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Research paper

3D seismic interpretation of the depositional morphology of the Middle to Late Triassic fluvial system in Eastern Hammerfest Basin, Barents Sea

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Integration of seismic, well and outcrop analog data provided realistic definition of the depositional morphology of the Snadd Formation in the Eastern Hammerfest Basin, Barents Sea. In this work the morphology of the depositional system was analyzed by using acoustic impedance seismic attribute on a high-resolution 3D seismic data. Five horizon slices were interpreted between the Snadd and Fruholmen Formation. Information about lithology and environment of deposition was inferred from wireline logs and by correlation to analogs of the De Geerdalen Formation in Spitsbergen and Snadd Formation in the NE Barents Sea. The Middle to Late Triassic sediments in the study area were deposited by a meandering fluvial system characterized by depositional forms such as flood plains, point bars, levees, overbank deposits and crevasse splays. In the southwest and the northeastern part of the seismic cube, the meandering channel is divided into low and high sinuosity channels, respectively. Sinuosity of the channel is related to the paleo topography of the Middle Triassic unit (S2) with sediment source area and flow direction being from the higher areas in the southwest to low areas in the northeast. This work shows that the Middle to Late Triassic sediments in the study area were possibly sourced from the southwestern part of the present-day Barents Sea in regions correlated to the Baltic and Uralian highs.

1. Introduction

The Triassic succession in the entire Barents Sea is largely dominated by prograding regressive to transgressive sequences sourced from the Baltic shield and Uralian Mountains (Glørstad-Clark et al., 2010, 2011) and they hold considerable potential for hydrocarbon generation (Johansen et al., 1993). However, the local evolution and environment of deposition of this sequence remains poorly documented in the Eastern Hammerfest Basin. The aims of this work are a) to unravel the paleo morphology and depositional processes of the Middle to Late Triassic interval and b) to provide an overview of their evolution and hydrocarbon potential.

Geologists and seismic interpreters often use three-dimensional seismic data and seismic attribute to study complex depositional systems (Alfaro and Holz, 2014; Deptuck et al., 2007; Nordfjord et al., 2005; Stuart and Huuse, 2012), investigate deep-water succession (Dalla Valle et al., 2013; Moscardelli and Wood, 2008), analyze sediment-dispersal pattern (Dong et al., 2014) and decipher the provenance or source area of deep-water sediments (Dong et al., 2014; Omosanya and Alves, 2013). Seismic slices can show images of deep-water depositional systems in map view, which can be analyzed from a morphological point of view (Deptuck et al., 2003; Posamentier and Kolla, 2003). Morphologic analysis when combined with seismic, borehole, conventional core, and biostratigraphic data can yield significant stratigraphic insight and understanding of otherwise complicated deep-water systems (Posamentier and Kolla, 2003; Deptuck et al., 2003).

In this work, we have used seismic interpretation (fault and horizon interpretation), horizon slicing, seismic genetic inversion (acoustic impedance) and other seismic geomorphologic observations to reconstruct the depositional system of the Middle to Late Triassic interval in some section of the Eastern Hammerfest Basin. The technique and approach used here is for investigating stratigraphic features whose geometry could not be established with certainty on conventional seismic profiles and structural maps. The paper starts with a brief review of the regional geology of the study

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area and method used for the research. The discussion section highlights the evolution and importance of the depositional system identified in this work.

1.1. Regional geology setting

The study area is a NE–SW oriented and salt-rich Paleozoic basin located in Southwestern Barents Sea (Fig. 1). Tectonic evolution of the Barents Sea and its basins is generally controlled by the Caledonian deformation and tectonic events of c. 240 Ma (Doré, 1995; Faleide et al., 1984; Gabrielsen et al., 1990; Koyi et al., 1993).

The oldest Paleozoic successions were deposited over a metamorphic basement that is dominated by Caledonian and Uralian trends (Doré, 1991; Johansen et al., 1993). As a consequence, Paleozoic strata in the Barents Sea evolved through a complex interaction of tectonics including Svalbardian of Devonian age and Carboniferous to Permian rifting (Gabrielsen et al., 1990; Gudlaugsson et al., 1998). Rifting at these times was coincident with the collapse of the newly formed Caledonian orogenic belts and progressive break up of supercontinent, Pangea (Dore, 1995). The oldest rocks in the Barents Sea include Paleozoic carbonates, coal, evaporites and clastics (Gudlaugsson et al., 1998). Marine sedimentation was prevalent from the Late Paleozoic to present time (Doré, 1995; Heafford, 1988).

In Triassic times, the entire Southwestern Barents Sea region was isolated from other Central European Basins (Dore, 1995). High subsidence and sedimentation rates continued across the entire Barents shelf and by middle Triassic the whole shelf was a marine environment (Smelror et al., 2009; Worsley, 2008). Through much of the Early to Middle Triassic, most of the southern to western shelf was distal to an oscillating but generally north-west prograding coastline with sand provenance first being from the Baltic shield and then increasingly from the Urals (Worsley, 2008). The Late Triassic was characterized by an extensive westward progradation of nearshore and coastal depositional environments when most of the southwestern Barents Shelf was dominated by prodelta shales (Smelror et al., 2009; Worsley, 2008). Fluvial and deltaic depositional systems were mostly developed in the southern part of the study area where fluvial systems are found on platform edge (Worsley, 2008).

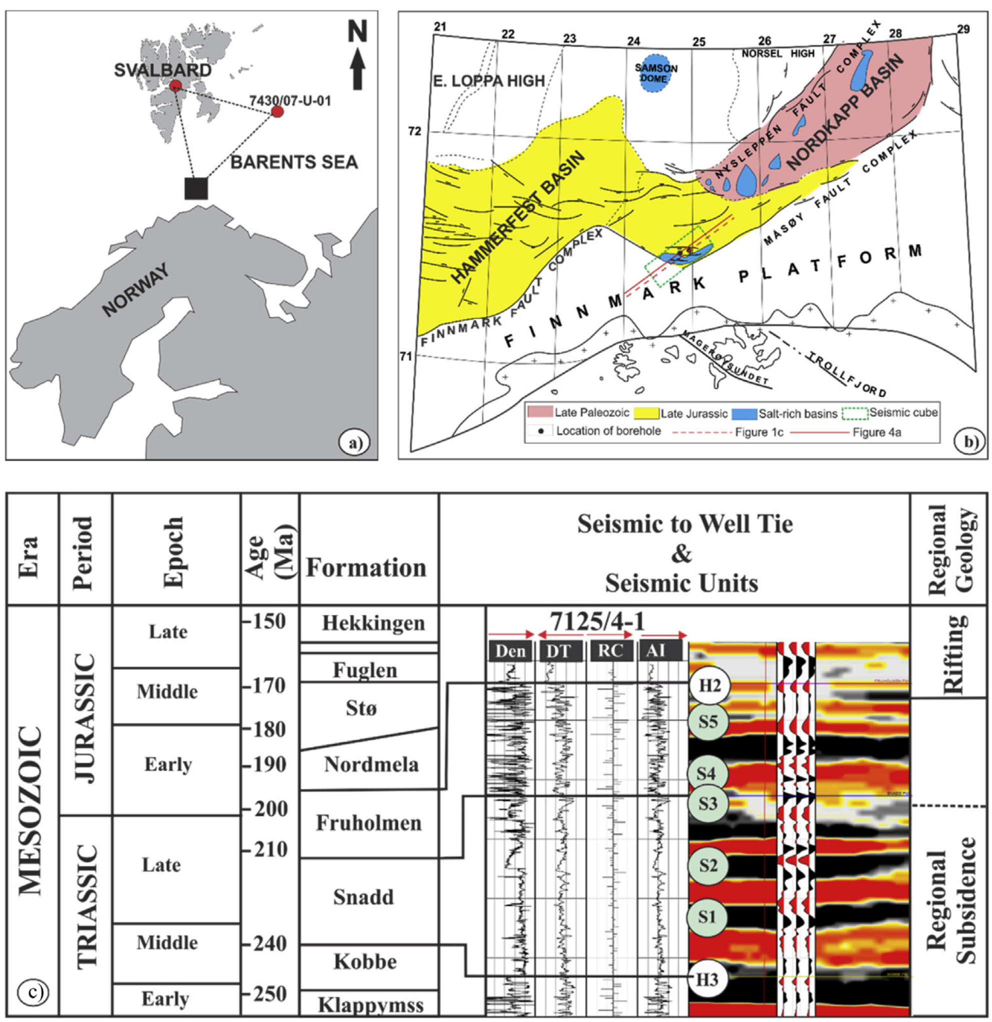

Figure 1. a) Location of the Barents Sea in the context of Norway and Svalbard b) Structural elements map of the study area (Modified from Gabrielsen et al., 1990). Also shown in the map is the location of the seismic cube and lines discussed in the text. N.B: *The black box in* Fig. 1a *correspond to the approximate location of* Fig. 1b *while the red circles denote the location of the outcrop analogs and the well discussed in the text. The dashed line is a correlation line between the three locations.* Fig. 1c: Abridged regional stratigraphy column of the Barents Sea. Lithostratigraphic information was obtained from the works of Dalland et al., 1988; Glørstad-Clark et al., 2010 and Mørk et al., 1999). Seismic well tie is done to correlate the seismic units to their depth equivalent in the borehole. The H2 horizon corresponds to the top of Fruholmen Formation while the H3 is top Kobbe Formation. Horizon slices were obtained between the zone marked by H2 and H3. Five additional slices were extracted within this zone by flattening the topmost H2 horizon. *Red arrow on the logs shows increasing value of the logs*. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)