Stable isotope fingerprinting of shallow gas in the subsurface and water of the Dutch North Sea for constraining leakage pathways

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The North Sea is home to both natural and anthropogenic sources of methane ebullition. Differentiating between naturally seeping shallow gas and shallow gas leaking from abandoned wells is challenging. Using compound-specific stable isotopes of methane and ethane, and the geochemical composition of gas we could differentiate between gases of different origins. At the Dogger Bank in the Dutch North Sea bubble plume was found at the location of well A15-03 (de Bruin et al., 2025). The isotopic and geochemical composition of gas samples from the bubble plume was compared with that of gas samples collected from mud gas and drill stem tests during drilling of well A15-03, and that of samples from a natural seepage area at the Dogger Bank (B13). The comparison revealed that well A15-03 was leaking from a producing shallow gas interval between 600–700 meters depth. Both shallower intervals and deeper sands were excluded based on their distinct isotopic signatures and lower gas saturation. Natural seepage, characterized by lighter $\delta^{13}C(CH_4)$ values was ruled out as a source due to the heavier isotopic signature of the bubble plume. Additional comparisons with onshore wells revealed similar stratigraphic and isotopic trends, supporting the interpretation of microbial methane origin and helping to exclude alternative sources such as biodegraded oil or radiolytic methane.

In conclusion, stable isotope fingerprinting proves to be a powerful tool in identifying methane sources and constraining leakage pathways. The findings have significant implications for environmental monitoring and regulatory oversight of abandoned wells in offshore hydrocarbon provinces.