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Research Paper

Shallow Gas Analysis in Skrugard Area, SW Barents Sea

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ABSTRACT: *In 2011, Skrugard discovery made an explorational breakthrough in the south-western Barents Sea. Earlier this year, Havis discovery (well 7220/7-1) was found in the same area. Both two discoveries are found in the same production license. The double flat spots were found in both Skrugard and Harvis discoveries. However, there are many dry wells in the same area before these two discoveries. The objective of this paper is to figure out why there found commercial hydrocarbon in Skrugard and Havis rather than other areas close to them. Through seismic interpretation, shallow gas was found in the study area, and gas-flow features were divided into three main categories: gas chimney, leakage along faults and leakage along weathering crust. Furthermore, they contribute to a better understanding of the petroleum system in the South-western Barents Sea.*

Keywords: *South-western Barents Sea, Skrugard, Seismic, Shallow gas, Gas-flow*

I. INTRODUCTION

Barents Sea is located north part of Europe, which is the greatest shelf area surrounding the Arctic Ocean. Physiographically, the Barents Sea is the region bracketed by the north Norwegian and Russian coasts, the Novaya Zemlya, Franz Josef Land and Svalbard archipelagos, and the eastern margin of the deep Atlantic Ocean (Dore, 1995; Emmel et al, 2015). The area of Barents is 1.4 million km^3 with an average water depth of 230 m.

There have been drilled 95 exploration wells in the Norwegian part of the Barents Sea, but there are only three commercial oil discoveries (Goliat, Havis and Skrugard) (Ostanin et al, 2013; Wilson, 2013) and one large gas discovery (Snøhvit) (Shi et al, 2013). The success of exploration rate is very low in this area. In the Barents Sea west margin, there have been drilled less than 15 exploration wells so far, which distributed in 40,000 km^2 area. Comparing to this, there have been drilled 1150 wells in 170,000 km^2 area in North Sea. Well density is very low in Barents Sea, so it is a very frontier area now.

In 2011, Skrugard discovery (well 7220/8-1) (Fig. 1) made an explorational breakthrough in the south-western Barents Sea (Gabrielsen et al, 2013; Løseth et al, 2014). Earlier this year, Havis discovery (well 7220/7-1) was found in the same area. These two discoveries are in the same Production License (PL 532), which is operated by Statoil, ENI and Pedro. Skrugard is located on the west flank of Loppahøyden (Polheim sub-platform), a steeply sloping with narrow, rotated fault blocks towards Bjørnøyabassenget.

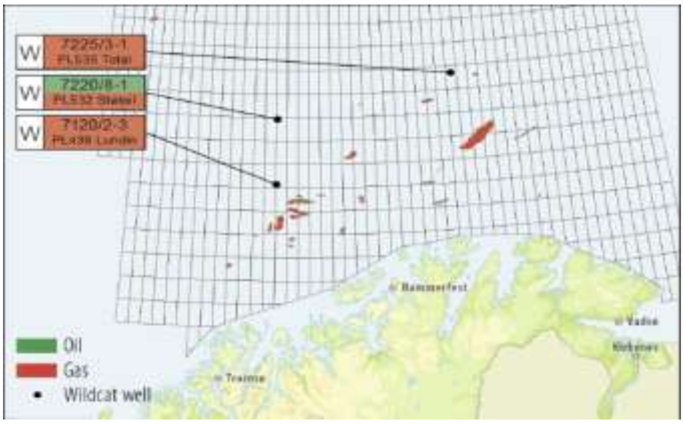

Fig.1 Discoveries in Barents Sea

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The southwest Barents Sea area includes the Bjørnøya basin, Sørvestsnaget basin, Tromsø basin and Harstad basin, which is a province of particularly deep Cretaceous and Cenozoic basins. Sørvestsnaget basin, Bjørnøya basin and Tromsø basins have equal rates of Early Cretaceous subsidence (Safronova et al, 2012). The Sørvestsnaget Basin subsequently showing more pronounced Late Cretaceous and Cenozoic subsidence than the Tromsø- and Bjørnøya basins (Breivik et al, 1998; Gernigon et al, 2014).

The evolution of the southern sheared margin is closely linked to the opening of the Norwegian-Greenland Sea (Skogseid et al, 2000). There are three main tectonic phases: 1) continent- continent transform prior to crustal break-up, 2) ocean- continent transform as the Atlantic spreading ridge propagated northwards along the shear zone, 3) a passive continental margin with no shear movement as the spreading ridge shifted still further to the north (Vågnes et al, 1997; Glørstad-Clark et al, 2011; Clark et al, 2014; Safronova et al, 2014). This margin separates the Lofoten Basin, which contain mainly Neogene sediments (Ryseth et al, 2003; Setoyama et al, 2011; Volkov et al, 2015).

The general stratigraphy of south-western Barents Sea is divided into three main successions: Paleozoic succession, Mesozoic succession and Cenozoic succession. Detailed formations and lithologic characteristic are given by Glørstad-Clark in 2010 (Fig. 2).

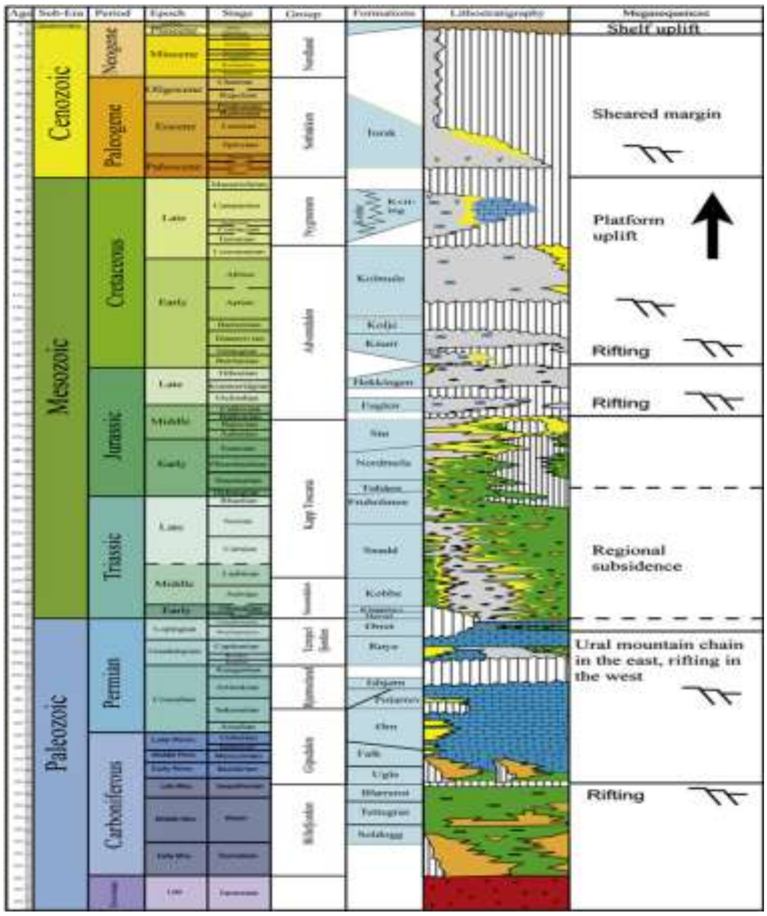

Fig. 2 General stratigraphy of western Barents Sea, with geological Time scale and megasequences (modified from Glørstad-Clark et al, 2010)

The petroleum system of the study area contains Late Jurassic system in Bjørnøya basin (Fig. 3) (Dengo and Røssland, 2013). For the regional aspect, the Hekkingen Formation from Late Jurassic is considered as the source rocks in SW Barents Sea (Vadakkepuliyambatta et al, 2013). Hekkingen Formation contains dark organic rich shales which were deposited in anoxic deep marine conditions, as consequence of the local barriers to circulation created by the Kimmerian movements (Dalland et al, 1988; Boitsov et al, 2011; Rajan et al, 2013). The most significant reservoir rocks in the study area are in the strata of Jurassic age, and the major discoveries have a principal reservoir rock of Stø Formation from Lower to Middle Jurassic. It is believed that 85% of the reservoir rocks exist within the Stø Formation in the Norwegian Barents Sea, and most of them are expected to generate natural gas (Dore, 1995; Duran et al, 2013). The Stø Formation consists of mature sandstones with thin beds of shale and siltstone. The depositional environment for Stø Formation is in prograding coastal areas, and shales and siltstone patches depicts regional transgressive episodes (Dalland et al., 1988; Duran et al, 2013).

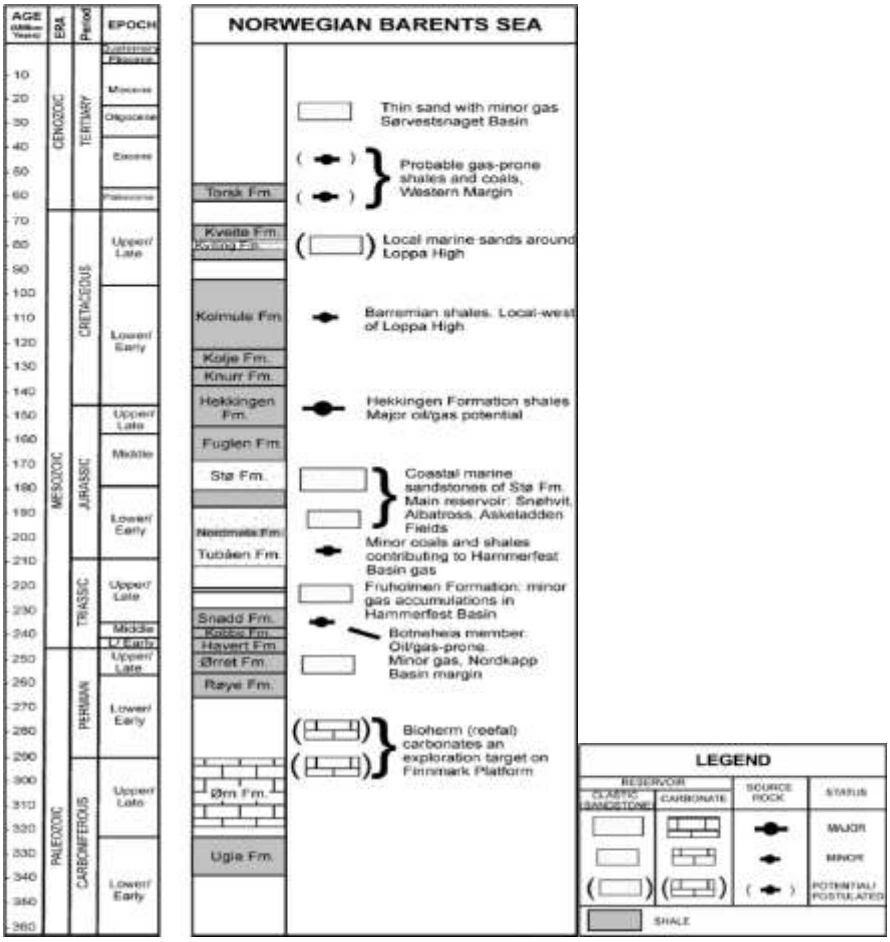

Fig. 3 Some major proven and potential reservoir and source rocks in the Barents Sea (modified after Dore, 1995; Ohm et al, 2008).

II. SEISMIC INTERPRETATION

The study area is located across the Loppa High (including Polhem Sub-platform) and Bjørnøya Basin (Fig. 4). In order to figure out the analysis and discuss the petroleum system in this area, the adjacent structural elements should be described here. The Skrugard fault is one of the parts of the Bjørnøyrenna Fault Complex, and it will be considered as one of the aspects in forming Skrugard oil province.

Fig. 4 The location of the structural elements adjacent to the study area (red outline)

Occurrence of shallow gas, gas hydrates and seafloor expulsion features has been reported from several areas of the SW Barents Sea (Andreassen et al, 1990; Perez-Garcia et al, 2009; Chand et al, 2012; Ostanin et al., 2012; Vadakkepuliyambatta et al, 2015). In the study are, there found many gas-leakage anomalies after the interpretation. Gas-flow features interpreted in this paper were divided into three main categories: 1) gas chimney, 2) leakage along faults and 3) leakage along weathering crust.

2.1 Gas Chimney

The first key profile line is F-86-301 (Fig. 5), which is a NE-SW trending 2D seismic line located at the boundary zone of Bjørnøya Basin and Loppa High. There are many wells (well 7219/9-1, 7220/7-1, 7220/5-1) close to this line, it means line F-86-301 contains many different geological structures. Furthermore, Havis discovery has already been reported found in well 7220/7-1, but 7219/9-1 was abandoned as a dry well. Interpretation of this line may give some ideas about why these two close wells have different oil shows.

From key profile 1, there exists an obvious zone with chaotic acoustic signals or so called acoustic masking. This chaotic acoustic zones distributed widely and the shape became small gradually with depth reducing. This anomalous zone terminated at the high-amplitude anomalies in the shallow formation that suggests the presence of gas. All these indicates that this anomalous zone can be interpreted as gas chimney. Gas chimney is defined as a region of distorted seismic signals resulting from irregularly distributed low-velocity gas-charged zones, formed due to an upward migration of gas/fluids.

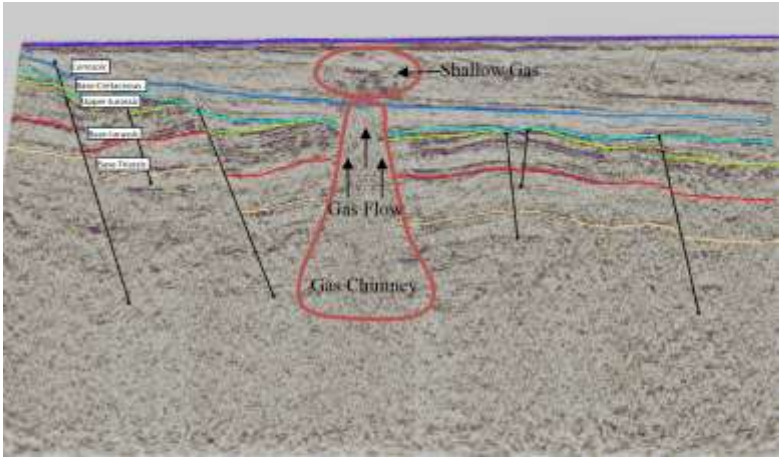

Fig. 5 Key Profile 1-2D Seismic Line F-86-301 and Gas Chimney

2.2 Leakage along faults

There exists many chaotic reflections and high amplitude anomalies close to the faults in the study area. From the key profile 2 (Fig. 6), highly chaotic and low-amplitude reflections occur close to the root of the major faults, suggesting fluid migration from a much deeper source and branching of fluid migration along the main faults. At the termination of the faults, high amplitude anomalies are visible which indicate the presence of the gas.

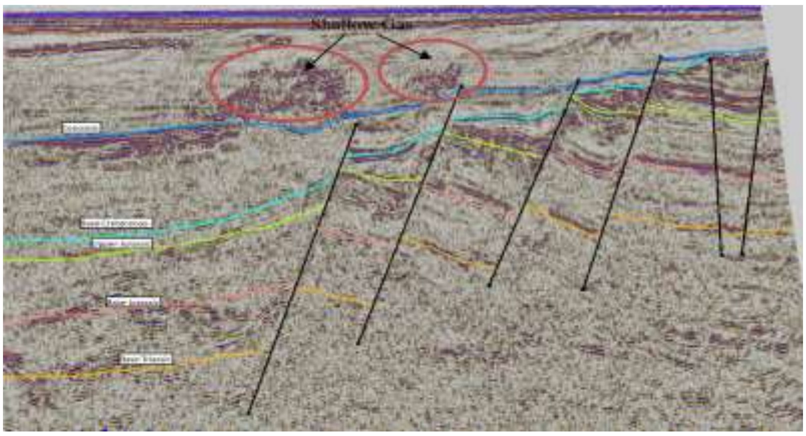

Fig. 6 Key profile 3 – 2D seismic line F-86-203 and shallow gas leakage along faults

2.3 Leakage along weathering crust

For the gas leakage along faults situation, the faults open is assumed and then gas can migrate along the faults from the deep source. But if the faults are assumed to be sealed, gas cannot migrate along the faults. Here, it is proposed that gas leakage along weathering crust. From key profile 3 (Fig. 7), an angular unconformity is visible. Over the fault there is high amplitude anomaly what is so called bright spot which is suggested as gas there. For the analysis above, if gas migrates along faults, there should be a high amplitude anomalies zone rather than only one bright spot. In this area, gas was assumed to migrate along weathering crust. When formation weathered and eroded after lifting, there can form good condition spaces and connections after new formation form and cover it. Gas then can migrate along this weathering or unconformity.

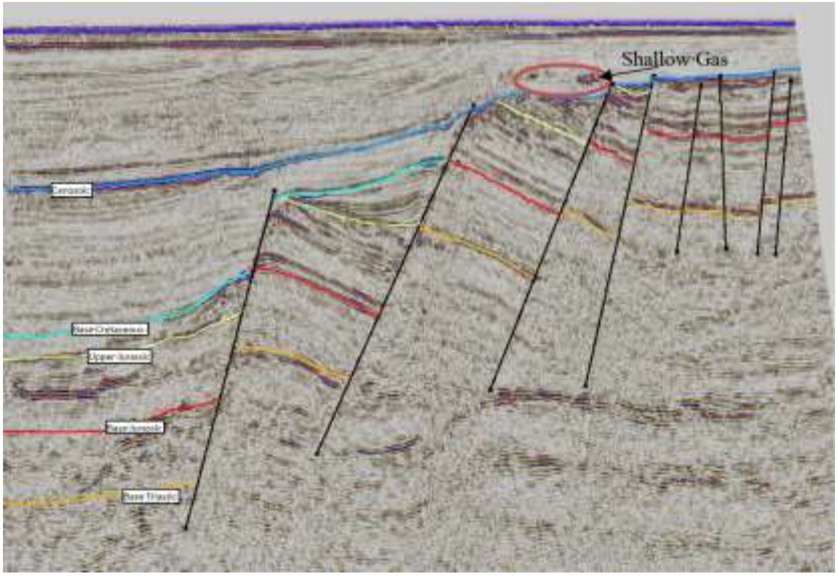

Fig. 7 Key Profile 2- 2D Seismic Line F-86-205 and gas leakage along weathering crust

III. DISCUSSION

In the south-western Barents Sea, the most significant reservoir rocks are in the strata of Jurassic age, and the major discoveries have a principal reservoir rock of Stø Formation from Lower to Middle Jurassic. For the regional aspect, the Hekkingen Formation from Late Jurassic is considered as the source rocks in SW Barents Sea. Hekkingen Formation is very thick, and it can generate significant quantities of hydrocarbons and extends regionally in the Barents Sea, Early Jurassic Nordmela and Tubåen Formations and Early and Mid Triassic Formations, Snadd, Kobbe, Klappmyss and Havert formations

The study area is in the Bjørnøya basin, which contains the Late Jurassic petroleum system. The Stø Formation from Jurassic age acts as the reservoir, the Snadd Formation acts as the source rock and the Hekkingen Formation act as the sea rock. There are many structure traps related to the faults in the study area, and there seems many potential traps containing hydrocarbon.

Based on the seismic interpretation, the three possible reasons for these dry wells are 1) Gas Chimney 2) leakage along faults and 3) leakage along weathering crust. Migration of fluids into shallow sediments and seepage into the ocean through the seafloor was probably the result of spillage and migration of hydrocarbons in response to uplift and erosion processes in the Cenozoic. These results are a consequence of the complicated geological history of the Barents Sea that includes several periods of exhumation and erosion, causing re-distribution of hydrocarbons within the basin.

References

[1]. Andreassen K, Hogstad K and Berteussen K A, Gas hydrate in the southern Barents Sea, indicated by a shallow seismic anomaly, First Break, 8(6), 1990, 235-245.

[2]. Boitsov S, Petrova V, Jensen H K, et al, Petroleum-related hydrocarbons in deep and subsurface sediments from South-Western Barents Sea, Marine environmental research, 71(5), 2011, 357-368.

[3]. Breivik A J, Faleide J I and Gudlaugsson S T, Southwestern Barents Sea margin, late Mesozoic sedimentary basins and crustal extension, Tectonophysics, 293(1-2), 1998, 21-44.

[4]. Chand S, Thorsnes T, Rise L, et al, Multiple episodes of fluid flow in the SW Barents Sea (Loppa High) evidenced by gas flares, pockmarks and gas hydrate accumulation, Earth and Planetary Science Letters, 331-332(1) ,2012, 305-314.

[5]. Clark S A, Glorstad-Clark E, Faleide J I, et al, Southwest Barents Sea rift basin evolution, comparing results from backstripping and time-forward modelling, Basin Research, 26(4), 2014, 550-566.

[6]. Dalland A, Worsley D and Ofstad K, A Lithostratigraphic Scheme for the Mesozoic and Cenozoic and Succession Offshore Mid- and Northern Norway, Stanvanger, Oljedirektoratet (Norwegian Petroleum Directorate), 1988, 46-50.

[7]. Dengo C A and Røssland K G, Extensional tectonic history of the western Barents Sea, Structural and Tectonic Modelling and Its Application to Petroleum Geology, Norwegian Petroleum Society (NPF), Special Publication, 1(1), 2013, 91-108.

[8]. Dore, A G, Barents Sea geology, petroleum resources and commercial potential, Arctic, 48(3), 1995, 207-221.

[9]. Duran E R, di Primio R, Anka Z, et al, Petroleum system analysis of the Hammerfest Basin (southwestern Barents Sea), comparison of basin modelling and geochemical data, Organic Geochemistry, 63(1), 2013, 105-21.

[10]. Emmel B, de Jager G, Zieba K, et al, A 3D map based approach to reconstruct and calibrate palaeo-bathymetries–Testing the Cretaceous water depth of the Hammerfest Basin, southwestern Barents Sea, Continental Shelf Research, 97(1), 2015, 21-31.

[11]. Gabrielsen P T, Abrahamson P, Panzner M, et al, Exploring frontier areas using 2D seismic and 3D CSEM data, as exemplified by multi-client data over the Skrugard and Havis discoveries in the Barents Sea, First Break, 31(1), 2013, 63-71.

[12]. Gernigon L, Brönner M, Roberts D, et al, Crustal and basin evolution of the southwestern Barents Sea, From Caledonian orogeny to continental breakup, Tectonics, 33(4), 2014, 347-373.

[13]. Glørstad-Clark E, Birkeland E P, Nystuen J P, et al, Triassic platform-margin deltas in the western Barents Sea, Marine and Petroleum Geology, 28(7), 2011, 1294-1314.

[14]. Glørstad-Clark E, Faleide J I, Lundschien B A, et al, Triassic seismic sequence stratigraphy and paleogeography of the western Barents Sea area, Marine and Petroleum Geology, 27(7), 2010, 1448-1475.

[15]. Løseth L O, Wiik T, Olsen P A, et al, Detecting Skrugard by CSEM-Prewell prediction and postwell evaluation, Interpretation, 2(3), 2014, 67-77.

[16]. Ohm S E, Karlsen D A and Austin, T J F, Geochemically driven exploration models in uplifted areas, examples from the Norwegian Barents Sea, AAPG Bulletin, 92(9), 2008, 1191-1223.

[17]. Ostanin I, Anka Z, di Primio R, et al, Identification of a large Upper Cretaceous polygonal fault network in the Hammerfest basin, implications on the reactivation of regional faulting and gas leakage dynamics, SW Barents Sea, Marine Geology, 332-334(1), 2012, 109-125.

[18]. Ostanin I, Anka Z, di Primio R, et al, Hydrocarbon leakage above the Snøhvit gas field, Hammerfest Basin SW Barents Sea, First break, 30(11),2012, 55-66.

[19]. Ostanin I, Anka Z, di Primio R, et al, Hydrocarbon plumbing systems above the Snøhvit gas field, structural control and implications for thermogenic methane leakage in the Hammerfest Basin, SW Barents Sea, Marine and Petroleum Geology, 43(1), 2013, 127-46.

[20]. Perez-Garcia C, Feseker T, Mienert J, et al, The Håkon Mosby mud volcano, 330000 years of focused fluid flow activity at the SW Barents Sea slope, Marine Geology, 262(1), 2009, 105-115.

[21]. Rajan A, Bünz S, Mienert J, et al, Gas hydrate systems in petroleum provinces of the SW-Barents Sea, Marine and Petroleum Geology, 46(1), 2013, 92-106.

[22]. Ryseth A, Augustson J H, Charnock M, et al, Cenozoic stratigraphy and evolution of the Sørvestsnaget Basin, southwestern Barents Sea, Norwegian Journal of Geology/Norsk Geologisk Forening, 83(2), 2003, 107-130.

[23]. Safronova P A, Andreassen K, Laberg JS, et al, Development and post-depositional deformation of a Middle Eocene deep-water sandy depositional system in the Sørvestsnaget Basin, SW Barents Sea, Marine and Petroleum Geology, 36(1), 2012, 83-99.

[24]. Safronova P A, Henriksen S, Andreassen K, et al, Evolution of shelf-margin clinoforms and deep-water fans during the middle Eocene in the Sorvestsnaget Basin, southwest Barents Sea, AAPG bulletin, 98(3), 2014, 515-544.

[25]. Setoyama E, Kaminski M A and Tyszka J, The Late Cretaceous–Early Paleocene palaeobathymetric trends in the southwestern Barents Sea-Palaeoenvironmental implications of benthic foraminiferal assemblage analysis, Palaeogeography, Palaeoclimatology, Palaeoecology, 307(1), 2011, 44-58.

[26]. Shi J Q, Imrie C, Sinayuc C, et al, Snøhvit CO 2 storage project, Assessment of CO2 injection performance through history matching of the injection well pressure over a 32-months period, Energy Procedia, 37(1), 2013, 3267-3274.

[27]. Skogseid J, Planke S, Faleide J I, et al, NE Atlantic continental rifting and volcanic margin formation, Geological Society, London, Special Publication, 167(1), 2000, 295-326.

[28]. Vadakkepuliyambatta S, Bünz S, Mienert J, et al, Distribution of subsurface fluid-flow systems in the SW Barents Sea, Marine and Petroleum Geology, 43(1), 2013, 208-21.

[29]. Vadakkepuliyambatta S, Hornbach M J, Bünz S, et al, Controls on gas hydrate system evolution in a region of active fluid flow in the SW Barents Sea, Marine and Petroleum Geology, 66(4), 2015, 861-72.

[30]. Volkov D L, Kubryakov A A and Lumpkin R, Formation and variability of the Lofoten basin vortex in a high-resolution ocean model, Deep Sea Research Part I, Oceanographic Research Papers, 105(1), 2015, 142-157.

[31]. Vågnes E, Uplift at thermo-mechanically coupled ocean-continent transforms, Modeled at the Senja Fracture Zone, southwestern Barents Sea, Geo-Marine Letters, 17(1), 1997, 100-109.

[32]. Wilson A, First Barents Sea Oilfield Development Emphasizes Oil Spill Preparedness, Journal of Petroleum Technology, 65(4), 2013, 88-92.