A seismotectonic study and minimum 1D velocity model for the Greater Geneva Basin, Western Switzerland

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In the framework of the Geothermie2020 project, the canton of Geneva and the Industrial Services of Geneva (SIG) are currently developing geothermal exploration in the Greater Geneva Basin (GGB), located in south-western Switzerland and neighbouring France. Before geothermal exploration begins, it is important to investigate the ongoing seismic activity, its relationship with local tectonic features, and the large-scale kinematics of the area. Background seismicity suggest that the local tectonic structures affecting the basin may still be active. Moderate-magnitude earthquakes have been identified along the Vuache fault, a major strike-slip structure crossing the basin. In this context we deployed a dense temporary network of 20 broadband stations around and within the GGB, during ~1.5 years, and reaching a detection threshold 0.5Mₗ.

Using a new coherence-based detector (LASSIE), we detected and located 158 events in our area of interest. However, only 20 events were located in the GGB, with local magnitudes ranging from 0.7 to 2.2Mₗ. We found no earthquakes in the Canton of Geneva where geothermal activities are taking place. We constructed a local minimum 1D velocity model with VELEST, using the recorded seismicity together with earthquakes from adjacent regions, in a total of 1263 P- and S-picks. The new velocity model allowed to relocate micro-seismic activity up to 11km depth along the main fault systems (i.e. Vuache, Cruseilles, Le Coin, and Arve) offsetting the GGB. We retrieved 8 new focal mechanisms for the area, using a combination of polarities and waveform inversion techniques (CSPS method). A stress inversion shows a tectonic deformation dominated by a quasi-pure strike-slip regime in the GGB, consistent with structural and geological data.

The study of microseismicity in a quiet sedimentary basin is challenging due to the scarce occurrence of seismic events combined with low signal-to-noise ratios and the often strong attenuation. However, the investigation of the sporadic (yet present) natural seismicity with dedicated dense networks could provide useful information about the GGB, even with a short-term experiment. We propose a newly-computed 1D velocity model that can be used in the GGB for seismic monitoring purposes throughout the geothermal project. This model can be easily improved later on, whenever more data is available. Monitoring the evolution and dispersion of
the seismic-activity through the identified seismogenic areas during the geothermal project is essential. Quantifying the seismic rate in the basin before geothermal operations start will help to quantify the impact that geothermal energy extraction might have on the GGB.