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Retrieving Seismic Reflective Waves from DAS VSP: a Case Study from MiDAS Project

Zhuo-Kang Guan[1], Hao Kuo-Chen[1], Chun-Rong Chen[2], and Kuo-Fong Ma[3]
[1]Department of Geosciences, National Taiwan University, Taipei, Taiwan
[2]Geological Resource Exploration Department, Industrial Technology Research Institute, Tainan, Taiwan
[3]Institute of Earth Sciences, Academic Sinica, Taipei, Taiwan

The Longitudinal Valley in eastern Taiwan situated at the boundary between the Philippine Sea Plate and the Eurasian Plate, making it one of the significant seismogenic regions in Taiwan. In 2018, a magnitude 6.4 earthquake occurred offshore of Hualien, at the northern end of this valley. More than 4,000 aftershocks received over following two weeks beneath the Longitudinal Valley. Surprisingly, Hualien City and the Milun Fault, situated near the epicenter, did not experience notable aftershocks. However, they did display evident co-seismic deformation during the mainshock. Milun fault Drilling and All-inclusive Sensing (MiDAS) project aims to establish a comprehensive and long-term monitoring system, which involves three boreholes encompassing the fault for both surface and subsurface geoscientific observations. This study utilized a 700-meter DAS (Distributed Acoustic Sensing) setup within the borehole A of the MiDAS project to conduct VSP (Vertical Seismic Profiling) experiments. Additionally, electrical logging and surface reflection seismic data were gathered. According to the 2D reflection seismic profile, the results depicted a gently sloping stratum on the northwest side arching towards the southwest. Most layers tapered beneath the Milun Terrace, and the fault-induced stratigraphic disturbance was not clearly discernible, making it challenging to determine if the layers were intersected by the fault. However, pronounced folding structures were evident beneath the terrace, correlating with areas of intense co-seismic deformation. From the VSP experiment, the data exhibited pronounced P-waves and Tube waves, suggesting the presence of fluids around the casing rather than rocks or cement. After data processing, the P-wave velocity correlated well with the downhole sonic logging data. Also, reflection signals with two-way travel times ranging from 0.27 to 0.45 seconds were observed in both seismic profiles. This suggests that the VSP effectively resolved reflection signals from depths of 340 to 612 meters. These signals displayed a high resemblance to lithology indicators such as Gamma ray and resistivity, confirming the authenticity of the separated reflection signals obtained from shallow depth, lower signal-to-noise ratio data.