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Structure and Deformation of the Central-Eastern Aar Massif

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The Aar massif in the Central Alps of Switzerland is a block of uplifted crystalline basement, which represents the largest External Crystalline Massif (ECM) of the Alpine orogen. Recent tectonic studies of structural and thermo-chronometric data have put new constraints on the deformation and uplift history of the Aar massif. These data suggest exhumation of crystalline basement along steep vertical shear zones as well as along-strike differences in the growth of the massif, which are accommodated laterally by NW-SE trending strike slip faults. With additional information from previous seismic tomography studies, delamination of the lower European crust as a result of slab rollback was proposed as the main driver for the uplift of the Aar massif.

In this study, we compare the aforementioned tectonic models with tomographic images of the crust. We present our most recent 3D tomography model, which is based on high-quality local earthquake travel times of the past 22 years. More than 50,000 P and 25,000 S-wave arrival times allow the imaging of the upper crust for major parts of the Central-Western Alps with a spatial resolution of 10x10x4 km. We focus our comparison on the central-eastern part of the massif. In particular, we study the structure of its eastern termination, where the crystalline basement plunges towards east beneath the Helvetic nappes and thermo-chronometric data predicts the maximum exhumation rates from ca. 10 Ma to present.

We assess the neotectonic deformation of the Aar massif and its cover by newly derived high-precision earthquake relocations, focal mechanisms, and geodetic data. We provide high-resolution insights into the source region of the ML 4.6 Urnerboden earthquake of 2017, which is also located near the eastern termination of the massif, where the Helvetic nappes are immediately adjacent to the northernmost outcrops of the crystalline Aar massif. Our results document a rare but striking agreement in the seismicity pattern observed within the Aar crystalline massif near its basement-cover contact with faults outcropping at the earth's surface in the Helvetic nappes due to neotectonic activity along subvertically oriented strike slip faults. Such agreement suggests that the entire upper crustal section down to the uppermost portion of the eastern Aar massif presently deforms as a block, with the deformation in the sediments of the Helvetic nappes not being decoupled from deformation within the underlying parautochthonous wedge of the Aar crystalline massif. This implies a change from Helvetic nappes thrusting mode active during the Miocene towards neotectonic activity dominated by strike-slip mode in the studied region.