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Overburden fluid flow features integrated in basin analysis

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Once detected and interpreted fluid flow features may represent a strong tool in the analysis of hydrocarbon plumbing systems. Several case studies are here given to exemplify some of the information that may gained from the study of fluid flow features.

In the eastern North Sea two sets of highly elongated pockmarks were discovered. The first set of 33 mid-Oligocene pockmarks have a pronounced orientation of 100-105°, while the second set consisting of 646 late-Miocene pockmarks have an orientation of 140-160°. The analysis of the pockmarks and their characteristic geometry led to conclusions concerning the direction, erosive power and development of contour parallel currents in the eastern part of the central North Sea.
Another Miocene fluid flow feature from the eastern North Sea is represented by a large asymmetric mound structure interpreted as a giant sand volcano extruded >1km upwards from the underlying sand-rich Siri Canyon reservoir. Thermogenic fluids are considered to be the main agent in the formation of the sand volcano and the elongated pockmarks and the two structures together suggest that the middle Miocene was a time of widespread and intense fluid expulsion resulting in the development of sediment remobilization structures and extensive pockmark formation.

Case studies from the Lower Congo Basin reveals numerous fluid flow features including a new type of pockmark association, consisting of up to 8 stacked paleopockmarks occurring within the depocentres of polygonally-faulted Plio-Pleistocene sediments. The majority of the stacked pockmarks initiated synchronously in the late Pliocene with a subordinate initiation phase in the mid Pliocene. The initiations appear to coincide with sea-level falls. The primary agents in pockmark formation are interpreted to be pore water expelled during early stage compaction together with biogenic methane and it is speculated that biogenic methane accumulated within and below a gas hydrate cap, which was repeatedly breached, forming pockmarks at discrete horizons separated by intervals of draping sedimentation. The stacked paleopockmarks are completely surrounded by polygonal faults and occur within polygonal fault cells. This demonstrates that early-stage compaction, dewatering of the Pliocene sediments, and pockmark formation occurred prior to polygonal faulting.
Other fluid flow evidence from the Lower Congo Basin includes present day seabed pockmarks clustered above salt structures, Miocene pockmark fields and high-amplitude pipes, bottom-simulating reflections (BSRs) and free gas zones and numerous low-amplitude chimneys originating from the deeper section. Together this wide range of fluid flow features has led to a combined interpretation of the evolution of fluid flow regime within an overburden salt mini-basin plumbing system from the Miocene to the present day. The Miocene fluid-flow regime is interpreted to be dominated by thermogenic fluids supplied via carrier beds and leaking vertically above structural highs leading to the formation of the pipes and the pockmark fields. The Pliocene-Pleistocene fluid-flow regime is interpreted to be dominated by short-distance vertical fluid migration and expulsion related to early stage diagenetic processes involving biogenic methane and pore water leading to the formation of the stacked pockmarks. The present-day fluid-flow regime is interpreted to be dominated by thermogenic fluids primarily controlled by kilometer-scale salt-flank-controlled migration leading to the formation of seabed pockmarks.

The case studies presented here emphasize the use of seismically imaged fluid-flow features in hydrocarbon systems analysis. The studies document 1) how fluid flow features may contribute to the understanding of the potential fluid sources in the plumbing systems, and 2) how the distinct geometry and details of fluid flow features may reveal other geological processes active at the time of the generation of the fluid flow features.