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Shallow seismic exploration of the Keuper layers outcropping on the shoulders of the Rhine Graben using P and S waves

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We have performed several seismic P and S waves profiles in Keuper layers outcropping on the shoulders of the Rhine Graben in order to investigate if the lithological and structural heterogeneity that characterize these layers can be detected at depths less than 100m. These shale and limestone layers contain anhydrite levels and are offset by faults that constitute potential hazards for shallow geothermal drilling.
7 short profiles have been done in the Keuper layers outcropping in Grünern (Baden-Württemberg), and 3 profiles in similar layers outcropping on the opposite shoulder of the Rhine Graben in Flexbourg (Alsace) where ancient gypsum mining is known.
We are using a hammer and between 48 to 72 vertical geophones for the P profiles, an Elvis horizontal vibrator (30-160 Hz) and 48 to 72 horizontal geophones for the S profiles. Intervals between geophones and shots varying from 50 cm to 2 m were used. For each profile, the recording spread is at a fixed location.
First refracted arrivals are observed up to the maximum offset of 100m. Travel times are adjusted with a layered model with dipping interfaces. The surface layer is characterized by a thickness from 1 to 7 m and velocities VP = 300 m/s and VS = 160 m/s. The underlying layer is characterized by a thickness from 6 to 10 m and velocities VP = 880 m/s and VS = 360 m/s. P velocity larger than 2000 m/s is observed below.
The first arrivals indicate the existence of shallow lateral velocity variations. Undulations of the interfaces or the presence of low velocity lenses in the shallow layer are apparent in the refracted arrival times. Strong reflections of refracted waves observed on one profile indicate the existence of steep discontinuities that may indicate subvertical faults.
Despite using small spatial sampling of shots and geophones, it has proven difficult to detect shallow reflections except on one P wave profile located close to the ancient gypsum mine in Flexbourg. There, clear reflections from depths 30 and 50 m are observed, possibly related to the gypsum level.