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Origin of H_2 and CH_4 gases in the Eastern São Francisco Basin, Brazil

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This multi-year study reveals a series of systems rich in He and H_2 gas, and a complex CH_4 cycle with multiple abiotic and biological sources. Surface gas seeps along rivers are dominated by microbial CH_4 related to near-surface processes in tropical sediments and wetlands. In contrast, samples from gas exploration wellheads have He (up to 1% by vol) and high concentrations of H_2 (up to 25-40% by vol. but consistently between at least 7-11%) for samples measured between 2012 and 2019. Here for the first time an exploration gas well discharging at surface shows evidence of the type of deep cratonic gases typically associated with the deep mines of the Witwatersrand Basin and Canadian Shield[1]. Specifically, some wells show a significant component of abiotic alkanes with high associated concentrations of H_2, higher hydrocarbons, and isotopic and geochemical characteristics associated with abiotic organic synthesis[2]. Noble gas analyses confirm a crustal rather than mantle source. Particularly notable is the elevated $^{21}Ne/^{22}Ne$ end-member identified in at least one gas well, and from other areas of the São Francisco Craton[3], that both show the characteristic elevated neon end-member value first identified in ancient fracture fluids from deep mines in Canada and South Africa[4,5].

Overall, these results demonstrate the H_2-rich gases in the Precambrian to early Paleozoic cratonic rocks of Brazil share important characteristics with the deep gas and ancient fluids first described in the deep mines of the Canadian Shield and Witwatersrand Basin. The exploration gas wells reflect a complex mixture of discharging gas associated with abiotic organic synthesis and H_2 production (likely related to radiolysis and/or serpentinization), and local mixing with what are likely more surficial sources of microbial CH_4.

[1]Sherwood Lollar et al. (2021) GCA 294:295-314. [2]Warr et al. (2021) GCA 294:315-334. [3]Magalhães et al, Goldschmidt Abstract (2021). [4]Lippmann-Pipke et al. (2011) Chem Geo 283:287-296. [5]Holland et al. (2013) Nature 497:357-360.