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Estimation of lithospheric extension by accounting for stretching and thinning of the sedimentary basin – An example from the Vøring margin, NE Atlantic

M. Wangen (1) and J.I. Faleide (2)

(1) Institute for Energy Technology, P.O.Box 40, N-2027 Kjeller, Norway, (e-mail: Magnus.Wangen@ife.no), (2) University of Oslo, Department of Geosciences, P.O. Box 1047, Blindern N-0316 Oslo, Norway

The Vøring basin offshore west of mid-Norway has formed as a result of several rift phases since the end of the Caledonian orogeny in Ordovician-Silurian times. The last (Late Cretaceous and Paleocene) rift phase ended with continental break-up of the Norwegian-Greenland Sea and magmatisme. Here we report results of a study where we have estimated the magnitude of extension and the tectonic evolution of a transect from the Vøring margin. The amount of stretching and thinning the crust has undergone is often measured by the so-called β-factor, which can be estimated from back-stripping of the basin and the corresponding tectonic subsidence. Such an approach does not take into account that the sedimentary basin is also stretched and thinned. In the Vøring basin, where the sediments may be thicker than the crust, it is important that also sediments and not only the crust have undergone extension. Here we suggest a simple procedure for the estimation of the β-factors, which takes into account that the sedimentary basin is stretched and thinned during the rifting phases. This approach approximates the deformations of the basin by pure shear. The pore space of the sediments follows the flow during pure-shear deformation, which is a simple approach that assures mass conservation. The basin and the crust are assumed to deform with the same β-factor. The procedure is demonstrated on a 2-D transect that spans the entire Vøring margin, from close to the continental-ocean boundary to near the main land Norway. The transect has thick Cretaceous formations, which is a characteristic feature of the sub-basins of the western part of the Vøring margin. The β-factors are computed for the case of four rift phases, but it is straightforward to do the same computation for more or less rift phases. The β-factors are compared with corresponding β-factors that do not include the effect of the extension and thinning of the sediments. The results show that the new procedure yields a larger β-factor for the first (Devonian) rift phase. The same applies for the Late Jurassic rift phase, which also becomes stronger. The Late Cretaceous and Paleocene rift phase becomes considerably weaker. The results, including a stronger Late Jurassic rift phase, explain better the formation of the accumulation space needed for the thick Cretaceous formations. The β-factors for each rift phase are given by simple expressions that allows for a sensitivity study. For example, it is shown that at an increase in the paleo water depth by 500 m increases the β-factor by $\Delta\beta = 0.14$ when the rift phase has a $\beta = 2$.