Isotopic Characterization of Natural Gas Seeps Identified in Peel Plateau, Yukon Territory, Canada

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Peel Plateau is a little explored potential petroleum region in Canada's northwest. Oil and gas exploration drilling during the 1960s and 1970s identified six minor gas occurrences in the Upper Paleozoic succession. New field work identified anomalous, circular, unfrozen openings in ice at the eastern structural front of the Richardson Mountains. A sample was collected from along this front on the Trail River (66°28', 135°08.3'), where gas bubbles were not obvious, but where the water is dark grey and has a strong sulfurous odour. This gas sample contains methane with $\delta^{13}C_{CH4}$ values of -42.8 ‰ and carbon dioxide with a carbon isotopic composition of -14.9 ‰. A gas sample collected from Turner Lake (66°10.3', 134°18.5') contains methane with a $\delta^{13}C_{CH4}$ value of -35.2 ‰ and carbon dioxide with a $\delta^{13}C_{CO2}$ value of -31.7 ‰. The sulphurous smell on Trail River suggests that H_2S may have been present in that sample, but that it could have been oxidized during its migration through the meteoric surface waters into which the gas is seeping. The carbon isotopic composition of the Trail River sample is similar to that reported by others for unaltered thermogenic gases from the Lower Cretaceous Mannville Group in southern parts of the Western Canadian Sedimentary Basin (WCSB), however it is inferred unlikely that the Trail River gas originated in the Mesozoic succession. The possible occurrence of H_2S is consistent with both an "overmature" thermogenic origin for the gas and its subsequent thermochemical sulphate reduction in the presence of sulphate-bearing Paleozoic strata.

Thermochemical sulphate reduction is commonly observed elsewhere in the southern WCSB where gases are hosted in or have migrated through the Paleozoic succession. The very low $\delta^{13}C$ value of carbon dioxide and the high $\delta^{13}C$ value of methane of the Turner Lake gas sample suggest that it has been altered significantly by microbial oxidation. Either the Turner Lake sample had origins like that of the Trail River sample and was subsequently moderately microbially degraded; or, it had a different, potentially even biogenic origin, and it was more extremely biodegraded. The results indicate at least one effective petroleum system is present in the Peel Plateau, probably with a source in the Paleozoic succession. The association of thermogenic petroleum seeps with structural features elsewhere in the WCSB has resulted in major petroleum discoveries, such as the Turner Valley and Norman Wells fields.