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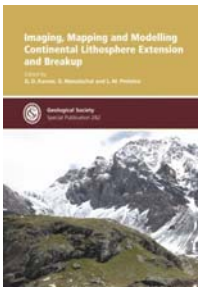
Imaging, Mapping and Modelling Continental Lithosphere Extension and Breakup, edited by G.D. Karner, G. Manatschal & L.M. Pinheiro, 2007. Geological Society Special Publication 282. The Geological Society of London, The Geological Society Publishing House, Unit 7, Brassmill Enterprise Centre, Brassmill Lane, Bath, BA1 3JN, United Kingdom. Hardback, 488 pages. Price GBP 100.00 (50.00 fellows GSL; 80.00 corporate affiliates; 60.00 other societies); USD 200.00. ISBN 978-1-86239-228-1.



Extension, breakup and rifting of the continents and their margins played an important role in the Earth's evolution, producing new portions of crust. The study of the Atlantic rift systems has been crucial to the development of many concepts of the earth sciences, such as those regarding plate tectonics, magnetostratigraphy, and even marine geology. One might wonder whether it is still possible to bring any news to the already existing knowledge on this subject.

The volume edited by Karner et al. is, apart from the editorial Introduction, a collection of 18 individual papers, each with an abstract, introduction and so on. They reflect presentations at a workshop that was held in the summer of 2004 in Pontresina (Switzerland). The 18 contributions, which are grouped into 6 sections, include several that deal with the North Atlantic (which is, indeed, a very impressive example of lithosphere extension). Some other regions (Australia, New Guinea, Oman, the Himalayas, the Eastern Mediterranean, the Black Sea, and the western USA) are mentioned "here and there".

The introductory remarks highlight fundamental questions and main uncertainties in the present knowledge on the extensional systems, but overviews mainly the contents of this volume. Surprisingly, only 17 out of the18 contributions are mentioned by the editors. A volume with apparently great ambitions (like this one has, considering the title) should have a very good historical and theoretical background. If such a background is not presented in the form of an individual, lengthy review, it should – in my opinion – be included in the introduction by the editors. This volume lacks an contribution with the backgrounds, indeed, but the editors handles the backgrounds nevertheless only in a very short form. Consequently, any professional or student who is not a specialist in extensional tectonics, will have some difficulties in reading and understanding this book.

The first section of the volume deals with models constrained with geological and geophysical data. Special attention is paid to the Newfoundland margin, including the Flemish Cap, and to the Iberian margin with the Galicia Bank. New evidence, particularly from seismic profiling, makes it desirable to reconsider the history of breakup and rift initiation in these areas. In general, the Late Triassic-Early Cretaceous rifting was stepwise. The most interesting is an origin of the unconformity related to what is called the "Aptian event". It was formed under submarine conditions, when regional tectonic stress favoured mass wasting. A number of contributions to this section deal with two other intriguing subjects. First, it is confirmed that the North Atlantic margins included a number of microplates like those constituting the cores of the above-mentioned Flemish Cap and Galicia Bank. They remained individual plates after the beginning of the rifting. The presence of such microplates suggests a strong heterogeneity of the Atlantic crust. Second, the origin of serpentinites is discussed extensively. This topic is especially hot now, since new evidence – especially from Japan (e.g., Hirauchi, 2006) – deepened our

insight. In the case of the North Atlantic, serpentinization occurred thanks to deep faulting, which destroyed the entire crust, which was less than 6-8 km thick.

The second section is devoted to the dynamic modelling of the Iberia-Newfoundland extensional system. The contributions examine the relative impacts of lithospheric strain softening and gravitational instabilities on the extension. The results from the application of thermo-mechanical models are compared with observations on the Newfoundland and Iberia margins. The conclusion is that replacement of the wide rift mode by the narrow rift mode took place in combination with a decrease in the extension rate. Another finite-element dynamic model helThe third section deals with kinematic modelling and comprises only two contributions. Surprisingly, it starts with an explanation of the Black Sea geodynamics (what a great step away from the North Atlantic!). The paper by Egan & Meredith is a very careful examination of this basin (perhaps the best ever made). A 2-D approach was used for its western part, whereas a 3-D approach was applied for its eastern part. The main conclusion is that the total crustal thinning contributed more to the development of this basin than did faulting. I would like to emphasize, however, that the origin of the Black Sea is still far from clear. Active contacts between numerous terranes, together with multiple back-arc processes, created a very unusual situation. Moreover, the Cretaceous birth of the Black Sea mentioned in the Egan & Meredith contribution seems questionnable, as a wide Black Sea - Caspian Sea Basin is interpreted for the Early Jurassic. One should therefore be very careful extrapolating results from the Black Sea to other regions. The contribution by Egan & Meredith has a most unusual organization: it contains a lengthy appendix (with the size of an individual paper), examining the application of a 2-D approach to the Iberian margin. The second contribution to this third section deals with the evolution of the Goban Spur, which is a large region on the European Atlantic margin. The margin model operates with an upwelling divergent flow field. The results of the application of this new model are consistent with those that can be expected for a non-volcanic margin. As the authors suggest, this model can be used for hydrocarbon prediction. Reading this, my immediate question was what they predict with respect to the possible occurrence of hydrocarbons in the Goban Spur, but this question remains unanswered.

The fourth section focuses on non-Atlantic offshore extensional systems, namely those from Australasia, in the form of detailed regional tectonic reviews. An abrupt boundary between continental rifting and sea-floor spreading is stated to exist for the Woodlark Basin. Perhaps I am too naive, but I searched all figures for any line (or anything else) that depicts this boundary, but in vain! Could it perhaps be the MCS line EW9910-13 (shown in Fig. 5) mentioned in the conclusions? If so, it is traceable by the presence of the igneous bodies. It is suggested that the transition from rifting to spreading was marked by a decrease in sedimentation. Another study in this fourth section demonstrates a similarity in the structure of three sectors located south-west and south off Australia. A non-volcanic origin of the Southern Rift System is suggested. The Kerguelen hotspot might have produced some tectonic peculiarities of the studied sectors. Paleotectonic sketch maps are strongly required for this contribution if an answer is to be obtained for two questions: (1) how did the Southern Rift System look like? and (2) how far was the Kerguelen hotspot from Australia in the mid-Cretaceous? Without these maps, the important conclusions lack clarity.

The fifth section examines the non-Atlantic onshore extensional systems. The first example comes from the Red Sea, where a strong difference between its northern and southern parts is established. New geophysical data explain this in terms of a rheologically stronger lithosphere in the northern Red Sea area, where full-size spearing will never occur. If so, it would be intriguing to see the future changes in the regional style of the plate tectonics. The second example considers the Alpine Tethys, the development of which is compared to that of the Iberia-Newfoundland system. This contribution is the pearl of the volume. All key tectonic features discussed herein are well illustrated, both in cross-sections and photos. It is great to see how it is possible to recognize the remnants of past extensional margins in strongly deformed geological edifices. From the numerous important conclusions drawn in this contribution, I should like to pay special attention to the comprehensive characteristics of the detachment faults, summarized in Figure 13 (p. 317). The third example dealt with in this fifth section of the volume is the

Eastern Tethys, which is reviewed by Robertson. A huge amount of data from Oman, the Himalayas and the Eastern Mediterranean is summarized and critically evaluated. Unfortunately, terranes of Iran, Afghanistan, and Pakistan like Makran, Lut, Sanandaj-Sirjan etc. are omitted. However, the tectonic evolution of the Eastern Tethys is described in a detail. This evolution was very specific and differed from that decribed with the volcanic and non-volcanic models that are applied traditionally. The breakup of the Eastern Tethys was caused by a persisting astenosphere flow, slab pull, and crustal weakening. It is important to note that the final breakup corresponded to the convergence along the Eurasian margin. From a sedimentological point of view, this review by Robertson explains the origin of the Mesozoic seamounts with carbonate platforms on their tops. In the beginning of this contribution, the Robertson emphasizes the confusion raised by the application of different names such as the Tethys, the Paleotethys, and the Neotethys. He prefers to tell about the Eastern Tethys, although the Paleotehys and the Neotethys are mentioned in the key Fig. 39 (p. 377). In my opinion, the work by Stampfli & Borel (2002) already standardized, with a clear explanation, the nomenclature of the "Tethyan" oceans. Even if one disagrees with Stampfli's reconstructions, one could easily follow his nomenclature of the oceans; an alternative would, rather than using existing names in a different way, be to present a new name. This latter option was chosen by Robertson, identifying the Triassic Tethys, the Intra-Tauride Tethys and the Southern Neotethys; it is therefore remarkable that these new names occur neither in his conclusions nor in his abstract. They are even absent in his key Figure 39! I think that the "pure" term "Tethys" should be used exclusively in a biogeographical sense. The contribution by Robertson is valuable, however, also because it is richly illustrated, and because the tectonostratigraphic sections of many regions, as well as the pretty photos are highly informative.

The sixth section of the volume includes four contributions, which are suggested to re-interpret extension mechanisms on the basis of the current theoretical knowledge. A new model of rifted continental margin accounting an upwelling divergent flow, unexpected results on detachment faults in the western United States, and an important role of initial weakness and viscosity of the lithosphere are considered. All these considerations give ample space for further thoughts. I should like to emphasize that both careful field studies (like that by Christie-Blick et al.) and physical-mathematical modellings (like those by Dyksterhuis et al. and Moresi et al.) may provide equally important results, which means that it is impossible as yet to conclude that virtual studies have won from field-based studies. The editors are to be congratulated with their approach that permitted to demonstrate both sides of geological modelling in this book.

I feel, however, that I have also to express some additional critical comments. The first concerns the title of the volume. Undoubtedly, modelling extension and breakup is discussed extensively in the book. But what about imaging and mapping? One might just as well question what is the difference between imaging and modelling? And does "mapping" mean "geological mapping?" Both words ("imaging" and "mapping") seem out of place in the title. In contrast, the word "margin" should have been included, because the present book deals mainly with continental margins. It may be true that the fairly badly chosen title may not diminish the importance of this volume. But this provocative and promising title may easily confuse potential readers, and they will certainly have the same questions outlined above.

The frequent use in the book of the term "passive margin" is also somewhat dubious. Fortunately, it is not included in the book title or in the title of any contribution. A distinction between active and passive margins, although it persists in the present-day literature, is a bit outdated. Studies in the North Atlantic have clearly indicated that passive margins were and are not really so passive (Stoker & Shannon, 2005). In his new remarkable textbook, Lowrie (2007) distinguishes between constructive, destructive, and conservative margins. The information from the volume under review suggests also that active geological processes take place on passive margins. Then, what is the justification for using this redundant term?!

Another point of criticism concerns the general organization of the book. Reading the titles of the various contributions, even a qualified specialist will wonder whether these papers discuss present-day or ancient extension. Perhaps even more important is the order of the various contributions. Why does the paper on the Black Sea open a section with the title "The Iberia-Newfoundland continental extensional system (kinematic modelling)?" It is also strange that the

first three (!) sections all are devoted to the North Atlantic, but that other sections also contain contributions dealing with this region. I think it also a flaw of the editors that they placed some highly important theoretical contributions behind the regional studies. Last, but not least, I noticed that a number of very important problems related to lithosphere extension are lacking. One of them is the intriguing extension of the Gondwanan margin. During the middle Paleozoic to early Mesozoic, a number of terrane ribbons (some were superterranes) were separated from Gondwana by the opening of a new ocean (Stampfli & Borel, 2002). What was the mechanism? How did these breakups begin? Addressing these and other relevant questions would certainly have increased the scientific value of the book considerably. Although a critical examination of Stampfli's model, as far as related to the Cimmerian events, is given by Robertson, I would certainly have enjoyed to see a detailed description for the entire Paleozoic-Mesozoic from anybody belonging to Stampfli's team or from any researcher advocating their ideas.

It seems not justified to mention here other topics that are not dealt with in the book as only papers from the Pontresina workshop are included. This is a common shortcoming of books that are derived from conferences, workshops or similar meetings .

The printing quality of this volume is high and illustrations are abundant. Many are in full colour and some large fold-out figures are included. This is very useful, because detailed and informative graphics are always required to understand a geological model. The book also contains a subject index, which is detailed and well-done.

In general, this volume, although it is not the ultimate reference work on extensional mechanisms, will be very suitable for those involved in extension modelling for any region. It provides a number of examples of various kinds showing how to do so.

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