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Estimation of Epsilon Parameter of Fracture Induced Anisotropy by In-Situ Seismic Refraction Survey

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Fractures have the ability to delay the arrival times of seismic wave. The rate of the delay depends on the direction of wave propagation with respect to fractures orientation; smallest delay parallel with the fractures and largest delay normal to the fractures. This can result in misinterpretation of true velocity of a rock mass and produce incorrect subsurface image. Thomsen's anisotropy parameters summarized this velocity variation to improve the accuracy of subsurface imaging. A seismic refraction survey was performed at a limestone quarry in Chemor, Perak, with existing outcrop showing an almost vertical fractures. The study was conducted to determine Thomsen's epsilon parameters that explain the anisotropic rate which is caused by the main fractures within the limestone. Three seismic lines were laid out on a flat surface below the outcrop; one survey line with 70 m length was laid out parallel with the strike direction; two lines were in the dipping direction where one of them crosses the fracture with 114 m length and the other one, a 70 m survey line, does not cross the fracture. Seismic refraction data were interpreted using General Reciprocal Method (GRM), Delay Time, and ABC Method. Analysis of the velocities of non-weathered layer uses the equation derived by Thomsen and indicates the epsilon parameter for the line that crosses the fracture and the one that does not cross the fracture are 0.57 and 0.08 respectively. Rock samples were collected from the study area and 1.0 x 2.5 Inches cores were prepared. Sonic measurement were performed using solid cores and later the cores were cut into two to create an artificial fracture in each cores. The epsilon value obtained from sonic measurements were much greater than the epsilon value obtain from the field because laboratory measurements are not influenced by the in-situ bulk properties of the rock mass. However, the laboratory measurement also shows the existence of anisotropy induced by the artificial fracture.

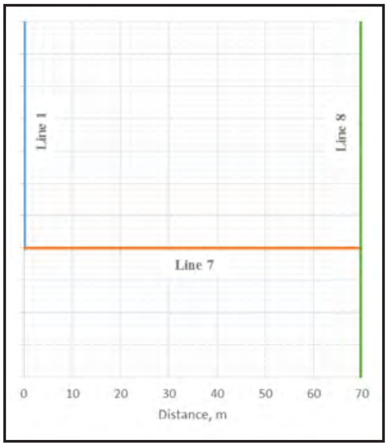

Figure 1: Orientation of in-situ seismic refraction: Line 7 is parallel with strike direction of 20° and is located directly above the fracture. Line 1 and Line 8 are perpendicular to the strike direction. Line 8 is extended across the fracture.

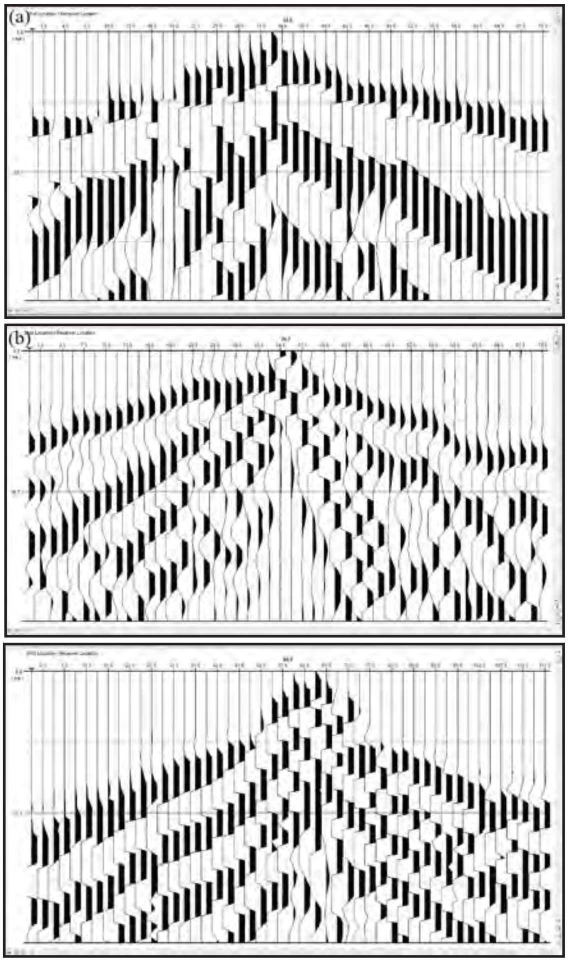

Figure 2: Recorded seismic signal of (a) Line 7, (b) Line 1 and (c) Line 8. Time arrival of the first breaks of Line 7 and Line 1 are almost similar but time arrival of the first break in Line 8 are longer. Since Line 8 is the only line that crossing the main fracture, this indicate that there is anisotropy induced by the fracture.

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