Geophysical Research Abstracts
Vol. 20, EGU2018-4867, 2018
EGU General Assembly 2018


# Imaging the velocity and the velocity variations of the Groningen gas reservoir in the Netherlands

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The Groningen gas field in the Netherlands is the world's 7th largest onshore gas field and has been in production since 1963. Since 2013, the year with the highest level of induced seismicity, the reservoir is monitored by two geophone strings at the reservoir level at about 3 km depth. In borehole SDM-1, 10 geophones were positioned from the top to the bottom of the reservoir with a geophone spacing of 30 m. Noise interferometry was applied to a data set of 33 days in 2013. We were able to accurately retrieve the P and S velocity structure within the reservoir and also determined the fast shear wave polarization direction. This direction is found to be similar to the maximum horizontal stress direction at nearby boreholes. The interferograms show both day-and-night and weekly variations reflecting the variations in anthropogenic noise. Analysis of the raw data showed that nearby passing trains cause high-frequency noise (up to 100 Hz) at regular intervals. These repetitive high-frequency signals can be used to monitor small temporal variations in the reservoir. Deconvolution interferometry of train signals, using a 6 month data set from 2015, indicates that the P wave velocity increased over this time span. This is likely explained by compaction within the reservoir.