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New 3D seismic velocity models for improved hypocenter location and seismoteconic interpretation of shallow seismicity in the Swiss Alps and its foreland

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Information on the structure of upper-crustal fault systems and their relation with seismicity is key to the understanding of neotectonic processes. Concerning the Swiss Alps and their northern foreland, precisely determined focal depths in combination with structural models provide important insight into the recent deformation styles of the upper crust (e.g. thin- versus thick-skinned tectonics) and thereby contribute to seismic hazard assessment. However, the complex velocity structure of the uppermost crust often hampers precise location of shallow seismicity and therefore limits tectonic interpretations (e.g. host lithology, identification and imaging of seismogenic fault zones).

In this study, we aim to reduce uncertainties in hypocenter parameters by improving P and S-wave velocity models of Switzerland and surrounding regions. In particular, we take advantage of improvements of the Swiss National Seismic Network in terms of station density and data quality. The high-quality travel-time data set collected by the Swiss Seismological Service (SED) over the past 20 years is used to solve the coupled hypocenter-velocity structure problem in 1D. Within the 1D inversion procedure, the quality of travel-time data is assessed and possible erroneous picks in the SED bulletin are identified. In a second step we perform a 3D local earthquake tomography with grid spacing between 5x5 and 10x10 km.

Finally, we constrain host lithologies of upper-crustal seismicity by comparing focal depths with the 3D velocity structure derived from the simultaneous inversion of travel times. Our interpretation does focus on two regions: 1) The source region of the ML 4.6 Urnerboden earthquake of 2017, which was located in the Helvetic nappes near the northernmost outcrops of the crystalline Aar massif. The seismotectonic interpretation considers absolute locations, 3D velocity structure, high-precision relative relocations, focal mechanisms, geological profiles, and structural and field analysis. Our results document a likely connection between seismicity near the basement-cover contact and faults outcropping at surface in the Helvetic nappes in strike slip mode. This suggests that the entire sedimentary cover (and maybe also the uppermost basement) presently deforms as a block, with deformation in the sedimentary cover not being decoupled from deformation in the crystalline basement. 2) Northern Switzerland, which is the region encompassing potential sites for national radioactive waste repositories. With the targeted inversion grid spacing of 5x5x5 km, we aim to separate the sedimentary cover from the crystalline basement. We also explore the possibility of resolving Permo-Carboniferous Trough structures in this region. We use the upper-crustal structures imaged by local earthquake tomography, relocated seismicity, focal mechanisms, available seismic reflection data, and geological information to improve the seismotectonic model of this region.