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High-resolution reflection seismics in pyroclastic sediments – a case study from the SESaR-project in Indonesia

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The sustainable use of geothermal resources for decentral electricity generation in Indonesia requires sophisticated pre-exploration, exploitation and monitoring due to the very complex geological conditions. High-resolution seismics for pre-exploration in areas with high geothermal gradients is an emerging new field of application. Therefore the development of new, site-specific methodical procedures of exploration is required to deal with the special lithologies and outer conditions. This is the background for the BMBF-financed SESaR (Seismic Exploration and Safety Risk study for decentral geothermal plants in Indonesia) project. Until now, we have investigated one site in Northern Sumatra and one in Western Java. Both of them are dominated by pyroclastic sediments.
The high-resolution reflection seismic survey carried out in Tarutung/North Sumatra was shot with both P-wave and S-wave sources (the ELVIS microvibrator of LIAG) and partly also with vertical hammer blow. Using a 48-channel geophone array (10 Hz S-wave, 14 Hz P-wave) and a geophone interval of 5 m (P-wave) and 1 m (S-wave), respectively, fourteen reflection seismic profiles were acquired. The P-wave data give unexpected results. At almost all locations clear reflection events and also refractions are missing indicating indifferent wave propagation. This is in strong contrast to the S-wave seismic signals that enable a clear wave propagation and also correlate to some subsurface reflectors. A small discordance structure interpreted as fault was clearly recognised at 5 m depth, bounding a travertine body that crops out at the surface.
Seismic measurements at Lembang/West Java, with same layout and equipment as described above, led to thirteen seismic profiles at four different locations. Additionally a hammer blow source was used at each location. The results are comparable to those of the Tarutung data. Most of the P-wave seismic data show poor signals. Only some single records contain weak reflectors. S-wave data show again better results with some reflected wave signals gained from the subsurface.
These results lead to the assumption that seismic P-wave reflection surveys in areas with pyroclastic sediments as in Tarutung and Lembang are not successful. This is probably caused by strong energy absorption and/or scattering in the upper pyroclastic layers. S-wave seismics seems to be the first choice for seismic investigations in such kind of geological area. The influence of local geological conditions on the seismic signal is subject of further investigation and discussion.