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Assessing the hydraulic connection between fresh water aquifers and unconventional gas production using methane and stable isotopes

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Unconventional gas developments pose a risk to groundwater quality and quantity in adjacent or overlying aquifers. To manage these risks there is a need to measure the background concentration of indicator groundwater chemicals and to map pathways of hydraulic connectivity between aquifers. This study presents methane (CH_4) concentration and isotopic composition, dissolved organic carbon concentration ([DOC]) and tritium (3_H) activity data from an area of expanding coal seam gas (CSG) exploration and production (Condamine Catchment, south-east Queensland, Australia).

The target formation for gas production within the Condamine Catchment is the Walloon Coal Measures (WCM). This is a 700 m thick, low-rank CSG resource, which consists of numerous thin discontinuous lenses of coal separated by very fine-to medium-grained sandstone, siltstone, and mudstone, with minor calcareous sandstone, impure limestone and ironstone. The thickness of the coal makes up less than 10% of the total thickness of the unit. The WCM are overlain by sandstone formations, which form part of the Great Artesian Basin (GAB). The Condamine Alluvium fills a paleo-valley carved through the above formations.

A combination of groundwater and degassing air samples were collected from irrigation bores and government groundwater monitoring boreholes. Degassing air samples were collected using an SKC 222-2301 air pump, which pumped the gas into 3 L Tedlar bags. The groundwater was analysed for 3_H and [DOC].

A mobile CH_4 survey was undertaken to continuously sample air in and around areas of agricultural and unconventional gas production. The isotopic signature of gas from the WCM was determined by sampling gas that was off-gassing from a co-produced water holding pond as it was the largest emission that could be directly linked to the WCM. This was used to determine the source signature of the CH_4 from the WCM.

We used Keeling plots to identify the source signature of the gas sampled. For the borehole samples these plots assume that there are only two sources of CH_4, each with a unique isotopic signature. When the two sources mix in varying proportions they will plot along a straight line in the Keeling plot. Geometric mean displacement was used to fit a regression line and determine the intercept value.

Within the Keeling plot, samples clustered according to their 3_H and [DOC] values. One cluster is associated with near surface biological processes, while the other cluster can be attributed to gas sourced from the WCM. This indicates that in places there is hydraulic connectivity between the WCM and the overlying Condamine Alluvium.

The results from this case study demonstrate that measuring 3_H activity, [DOC] and CH_4 concentrations in combination with CH_4 isotopic analysis can provide an early indicator of hydraulic connectivity in areas of expanding unconventional gas development.