



Research paper

Palynology and depositional environments of the Middle – Late Triassic (Anisian – Rhaetian) Kobbe, Snadd and Fruholmen formations, southern Barents Sea, Arctic Norway



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ABSTRACT

The Middle to Upper Triassic series in the Norwegian Barents Sea represents an important target for hydrocarbon exploration. However, the dating and correlation of these rocks are problematic due to the scarcity of age-diagnostic macrofossils, lateral facies variation and the overall thickness of the succession. Palynology has proven to be a useful dating tool but further work is necessary to improve the zonal resolution, particularly for the Upper Triassic Series. The current paper presents a detailed palynostratigraphy of the Middle – Upper Triassic succession in four exploration wells (7120/12-2, 7228/2-1s, 7-1a and 9-1s) drilled in the Hammerfest and Nordkapp basins. Eleven informal palynological zones are described from the stratigraphic interval spanning the Kobbe, Snadd and Fruholmen formations, which constitute regionally significant hydrocarbon source and reservoir rock facies. The results of this study contribute to a higher resolution palynostratigraphy for the Middle to Upper Triassic strata of the southern Barents Sea (SBS), and an improved correlation with the stratigraphy of the Svalbard Archipelago. Palynofacies data for the succession, presented here for the first time, indicates depositional environments ranging from fluvio-deltaic to offshore marine.

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1. Introduction

The Barents Sea encompasses the vast area of continental shelf (approximately 1,400,000 km²) located between Norway and the Kola Peninsula, the Svalbard Archipelago, Novaya Zemlya, and Franz Josef Land (Fig. 1). The southern part of the Norwegian Barents Sea has been the focus of hydrocarbon exploration since the 1980s, with the Triassic and Jurassic systems of the Hammerfest Basin as the primary targets (Lundschien et al., 2014). During this time, several discoveries have been made, including the important Snøhvit and Goliat fields. Beyond the Hammerfest Basin, exploratory drilling has been less successful, with discovery of only small accumulations and/or residual hydrocarbons encountered (Henricksen et al., 2011). However, industry focus has increased in recent years following new discoveries such as Alta/Gohta, Johan Castberg, and Wisting.

With the development of several play models for the Triassic succession in the region (e.g. Larsen et al., 1992, p.325; Henricksen

et al., 2011, p.191–192) comes a need for a robust stratigraphic framework. Since age-diagnostic macrofossil remains are rare within Triassic rocks in the area, particularly within the Upper Triassic Series, palynology represents the best dating method. Previous palynological studies in the southern Barents Sea (SBS) (e.g. Hochuli et al., 1989; Vigran et al., 1998, 2014) have outlined preliminary palynozonal schemes for the Triassic succession. However, zonal resolution remains relatively poor for the Upper Triassic Series. Triassic strata analogous to those of the SBS are well exposed across the islands of the Svalbard Archipelago, and have been penetrated in several scientific cores drilled in the Kong Karls Land and Sentralbanken High areas (Fig. 1). Although hydrocarbon exploration is prohibited in this northern region, recent studies of the Upper Triassic stratigraphy in the area (e.g. Mueller et al., 2016; Paterson and Mangerud, 2015; Paterson et al., 2016b) have demonstrated the potential for increased zonal resolution. In order to relate these findings to the SBS, a detailed re-investigation of the palynological succession is necessary. Recent palynofacies studies of the Middle – Upper Triassic in the northern Barents Sea and Svalbard (Mueller et al., 2014; Holen, 2014; Landa, 2015; Meltveit, 2015; Miljeteig, 2016; Paterson et al., 2016a & b) have

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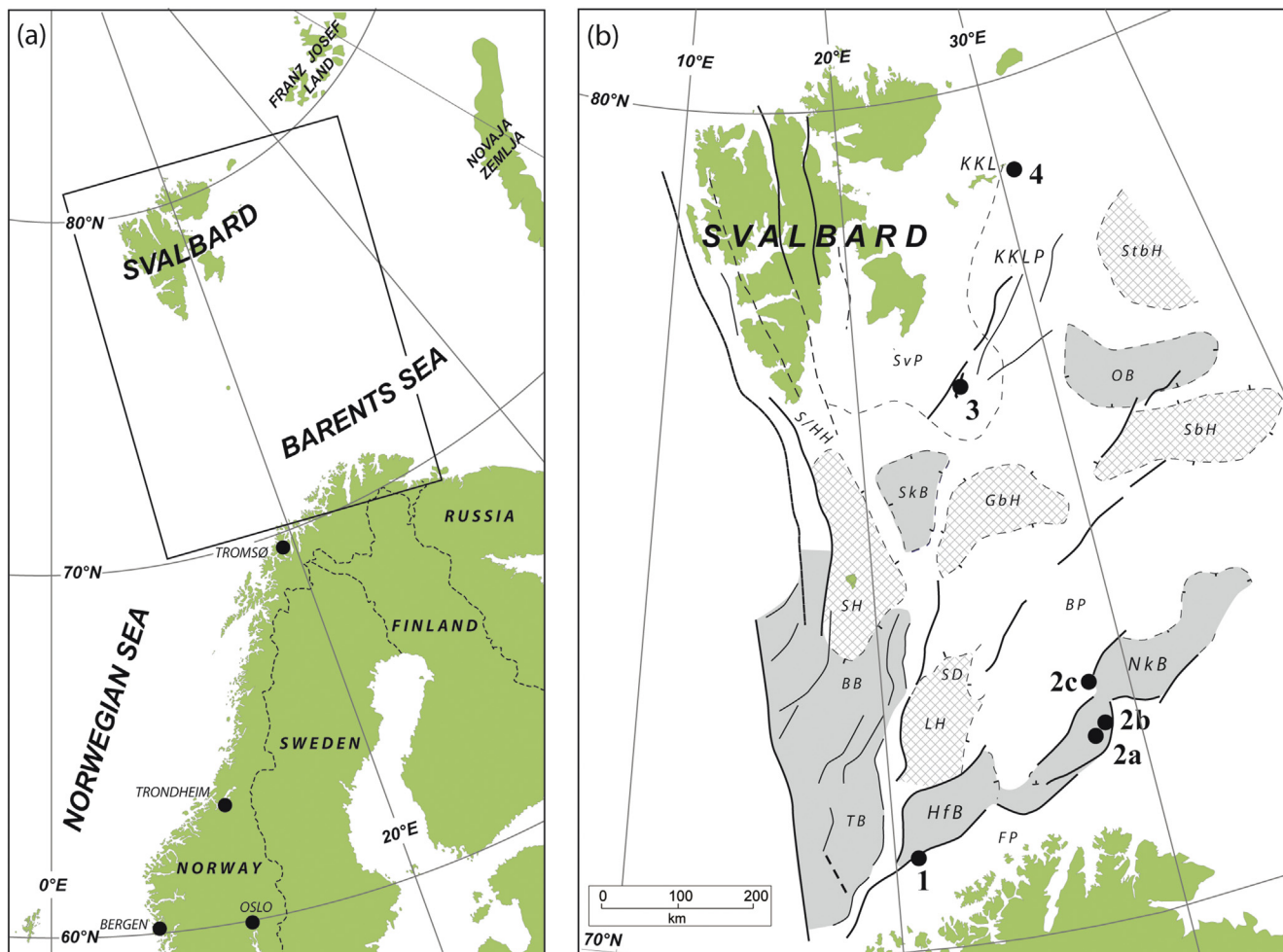


Fig. 1. Regional map of the western Barents Sea with schematic overview of major structural elements (after Nøttvedt et al., 1992; Worsley et al., 2001) with localities analysed herein (1 = well 7120/12-2, 2a = 7228/2-1s, b = 7228/9-1s, c = 7228/7-1a) and in previous studies (3 = Hopen, 4 = offshore Kong Karls Land). Abbreviations: BB = Bjørnøya Basin, FP = Finnmark Platform, GbH = Garderbanken High, HfB = Hammerfest Basin, KKL = Kong Karls Land Platform, LH = Loppa High, NkB = Nordkapp Basin, OB = Olga Basin, SbH = Sentralbanken High, SD = Svalis Dome, SH = Stappen High, S/HH = Sørkapp/Hornsund High, SkB = Sørkapp Basin, StbH = Storbanken High, SvP = Svalbard Platform, TB = Tromsø Basin.

contributed to an improved palaeoenvironmental interpretation for the succession. Such data would undoubtedly improve the understanding of source and reservoir rock development in the SBS. However, no studies of this kind have hitherto been published from the region.

This paper presents the results of a palynostratigraphic study of 213 cutting, core and sidewall core samples, from the Middle to Upper Triassic (Anisian – Rhaetian) succession penetrated by four exploration wells (7120/12-2, 7228/2-1s, 7228/7-1a, 7228/9-1s) from the Hammerfest and Nordkapp basins (Fig. 1, localities 1 & 2). The results demonstrate that the palynozonation outlined by Paterson and Mangerud (2015) and Paterson et al. (2016b) may be applied in the SBS. Palynofacies data for the Middle to Upper Triassic of the region is presented for the first time.

2. Geological setting

2.1. Hydrocarbon potential

The organic-rich mudrocks of the late Early (Olenekian) – Middle Triassic (Anisian) age Steinkobbe Formation (Fig. 2) constitute the principal hydrocarbon source rock in the SBS

(Lundschieen et al., 2014). Meanwhile, penecontemporaneous fluvio-deltaic and marginal marine sandstone facies of the Kobbe Formation (Fig. 2) represents potential reservoir facies (Henricksen et al., 2011; Lundschieen et al., 2014). Both formations represent partial time equivalents of the Bravaisberget and Botneheia formations on Svalbard (Mørk et al., 1999, p. 156–162). Fluvio-deltaic deposits of the overlying Ladinian to Carnian age Snadd Formation, and the correlative Tschermakfjellet and De Geerdalen formations (Fig. 2), contain proven hydrocarbon reservoir and source rock intervals (Henricksen et al., 2011; Ryseth, 2014), as does the Norian – Rhaetian age Fruholmen Formation (Pedersen et al., 2005; Lerch et al., 2016).

2.2. Lithostratigraphy

2.2.1. Fruholmen Formation

The Fruholmen Formation was first described by Worsley et al. (1988) from the Hammerfest Basin well 7121/5-1. The formation is 221 m thick in the type well, and 198 m thick in the hypostatotype well 7120/12-1. The Fruholmen Formation is divided into three members, (in ascending order) the Akkar, Reke and Krabbe (Mørk et al., 1999). The Akkar Member consists of grey to dark grey

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