THE THERMAL AND MATURATION HISTORY OF TERTIARY ARCTIC BASINS – A 3D INSIGHT INTO THE MACKENZIE BASIN, CANADA

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Due to Plio-Pleistocene surface cooling and deep permafrost formation, Arctic basins in many cases have exceptional temperature histories. Understanding this is not only vital for conventional hydrocarbon exploration but also for studies on sub-permafrost gas hydrates. In most cases basin history is further complicated by tectonic uplift and erosion. A good example of this is the Mackenzie Basin, situated in northwestern Arctic Canada.

Due to extensive hydrocarbon exploration in the area for more than 40 years, a huge amount of subsurface data is available. This allowed us to reconstruct the stratal architecture of the exceptionally thick (up to 10 km) succession of Tertiary sediments. The succession consists of 8 stacked deltaic units (Fish River, Aklak, Taglu, Richards, Kugmallit, Akpak, Mackenzie Bay and Iperk Formations) that formed in response to hinterland uplift and sea level change. The Mackenzie Basin is characterized by complex and changing stress fields. This is due to its position in the transition zone between a compressive setting in the west (Beaufort Foldbelt) and an extensional passive margin setting in the east (Eskimo Lakes Fault Zone). In addition, the area was influenced by pulses of uplift in the Brooks Range to the southwest. Four main events of uplift and erosion in the Mid and Late Eocene, Late Oligocene and Late Miocene considerably affected the thermal history of the basin. The Late Miocene event resulted in a basin scale unconformity, the sub-Iperk unconformity.

The present contribution seeks to unravel the influences using 3D basin modelling. The model is calibrated by well temperature and vitrinite reflectance data down to the maximum depth of drilling of 4-5 km and allows us to reconstruct the thermal history beyond this depth. Model predictions and well temperature data indicate low present day gradients of 2 to 2,2°C/100 m. Vitrinite reflectance data indicate low maturities (<0,5% Ro) of sediments at depths shallower than 2500 m in the onshore area and shallower than 3000–4000 m offshore and thus also low temperature gradients during the past. Maturity increases to the southwest of the basin where uplift of Eocene sediments of more than 2000 m occurred. Low maturity thus is not only a consequence of low temperature gradients but also of uplift which, in the case of the Late Miocene event inhibited further maturation in the largest part of the basin since due to fast loading with Pliocene sediments, surface cooling and permafrost formation the process of re-equilibration was retarded. This may be a common feature in many arctic basins and has to be considered if hydrocarbon generation potential and composition of sediments are studied.