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Paleoseismology of the Seyring-Aderklaa Fault System, Vienna, Austria

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The Aderklaa- and Seyring faults are part of a series of normal faults accommodating active extension west of a releasing bend of the Vienna Basin strike-slip system. The faults are located in the urban area of Vienna and adjacent Lower Austria. The proximity to the Vienna city centre (ca. 13 km), high population density and the focus on the area for future urban development result in high vulnerability and risk. Exploration for deep geothermal energy in the immediate vicinity of the faults adds a further risk factor. The fault system was therefore the subject of focused paleoseismological investigations including spatial fault mapping of industrial 3D seismic, high-resolution near-surface geophysics, stress modelling (Levi et al. 2023, IJES), drilling and trenching.

The active fault system consists of two sets of (N)E- and (S)W-dipping normal faults, respectively, both offsetting Pleistocene terraces and capturing local streams. While cryoturbation prevents the identification of individual paleoearthquakes for the (S)W-dipping Aderklaa Fault (slip rate: 0,03 mm/y; Weissl et al., 2017, Quaternary International), three trenches (GER1 to GER3) revealed a detailed Late Pleistocene paloeoearthquake history for the (N)E-dipping Seyring faults. GER2 and GER3 exposed four event horizons in loess dated to 25 ka, 17-16 ka (two events) and 15 ka cal BP. Sand intrusions in a rupture surface of the youngest event prove liquefaction and seismic deformation. The exposed faults are antithetic secondary faults with respect to the W-dipping main normal fault formed by crestal collapse of a rollover above the main fault. The main fault does not cut up through the exposed section but offsets the base of a 400-200 ka old river terrace for 7 m and causes a 50-70 cm downward flexure of a 25 ka old paleosurface. Slip rates calculated independently from both markers are 0,02 mm/a, the average recurrence interval of paleoearthquakes is ca. 6.000 a. Trench GER1 excavated a second fault of the Seyring system with a normal offset of the base of aforementioned terrace of 8 m. Oppenauer et al. (2022; Pangeo 2022) identified six events that occurred between 32 and 14.8 ka BP corresponding to an average a recurrence rate of approximately 5,300 years. Two events formed colluvial wedges with 20 cm height each allowing to estimate the associated magnitudes with M≈6,4. The average slip rates calculated from the offset terrace and trench data are 0,02 mm/a. Whether the paleoearthquakes identified in GER2 and GER3 are time-correlated with the events recognised in GER1 is subject of current investigation.

We conclude that the Aderklaa and Seyring fault system consists of a minimum of three active

faults with slip rates of 0,03-0,02 mm/a. Each fault needs to be taken into account in the assessment of regional earthquake hazard and risk. Available data for hazard modelling include: reliably determined fault kinematics consistent with the regional seismotectonic model of the Vienna Basin fault system; fault geometries accurately determined from 3D seismic down to ca. 4 km depth; fault slip rates; average earthquake recurrence intervals; and recent stresses derived from a borehole-derived 1D stress model.