

Tectonic Evolution of the North Sea Rifts

edited by D.J. Blundell and A.D. Gibbs, published by Oxford Science Publications in 1990.

Review by Christopher G. Kendall

Apparently, this book developed from Peter Ziegler's interest in helping an international understanding of rift systems. He felt that the North Sea Rift System, because the activities of oil industry exploration have caused it to be known in such considerable detail, would act as a fine setting to test new ideas about rift system development. At the same time, he felt these ideas might be put to profitable use, since the North Sea is a major hydrocarbon province.

The book is divided into 13 chapters. These deal in part with the sedimentary fill of the North Sea Basin, but focus more on the tectonic evolution and style of the North Sea. The illustrations, which are well drafted in a uniform style, include paleogeographic maps, thin section photomicrographs, tectono-sedimentary events, maps of regional tectonic elements of the North Sea, and a variety of cross sections of basin models, crustal models and seismic.

The book begins with a chapter by Peter Ziegler on the tectonic and paleogeographic development of the North Sea Rift System. This paper traces the paleogeography of the North Sea from the Devonian through to Tertiary fill of the North Sea. It raises the question as to whether the rifting is caused by the crustal thinning, or by mechanical stretching alone. Ziegler recognizes that the Moho discontinuity may have been seriously destabilized by extension during this time. The paper has many of the maps and diagrams that are similar to those published elsewhere by Ziegler.

Next is a paper by Klemperer and Hurich on the lithospheric structure of the North Sea from deep seismic reflection profiling. The authors describe how deep seismic reflection profiling can be used to understand the regional tectonic development of the North Sea. They show that the reflectivity of the lower crust can be used to determine the extensional deformation undergone by the crust. They feel that extensional faults of a crustal scale are not imaged, leading them to the conclusion that deformation of the lower crust at least may be "distributed" rather than "localized."

A paper by G.A. Day et al. follows, describing the North Sea gravity map, and complemented by a paper by one by Fichler and Hospers, who describe gravity modeling Viking graben area. The latter conclude that 3-D gravity modeling, combined with deep seismic interpretation, are important to the investigation of the deep crustal structure of the Viking graben area. Their results favor a stretching model for North Sea graben development.

Next, Hollinger and Klemperer describe how gravity and deep seismic reflection profiles across the North Sea rifts can be used to determine that there is a good agreement between the gravity Moho and the reflection and refraction Mohos, implying that the average thickness of the crystalline crust in the basin area of the North Sea is remarkably homogenous. They recognized that the reflection Moho corresponds to the density/velocity jump at the base of the crust, imaged by the gravimetric and seismic wide angle method and does not permit extension basaltic underplating.

Latin, Dixon and Fitton describe rift-related magmatism in the North Sea Basin, and how various igneous rocks in the North Sea Rift System can be related to melt generation in rifts, particularly the Mesozoic rift-related magmatism of the North Sea Basin. Their general conclusion is that the Mackenzie and Bickle model does not explain all the observations made

for the North Sea. The reason the model did not fit is that melt fractions were small and couldn't be used to resolve the temperature of the extension. However, in most stretched part of the North Sea, some quantification was possible where magmas were capable of being derived from dry peridotites and here the Mackenzie Bickle model could be applicable.

Gibbs then describes the linked fault tectonics of the North Sea and explains how these can be applied at all scales to the North Sea Basin to assist in the understanding of the development of the basin from the tectonic and structural viewpoint. A problem with Gibbs' observations, which he acknowledges, is that the models themselves were sensitive to changes in the assumptions. Gibbs concludes that conventional balanced cross section analysis, coupled with map analysis, provides the best tool for understanding the structural development of the region. Despite problems with error in the models, Gibbs feels that for the hydrocarbon explorationist, the different models may well be within the limits of the observational error.

Gabrielsen et al. follow with a paper entitled "Architectural Styles of Basin Fill in the Northern Viking Graben". This paper shows that sand development and distribution appears to be controlled by tectonics and eustasy in two different ways. They think the sand is trapped because of topographic differences and availability of the sediment, and the resulting drainage pattern. Secondly, during stages of thermal cooling, basin extent was greatest, but the basin topography least.

Roberts, Yelding and Badley describe a kinematic model for the orthogonal opening of the late Jurassic North Sea Rift System, Denmark and mid-Norway. This paper shows that there are two kinematically closed triangles linked through the North Sea Graben. Their feeling is that there were two lithospheric stretching events within North Sea Rift, probably Triassic and late Jurassic age, with minor extension, but significant extension occurring in the early to mid-Jurassic. The late Jurassic, they acknowledge, is the time when most of the effects of extension can be recognized.

Next is a paper by J. Cartwright on the structural evolution of the Ringobing-Fyn. This paper shows that there was a regional tectonic magnetic event in the late Carboniferous/early Permian. The author believes that fractures developed associated with this feature which were active as transforms in the late Caledonian then reactivated in the later deformational episodes. This paper has a bunch of very nice cross sections and seismic.

N. White then describes how the uniform stretching model works in the North Sea, illustrating this with a variety of cross sections, seismic and maps. White believes that the uniform stretching model is the simplest possible way to successfully account for most of the major observations of the North Sea.

Marsden et al. describe the application of a flexural cantilever simple-shear/pure-shear model of continental lithosphere extension to the formation of the northern North Sea Basin. The extension of 60km estimated for the Viking Graben can be predicted with a Triassic extension of 38km, and a 22km extension in the Jurassic.

Finally, there is a paper on hydrocarbon plays and rifting in the North Sea by A.M. Spencer and R.M. Pegrum. This paper lists source rocks' maturity, hydrocarbon plays in terms of pre-rift plays, middle pre-Jurassic/lower middle Jurassic plays and then synrift plays in terms of the upper Jurassic/lower Cretaceous and upper Cretaceous and Paleogene plays.

This small book summarizes much of the information that a geologist or geophysicist would need to understand the tectonic evolution of the North Sea Rift. It is really aimed at the

structural geologist or geophysicist with an interest in plate tectonics and rifting. It would be useful to those exploring in the North Sea who have a need to gain an understanding of the causes of the sedimentary fill and tectonic style of the area. In summary then, this book focuses on the causes of rifting and tracks these using deep seismic reflection profiling, gravity, examination of magmatism in its timing and temperature, the examination of structural timing and style, and an examination of various geophysical models, including stretching, flexural cantilevers, etc. Finally, there is an examination of the overall history of the North Sea in terms of its paleogeography and the relationships of hydrocarbon plays to the rifting and sedimentary fill of the basin. The book contains abundant current references to previous work on the area, which could lead to a greater understanding of the causes and fill of the North Sea.