Beyond Conventional Petroleum Systems Modelling: Thermogenic and Biogenic Hydrocarbon Emissions through Geologic Time

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Petroleum systems modelling is a powerful tool when it comes to the assessment of the generation, migration and accumulation of hydrocarbons, but also allows to study the hydrocarbon losses from sedimentary basins and the evolution of this process through time. This characteristic may allow us to contribute to the understanding of climate history, considering the strong greenhouse potential of methane, one of the main hydrocarbons generated during organic matter maturation. Here we present the analysis and quantification of hydrocarbon leakage from two important sedimentary Basins in Canada, the Western Canada Basin and the Mackenzie Basin.

The Western Canada Basin is characterized by immense quantities of in-place heavy oil and tar. Hydrocarbon accumulation and leakage was addressed using a 3D basin model of limited extent described by Higley et al. (2009, AAPG Bulletin, v. 93, p. 203-230). The emission of thermogenic gas from the basin began at 65 Ma and continues to the present, maximizing during the onset of uplift and erosion (58 Ma) and the subsequent 20 Ma. Biogenic methane generation was estimated using biodegradation rates reported by Larter et al. (2003, Organic Geochemistry, v. 34, p. 601-613) and an assumed average degree of biodegradation of 50%. Values calculated range from 10^{17} to 10^{18} grams of methane produced during 58 million years of biodegradation. Quantities of total (thermogenic + biogenic) methane emitted by the basin at 55 Ma are in the order of 10^{16} g, which is not enough to invoke a climate effect. However, the values here presented are only minimum estimates, a 3D model of the entire basin is currently being developed, aiming at a better representation of the petroleum system and better emission estimates.

The Mackenzie Basin consists of a Tertiary deltaic depositional sequence overlying Mesozoic sediments. A previous model developed by Kroeger et al. (2009, AAPG Bulletin, v. 93, p. 1209-1234), was used for the analysis of gas leakage process. Emissions at the top of the sequence started around 40 Ma, reaching maximal values during the late Eocene and Oligocene. This basin could have released around 10^{15} g of thermogenic methane during its evolution. Current leakage is hindered by permafrost and abundant gas hydrates requiring an improvement of the temporal resolution of the model, which is in progress. Field work in the area is planned in order to study the rates and composition of the gas being released.