Linking soil gas monitoring to geological hydrogen systems: measurement approaches and best practices

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Understanding geological hydrogen systems requires reliable surface detection methods, yet unlike traditional hydrocarbon and mineral exploration, where decades of empirical data established threshold values, natural hydrogen research lacks established baselines for what constitutes a meaningful anomaly. To use soil gas measurements as an effective tool for characterizing subsurface hydrogen systems, we must understand instrument limitations, background hydrogen values in soil, and what complementary data are needed for reliable interpretation of monitoring datasets.

Current technology constraints present a significant challenge for natural hydrogen soil gas sensing. Field-appropriate commercially available sensors exhibit limited operating ranges, cross-sensitivity to humidity and other gases, baseline drift over time and exposure, and hysteretic dynamics. CSIRO developed Seeptracker, a multi-gas monitoring device measuring hydrogen, methane, carbon monoxide and carbon dioxide, to address these challenges. Here we share findings on the commercially available hydrogen sensing components within Seeptracker and results from deploying this instrument across diverse geological settings worldwide.

Seeptracker utilises multiple commercially available sensors and employs an extensive calibration routine to improve gas measurement accuracy. Its development revealed the challenge of balancing sensing quality, deployment compatibility and cost scaling. Achieving suitable long-term autonomous field deployment requires a clearly defined study scope, a well-characterised sensor package and a robust calibration routine to address the multivariate measurement challenge.

Interpreting multi-gas measurements introduces both opportunities and risks, including false positives. Effective interpretation of soil gas data for understanding subsurface hydrogen production and migration requires integration with complementary datasets. Geological mapping identifying serpentinisation fronts, radiolytic source rocks or fault systems provides essential structural context. Geophysical surveys, particularly magnetotellurics and gravity, can delineate subsurface fluid pathways and potential trap geometries. Geochemical analysis of associated gases, including helium, nitrogen and noble gas isotopes, can enable source discrimination and migration pathway characterisation.

Our Seeptracker deployments across diverse settings suggest that sustained hydrogen concentrations in soil gas serve as an effective indicator of subsurface hydrogen systems, but cannot be used in isolation. Detailed follow-up investigation is essential, particularly to establish spatial coherence, temporal stability and to ensure that measured hydrogen is geological in origin. Continuous monitoring capturing temporal variability, rather than single-point measurements, substantially enhances interpretation confidence.

We present the performance and limitations of current hydrogen sensors within Seeptracker, alongside soil gas monitoring results from sites worldwide. We show in greater detail studies from Australia, where interpretation of soil gas data is constrained by geochemical, geophysical and isotope datasets,

demonstrating how integrated approaches strengthen our understanding of subsurface natural hydrogen systems.

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