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Evolution of a weak fault at the fossil brittle-to-viscous transition, Cap de Creus, Spain

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We investigate the evolution of shear zone networks at a fossil brittle-to-viscous transition (BVT) and examine the implications this has for fault weakening on the crustal scale. The investigated, fossil BVT occurs within a transpressive, late Palaeozoic shear belt exposed at the northern Cap de Creus (Spain). There, the metapsamitic and -pelitic rocks contain a prominent foliation that predates the greenschist facies, mylonitic shear zones at the BVT. This foliation is generally oriented at high angles to the shear zones, making it an excellent strain marker.

The shear zone networks we studied occur on length scales from several hundred meters to a few centimetres. The following processes are involved in networking: Shear zone nucleation is initiated by mode 2 cracks that form parallel to the macroscopic shearing plane. Fracture propagation is preceded by homogeneous ductile shearing of the pre-existing foliation in the tip process zones. In some cases, cracks propagate through these zones, discordantly cutting the sheared foliation. Going from the process zone towards the mylonitic center of the shear zones, the closely spaced cracks at the tip coalesce and the pre-existing foliation rotates into concordance with the shearing plane where it is overprinted. A new, mylonitic foliation forms that is best developed in the middle segments of the shear zones, where displacement is the greatest. The contiguity of the mylonitic foliation and cracks in the context of a continuous displacement gradient along the length of the shear zones suggests that the transition from brittle to viscous deformation is strain dependent. In the middle parts of the shear zone, the rotation of the older, adjacent foliation manifests a continuous, lateral strain gradient normal to the shear plane. There, cracks also emanate from the shear zone margins and truncate the drag folds. Fractures splay from the sides and tips of individual shear zones both across and along the shearing plane, eventually interconnecting to form a

through-going network of shear zones sub parallel to the shearing plane. With progressive deformation, lozenges of less deformed wall rock between the networked shear zones are consumed from their margins to their centres. Fractures propagate from adjacent shear zones into the lozenges, compartmentalizing them. Rotation and reactivation of the foliation in the compartments towards the C-plane incorporates these volumes into the shear zone. In this way, shear zone networking allows deformation to become homogeneous on a larger scale than at the onset of fracturing and shearing.

The development of a dense network of shear zones along the late Palaeozoic northern Cap de Creus shear belt is interpreted to have weakened the entire crust significantly. This supports the idea of the crustal scale BVT as a depth interval of strain-dependent weakening, within which detachment is localized.