REVIEWS

Non-volcanic Rifting of Continental Margins: A Comparison of Evidence from Land and Sea

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Non-volcanic rifted margins are distinguished from their volcanic counterparts by a lack of significant magmatic underplating or seaward-dipping reflectors, a wide transitional zone adjacent to thinned continental crust that may contain serpentinized peridotites, and atypically thin oceanic crust at the continent-ocean boundary. The West Iberia margin has become the type example of non-volcanic margins, with interpretations of margin structure and evolution based on, and constrained by, numerous geophysical surveys, ODP drilling and dredge sampling. Despite decades of research, outstanding questions remain about the mechanisms controlling extension, including the role of detachment faulting, and the lack of magmatism at non-volcanic margins.

This book is the outcome of a 1999 meeting of the Geological Society of London and evolved from discussions during Ocean Drilling Program Leg 173 off West Iberia. The volume includes an interesting collection of 26 papers that describe and discuss various aspects of West Iberia and other non-volcanic margins. This book is unique in that it combines studies of present-day passive margins, where basement structures are commonly buried beneath sediments, with observations from preserved and exposed, but tectonically overprinted, margin remnants in mountain belts. The editors have grouped the papers into four main sections based primarily on the type of study; each section contains four to ten papers. In most cases the papers within each grouping complement each other well, although the section on Tectonics and Stratigraphy contains a somewhat diverse set of papers that cover several margins and disciplines of study. An introduction by the editors provides a nice overview of each paper plus concluding comments relevant to current studies of non-volcanic margins.

The first paper in the volume, by Boillot and Froitzheim, outlines a few of the scientific problems that remain in understanding the processes that control continental break-up and the onset of seafloor spreading. Following a brief discussion of known characteristics of the West Iberia margin, the authors pose and discuss remaining problems, such as the significance of ophicalcite breccias, the interpretation of dipping reflectors, the degree of symmetry of rift systems, and the location and definition of the ocean-continent transition. The remainder of the volume is divided into four sections: (1) ***Margin overviews***, (2) ***Exhumed crust and mantle***, (3) ***Tectonics and stratigraphy***, and (4) ***Numerical models of extension and magmatism.***

The first section, ***Margin overviews***, includes four papers that describe and discuss the characteristics of present-day non-volcanic margins and a fifth paper that describes margin remnants from the southern Alps. Huchon et al. discuss strain localization and 3-D effects associated with a propagating rift beneath the South China Sea, and conclude that continental break-up is primarily controlled by the amount of stretching of continental crust. Sayers et al. interpret the continent-ocean transition zone in the central Great Australian Bight as containing highly deformed and intruded extended continental crust with a thin layer of serpentinized peridotite above an elevated mantle, structures that resulted from deformation partitioning within the crust and mantle. Chalmers and Pulvertaft review the development of the Labrador Sea, Baffin Bay and Davis Strait regions and note that the nature of the thin crust beneath Baffin Bay and the position of the continent-ocean boundary along the Labrador Sea margins remain enigmatic. Whitmarsh et al. propose the process of "octagenesis" to explain the transition in time and space from largely amagmatic rifting and break-up of continental lithosphere off West Iberia to the production of oceanic crust by magmatic processes during sea-floor spreading. This interesting process involves the emplacement of melt in isolated, margin-parallel intrusive bodies within the continent-ocean transition zone during extension; subsequent bodies are emplaced at higher levels and closer spacing farther oceanward until an effectively continuous layer is formed that is magnetically indistinguishable from oceanic crust. Bertotti describes a remnant Mesozoic passive continental margin exposed in the Southern Alps of Northern Italy and Switzerland which he concludes initially extended in association with a Mid-Triassic thermal anomaly. Cooling of the anomaly led to strengthening of the thinned crust and shifted the locus of extension to produce an abandoned extensional structure similar to those seen today (e.g., on the

Norwegian margin).

The second section, ***Exhumed crust and mantle***, contains six papers, four of which address the Iberian Abyssal Plain and two the Alps. Abe and Hébert et al. discuss petrochemical and element analysis results that show the peridotites beneath the ocean-continent transition zone at the West Iberia margin are derived from continent-type mantle. Gardien et al. examine amphibolites from the Iberia Abyssal Plain and derive a three-stage metamorphic evolution that includes an early high-temperature and -pressure stage followed by retrogression under medium-temperature and -pressure conditions and a final metamorphic stage under sea-floor conditions. Zhao presents the results of paleomagnetic and rock magnetic studies of serpentinized peridotites from the Iberia Abyssal Plain and concludes that the peridotites were emplaced during Aptian

Barremian time and recorded the middle Cretaceous geomagnetic field. Desmurs et al. examine the field relationships of ophiolitic rocks from the Alps of eastern Switzerland and determine that the serpentinites represent subcontinental rocks exhumed to sea-floor along a low-angle detachment fault, while gabbros and younger pillow basalts indicate a steady process of extension, magma generation and emplacement at a slow-spreading ridge. Müntener and Hermann examine the petrology and microstructure of rocks from the remnants of a Mesozoic passive margin in the Southern Alps. They conclude that crustal-scale shear zones exhumed the lower crust and upper mantle to shallow crustal levels and suggest that boudinage of the lower crust occurred during early rifting.

The third section, ***Tectonics and stratigraphy***, contains ten papers representing a wide range of modelling, field mapping and laboratory studies from various margins. Buck and Lavier apply numerical modelling techniques to the study of different classes of normal faults, and determine the conditions necessary to develop large-offset normal faults. Abers uses examples from the Woodlark Basin and Gulf of Corinth to show that seismicity and movement occur on low-angle normal faults in rift zones. Roller et al., Robertson et al., Lackschewitz et al. and Resig et al. focus on the Woodlark Basin, presenting results of microstructural analysis, basin development, stratigraphic mapping, and age dating. Manatshal et al. report on microstructural investigations of detachment faulting at the West Iberia margin, while Wilson et al. examine syn-rift stratigraphy from the southern Alps and West Iberia margin. Fault analyses of the Red Sea - Gulf of Suez rift system are presented by Khalil and McClay, and Song et al. present similar work for the western margin of Australia. These two margins do not display low-angle extensional normal faults as seen on the West Iberia margin, and the role of transfer faults is discussed.

The final section of the book, ***Numerical models of extension and magmatism***, includes four papers that describe numerical studies aimed at determining the conditions under which non-volcanic rifted margins can form. A difficulty in modelling this type of margin is inhibiting melt production during the crustal extension stage, and previous models have invoked low mantle temperatures and crustal-scale detachments to explain the absence of melt. It is interesting to compare the different approaches used by these authors to explain the evolution of non-volcanic margins. Clift et al. apply the flexural-cantilever model to the South China margin to forward model extension of the upper crust (using seismic data to constrain estimates of brittle faulting) and the lower crust, which is assumed to deform in a ductile manner. Bowling and Harry use finite element models of rifting to propose that extension of a rheologically homogeneous crust can inhibit magmatism by delaying lithospheric necking and the onset of decompression melting until the last stages of rifting. Alternatively, Minshull et al. apply pure shear models of extension and suggest that melt production at the time of break-up may have been reduced by some combination of lateral heat conduction, depth-dependent stretching, and reduced mantle temperatures. Pérez-Gussinyé investigate the stretching factors at which the entire crust becomes brittle, allowing fluids to penetrate to mantle levels and begin large-scale serpentinization. If this occurs while the uppermost mantle is within the temperature stability field of serpentinite, serpentinization should commence immediately, and model results for two serpentinized margins (West Iberia and SW Greenland) are consistent with observations.

This book provides an excellent overview of recent advances in the study of non-volcanic margins. The comparisons of other non-volcanic margins, such as Woodlark Basin and preserved Mesozoic margin remnants in the Alps, with West Iberia, are particularly interesting as they give the reader a better understanding of features "typical" of non-volcanic margins and the range of interpretations supported by the data. As with most Geological Society of London special volumes, the quality of publication is quite high, with clear text and excellent reproduction of figures and photographs. Researchers working on rifted margins will definitely want to read this book, and it should also appeal to others interested in understanding the structure and evolution of passive margins.

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Landscape evolution results from a great variety of geological and geographic conditions through time. Geological processes such as tectonics, physical characteristics such as lithology, and geographic effects exerted by climate and human activity are all involved. The interaction of these processes controls and directs denudation, drainage and therefore erosion. For example, low-