Chapter 1

Preamble

1.1 What is the dissertation about?

This doctoral thesis investigates the processes related to strain localization in shear zone networks at the brittle-to-viscous transition. The investigation was undertaken as part of the German Science Foundation project "Determinates of ductile strain localization in the continental lithosphere on different length- and time-scales" (DFG grant Ha 2403/6, principal investigator Prof.Dr. M.R. Handy). In the course of this project field work was performed in the Aar Massiv, Switzerland, in Laas, Italy as well as at the Cap de Creus, Spain. This doctoral thesis focusses on data collected at the Cap de Creus. Results from the Swiss and Italian field areas are published in two diploma thesis (Schrank, 2005, Hauten, in prep.) and several conference contributions (Schrank et al., 2003, Schrank et al., 2005, Hauten, 2006). Data of a third diploma student (R. Christmann) who worked at the Cap de Creus (Christmann et al., 2005, Christmann, in prep.) are not used in this thesis, with the exception of a foliation trajectory map, which was used with kind permission of R. Christmann to quantify scales of strain localization on decameter-scales.

The thesis complements existing work on the formation of shear zones at the Cap de Creus by investigating the boundary conditions of strain localization at the brittle-to-viscous transition in terms of deformation mechanisms and kinematics. To do so, extensive structural field work was performed together with structural mapping of relevant areas to develop a model for the process of networking of shear zones. Key outcrops were sampled with kind permission of the Catalan authorities to gain insight into the microstructural

processes that are related to the formation of isolated and networked shear zones. Microstructural investigations focussed on the identification of, and the relation between deformation processes, as well as determining syndeformational temperatures and differential stresses within the networked shear zones. The scaling properties of shear zones were quantified using newly-developed parameters to investigate the influence of preexisting fabrics on shear zone formation.

1.2 Structure of the work

The thesis comprises three parts: (1) A general introduction to the scientific topics addressed in the dissertation. (2) Four scientific manuscripts which document and discuss the scientific work that has been conducted. Manuscripts number two (Chapter 4) and three (Chapter 5) share a *Geological Background*-section to avoid unnecessary repetitions of common background information. Before submission to the "Journal of Structural Geology" this will be split. (3) A concluding chapter summarizing the principal outcomes of this study, linking the individual papers and illustrating this work's contribution to ongoing scientific debates. Finally, a printed and electronic appendix contains appendices to the individual chapters as well as complementary data.

1.3 Scientific manuscripts

The central part of this thesis is formed by four scientific papers. The first of them is already published, the latter three are going to be submitted for publication in international, peer-reviewed journals in the immediate future. Because all of these manuscripts are multi-author manuscripts, each author's contribution will be outlined in the following.

Chapter 3: *Networking of shear zones at the brittle-viscous transition (Cap de Creus, NE Spain)*, by F. Fusseis, M.R. Handy and C. Schrank. All three authors were affiliated with the Freie Universität Berlin, Department of Geology, when work on this manuscript started. C. Schrank is now affiliated with the University of Toronto, Department of Geology. The manuscript was published in the *Journal of Structural Geology* (2006, Vol. 7, p. 1228-1243). The data and models for the formation of shear zone networks at the Cap

de Creus documented in this manuscript provide the scientific framework for all subsequent papers.

F. Fusseis was responsible for basic ideas, the scientific content and the collection of the data. He wrote preliminary versions of the manuscript that were later edited and improved with respect to spelling and semantics by M.R. Handy. Furthermore, M.R. Handy contributed to discussions of the topic and improved the scope of the manuscript. C. Schrank assisted in data acquisition in the field, participated in the development of the method for estimating the maximum shear strain in shear zones and reviewed an earlier version of the manuscript.

Chapter 4: *Strain localization at the brittle-viscous transition (Cap de Creus, NE Spain)*, by F. Fusseis and M.R. Handy, both affiliated with the Freie Universität Berlin, Department of Geology. This manuscript is intended to be submitted, in a slightly modified form, to *Journal of Structural Geology*. The paper focusses on the microstructural evolution of propagating shear zones and thereby complements field observations presented in chapter 3.

F. Fusseis contributed the ideas, the scientific content and the underlying microstructural data. He wrote preliminary and the final version of the manuscript. M.R. Handy edited and improved semantics and readability of the paper and contributed to discussions of the topic.

Chapter 5: *The evolution of decameter-wide shear zones at the Cap de Creus, NE Spain* by F. Fusseis and M.R. Handy, both affiliated with the Freie Universität Berlin, Department of Geology. This manuscript is intended to be published in a revised form. It investigates the roles of fracturing, viscous grain boundary sliding and dislocation creep in the formation of shear zone networks by comprising field and microstructural observations. Parts of this manuscript complement field observations that have been described in Chapter 3.

F. Fusseis contributed the scientific content and the data and wrote the paper. M.R. Handy gave useful feedback on an earlier version of the manuscript and contributed to the discussion on shear zone interconnection and the formation of ultramylonites.

Chapter 6: *Multiscaling of shear zones* by C. Schrank, M.R. Handy and F. Fusseis. All three authors were affiliated with the Freie Universität Berlin, Department of Geology, when work on this manuscript started. C. Schrank

is now affiliated with the University of Toronto, Department of Geology. This manuscript is going to be submitted to the Journal of Geophysical Research.

The method for multiscaling shear zones was developed and implemented by C. Schrank based on an approach initially proposed and formulated by M.R. Handy. C. Schrank refined and developed most of the parameters and routines used to analyse localization. He wrote an outline of the manuscript, which was later added to and rewritten by M.R. Handy. F. Fusseis participated in the development of the parameter Iloc, provided most of the field data and wrote parts of earlier versions of this paper. All authors actively contributed, as part of our working group, to discussions that helped to improve the content and the structure of this work.