New insights into structure and seismicity of the Central Alps from 3D Pg and Sg tomography and improved hypocenter relocations

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Accuracy of hypocenter location, in particular focal depth, is a precondition for high-resolution seismotectonic analysis of natural and induced seismicity. For instance, linking seismicity with mapped fault segments requires hypocenter accuracy at the sub-kilometer scale. In this study, we demonstrate that inaccurate velocity models and improper phase selection can bias absolute hypocenter locations and location uncertainties, resulting in errors larger than the targeted accuracy. To avoid such bias in densely instrumented seismic networks, we propose a coupled hypocenter-velocity inversion restricted to direct, upper-crustal Pg and Sg phases. The derived three-dimensional velocity models, combined with dynamic phase selection and non-linear location algorithms result in a highly accurate earthquake catalog, including consistent hypocenter uncertainties. We apply this procedure to about 60'000 Pg and 30'000 Sg quality-checked phases of local earthquakes in the Central Alps region. The derived tomographic models image the Vp and Vs velocity structure of the Central Alps' upper crust at unprecedented resolution, including small-scale anomalies such as those caused by a Permo-Carboniferous trough in the northern foreland, Subalpine Molasse below the Alpine front or crystalline basement units within the Penninic nappes. The external Aar Massif is characterized by low Vp/Vs ratios of about 1.625-1.675 in the depth range of 2-6.5 km, which we relate to a felsic composition of the uplifted crustal block, possibly with increased quartz content. Finally, we discuss along-strike variations imaged by relocated seismicity in the Central Alps and demonstrate how joint interpretation of velocity structure and hypocenters provides additional constraints on lithologies of upper-crustal seismicity.