Practical Aspects of Natural Gas Analysis by Stable Carbon Isotope Mass Spectrometry

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As Australia embraces a potential energy transfer from oil to natural gas, there are renewed efforts to understand the controls on natural gas formation and preservation. Stable carbon isotope composition of individual C_1 to C_5 gaseous hydrocarbons and of carbon dioxide currently are the primary basis for interpretations on Australian natural gases [1]. Increasingly, this isotope data is obtained using methods based on continuous flow gas chromatography-combustion-isotope ratio mass spectrometry (GC-C-IRMS).

This paper summarises the experience gained at Geoscience Australia and the challenges faced in analysing gases at non-equilibrium pressures, concentration techniques for trace components and interfacing mass spectrometry with high temperature pyrolysis techniques. These three aspects are expanded on below:

- Natural gases received by the Commonwealth under the Petroleum Submerged Lands Act (PSLA) 1967 (as amended) and through core program research are at varying pressures and not necessarily representative of reservoir conditions. It has been shown that the stable carbon isotopic composition is relatively insensitive to large pressure differentials of over two orders of magnitude (1 to 200 atmospheres), whereas molecular composition shows much greater sensitivities.
- Dry gas (>97% methane) can result from a variety of processes, by addition of biogenic methane, by generation at high subsurface temperatures where liquid hydrocarbons are unstable or by in-reservoir biodegradation. The ability to isotopically analyse the trace wet gas components is crucial in identifying these various origins. As well, the carbon isotopic composition of residual CO_2 is critical.
- Direct carbon isotopic analysis of evolved gases from temperature programmed open-system pyrolysis (Py-GC-C-IRMS) of the source organic matter can be used to follow the evolution of the carbon isotopic signature through the process of petroleum generation. Initially generated methane (immature) from low temperature pyrolysis is enriched in ^{13}C and could be mistaken for high temperature methane (overmature) with similar isotopic composition. On the other hand, methane associated with oil generation, within the intermediate temperature range that defines the 'oil window' (mature) is further depleted in ^{13}C. In combination with the carbon isotopic composition of the wet gas components (C_2-C_5), the immature, mature and overmature zones are readily distinguished

Thus, techniques developed for and results obtained from GC-C-IRMS and Py-GC-C-IRMS has led to an improved understanding of the source, maturity and preservation history of Australia's natural gases in the sedimentary environment.

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