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# Integrative velocity model building for imaging a geothermal reservoir in southern Tuscany, Italy

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Deep geothermal reservoirs are generally characterized by high temperatures and pressures, sometimes located in hard rock environments and even close to a super-critical state. For characterization of such a deep super-critical geothermal reservoir, the imaging of the subsurface at the highest possible resolution is required to reduce the uncertainties in exploration prior to the drilling phase.

Several seismic surveys were carried out for characterization of a possible drilling target within a deep super-critical geothermal reservoir in Tuscany (project DESCRAMBLE). Seismic data were acquired in the form of 2D seismic reflection surveys as well as Vertical Seismic Profiling (VSP), the latter complemented by simultaneous recording of the source signals by a surface network covering an area of approximately 6 km x 6 km around the drill site. The investigation area itself is characterized by a complex geology with strong velocity contrasts, near-surface inhomogeneities and fracture zones.

At first, the processing of the recorded seismic wavefields aimed at the determination of a seismic velocity model by a multidisciplinary approach. The application of conventional methods is limited due to the low resolution of the stacking velocities, significant lateral velocity changes and strong influence of noise. We performed first-arrival traveltime tomography and derived borehole velocities to tackle the complexity of the geology. Below the bottom of the borehole, results from laboratory measurements of rock samples from deeper neighboring wells were integrated into the velocity model. This approach limits the ambiguity, which depends on the existence and distribution of the neighboring wells in the investigation area. The results contribute to a robust migration velocity model used for an uncertainty depth analysis at the target horizon.

In a next step, the influence of the velocity model on imaging is tested within an advanced seismic imaging workflow for several 2D reflection seismic profiles. The application of focusing migration methods compensated for the influence of the metamorphic environment on the recorded seismic wavefield and revealed a clearer image of the target horizon. Further investigations will focus on the derivation of the seismic parameter contrast by illuminating the target horizon at different angles.