Mapping active faults in the region of Vienna to minimize seismic risks associated with geothermal energy production

Weissl, Michael[1]; Flores-Orozco, Adrián[2]; Decker, Kurt[1]

1 Institute of Geology, University of Vienna, Josef-Holaubek-Platz 2, A-1090 Vienna, Austria; 2 Technical University of Vienna, Department of Geodesy and Geoinformation, Research Division Geophysics, Wiedner Hauptstraße 8 / E120-03, A-1040 Vienna, Austria.

In the last decades, the increasing need for renewable energies led to an exponential growth of enhanced geothermal projects in many parts of the World, including continental Europe. That led to several episodes of unpredicted induced seismicity, which in some instances resulted in the temporary interruption of the geothermal activities or even to the complete cancelation of projects. Unwanted seismicity can occur as an effect of pore pressure build-up during the injection of cooled water which is associated with the decrease of the effective normal stress acting on faults and therefore can lead to unpredicted fault-slip and triggered seismicity. The recognition and precise mapping of active and critically stressed faults which could be triggered by injection was therefore analysed during the project GeoTief 3D EXPLORE. The project addressed the exploration of hydrothermal resources in Vienna. A substantial effort was made to identify, map, and assess, Quaternary faults to delimit areas where the reinjection of thermal water should be avoided. In the Miocene pull-apart Vienna Basin several small fault-delimited depressions developed during the Quaternary. These basins are delimited by active normal faults branching off the main strike slip fault of the Vienna Basin Transform Fault System. Displacements during the Pleistocene left distinct marks in the late Pleistocene landform configuration of fluvial terraces. Fault scarps and fault-related valleys are clearly cognized in high resolution LiDAR and satellite images. Fault slip rates can be estimated from the thickness of Quaternary fluvial sediments forming growth strata in the fault-delimited basins. Therefore, a first objective was the modelling of the horizon “Base Quaternary” and the calculation of the thickness of Quaternary sediments from literally thousands of shallow drillings in the Vienna Basin. To achieve an accurate active fault map of Vienna and its surrounding, Quaternary sediment data and geomorphological data were supplemented by high-resolution geophysical mapping of near-surface faults (ERT, 2D reflection/refraction seismic) and interpretation of deep 2D/3D reflection seismic. In the geothermal prospection area data highlight two major normal fault systems referred to as the Seyring and Aderklaa faults, each comprising of several fault splays. Paleoseismological evidence proves that both systems were the loci of strong prehistoric earthquakes (Weissl et al., 2017, Quaternary International, 10.1016/j.quaint.2016.11.022; Oppenauer et al., 2022, this volume). The evidence of Quaternary fault slip, the occurrence of strong paleoearthquakes and evidence for critical stressing of at least one of the faults (Levi et al., 2022, this volume) calls for utmost carefulness when selecting sites for the injection of cooled thermal water.