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Research paper

# Upper Permian carbonates at the northern edge of the Zechstein basin, Utsira High, Norwegian North Sea

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ABSTRACT

The first detailed description of Zechstein carbonates and their diagenesis along the northern margin of the northern Zechstein basin is based on core material from four wells on Utsira High in the Norwegian sector of the North Sea. It provides a generic link to the better known southern Zechstein basin, and northwards to the Late Permian East Greenland basin. The Zechstein succession consists of shale-carbonate cycles, and anhydrite only occurs in the uppermost preserved cycle, believed to correlate to Zechstein 4. The eleven carbonate facies reflect deposition in shallow shelf and arid shoreline environments, and resemble Zechstein-2 and -3 carbonate facies from the southern Zechstein basin. The carbonates are pervasively dolomitized by an early texture-preserving dolomite characterized by $\delta^{18}O$ values between −6‰ and +2.4‰ similar to dolomites in the southern Zechstein basin, and $\delta^{13}C$ values between −0.7‰ and +5‰ which is significantly lower than time-equivalent dolomites from the southern Zechstein basin. Later, subaerial exposure and fresh water infiltration during the late Permian or early Triassic caused replacement of the upper part of the dolomite by crystalline, fabric destructive calcite (dedolomite). The dedolomitized zone is up to 23 m thick and calcite crystals are characterized by moderately negative $\delta^{18}O$ values in the range −8‰ to −5.5‰, characteristic for meteoric water. The Utsira High carbonates thus share a depositional history with the classical Zechstein carbonates whereas their diagenesis seems to have more in common with the time equivalent succession in East Greenland. Early leaching and dolomitization enhanced porosity whereas subsequent late Permian – early Triassic subaerial exposure and widespread dedolomitization had profound negative impact on reservoir properties of the Zechstein carbonates.

## 1. Introduction

The Upper Permian Zechstein sediments in NW Europe were deposited in a semi-enclosed basin around 25° N paleolatitude and form a classical saline giant (e.g. Scotese and Langford, 1995; Ziegler, 1990). The sediments are best known in the southern part of the basin where mining has been taken place for centuries, and Zechstein sediments have been targets for hydrocarbon exploration onshore Poland, Germany, Denmark and UK, and in the North Sea Basin. The northern limit of the Zechstein basin and its northward connection to the Boreal basins of Greenland, Svalbard and the Barents Shelf is still poorly understood due to lack of outcrops and the limited number of offshore wells penetrating the Permian (Glennie et al., 2003). However, from seismic and well data it is evident that salt deposition continued north of the Mid-North Sea – Ringkøbing-Fyn High into the central parts of the northern Zechstein basin as far north as 59°50′N (Taylor, 1998). Upper Permian halite has not been reported further to the north, but gypsum and anhydrite are an integrated part of the Permian depositional system in East Greenland and have also been reported from the Permian in wells on the mid-Norwegian shelf (Stemmerik, 1995, 2001).

The present paper provides the first detailed description of Zechstein carbonates and their diagenesis along the northern margin of the northern Zechstein basin. It is based on more than 100 m of core from four exploration wells in southern Utsira High, blocks 16/2 and 16/3 in the Norwegian part of the North Sea (Fig. 1). It aims to document the depositional environment and diagenetic evolution of Zechstein carbonates along the northern fringe of the Zechstein basin. Comparison to the classical Zechstein successions to the south and the time-equivalent successions further to the north in central East Greenland allows better constrain on climatic control on deposition and diagenesis along the N-S oriented Permian seaway between Norway and Greenland (e.g. Stemmerik, 2001). The carbonate facies are broadly similar to those recognized further to the south in Zechstein-2 and -3 (Ca-2 and Ca-3) from Denmark, Germany, Poland and UK whereas the carbonates have experienced a complex diagenesis with evidence of pervasive fresh water infiltration much similar to what has been

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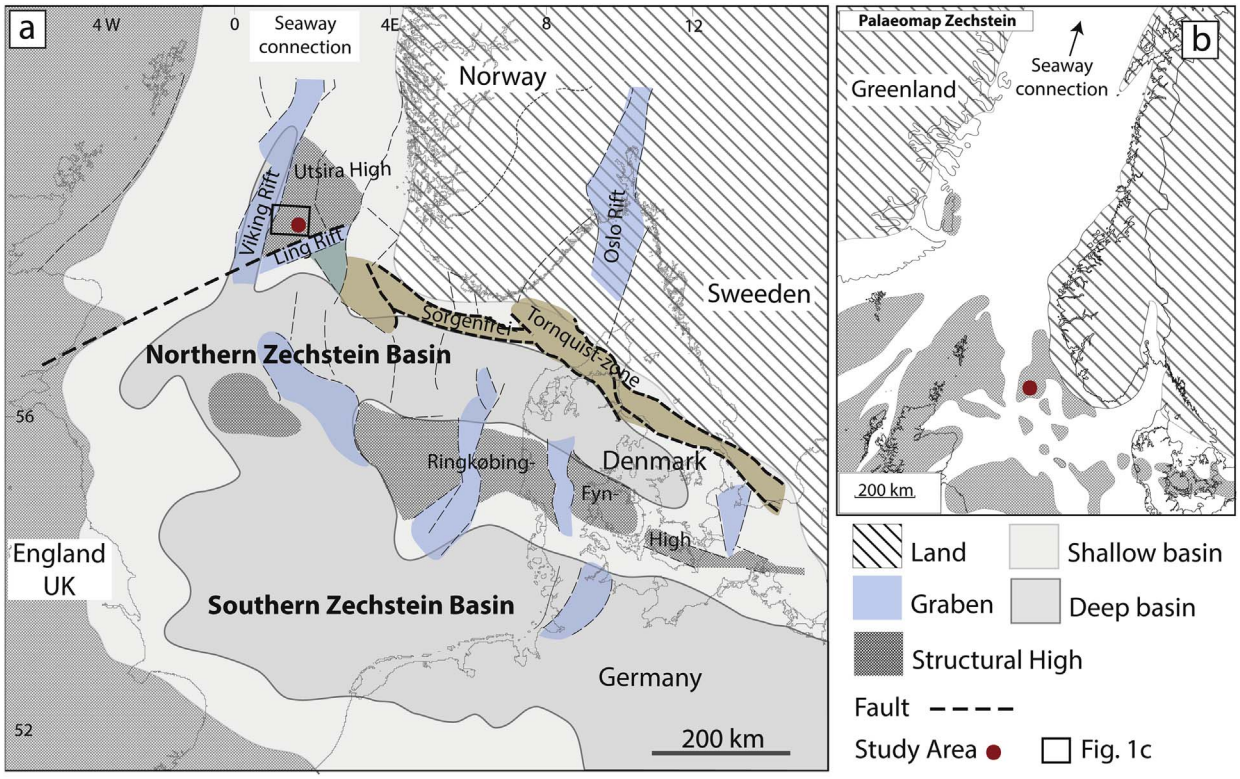


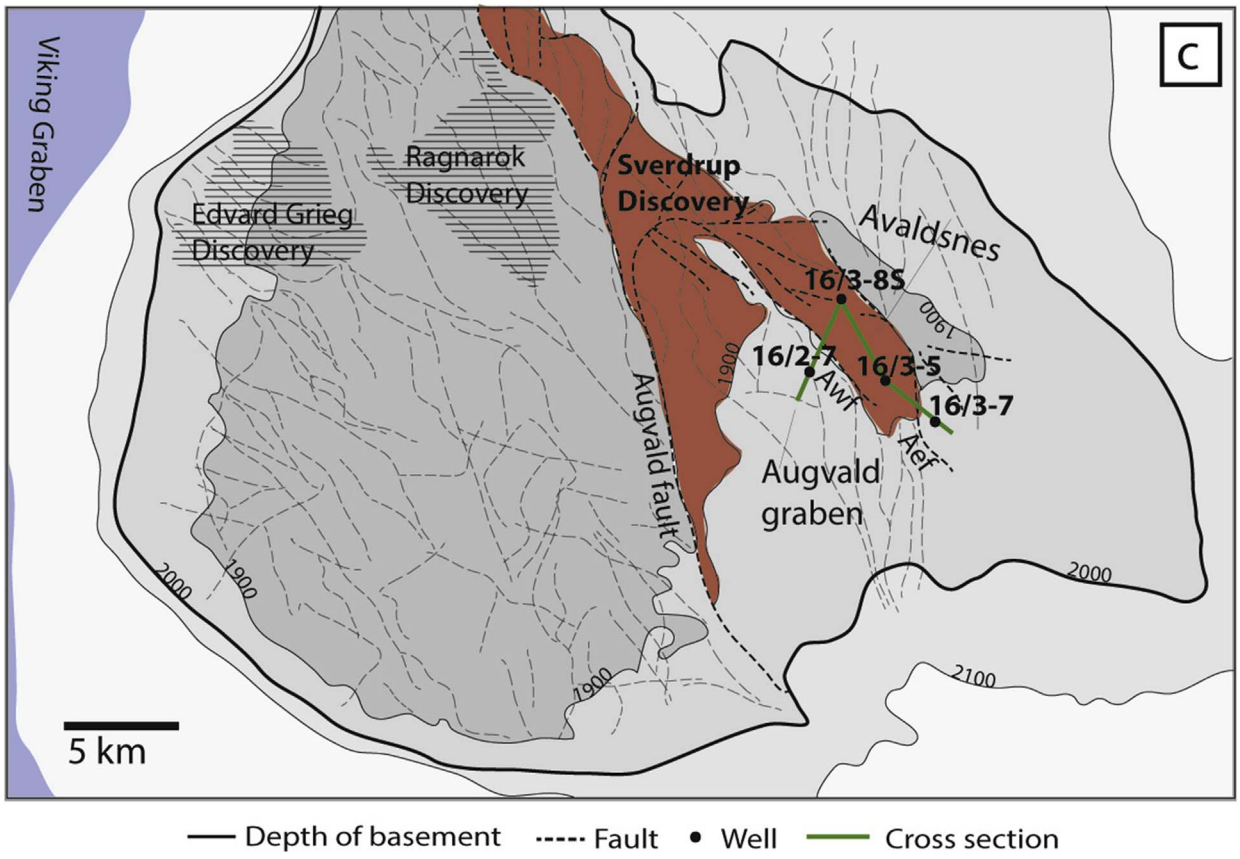


**Fig. 1.** Overview map of the study area. (**a**) The location on Utsira High in the Norwegian North Sea. The outline of the Zechstein basin is illustrated on the map together with important present day structural elements. (**b**) Paleomap showing the positions of East Greenland, Norway, UK and Denmark in the Permian. (**c**) Location of the studied wells on Utsira High.