SECONDARY OIL MIGRATION ROUTES INTO THE JOHAN SVERDRUP FIELD

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Molecular traces for secondary petroleum migration and reservoir filling histories are commonly based on relative composition of polar petroleum constituents, as the functional groups of hetercompounds are assumed to interact with surfaces of the mineral or organic matrix of the pore system (Larter et al., 1996). The retention of polar compounds upon interaction with pore system surfaces leading to their preferential relative depletion in oils migrated for longer distances before reaching a reservoir is termed geochromatography. Although the dominant proportion of polar compounds in petroleum may reside in the asphaltene fraction, commonly the polar constituents of the maltene fraction are analysed due to better analytical accessibility. Amongst polar maltenes the carbazole fraction (besides phenols, xanthones, carboxylic acids, etc.) has received the most attention due to its enhanced concentration in black oils. Generally, two aspects in relative carbazole distribution are investigated, i) shielding of the pyrrole hydrogen functionality by alkyl groups, minimizing geochromatographic retention, and ii) relative concentration of benzocarbazole isomers, with the benzo[a]carbazole isomer being preferentially removed from migrating oils by its molecular shape.

The Johan Sverdrup Field is the largest discovery in the North Sea over the past 20 years and is expected to contribute about 25% to the future Norwegian oil reserves. The field is located in the Utsira High region, some 150 km west of Stavanger. The Johan Sverdrup Field is surrounded by oil and gas fields to the West (Ivar Aasen, Edvard Grieg, Gudrun), to the North (Hanz and Grane) as well as to the Southwest (Luno II). Analysing compositions of oils in reservoirs of similar age (Basement, Zechstein, Triassic, and Jurassic) as in the Johan Sverdrup Field from the surrounding fields may offer insight into migration routes feeding the different reservoirs and guide in identification of potential migration routes around the Utsira High.

We have analysed a set of 30 oils from the Utsira High region, 14 of those derived from the Johan Sverdrup Field itself. A further 16 oils are under investigation and will help to constrain migration routes, reservoir compartmentalization and thus reservoir filling histories in more detail. Oil maturity assessment identified reservoirs on the Gudrun terrace as being most mature (Fig. 1a), followed by those reservoired in the Ivar Aasen and then the Edvard Grieg field. Oils from the Johan Sverdrup filed are of virtually identical and low maturity, comparable to those of the Luno II field. The regional benzo[a]/(benzo[a]+benzo[c])-carbazole pattern differed from that of molecular maturity ratios (Fig. 1b), indicating that carbazole distribution is primarily controlled by migration rather than thermal maturity. Highest values on the Gudrun terrace indicate closest proximity to the kitchen in the Viking Graben (Fig. 1b), whereas lower values in the Johan Sverdrup Field attest to longer distance migration. Filling routes from the South-West into the Johan Sverdrup Field are unlikey, as the Luno II deposit shows the lowest ratios and hence the longest migration distance. Within the Johan Sverdrup field, the reservoir compartment of the Lista Graben shows lower values, indicative of reservoir compartmentalization not identified by maturity proxies. This compartment must have been charged by longer migrated oils, potentially those that filled the Luno II deposit. Synthesis of molecular migration tracers with structural information will

show whether a migration path from the Viking Graben towards the East then circumventing the Utsira High to fill Luno from the North is feasible.

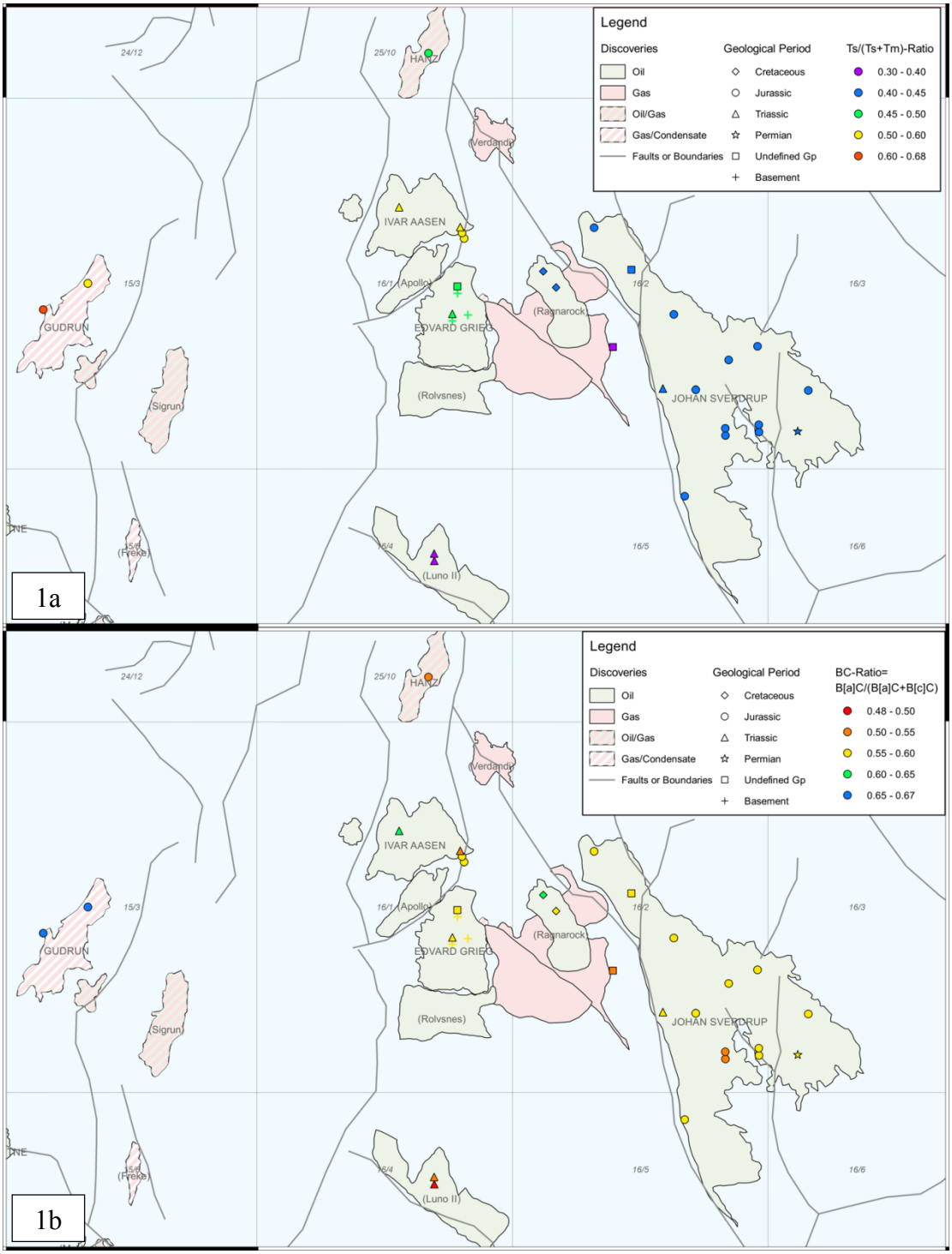

Figure 1: *Regional map of a) oil maturity determined by Ts/(Ts+Tm) and b) migration trends via the benzo[a]/(benzo[a]+benzo[c]-carbazole-ratio. For the latter high values indicate proximity to the source kitchen and low values as encountered in the Luno II Field argue against a filling directly from the Graben to the West but may argue for a charging form the North.*

References:

Larter et al., Molecular indicators of secondary oil migration distances 1996, *Nature* 383, 593 - 597