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Seismic deformation in the Western Alps : new insights from high resolution seismotectonic analysis

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In the Western Alpine arc, GNSS measurements indicate that the far field convergence responsible for the Oligo-Miocene continental collision is now over. However, seismicity and slow deformation are still active. Former collisional tectonic features, such as the Penninic Front, are nowadays reactivated as normal faults. Indeed, geodetic and seismotectonic studies show that the inner part of the chain is undergoing transtensional deformation, although local compression is observed in the foothills at the periphery of the arc. Due to the low to moderate seismicity of the Western Alps, the stress and strain fields remain partly elusive.

The aim of the present study is to quantitatively assess the current seismic stress and strain fields within the Western Alps, from a probabilistic standpoint. We used a new set of more than 30,000 Alpine earthquakes recorded by the dense local Sismalp seismic network since 1989. We first computed well-constrained focal mechanisms (f.m.) for more than 2,000 events with M_l ranging from 0.5 to 4.9 based on first motion (P-wave) polarity. This is the first time that such a huge focal mechanism dataset can be analyzed in the Alps. Corresponding events have been localized using a 3D velocity model (B. Potin, 2016). The global distribution of P and T axes dips confirms a vast majority of dextral transtensive focal mechanisms in the overall Alpine realm. We interpolated these results based on a Bayesian interpolation method, providing a probabilistic 2D map of the styles of seismic deformation in the Western Alps. Compression is robustly retrieved only in the Pô plain where seismicity depth differs from the shallow seismicity of the Western Alps. Extension is localized at the center of the belt. Importantly, extension is clustered instead of continuous along the belt. We then summed seismic moment tensors in homogeneous volumes of crust, to obtain seismic strain rates directly comparable to geodetic ones. Last, we inverted f.m. together in specific areas to obtain principal stress directions. A major outcome is the orientation of the extension, which is surprisingly oblique to the arc, rather than normal, as commonly thought.

These results bring new insights on the geodynamic processes driving the seismotectonic activity of the Western Alps, such as the relative contributions of crustal tectonics and deep processes.