Microbial and hydrogeological controls on the origin and evolution of coal seam gases and production waters of the Surat Basin, Australia

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Until recently, the Walloon coal measures and its coalbed methane reserves in the Surat Basin had been poorly studied and little data was available in the public domain. Detailed geochemical studies of Walloon Subgroup waters and associated coal bed gases are essential for understanding gas generation, groundwater evolution, recharge, flow paths and general aquifer behaviour of the Surat Basin, part of the Great Artesian Basin (GAB).

Co-produced water and gas samples were collected from 52 methane production wells spanning the 3 main gas producing areas of the Surat Basin (Roma, Undulla Nose, Kogan Nose) and subjected to a comprehensive suite of geochemical analyses (cations, anions, δ^2H, $\delta^{18}O$, $\delta^{13}C_{DIC}$, $\delta^{13}C\text{-}CH_4$, $\delta^2H\text{-}CH_4$, $\delta^{13}C\text{-}CO_2$,^{14}C, nutrients, dissolved and total metals). This was the first geochemical study to collect co-produced water and gas from the 3 gas production regions as most previous work concentrated on the gas fairway on the Undulla Nose.

Distinct spatial trends were found between each production locale for both water and gas data. Water compositions were distinct, reflecting the different lithology of adjacent recharge zones, differing fluid-rock interactions, likely different microbial consortia, and the extent of methanogenesis. In the present gas fairway, the Undulla Nose waters had the highest median alkalinity (1841 mg/L) and were found to have a Na^+ excess (1050 mg/L) and a lower than expected median $\delta^{13}C_{DIC}$ (14.0‰). Co-mingled, methane carbon isotope values ($\delta^{13}C$ -57‰ to -44.5‰) from both the upper (Juandah) and lower (Taroom) coal measures plot within the mixed 'thermogenic/microbial' genetic field. By contrast, deuterium isotopic difference [$\Delta D(H_2O\text{-}CH_4)$] values and cross-plots of $\delta^2H\text{-}H_2O$ and $\delta^{18}O\text{-}H_2O$ suggest that microbially mediated CO_2 reduction is the dominant methane generation process in situ. At a given depth, the Undulla Nose waters in the east are more depleted in ^2H and ^{18}O than elsewhere in the Surat Basin, which may suggest these samples have been more heavily impacted by water-rock-microbial reactions.