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Multi-station Analysis of Surface Wave Dispersion Using Distributed Acoustic Fiber Optic Sensing

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SUMMARY

Multi-station analysis of surface wave dispersion to evaluate the near subsurface has been used in geotechnical applications for more than 15 years. A fiber optic cable used as array of distributed horizontal component seismic receivers for the analysis of surface wave dispersion is used in an extended setup here by the recording of active hammer blows. Their first analyses reveal low-frequency signal recordings with good continuity that can be used for further processing.

Introduction

Generally, several vertical or multi-component geophones are deployed on the ground to monitor the propagation of surface waves. This study reports about applying a fiber optic cable as an array of distributed horizontal component seismic receivers for the analysis of surface wave dispersion.

Case study in Iceland

Within the framework of the EC funded project IMAGE (Integrated Methods for Advanced Geothermal Exploration) a 15.3 km long fiber optic cable, deployed at the ground surface on the Reykjanes peninsula in Iceland, was used for the acquisition of continuous distributed acoustic sensing data (DAS) for a period of 9 days (Reinsch et al., 2016).

During this time, additional 30 hammer shots were performed along the cable to calibrate the spatial distribution of the acoustic information. At several locations, the signal of the hammer shot can be followed for more than 100 m in both directions along the cable. Most of the signal energy is contained within a frequency range from approximately 10 Hz up to 40 Hz. Coherent data is observed up to a frequency of at least 40 Hz. SASW (Spectral Analysis of Surface Waves), MASW (Multichannel Analysis of Surface Waves) and fk-analysis (frequency-wavenumber) are used to calculate the surface wave dispersion. Although Rayleigh surface waves dominate the response of the optical cable, individual refracted waves can be observed, too, that are used to calculate a P-wave velocity model of the subsurface. The P-wave velocity model is used as a constraint for the surface wave inversion. Preliminary results, indicating a strongly heterogeneous subsurface, will be presented.

Conclusion

Standing at the beginning of understanding horizontally registered components after signal excitation mainly referring to vertical incidence, we suppose that this technology opens new seismic and strain mapping tools for subsurface features, once proven stable.

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References

Reinsch, T., Jousset, P., Henninges, J., Blanck, H. (2016 online): Distributed Acoustic Sensing Technology in Magmatic Geothermal Areas – First Results from a Survey in Iceland - Proceedings, European Geothermal Congress (Strasbourg, France 2016).