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Narrow shear zones within broad transpression zones

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In obliquely convergent margins the entire upper plate may be subjected to regional transpression. Within this broad region of transpression, deformation may become localized into margin-parallel shear zones due to the effects of magma-related thermal softening, reaction weakening and or reactivation of inherited structures. In this scenario, we can expect the margin-parallel component of non-coaxial deformation to become partitioned into narrow (0.1 – 1 km) shear zones, while the margin normal component of coaxial strain is distributed across a broad transpression zone (10 – 100 km). Here we investigate a model of ductile transpression in which a thin, low-viscosity layer (the shear zone) is sandwiched in the middle of a higher viscosity zone (the broad transpression zone). Material in the transpression zone is free to extrude vertically but is confined laterally. Because the thickness of the shear zone is small compared to its other two dimensions, it is constrained to match the in-plane strain of the surrounding rocks. The strain response of such models is examined analytically and with analogue experiments. The significant parameters are bulk convergence angle, alpha, and viscosity ratio, m. We aim to predict how both the instantaneous and finite strains vary in both the shear zone and the surrounding transpression zone in time and space, as a function of alpha and m. The resulting strain and vorticity patterns can be used to interpret complex fabric and kinematic relationships in exhumed obliquely convergent margins.

Analytical modelling deals with small strains and strain rates within zones of infinite extent and idealised geometry. Analogue experiments are used to confirm the analytical models and to study the consequences of finite strain accumulation over time. As expected, the horizontal shear strain is concentrated in the low viscosity shear zone, but that zone is also stretched vertically, to match the vertical extension of the wall rock. Varying alpha and m leads to a number of interesting situations. For example, lineations (i.e. the directions of maximum principal strain and strain rate) in the narrow shear zone can be horizontal, while those in the adjacent domain are vertical, or the deformation in the surrounding rocks can be dominated by vertical stretching, whereas pure flattening strain occurs in the shear zone. The results of modelling such ‘dual viscosity transpression’ systems also indicate that erroneous interpretations of regional kinematics in upper plate settings may arise from field-based structural observations.