Gas sources in the Springbok Sandstone and GAB aquifers

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Introduction

- The Surat Basin hosts various industries that extract groundwater including for coal seam gas (CSG), feedlots, town water supply and agriculture. Gas has been observed in some bores drawing groundwater from different aquifers across the basin. While methane can occur naturally in aquifers, biogenic CSG has been extracted from the Walloon Coal Measures, raising questions on the *sources* of gas in overlying aquifers.
- In our previous study, we found the majority of bores we sampled in Great Artesian Basin (GAB) aquifers overlying the Walloon Coal Measures had gas that had been generated *in situ* in the aquifer by microbes (primary microbial CO_2 reduction and acetate fermentation) (Figure 1, Figure 2) (Pearce et al., 2022), *i.e. not leakage*
- However, A gassy Springbok Sandstone bore had gas signatures that overlapped CSG (secondary microbial CO_2 reduction). Other signatures such as strontium isotopes of groundwaters also overlapped.
- This study focusses on gas sources and groundwater connectivity in the Springbok Sandstone.

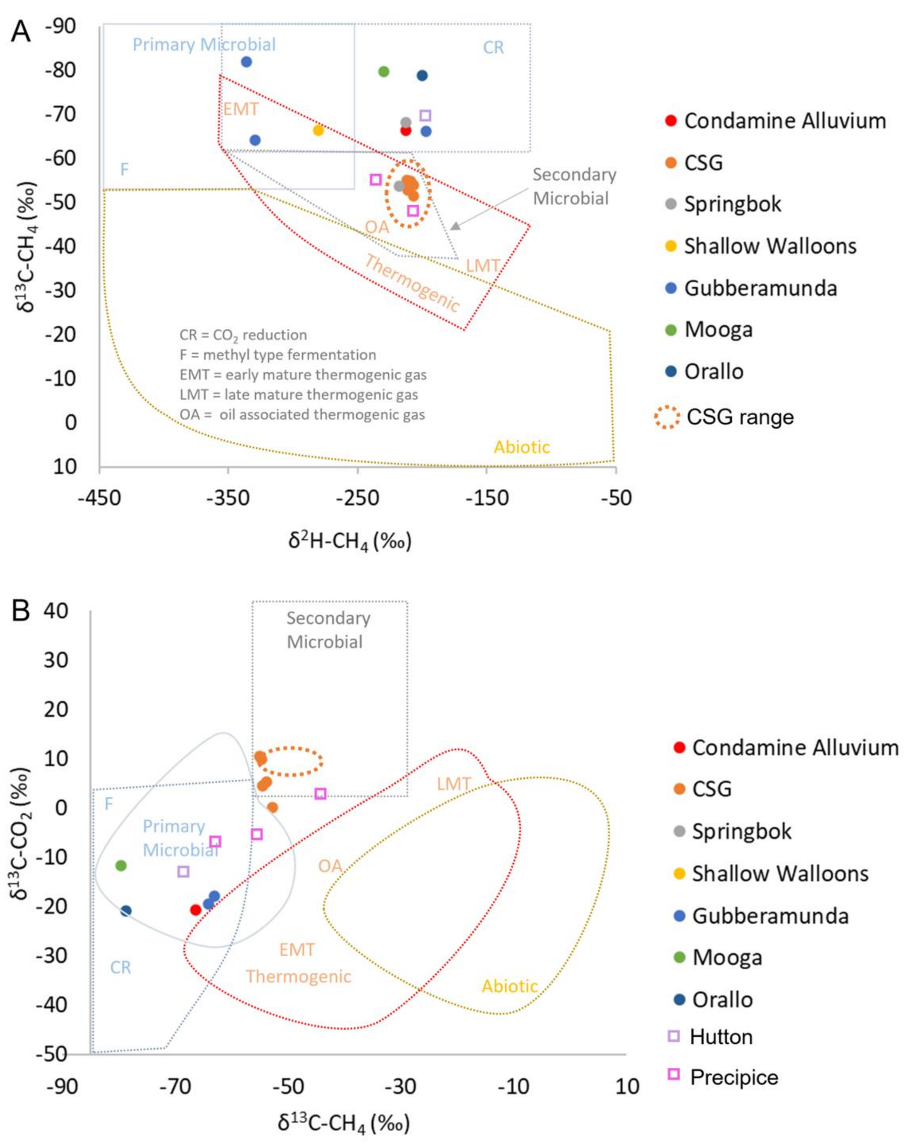


Figure 1: Stable isotopes of methane and CO_2 in GAB aquifer bore samples and CSG (Pearce et al., 2022).

Methods

- Groundwater and dissolved gas samples collected from bores mainly in the Chinchilla – Dalby region.
- Methane concentrations measured at ALS from vial containers, and Stratum Reservoir from Isoflask closed sample containers.
- Stable isotopes of methane, CO_2, water, dissolved inorganic carbon (DIC), SO_4 measured at The University of Queensland's Stable Isotope Geochemistry Laboratory (UQ SIGL).
- Waters analysed for cations, anions, alkalinity, dissolved organic carbon, metals (ALS and UQ EGL lab).
- Sr isotopes of groundwaters (UQ RIF lab).
- ^{14}C, ^{36}Cl, tritium tracers (at ANU and ANSTO).

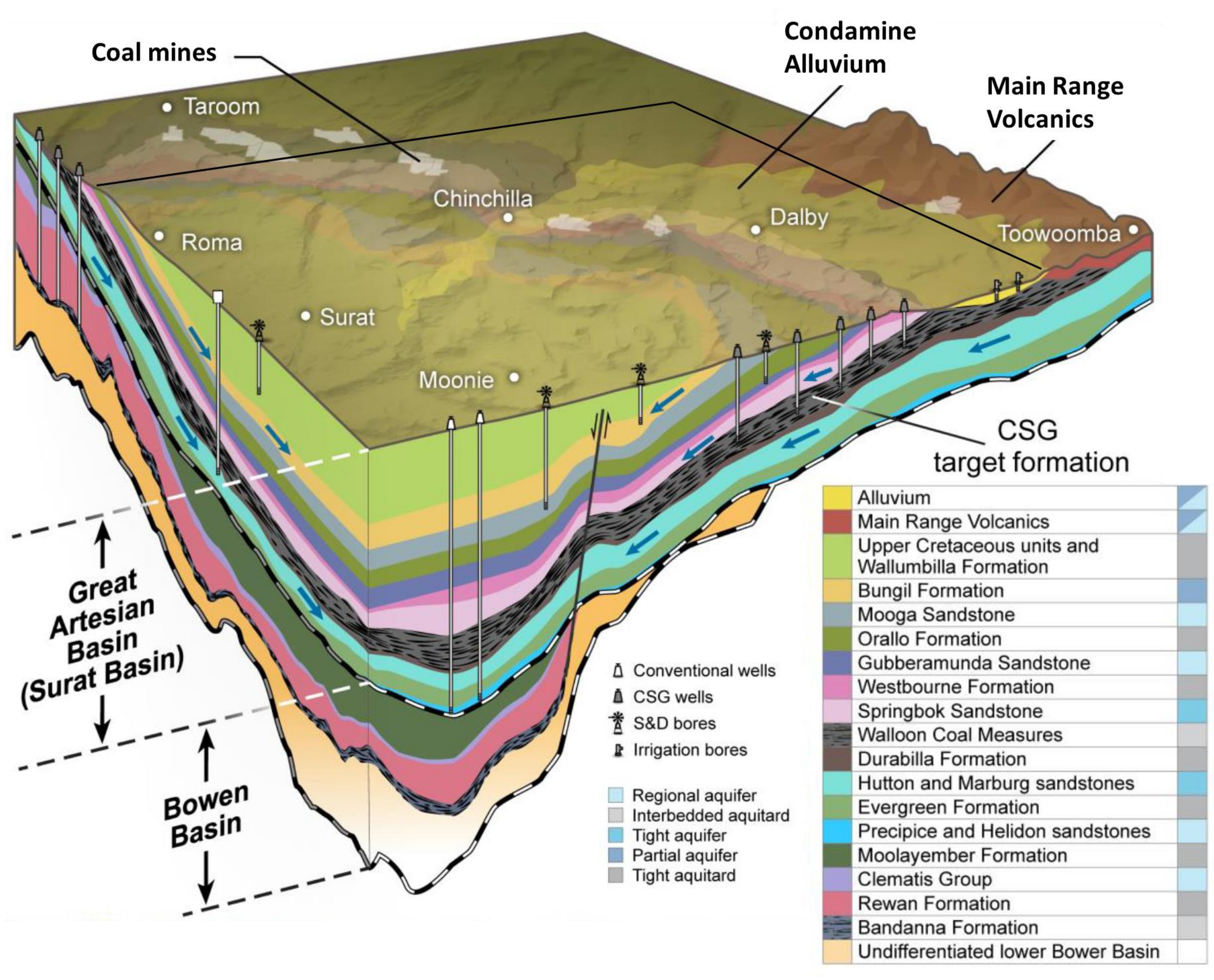
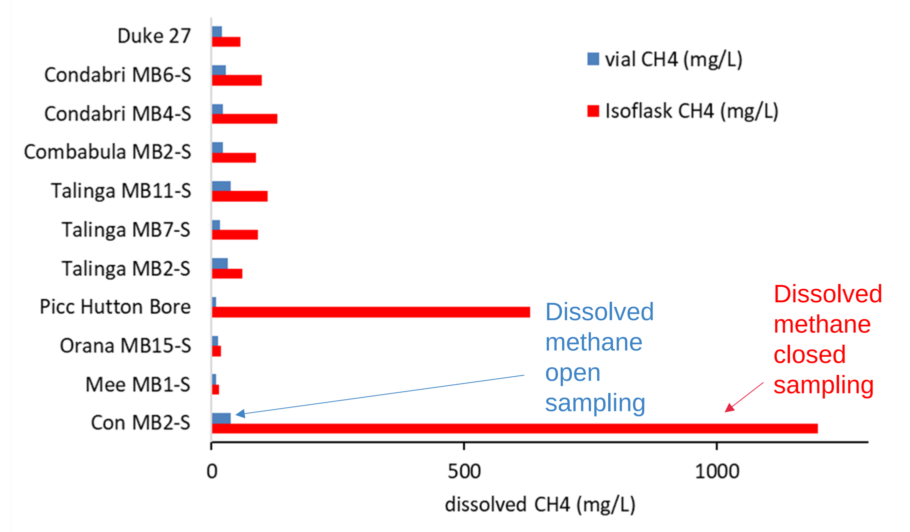


Figure 2: Aquifers of the GAB in the Surat Basin. The Springbok Ss is the main focus of this study, with bores also sampled in the overlying Gubberamunda, underlying Walloon Coal Measures, and others (modified after OGIA 2021).



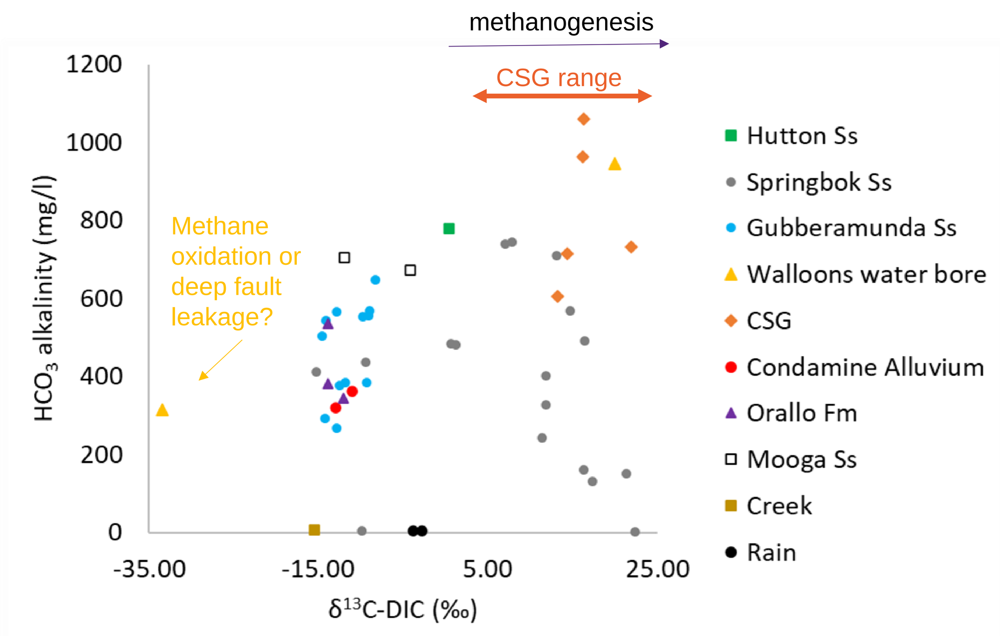


Figure 3: Top: Examples of dissolved methane concentrations in Springbok bores sampled via closed method (isoflask in red), and open method (vials in blue). Below, alkalinity vs $\delta^{13}C$-DIC, positive values can indicate strong microbial methane generation (methanogenesis). Orange arrow indicates Surat CSG $\delta^{13}C$-DIC range reported previously (Baublys et al., 2015; Owen 2016).

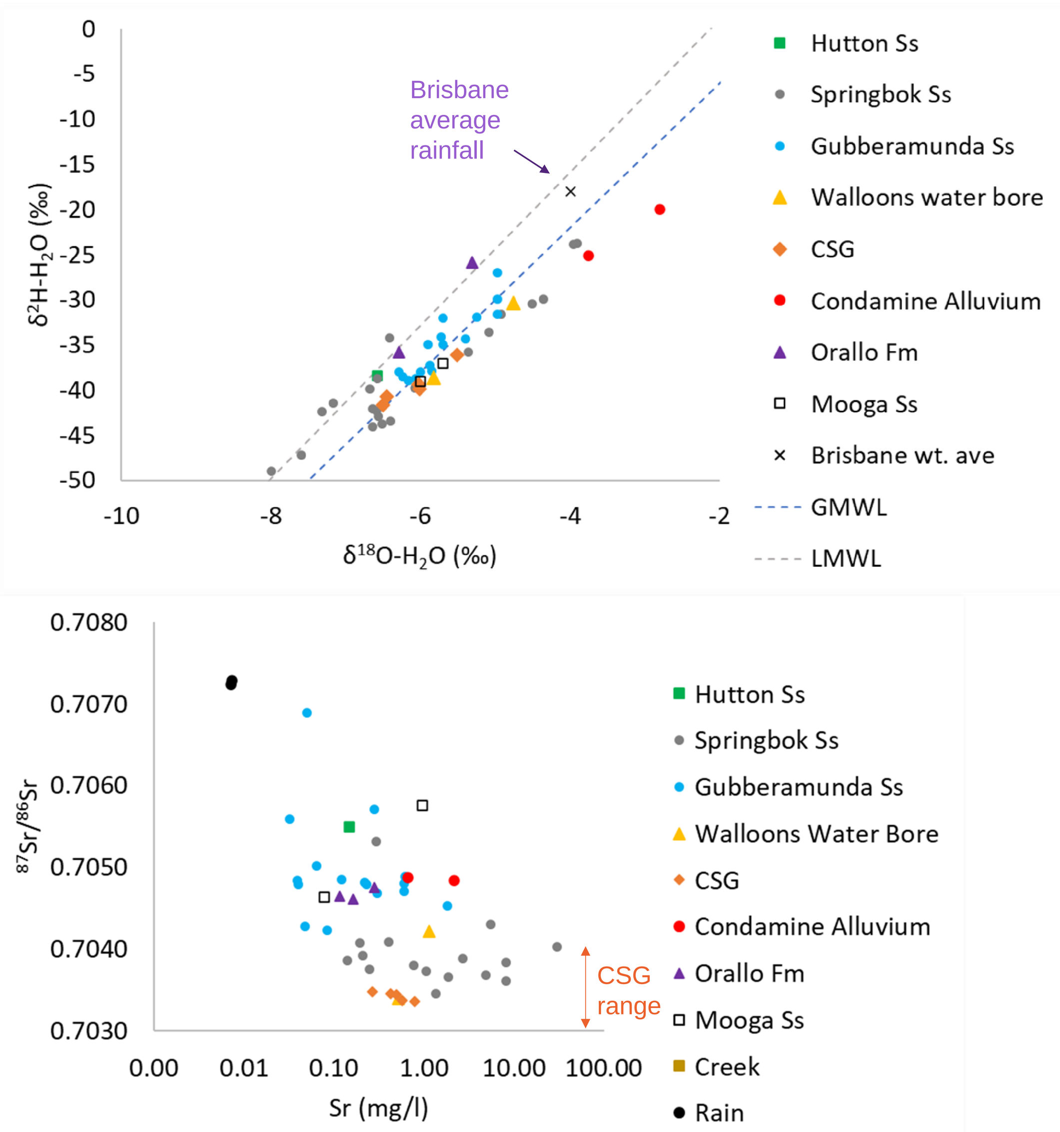
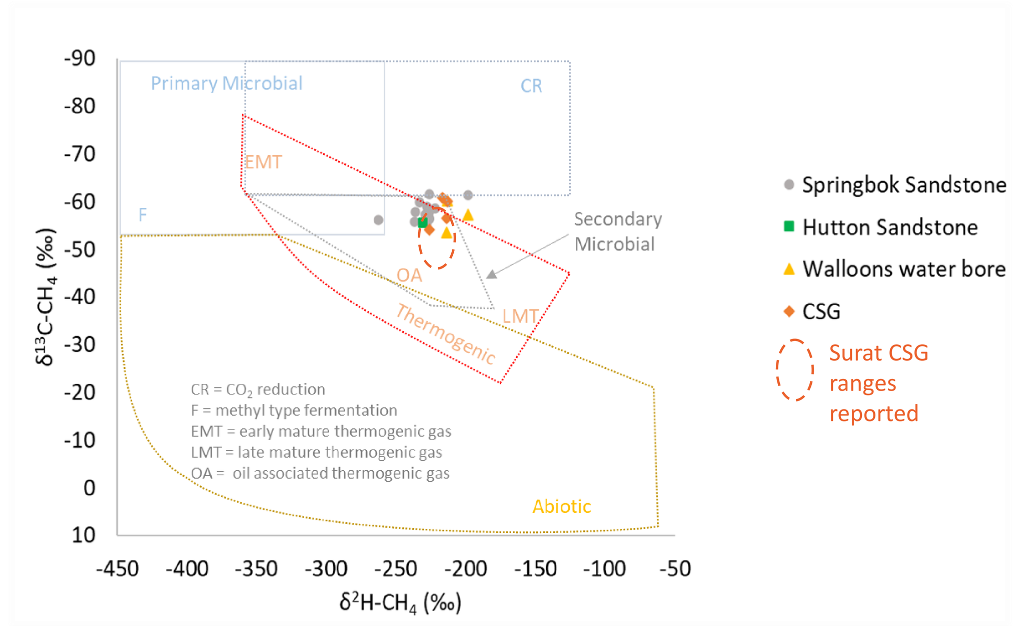


Figure 5: Top: Stable isotopes of groundwaters and production waters plot along the local and global meteoric water lines (GMWL). Groundwaters are more depleted than Brisbane average rainfall. Below, the majority of Springbok Sandstone groundwater strontium isotope values overlap the CSG production water range (Surat CSG range orange arrow, Baublys et al., 2019, Pearce et al., 2022). The other aquifers have more radiogenic values. Rain = local raintanks.

Figure 7: A monitoring bore being pumped, and sampling dissolved gas with a closed sampling method.



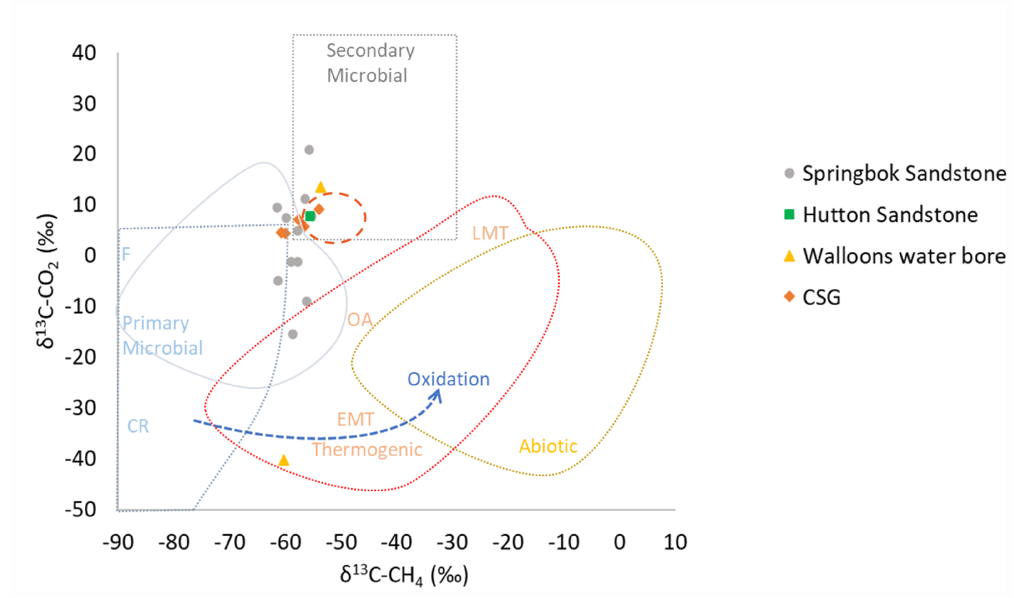


Figure 4: Stable isotopes of gases sampled from the Springbok Sandstone and other bores. A group of bores overlap/borderline with CSG signatures, a second group of bores especially with depleted (negative) $\delta^{13}C$-CO_2 likely have gas generated in situ. One Walloons water bore either has methane oxidation is occurring, or migration of gas from a deeper source (fault?). Surat CSG range from (Baublys et al., 2015;Owen et al., 2015; Pearce et al., 2022).

Results

- Majority Springbok groundwaters analysed so far contained high concentrations of methane and elevated $\delta^{13}C$-DIC with methanogenesis (microbial methane generation) occurring.
- Stable isotopes of gases showed two populations: a) methane from secondary microbial CO_2 reduction (overlapping/borderline with CSG signatures), or b) from primary microbial CO_2 reduction, bugs producing methane in situ in the aquifer.
- Springbok waters overlap Surat CSG production water ranges with low, less-radiogenic $^{87}Sr/^{86}Sr$ than Gubberamunda Sandstone etc.
- Majority of Springbok groundwaters analysed so far have long residence times (old waters) mixing with modern water (tritium present) – surprising….

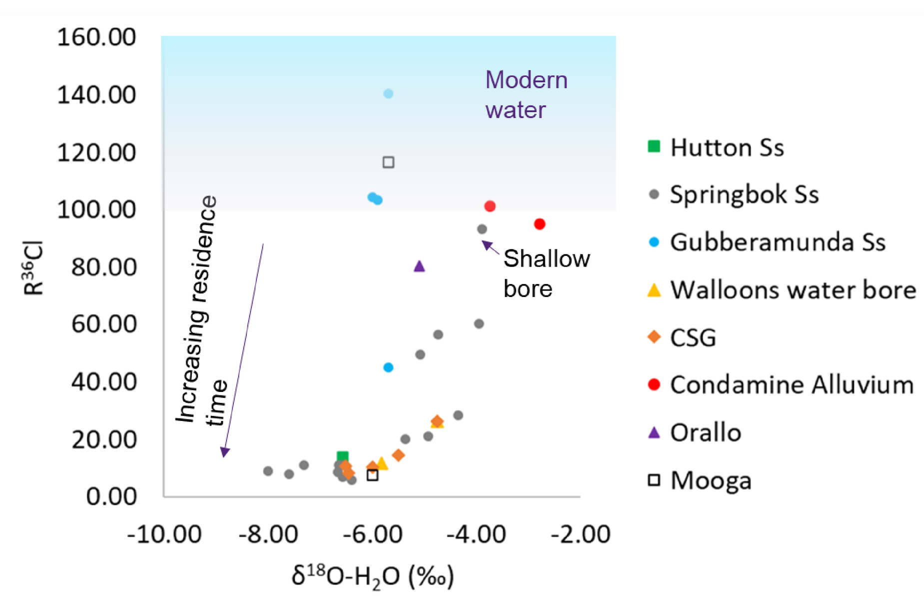


Figure 6: $R^{36}Cl$ vs $\delta^{18}O$-H_2O. Lower $R^{36}Cl$ generally indicate longer residence time waters. More depleted (negative) water isotopes can indicate recharge during older colder climate or recharge from large monsoonal events travelling across land from northern Australia.

Conclusions

- The Springbok bores with gas isotope signatures overlapping CSG may reflect a) connectivity to the reservoir or b) methane generation in the Springbok where coal is present via the same processes as the CSG reservoir.
- Overlapping $^{87}Sr/^{86}Sr$ may reflect a) groundwater migration or b) that the Springbok Sandstone recharge waters and Sr sourced mineral content are similar to the CSG reservoir.
- A new centre project is characterising $^{87}Sr/^{86}Sr$ sources in Springbok and Walloon Coal Measures core material
- ^{36}Cl indicates long residence time (old) waters but tritium is also present – mixing old groundwaters with modern water!
- Differentiating sources of gas and groundwater connectivity in the Springbok Sandstone bores is more complex / less clear cut than for bores in other aquifers investigated previously.
- Further analysis and interpretation of the data is ongoing.

Suggested Future Work: A regional study of the Condamine Alluvium that contains ~ 8000 water bores is also needed to understand conflicting observations of gas leakage. Multi-isotope studies focussed on Walloons water bores/Hutton Sandstone etc. both host groundwater extraction and landholder bores, and are predicted to be impacted by drawdown. Expansion of these methods to study Bowen Basin or NT regions. The methods presented here are also applicable to understand the origins of gas seeps in soils, and to monitor CO_2 storage and other energy storage sites.

Pearce et al., 2022. Methane in aquifers and alluvium overlying a coal seam gas region: Gas concentrations and isotopic differentiation, Science of the Total Environment https://doi.org/10.1016/j.scitotenv.2022.160639

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