

Research paper

Petroleum source, maturity, alteration and mixing in the southwestern Barents Sea: New insights from geochemical and isotope data

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ABSTRACT

The Hammerfest Basin (HB) is an important area for petroleum exploration in the southwestern Norwegian Barents Sea. This contribution is aimed to characterize oils and condensates hosted in Triassic and Jurassic reservoirs, establish genetic relationships and to assess maturity, mixing and petroleum alteration processes. The research was based on geochemical as well as bulk and compound-specific stable carbon and hydrogen isotope analyses of oil and condensate samples from all major fields and discoveries in the HB, including extracts from Jurassic and Triassic source rocks. Interpretations of light hydrocarbon composition and isotope data clearly identify four main petroleum groups affected by microbial degradation, water washing, evaporative fractionation and high thermal maturity level. Based on polycyclic aromatic hydrocarbons (PAHs), marine and higher-plant-derived biomarkers and carbon isotopic composition ($\delta^{13}\text{C}$) of individual petroleum hydrocarbons, four petroleum families (I–IV) are recognized in the HB and a distinction can be made among oils and condensates from different stratigraphic levels and sectors of the Basin. Most oils and condensates from the HB consist of mixtures with small maturity variations; however, oils from Middle Triassic reservoirs in the Goliat field showed larger maturity variations according to biomarker, PAH and light hydrocarbon–maturity ratios. In the HB, geochemical and isotopic data allowed unraveling mixtures of hydrocarbons derived mainly from Jurassic, Triassic and Paleozoic source rocks.

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1. Introduction

The Hammerfest Basin (HB) is located in the southwestern part of the Norwegian Barents Sea (NBS), a large geological province that is nearly twice the size of the Norwegian North Sea and that includes several sedimentary basins of Paleozoic and Mesozoic age (Fig. 1). The NBS is characterized by a complex tectonic history (e.g., Vorren et al., 1991; Faleide et al., 1993; Dimakis et al., 1998) and the occurrence of several source intervals ranging in age from Lower Carboniferous to Lower Cretaceous (e.g., Johansen et al., 1992; Larssen et al., 2002; Ohm et al., 2008). This has not only resulted in a very complex history of petroleum generation, migration and

trapping, but also in different scenarios of petroleum mixing and alteration in the HB reservoirs.

Although many authors have assessed the potential source rocks from different source intervals in the NBS (e.g., Johansen et al., 1992; Larsen et al., 1992; Linjordet and Grung-Olsen, 1992; Larssen et al., 2002; Ohm et al., 2008; Van Koeverden et al., 2010), only a few geochemical studies have been carried out using oil and condensate samples from the HB (Ohm et al., 2008; Duran et al., 2013a,b; Killops et al., 2014).

Ohm et al. (2008) analyzed several samples of petroleum from the Norwegian Barents Sea and suggested mixing of oils from Upper Jurassic, Triassic and Paleozoic source rocks. The same authors also reported biodegradation and water washing in crude oils from the Goliat field, and suggested that the loss of water-soluble aromatic compounds was due to long-distance migration or migration through a carrier rock with a high surface to volume ratio. Duran et al. (2013a) compared basin modeling predictions and geochemical data of fluid samples from the Hammerfest Basin. They suggested that petroleum charges from Upper Jurassic and

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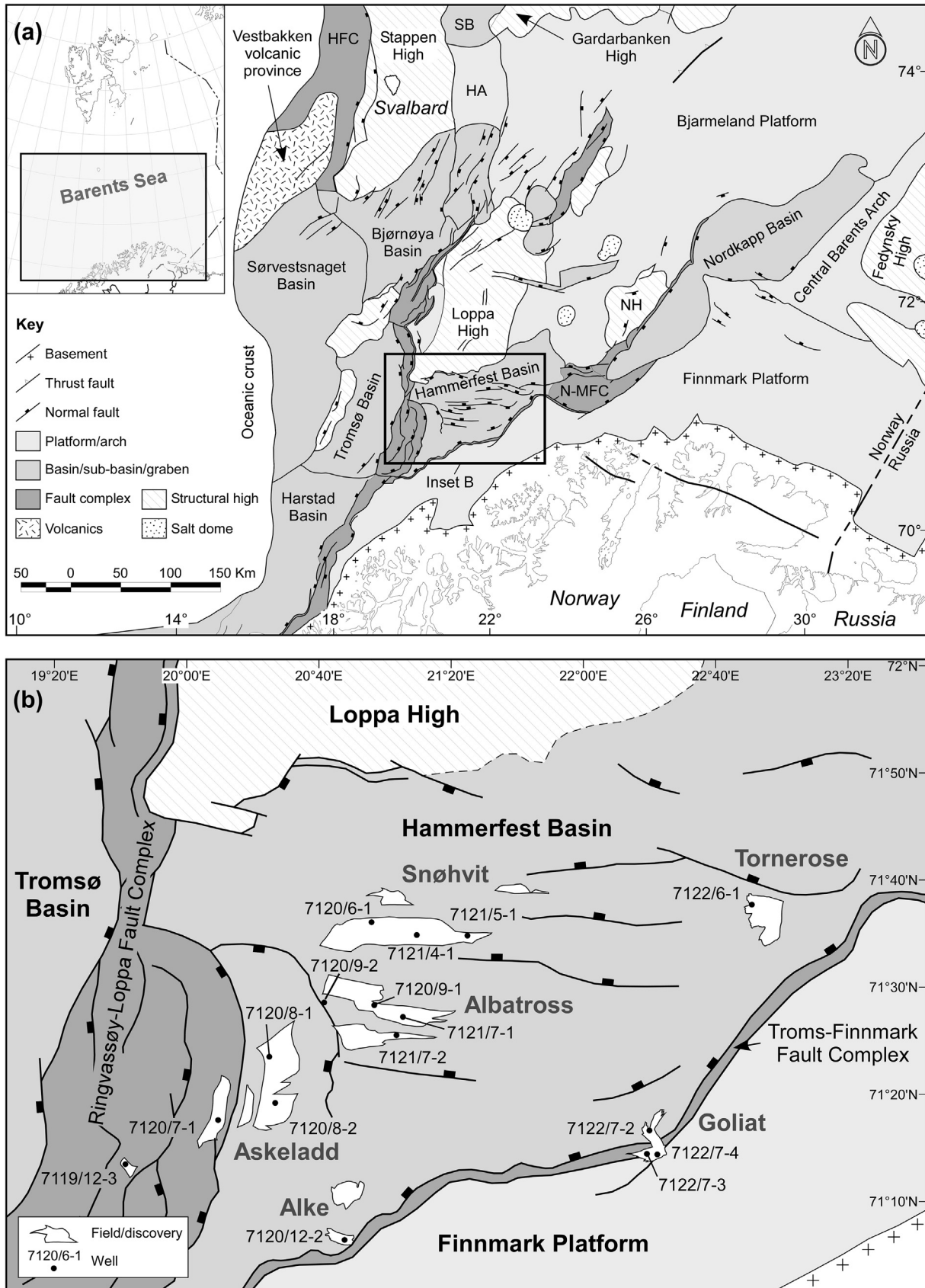


Fig. 1. (a) Index map showing major structural elements of the large Barents Sea geological province and the relative location of the Hammerfest Basin, boxed area expanded in (b) well location map with the major structural elements, fields, discoveries and sampled wells for fluids and rocks in the study area. HA = Hopenbanken Arch, HFC = Hornsund Fault Complex, NH = Norsel High, N-MFC = Nysleppen-Måsøy Fault Complex, SB = Søkkapp Basin. Map composed from Gabrielsen et al. (1990), Larsen et al. (2002), and Norwegian Petroleum Directorate (2014).

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