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Ductile shear zones – future perspectives

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About 50 years ago, John Ramsay and colleagues established the thorough foundation for the field-scale observational and mathematical description of the structures, deformation, and kinematics in ductile shear zones. Since then, these probably most important instabilities of the ductile lithosphere enjoyed an almost explosive growth in scientific attention. It is perhaps fair to say that this tremendous research effort featured four main themes:

[1] The historic scientific nucleus – quantification of shear-zone geometry, strain and associated kinematic history from field observations

[2] Qualitative and quantitative analysis of microphysical deformation mechanisms in the field and the laboratory

[3] Shear-zone rheology

[4] The development of physically consistent mathematical models for shear zones, mainly using continuum mechanics.

In concert, these four cornerstones of shear-zone research enabled tremendous progress in our understanding of why and how ductile shear zones form. So, what are some of the outstanding problems?

A truly comprehensive model for ductile shear zones must account for the vast range of length and time scales involved, each easily covering ten orders of magnitude, as well as the associated intimate coupling between thermal, hydraulic, mechanical, and chemical processes. The multi-

scale and multi-physics nature of ductile shear zones generates scientific challenges for all four research themes named above. This presentation is dedicated to highlighting exciting challenges in themes 2, and 3 and 4.

In the microanalytical arena [2], the nano-scale is an exciting new frontier, especially when it comes to the interplay between metamorphism and ductile deformation. The nano-frontier can be tackled with new synchrotron methods. I showcase some applications to fossil shear-zone samples and discuss opportunities for in-situ experiments. In the domain of rheology [3], I present some simple experiments with strain-softening materials and field observations that support the notion: transient rheological behaviour is very important for shear localisation. In the modelling domain [4], some recent examples for the intriguing physical consequences predicted by new multi-physics and cross-scale coupling terms in ductile localisation problems are illustrated.