In the eclogitic micaschist complex (EMC), the Corio-Monastero metagabbro contains zircon with rims that crystallized at HT metamorphic conditions and date at ~277 Ma. Local recrystallized rims yield ages at ~230 and ~190 Ma, indicating two (fluid-induced?) episodes. During exhumation this gabbro was intruded by dikes. In one of these zircon shows two age populations at ~270 and ~235 Ma. Two intermediate to felsic intrusions in the EMC yield ~277 and ~266 Ma.

In the Valpelline Series of the Dent Blanche unit, three stages of amphibolite to granulite facies metamorphism are evident: The age data show ~287 Ma, ~274 Ma, and ~263 Ma. These metamorphic stages clearly postdate the Variscan metamorphic cycle, which occurred around 350 Ma, as confirmed by this study.

In the Emilius Klippe preliminary results indicate a Permain HT evolution as well: Basic intrusives have been dated at ~290 Ma (compare BUSSY et al., 1998) and a granitic intrusive at ~283 Ma. Zircon and allanite, both interpreted to be of metamorphic origin, cover an age range clustering at ~276 Ma.

These ages, together with petrological data, evidence that the middle and lower crust in several Austroalpine units in the internal Western Alps experienced a regime of high temperature in Permian times. The time span recorded in zircon ranges between ~290 and ~260 Ma. Age relics of the Variscan orogeny are sparse, and so far no evidence has been found of the regional HT metamorphism at ~310 Ma, known in the Ivrea Zone (e.g. EWING et al., 2013). It remains to be explored whether the differences among age data are due to differences in the Permian metamorphic history of these units or whether they merely reflect chemical differences (e.g. in the growth of zircon) due to local compositional differences or the structural position of the samples analyzed.

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3D FEM modeling of fold nappe formation in the Western Swiss Alps

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Many three-dimensional (3D) structures in rock, which formed during the deformation of the Earth’s crust and lithosphere, are controlled by a difference in mechanical strength between rock units and are often the result of a geometrical instability. Such structures are, for example, folds, pinch-and-swell structures (due to necking) or cuspate-lobate structures (mullions). These structures occur from the centimeter to the kilometer scale and the related deformation processes control the formation of, for example, fold-and-thrust belts and extensional sedimentary basins or the deformation of the basement-cover interface. The 2D deformation processes causing these structures are relatively well studied, however, several processes during large-strain 3D deformation are still incompletely understood. One of these 3D processes is the lateral propagation of these structures, such as fold and cusp propagation in a direction orthogonal to the shortening direction or neck propagation in direction orthogonal to the extension direction. Especially, we are interested in fold nappes which are recumbent folds with amplitudes usually exceeding 10 km and they have been presumably formed by ductile shearing. They often exhibit a constant sense of shearing and a non-linear increase of shear strain towards their overturned limb. The fold axes of the

Morcles fold nappe in western Switzerland plunges to the ENE whereas the fold axes in the more eastern Doldenhorn nappe plunges to the WSW. These opposite plunge directions characterize the Wildstrubel depression (Rawil depression). The Morcles nappe is mainly the result of layer parallel contraction and shearing. During the compression the massive limestones were more competent than the surrounding marls and shales, which led to the buckling characteristics of the Morcles nappe, especially in the north-dipping normal limb. The Doldenhorn nappe exhibits only a minor overturned fold limb. There are still no 3D numerical studies which investigate the fundamental dynamics of the formation of the large-scale 3D structure including the Morcles and Doldenhorn nappes and the related Wildstrubel depression. We study the 3D evolution of geometrical instabilities and fold nappe formation with numerical simulations based on the finite element method (FEM). Simulating geometrical instabilities caused by sharp variations of mechanical strength between rock units requires a numerical algorithm that can accurately resolve material interfaces for large differences in material properties (e.g. between limestone and shale) and for large deformations. Therefore, our FEM code combines a numerical contour-line technique and a deformable Lagrangian mesh with re-meshing. With this combined method it is possible to accurately follow the initial material contours with the FEM mesh and to accurately resolve the geometrical instabilities. The algorithm can simulate 3D deformation for a visco-elasto-plastic rheology. Stresses are limited by a yield stress using a visco-plastic formulation and the viscous rheology is described by a power-law flow law. The code is used to study the 3D fold nappe formation, the lateral propagation of folding and viscoplastic necking from an initially localized perturbation and also the lateral propagation of cusps due to initial half graben geometry. Thereby, the small initial geometrical perturbations for folding and necking are exactly followed by the FEM mesh, whereas the initial large perturbation describing a half graben is defined by a contour line intersecting the finite elements, where more numerical integration points are applied.

Micro-seismic characterization of the Fribourg Lineament - Switzerland

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This analysis investigates low-magnitude seismicity generated within the Fribourg area (Western Molasse Basin (WMB) - Switzerland). It focuses on the Fribourg Lineament (FL), an alignment of weak seismicity that showed recent signs of increased activity (KASTRUP et al., 2007). The FL runs in a North-South direction east of the city Fribourg and is parallel to the Fribourg syncline. Orientation of these two features differs strongly from the surrounding tectonic structures that show a general SW-NE trend.

The FL has been monitored since 2010 by two sparse mini-arrays (seismic navigating systems - SNS). Each SNS consists of one central 3D short-period (1Hz) sensor surrounded by three 1D short-period (1Hz) sensors. They are deployed in a tripartite geometry with an aperture of 100 m, which is best suited for azimuth and apparent velocities determination of incoming signal (JOSWIG, 2008). The recordings of the two SNS are complemented by records of three permanent stations of the Swiss Seismological Service (SED).

Event detection is done by visual event screening of continuous data sonograms (SICK et al., 2012). Sonograms are spectrograms based on power spectral density (PSD) matrix, noise adapted, muted and pre-whitened. Special features of sonograms allow for the extraction and recognition of earthquake signals by visual pattern recognition near to 0 dB signal to noise ratio. Detected events are then located using HypoLine, a software especially