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INTRODUCTION

Continental extension: Introduction

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In 2004, Geologische Vereinigung and Société Géologique de France held their annual meetings together in Strasbourg. Strasbourg, located in the Upper Rhine Valley Graben was the appropriate location for the symposium on ''Continental extension'' that was held from September 21 to September 23. Some 50 contributions, both general reviews and regional case histories were presented. Of these, eight original papers are assembled in this issue of the International Journal of Earth Sciences.

The Rhine Graben has long been a pilot area for the study of continental rifting of narrow type. The Upper Rhine Graben is here the focus of the paper of Hinsken et al. who document in detail the interrelation between exogenic and endogenic processes, which in turn determine environment and facies of the graben fill. In particular, they show how thickness and facies of the sediments reflect the width of the different segments of the graben. A deep, through-like evaporite basin developed in the narrowest part of the graben where subsidence and sedimentation rates were highest. Bourgeois et al. investigate the relationships between the European Cenozoic Rift System and lithospheric folding in the northwestern foreland of the central and western Alps. By constructing depth maps of the top of the pre-Mesozoic basement and the Moho, and by dating rifting and lithospheric folding from sedimentary accumulation curves in the Upper Rhine Graben, they are able to separate the effects of rifting (37–17 Ma) and of lithospheric folding (17–0 Ma) in the Alpine foreland: Grabens of the Cenozoic Rift System were tilted around folds as testified by the sedimentary record of the grabens, and the geometry of the folds is consistent with that of lithospheric buckle folds in analogue or numerical models.

With increase of stretching, narrow continental rifts evolve into passive margins and continental break-up according to a process whose symmetry or asymmetry has been much debated over the last 20 years. The alternative of pure-shear versus simple-shear extension during continental break-up is discussed by Reston and Pérez-Gussinyé, and by Nagel and Buck. Both pairs of authors argue from different perspectives, Reston and Pérez-Gussinyé's discussion is based on evidence from the North Atlantic margins, Nagel and Buck's refers to numerical modelling. Both conclude that a transition from symmetric to asymmetric rifting is a late development, after embrittlement of the crust and the uppermost mantle in the absence of rheologically weak layers. Reston and Pérez-Gussinyé advocate the effects of mantle serpentinization on strain localization and the onset of asymmetric structures, whereas Buck and Nagel emphasise the dominant role of a weak middle (instead of lower) crust in the decoupling of mantle and upper crust during symmetric early rifting. Late-stage asymmetric rifting is also compatible with the structural and stratigraphic record of the northern Apennines and Corsica as discussed by Marroni and Pandolfi, whereas the record of early rifting in the future Alps and

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Apennines appears to favour symmetrical rifting with listric faults soling in the middle crust.

Extension also plays an important role in the evolution of mountain belts. Extension during and after Alpine orogeny is theme of the contributions of Brun and Soukoutis and Sue et al. Brun and Sokoutis reconstruct the exhumation of a pile of metamorphic thrust nappes in the post-collisional core complex of the Rhodopes. Ongoing exhumation within the dome was accompanied by the synkinematic emplacement of granitic plutons and by block rotation, documented by paleomagnetic data and the pattern of stretching lineations, finally resulting in a crustal opening of up to 120 km. Above the exhumed metamorphic and plutonic rocks, steep normal faults and flat extensional ramps controlled the installation of Cenozoic extensional basins. Sue et al. provide an important synthesis on the active tectonics of the Western Alps, taking advantage of a wealth of seismotectonic, morphotectonic, GPS, structural and other data. Today, the high parts of the Alps are characterized by extension, their borders by transpression or compression, whereby the extensional areas can be correlated with those of the thickest crust. In contrast to the late Miocene, the latest tectonic movements within the Alps appear to be ruled by isostasy/buoyancy forces rather than by convergence between Adria and Europe.

Finally, another debate with respect to rifting is whether post-Variscan extension and magmatism in the future Alpine margins are precursors of the late Triassic and early Jurassic phases of rifting. High-precision U–Pb zircon dating presented by Schaltegger and Brack suggests that post-Variscan extension and magmatism occurred during an extremely short time interval of only 10 million years, contemporaneous along the entire transect of the southern Alps. Crustal extension and magmatic activity appear to correlate in time with the onset of large-scale strike-slip movements leading from the early Permian Pangea B to the late Permian Pangea A plate configuration. This event is not related to later rifting that led to the opening of the different branches of Tethys.

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