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Detection and Origin of Hydrocarbon Seepage Anomalies in the Barents Sea

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We have collected more than 450 gravity cores in the Barents Sea to detect hydrocarbon seepage anomalies and for seismic-stratigraphic tie. The cores are from the Hoop Area (125 samples) and from the Barents Sea SE (293 samples). In addition, we have collected cores near seven exploration wells. The samples were analyzed using three different analytical methods; (1) the standard organic geochemical analyzes of Applied Petroleum Technologies (APT), (2) the Amplified Geochemical Imaging (AGI) method, and (3) the Microbial Prospecting for Oil and Gas (MPOG) method. These analytical approaches can detect trace amounts of thermogenic hydrocarbons in the sediment samples, and may provide additional information about the fluid phases and the depositional environment, maturation, and age of the source rocks. However, hydrocarbon anomalies in seabed sediments may also be related to shallow sources, such as biogenic gas or reworked source rocks in the sediments. To better understand the origin of the hydrocarbon anomalies in the Barents Sea we have studied 35 samples collected approximately 200 m away from seven exploration wells. The wells included three boreholes associated with oil discoveries, two with gas discoveries, one dry well with gas shows, and one dry well. In general, the results of this case study reveal that the oil wells have an oil signature, gas wells show a gas signature, and dry wells have a background signature. However, differences in results from the three methods may occur and have largely been explained in terms of analytical measurement ranges, method sensitivities, and bio-geochemical processes in the seabed sediments. The standard geochemical method applied by APT relies on measuring the abundance of compounds between C1 to C5 in the headspace gas and between C11 to C36 in the sediment extracts. The anomalies detected in the sediment samples from this study were in the C16 to C30 range. Since the organic matter yields were mostly very low, the detectable signal by the standard method was commonly overprinted by recent immature organic matter. Therefore, the identification of small hydrocarbon anomalies at the beginning of the measurable analytical range (C11 to C15 was often not possible with this method. The AGI method relies on passive adsorbents collecting volatiles and semi-volatile compounds in the C2-C20 range that are released from the sediments. The patterns of compounds found in sediments collected close to oil wells were in the C5 to C14 range and were used to define anomalous samples elsewhere. The MPOG method relies on the presence of C1-C9 hydrocarbon oxidizing bacteria in the sediments. These bacteria are only present if seepage is active and provides enough nutrients for them to survive. Using these three methods and integrating the different results allowed us to detect a broader range of carbon compounds from the sediment samples. However, the results may be conflicting with the geochemical signatures found by the other two methods. For example, a bacterial anomaly in a sample may correspond to a geochemical background signature. This situation has been interpreted to occur in areas with intense seepage where blooms of bacterial populations consume most of the volatile compounds resulting in a bacterial anomaly and geochemical background signature. In addition, we interpreted a geochemical anomaly in the heavy carbon number range to correspond to a residue when volatiles were not detected using the other two methods. The confidence in interpretation the origin of the hydrocarbons can be enhanced when integrating the results with high-resolution seismic data and other geophysical data. In conclusion, this case study supports the use of different analytical methods to understand the bio-geochemical processes controlling the composition of the seeping fluids during migration, but also to more confidently identify thermogenic hydrocarbons from leaking charged structures.