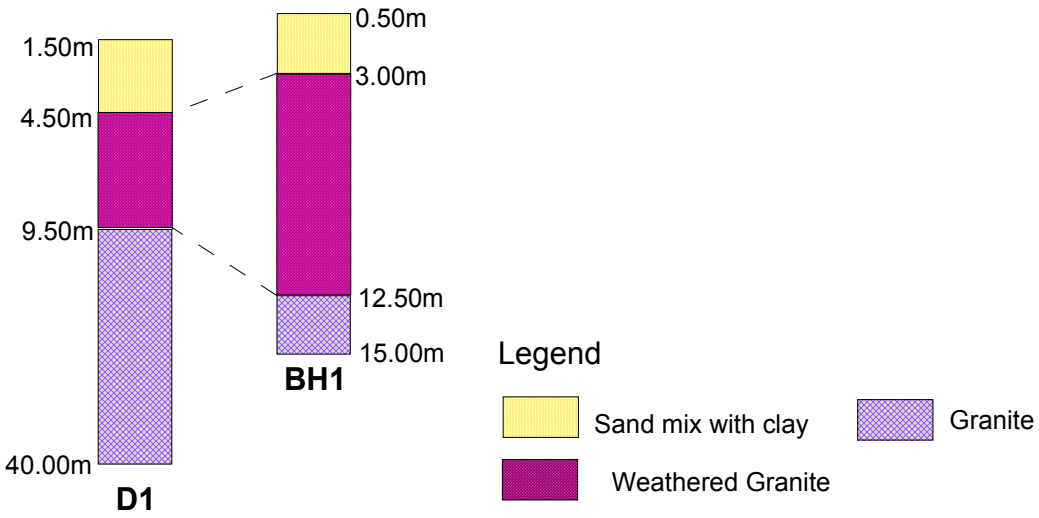

Fig. 4: Borehole data cross section.

Fig. 5: Coarse-grained granite rock boulder.

4. Conclusion

Geological contact can be located by utilizing seismic refraction method. Generally the study area consists of 2 main zones; alluvium mix with boulders with velocity of 400-1400 m/s and granite bedrock with velocity of 2100-6000 m/s. Correlation with borehole data has confirmed the seismic result. Thus, the geological contact is between granite bedrock and alluvium with thickness of alluvium is 4.1-28.7m.

5. Acknowledgements

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