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Earthquakes and slow slip events in the middle crust – arguments for the significance of meso-scale kinematics

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A wealth of geophysical and geodetic evidence suggests that in mid-crustal segments of convergent and transform plate boundaries strain energy is dissipated by a range of complex phenomena that include earthquakes and slow slip events. The underlying micromechanics of deformation at the brittle-viscous transition are poorly understood but intensely investigated. An aspect that is often overlooked by these investigations concerns the meso-scale structures that manage the up-scale propagation of a micro-scale instability to become a geophysical or geodetic signal, with a footprint on the hecto- and kilometre-scale. These structures are preserved in the exhumed rock record and can be investigated in field studies.
An excellent field laboratory that provides most stunning insights into the mid-crustal segments of a transpressive fault is the Northern Shear Belt at the Cap de Creus, in NE Spain. The shear belt comprises a greenschist-facies shear zone network, whose formation involved shear zone propagation along precursory fractures and whose internal scaling is governed by pre-existing anisotropies of the host rock. In this presentation, I will demonstrate that within the shear zone network, different types of fault rock occur, and show evidence that their distribution is tied to the kinematic evolution of the network. I will present the structural inventory of the low-strain domains in between the networked shear zones and suggest that their deformation may be critical for the functioning of the network.
If different fault rocks, each with a distinct micromechanical signature, reflect different slip phenomena, then their spatial distribution holds the key to understanding how instabilities on the micro-scale evolve into geophysical or geodetic signals. However, the information that is hidden in these signals can only be unlocked by an integrated view on the kinematics of all structural elements of shear zone networks. I will close with a discussion of the tectonic implications of these my observations.