

Constraining the Source of Natural Hydrogen Gas in the Southern Paraná Basin (Brazil)

Introduction

This study investigates the occurrence of natural hydrogen gas (H₂) within the Paraná Basin, Brazil. H₂ represents a potential clean energy source, with its conversion producing water vapor instead of greenhouse gasses, unlike fossil fuels. While manufactured hydrogen is a way to store energy, natural hydrogen exploitation is a way to produce energy, parallel to oil or natural gas. The pioneer production of natural hydrogen gas started in Mali where a natural hydrogen gas reservoir was found in a groundwater drill (Prinzhofer et al., 2018). Since this discovery in Mali efforts have been made worldwide to find new natural H₂ occurrences. In Brazil, some research was done in order to find a natural hydrogen reservoir, for now, the most promising region for natural hydrogen production is in the southern region of Paraná Basin (Serratt et al., 2022).

The Paraná Basin, encompassing roughly 1.5 million km², is a large Paleozoic-Mesozoic intracratonic basin, the biggest in South America (Milani et al., 2007). The basin is partially overlaid by the Paraná Large Igneous Province (LIP) and intruded by numerous sills and dikes (Milani et al., 2007). The records of hydrogen gas in the basin range from 0.14% to 8.79% H₂, data from formation tests in legacy wells. Just four wells were analysed by H₂ content in a total of more than 120 drilled in Paraná Basin. The highest content was found in well 2-LV-1-RS, all of that in the southern region of Brazil (Rio Grande do Sul and Santa Catarina states). In a basin where reservoir rocks and seals are well known, the understanding of the H₂ source remains the main challenge to change from a conceptual stage to an exploratory stage. This research aims to establish a clear, cheap, and effective approach for evaluating the economic feasibility of H₂ exploration within the southern Paraná Basin.

Theory

The presence of H₂ gas concentrations in the Paraná Basin, as identified in wells 1-TV-2-SC, 1-TV-3-SC, 2-PL-1-SC, and 2-LV-1-RS (Table 1 and Figure 1), suggests a source rock. However, the exact origin remains undetermined. Serratt et al. (2024) list all the possibilities of sources: I) Radiolysis; II) Rock Alteration; III) Mantle or Core leaking; IV) Organic matter maturation. The Serratt et al. (2024) study points out that the most probable source for the Paraná Basin hydrogen system is related to organic matter maturation due to funds being related to non-commercial volumes of natural gas. However, the issue of the source rock remains not solved. The challenge to evolve from a prospection stage to exploration requires understanding hydrogen's natural system sources. This process of understanding could be guided by different scientifically well-established methodologies. Regarding these methodologies, He isotope analysis can point to a mantle source contribution. The basement nature can provide information on mineral alteration source, radiolysis source. Finally, the development of a regional thermal model can establish the maturation of organic matter and the generation potential of these rocks.

Well	Depth(m)	Formation	H2%	He%	CH4%	
1-TV-2-SC	2908-2917	Furnas		3.06	0.83	93.37
1-TV-3-SC	2014-2018	Rio Bonito		2.43	0.13	95.44
2-LV-1-RS	1487.13 - 1520	Teresina		0.86	1.03	97.76
2-LV-1-RS	1487.13 - 1520	Teresina		3.23	X	96.42
2-LV-1-RS	1487.13 - 1520	Teresina		1.5	0.93	97.19
2-LV-1-RS	2209.68 - 2223	Rio Bonito		2.85	0.24	94.71
2-LV-1-RS	2230.89 - 2262	Rio Bonito		4.49	0.3	92.83
2-LV-1-RS	2313.08 - 2334.50	Rio Bonito		8.79	0.31	87.68
2-LV-1-RS	2272.2 - 2277	Rio Bonito		4.06	0.35	92.66
2-PL-01-SC	2078.20 - 2109.30	Rio Bonito		0.14	0.33	98.61
2-PL-01-SC	2110.10 - 2138.90	Grupo Itararé		1.04	0.42	97.48

Table 1. Volume percent of main gases in aforementioned wells. Data source: ANP (Brazilian National Agency of Petroleum, Natural Gas and Biofuels) well reports.

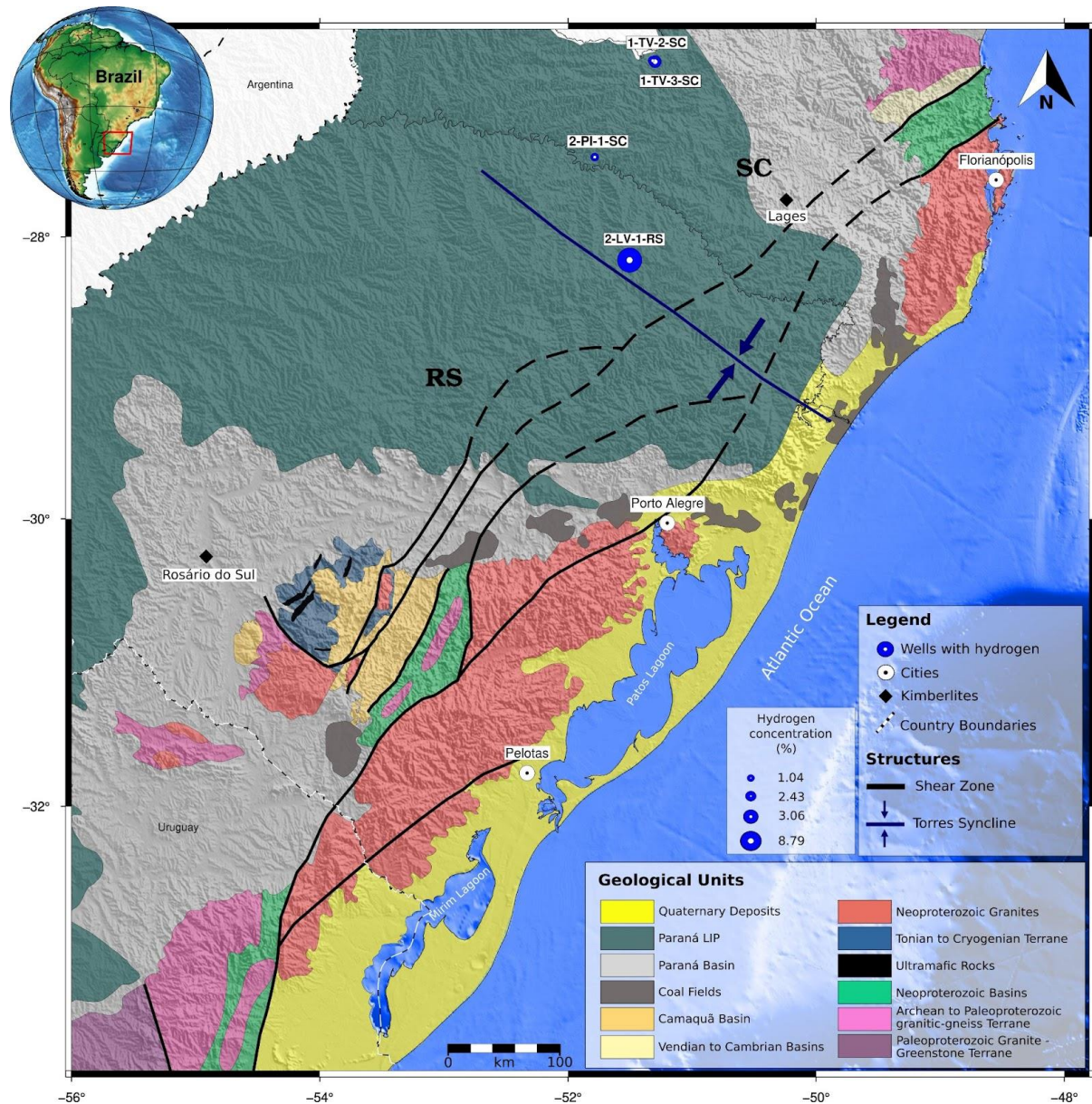


Figure 1 Geological map highlighting the position of the wells with anomalous values of Hydrogen gas.

These studies could partially be carried out with legacy data. Legacy data (wells and seismic data) of the Basin can be used to create a thermal model, and the basement characterization can be studied from the well cores and potential geophysics (Figure 1). However, for He isotopes analysis, acquiring this new data is more challenging and could require drilling a well. We here propose an alternative to reduce the exploratory risks and costs related to drilling a well. This alternative methodology consists of the construction of the framework with legacy data and access free-gasses in groundwater wells. Due to pressure differences, gasses naturally migrate from within the rock towards the lower pressure zone created by a water well. Due to this migration analysis of the free gasses in these water wells near the well 2-LV-1-RS can lead us to find more hydrogen anomalies and sampling He. In this context gas measurement devices can provide a first qualitative analysis that could be complemented by gas sampling and quantitatively analysed in a lab. This methodology could be applied to any basin worldwide and can be a cheaper and more effective approach to locating an exploratory well.

Conclusions

Prior studies have documented the presence of natural H₂ gas in the southern Paraná Basin with reservoir rocks and seals well known. However, to transition from a preliminary exploration (prospection) stage to a more focused exploration phase, a precise understanding of the H₂ source is crucial. This study proposes a depicted methodology for gathering crucial data for pinpointing the source and understanding the geological hydrogen system. Constraining the source is essential for transitioning from a promising hypothesis to the realization of H₂ production in the basin.

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