

THE STRUCTURAL OUTLINE OF THE HORN GRABEN¹

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ABSTRACT

Olsen, J. C. 1983 The structural outline of the Horn Graben. In: J. P. H. Kaasschieter & T. J. A. Reijers (eds.): Petroleum geology of the southeastern North Sea and the adjacent onshore areas (The Hague, 1982) – Geol. Mijnbouw 62: 047-050.

The structural outline of the Horn Graben is discussed on the basis of four seismic lines and the Danish North Sea wells R-1, S-1 and C-1. The basic outline of the general N-S trending Horn Graben is defined by several deep-seated faults established during the Early Permian or possibly pre-Permian. During the Late Permian, Triassic and Jurassic, these faults were reactivated, and created in the southern area an asymmetrical graben with a very pronounced western flank. The western flank becomes less pronounced towards the north, where the tectonic activity created an asymmetrical graben with a pronounced eastern flank.

INTRODUCTION

One of the major structural features in the Danish area is the WNW-ESE trending Ringkøbing-Fyn High, which separates the Norwegian-Danish Basin from the North German Basin. The high is divided by several graben systems, of which the Horn Graben is one of the most prominent. To the west the Horn Graben is limited by the East North Sea Block, and to the east by the Holmsland Block (Fig. 1). The structural outline of the Horn Graben is discussed on the basis of the Danish North Sea wells S-1, R-1 and C-1 tied to four seismic lines, shot by Nopec in 1981. The author is grateful to the company for the possibility of using their data.

STRATIGRAPHY AND LITHOLOGY

Only the R-1 and S-1 wells are situated in the Horn Graben proper. The well C-1 is located on the northern flank of the Holmsland Block (Fig. 1). Well correlation is shown in figure 2, and as indicated, none of the wells have penetrated the Permian sequence.

Permian

The Early Permian Rotliegendes has been drilled in the wells C-1 (> 10 m) and R-1 (> 230 m), but base Rotliegendes was not reached in any of the wells. The lower part of Rotliegendes consists of basalts. Upward it grades into weathered basalts with associated poorly sorted sandstones.

The Late Permian Zechstein is absent in the R-1 well. The C-1 well penetrated 528 m of Zechstein evaporites, mainly consisting of rock salt.

Triassic

The Triassic has been drilled in all three wells, and there are great differences in thicknesses. The sequence is very thick in the S-1 well (> 2208 m), it measures in the C-1 well 1156 m and 442 m in the R-1 well. The lower part of the Triassic, the Buntsandstein, consists of redbeds with a low content of anhydrite and carbonates. The Buntsandstein is overlain by the Muschelkalk, mainly composed of mixed lithologies of anhydritic and dolomitic claystone and dolomite. The Muschelkalk is overlain by the Keuper, mainly composed of silty claystones with some evaporitic sequences. Rhaetian sediments have not been identified in the area.

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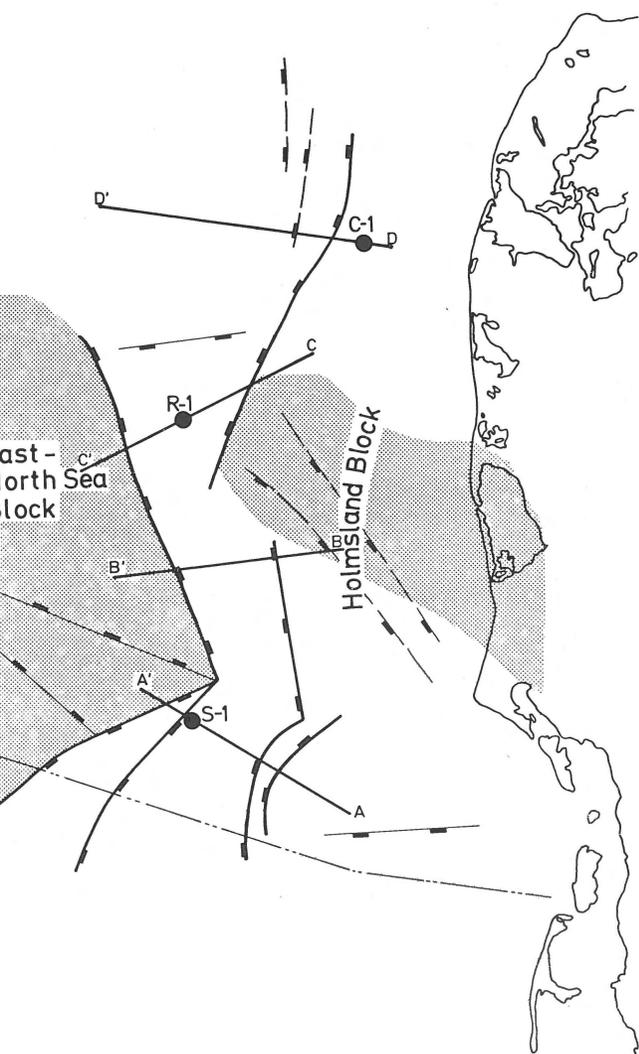


Fig. 1
Structural outline of the Horn Graben with locations of wells and seismic sections

Jurassic

Only sediments of Late Jurassic age have been drilled. R-1 and S-1 penetrated 40-60 m and C-1 115 m. The sediments consist of claystones.

Cretaceous

The Lower Cretaceous is present in all the wells. The R-1 well penetrated 75 m, and the S-1 and C-1 wells approximately 150 m. The sequence consists of claystone. The Upper Cretaceous sediments consist of limestones.

Tertiary and Quaternary

The sequences are composed of mixed lithologies of shale and sand.

DISCUSSION OF STRUCTURAL SECTIONS

In order to illustrate the structural style and the geological evolution, four seismic sections have been selected (Fig. 3; locations are shown in Fig. 1).

Section 1 – A cross-section in the southern part of the area. The SW-NE trending faults defining the western margin of the Graben are the most prominent and delimit the distribution of the Permian and Triassic sequences. The faults defining the eastern side of the Graben are small and have only partly controlled sedimentation. The seismic character of the Zechstein, however, indicates a facies change across the fault, and the thickness of the Buntsandstein is affected. The rest of the Triassic sequences have overstepped the fault without changes in thickness. The apparent thinning is due to post-depositional erosion. The southern part of the Graben is basically a halfgraben that has been active from Permian time with major subsidence during Triassic. Only minor adjustments in the faults are observed after Late Jurassic time.

Section 2 – A cross-section in the southern part, north of where the trend of the Graben changes towards a N-S direction. The faults defining the western margin of the Graben are very prominent and delimit both the distribution of the pre-Permian Palaeozoic and the Permo-Triassic sequences. The faults defining the eastern side of the Graben have been very active in pre-Permian time, but have only had minor movements during deposition of the Permo-Triassic sediments. In Late Triassic - Jurassic, the eastern fault and possibly also the western fault have been reactivated and delimit the distribution of the Late Jurassic sediments. The Graben is also in this area a Triassic halfgraben. There is only minor fault activity observed after Jurassic time.

Section 3 – A cross-section in the central part of the area, where the Graben intersects the East North Sea High and the Holmsland Block (sensu stricto). The western fault here also has a considerable throw, but this is related to pre-Permian Palaeozoic sediments. Only minor adjustments along the fault have taken place during the Permian and Triassic. The eastern faults have also major throw in the pre-Permian and Permian, but they were reactivated in Late Triassic - Early Jurassic time. The Graben is in this area basically a Palaeozoic graben. The Triassic halfgraben on top of this has, contrary to the southern area, maximum thickness of sediments towards the east.

Section 4 – A cross-section in the northeastern part of the Graben, partly out into the Danish-Norwegian Basin. The western fault is situated west of this section. Just north of section 3, there are only minor or no post-Permian movements along the fault. Opposite to that, the NE-SW trending eastern fault shows considerable throw in the Triassic sequence. It is important to note that the fault was reactivated

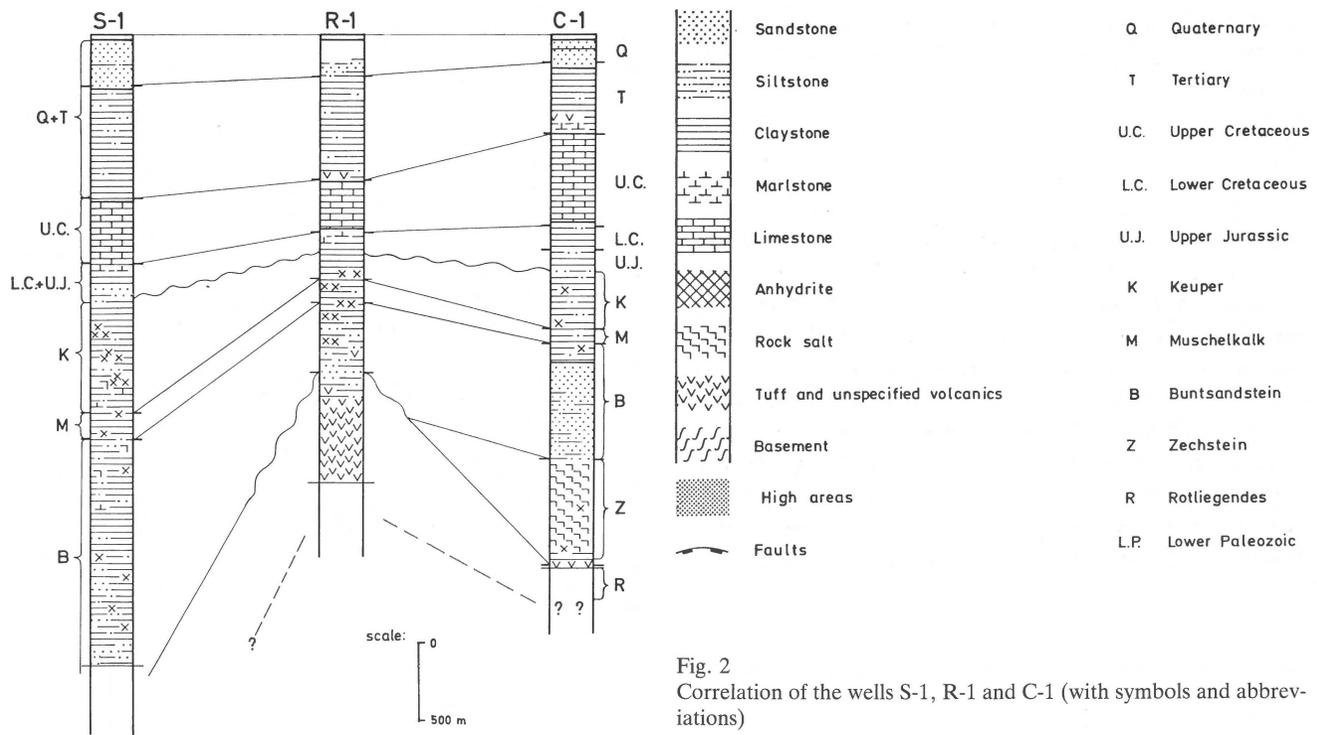


Fig. 2 Correlation of the wells S-1, R-1 and C-1 (with symbols and abbreviations)

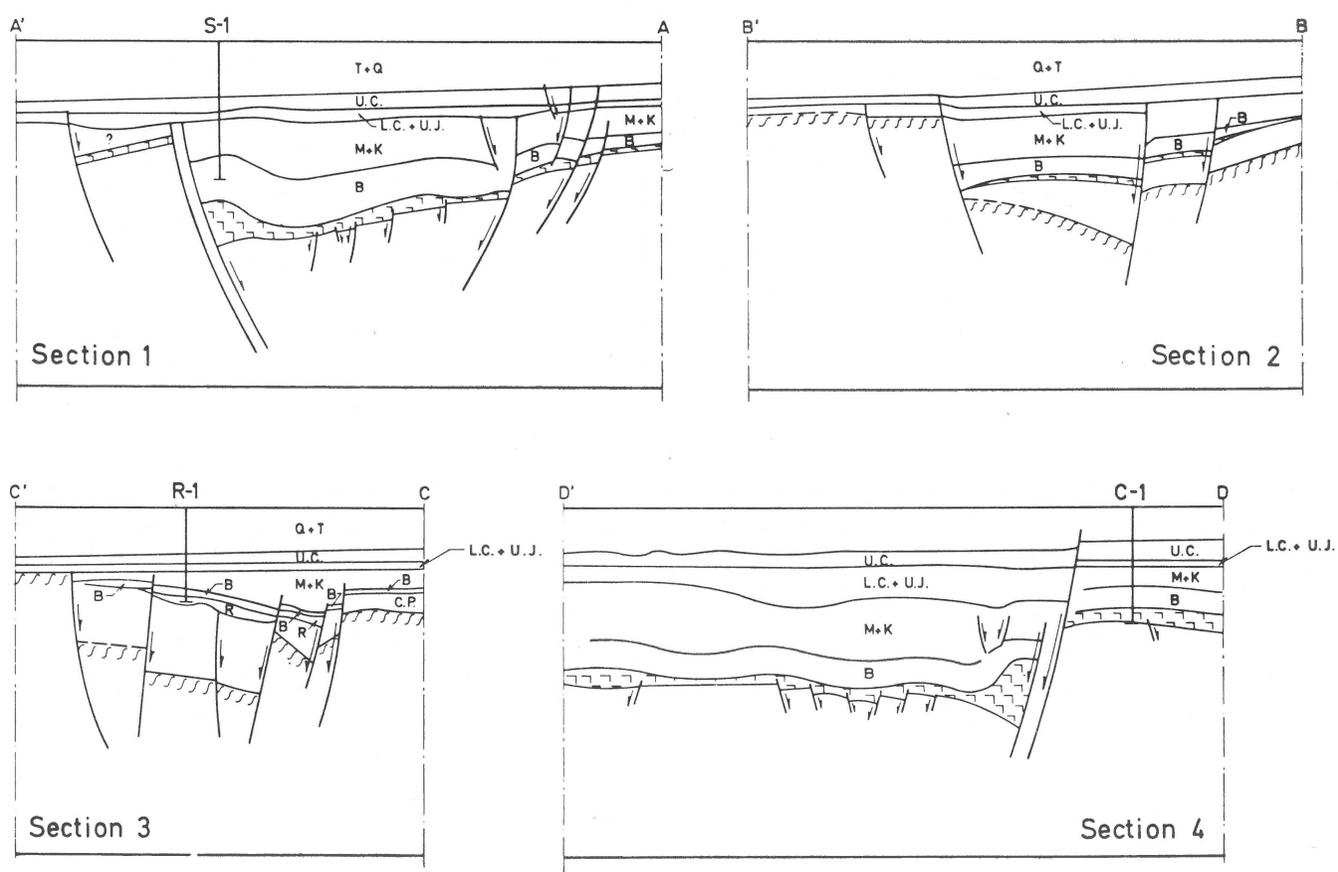


Fig. 3 Seismic sections from the Horn Graben area. For locations see figure 1.

in Jurassic time, and it controlled the thick deposition on the downthrown side of the fault. Faulting continued up into the Tertiary.

CONCLUSION

The seismic sections indicate that the basic outline of the Horn Graben was established during the Early Permian or pre-Permian. To the south the western flank is the most prominent and it controls the distribution of the Permian and Triassic deposits. The eastern flank affects only to a minor degree the distribution of the Permo-Triassic sediments. Towards the north the importance of the western flank diminished, and the faults were inactive during the post-Tertiary. In this direction the importance of the eastern flank increased, and towards the north it controlled the distribution of both the Triassic and the Jurassic deposits.