Kinematics of active faults in the Eastern Alps

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Recent tectonic activity in the Eastern Alps is mostly concentrated in the system of strike slip faults that accommodate their east directed lateral extrusion. Present day activity of these strike slip faults is documented by several indirect geological, geophysical or geomorphological observations. However, none of the approaches has provided full characterization of present-day kinematic behaviour of particular faults. Here we present results of the first direct observation of fault activity at six sites (caves) in the Eastern Alps based on three dimensional movement monitoring. The sites are located in tectonically active areas close to major fault systems, which include Salzach-Ennstal-Mariazell-Puchberg Fault System, Mur-Mürz Fault System, Vienna Basin Transfer Fault, Periadriatic Line, and Pöls-Lavanttal fault system (Fig. 1). We had monitored subsidiary and/or conjugated faults associated to these major fault systems over a 1.5 – 2.5 -year observation period. Fault activity was recorded by high-resolution three-dimensional Moiré extensometers TM71, which recorded displacement of fault blocks in three orthogonal directions with resolution up to 1 μm. The measurements were registered automatically by web-cameras every 24 hours. The recorded fault activity was also compared to the seismicity near the monitored faults.

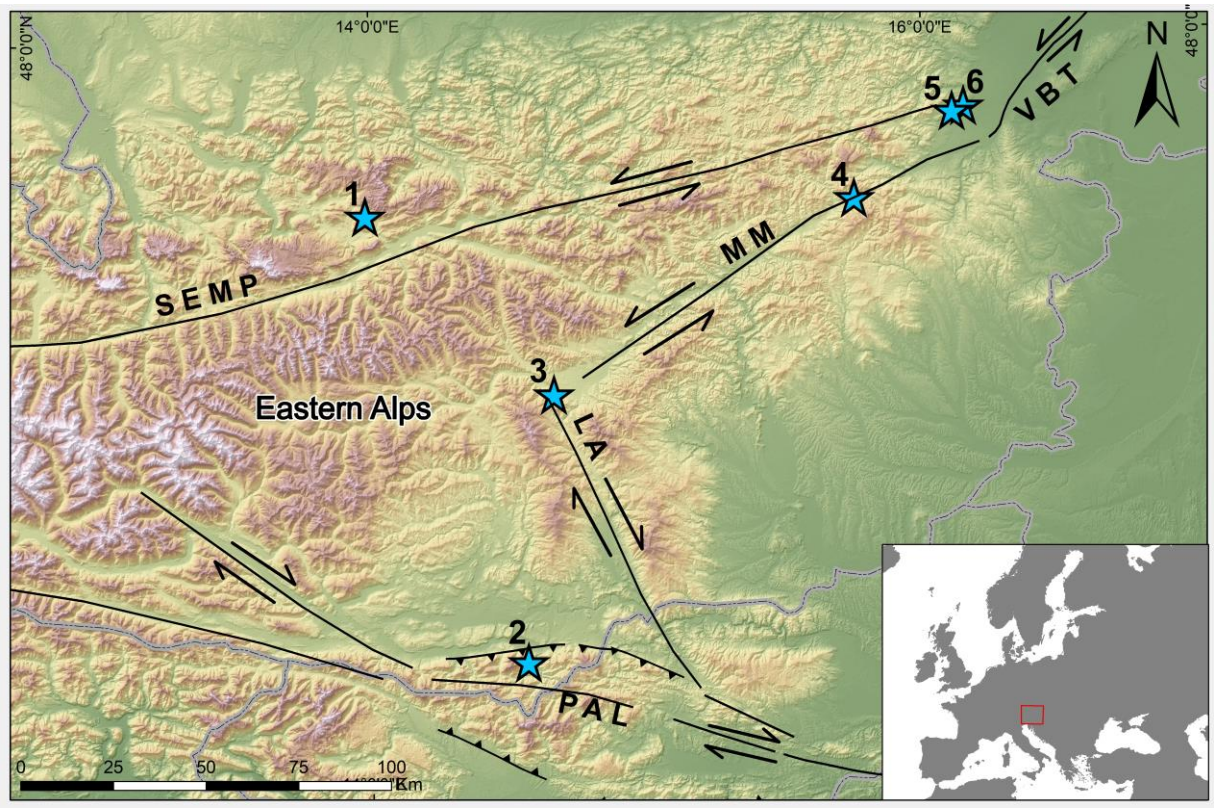

Fig. 1. Simplified sketch map of the main active fault systems in the Eastern Alps and the location of fault monitoring sites. 1 – Bullen Cave, 2 – Obir Cave, 3 – Geierkogel Cave, 4 – Zederhaus Cave, 5 –Emmerberg Cave, and 6 – Eisenstein Cave, SEMP – Salzach-Ennstal-Mariazell-Puchberg fault system, MM – Mur-Mürz fault system, VBT – Vienna Basin Transfer fault, LA – Pöls-Lavanttal fault system, PAL – Periadriatic Line fault system.

Monitoring network recorded aseismic displacements at micrometre level at all monitored faults during several activity phases that usually also coincided with periods of increased local seismicity. The annual displacement rates were mostly about an order of magnitude smaller than the rates of the entire crustal wedges revealed from the Global Navigating Satellite Systems. The biggest activity and average annual displacement rates were observed in the seismically most active regions along the Mur-Mürz fault, along the Periadriatic fault and in the North of the SEMP central part in Totes Gebirge Mts.

The particular displacements consisted of a variety of mechanisms and faulting regimes, such as strike slips, normal slips, reverse slips, displacements with movement component perpendicular to the fault plane (dilatation or compression) and their combinations. Fault dilations and compressions were mostly associated with thermal-volumetric variations, normal dip-slips and downward hanging-wall displacements originated due to gravitational relaxation or mass movement.

Displacements with the same mechanisms as their associated major fault systems or with an upward component were attributed to tectonic creep and strain built-up during the interseismic period. On the other hand, the countervailing displacements opposite to the master fault kinematics were most probably caused by elastic rebound. They were usually registered few days in advance to distinct local earthquakes that were simultaneously activated at locked segments within the same deformation band. Therefore, the countervailing events could be considered as an indicator of impending near earthquake within the rebound zone.