

EFFECT OF SOURCE, MATURITY AND BIODEGRADATION ON THE D/H RATIO OF AUSTRALIAN NATURAL GAS

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Compound specific isotope analysis (CSIA) of stable carbon isotopes for individual C₁ to C₅ gaseous hydrocarbons has been routinely used for over two decades to determine the origin of natural gas (James, 1983, 1990; Schoell, 1983; Boreham et al., 2001). Here we report gas–gas correlations based on the more recent CSIA application of the hydrogen isotopic composition (D/H ratio) of Australian natural gas (Boreham 2004). The influence of source, maturity and in-reservoir alteration (biodegradation) on the C₁ to C₅ gaseous hydrocarbons is documented and, in combination with complementary carbon isotope data, provides a powerful tool for the study of the origin and correlation of the natural gas.

Source influence in natural gases from Australian sedimentary basins shows a wide range in hydrogen isotopes with $\Delta D \sim 160$ ‰ for both methane (δD -290 to -135 ‰) and *iso*-butane (δD -255 to -94 ‰). On the other hand, the carbon isotopic range is an order of magnitude less (Boreham et al., 2001). The source rock ages of Australian natural gases studied herein include the latest Proterozoic in the Amadeus Basin and most of the Phanerozoic from Ordovician (Amadeus Basin) to Early Eocene (Bass Basin). Gases generated from older marine source rocks are most enriched in D whereas gases sourced from younger terrestrial coals are amongst the most depleted in D. On the other hand, for carbon the marine-sourced gases are the most depleted in the heavier isotope (¹³C; Boreham et al., 2001).

Maturity attenuates the isotopic signature of natural gases for methane and results in carbon isotopic variations approaching those of source effects (Boreham et al., 2001). A Cooper Basin maturation sequence from mature oil-associated wet gas to highly overmature dry gas shows ΔD enrichments of ~ 50 ‰ for methane (δD -162 to -116 ‰), with smaller isotopic enrichments observed for the wet gas components. Overall, maturity has a much lower δD variation than that associated with source and biodegradation effects.

Biodegradation of natural gas produces a drier gas, due to the addition of biogenic methane and selective removal of wet gas components in the order propane > *n*-butane \sim *n*-pentane > *i*-pentane > ethane \geq *i*-butane (Boreham et al., 2001). Addition of biogenic methane to natural gases from the Carnarvon Basin results in little change in $\delta D_{\text{methane}}$, unlike the large depletion in ¹³C_{methane} (Figure 1). Almost complete biodegradation of the wet gas components

leads to δD enrichments of up to 225 ‰ (Figure 1); slightly larger than the ΔD source effects. The strong positive correlation between hydrogen and carbon isotopes for the individual wet gas components implies a kinetic control on the isotopic composition, which is consistent with a biological-mediated process.

Examples will be given from the across Australia (e.g. Otway Basin and the North West Shelf) where the hydrogen isotopic composition of natural gas offers the only conclusive means of resolving multiple petroleum systems.

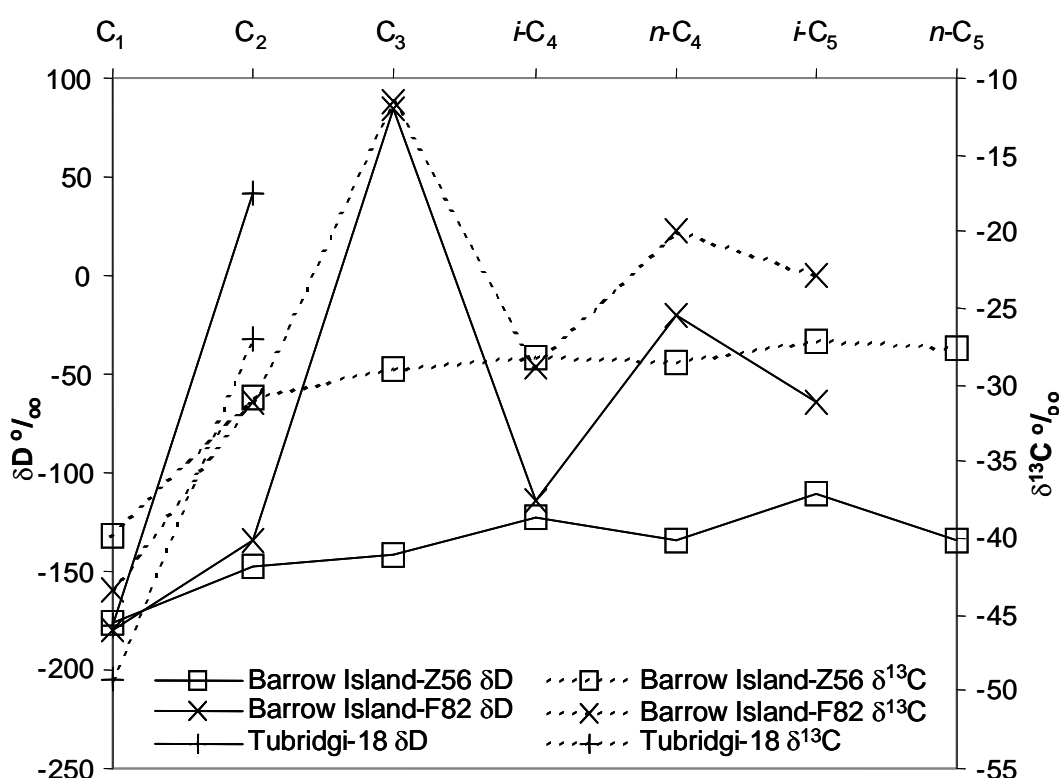


Figure 1. Hydrogen and carbon isotopic composition of individual gaseous hydrocarbons from a biodegradation sequence from the Carnarvon Basin, Western Australia. The gases have the same Late Jurassic mixed marine-terrestrial source.

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