HELIOS
ARAGÓN

The hydrogen system of Europe's first natural hydrogen project

AAPG Hydrogen 2022 Virtual Technical Symposium

Chris Matchette-Downes

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Chris Atkinson, Chris Matchette-Downes and Sandra Garcia-Curiel

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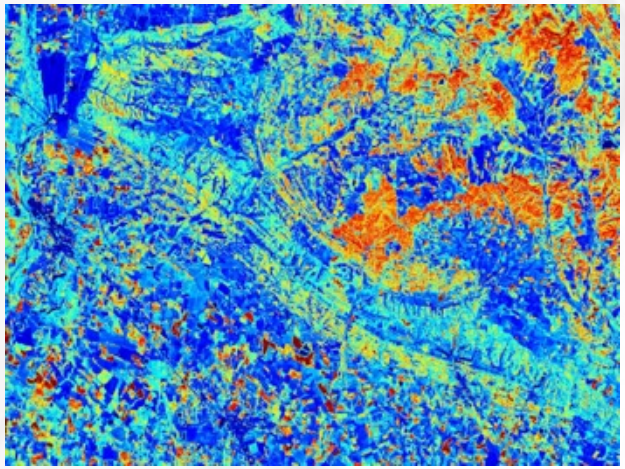
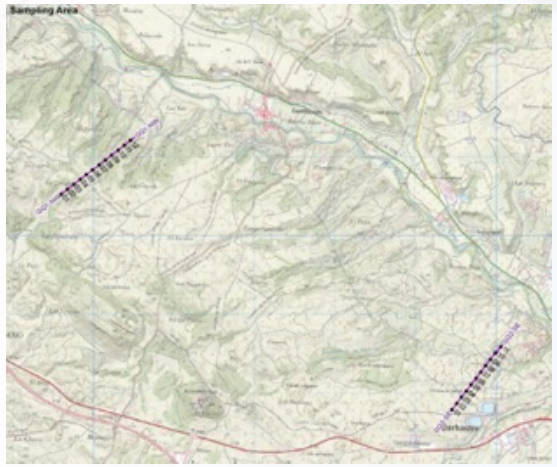
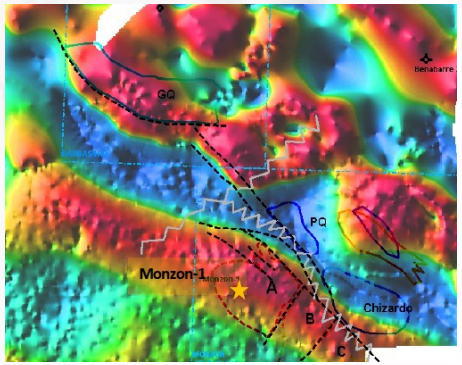






Dossier

L'HYDROGÈNE : ORIGINE, HABITAT ET EXPLORATION

Natural hydrogen in the Monzon-1 well, Ebro basin, northern Spain

Christopher Atkinson[1], Christopher Matchette-Downes and Sandra Garcia-Curiel.

Introduction

Sixty years ago, Spain was amid an energy crisis. Totally reliant upon imported oil and with limited in-country alternatives an aggressive campaign of hydrocarbon exploration drilling was initiated throughout the country. Between 1954 and 1964 the finances of its national oil company were bolstered; state of the art drilling equipment was purchased and together with several international partners multiple wells were drilled. One of the prospective areas chosen for exploration drilling was the Ebro Basin and the associated South Pyrenean foothills located in the northern part of the province of Aragón. It was here on March 7th, 1963, that Empresa Nacional de Petróleos de Aragón ("ENPASA") spudded the Monzón-1 exploration well. The well drilled to a total depth ("TD") of 3715 metres below ground level ("mBGL") and encountered shows of methane in fractured Infra-Liassic carbonates which upon drill-stem testing failed to flow at commercial rates. Consequently, the well was plugged and abandoned as an exploration dry hole. Importantly, the well also encountered shows of hydrogen at two levels. The deeper of the two, within the Triassic Bunter Sandstones, was significant enough to be specifically highlighted in the final well report. In 1963 hydrogen was of no interest but fast forward to today and this "dry hole" in Aragón could be a key component in the largest energy transition the world has ever seen.

Location, geological and structural setting

The Monzón-1 well was drilled just a few kilometres southeast of the town of Monzón in Huesca province, Aragón, Spain (Fig. 1). Geologically, it is located at the juxtaposition of the Southern Pyrenean Thrust Belt and the Ebro Basin, to the south of the Pyrenean Mountains (Fig. 1 and Munoz (1992)). It lies immediately south of a salt-cored «triangular» zone of deformation known as the Barbastro Anticline (Fig. 1). The southernmost thrust sheets of the South Pyrenean deformation belt lie a few kilometres to the northeast of the well along the northern flank of the Barbastro Anticline (Fig. 1). The well penetra-

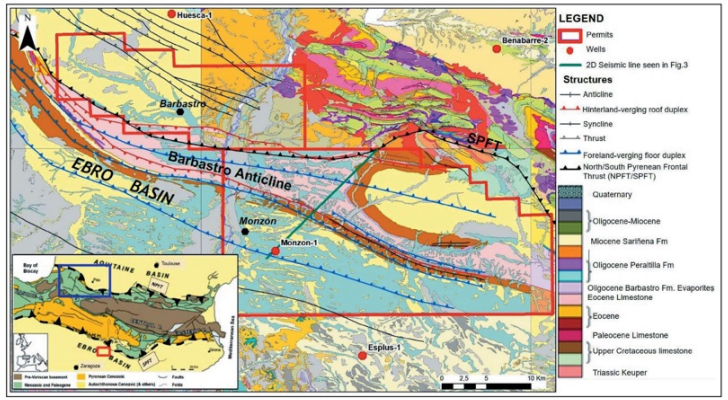


Figure 1. Location and geological setting of Helios Aragon Exploración S.L. permits (red polygon) and the Monzón-1 well. Blue box on insert figure denotes location of area of natural hydrogen emanations studied in the North Pyrenees by Lefeuvre et al., 2021.

1. Helios Aragon Pte Limited, Singapore/Helios Aragón Exploración S.L., Madrid, Spain.

NATURAL HYDROGEN

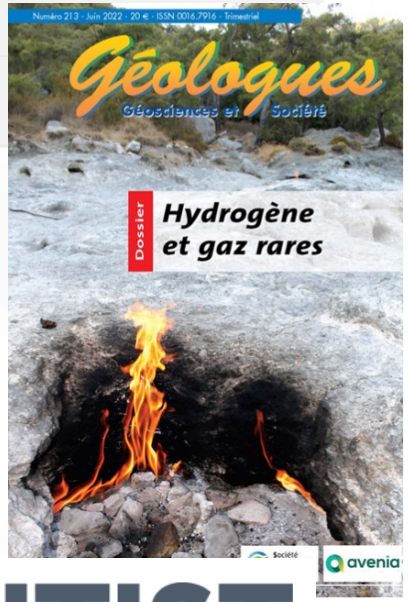
- A natural free molecule accumulation of hydrogen within the Earth, formed by a variety of geological processes
- Increasingly recognized by industry as having commercial scale and the potential to revolutionize the clean energy transition by providing the cheapest source, with no requirement for storage
- Currently being produced at 98% purity from the Bourakebougou field in Mali to supply a local power station
- The next couple of years will see ***first-mover companies secure high-potential acreage positions in areas with proven hydrogen seeps and shows***
- Helios has two 100%-owned evaluation permits (Barbastro and Monzón) in Spain, covering 60,200 hectares, with proven hydrogen and is leveraging geological knowledge from Aragón to pursue opportunities within the EU

ANALYSIS | Will natural hydrogen extracted from the ground be the next global gold rush?

The existence of naturally occuring H2 has been known about, but not well understood, for centuries — but this could be about to change, writes Rystad Energy Hydrogen Research

7 November 2022 11:16 GMT *UPDATED 7 November 2022 11:33 GMT*

By **Rystad Energy Hydrogen Research**



GEOSCIENTIST

The magazine of the Geological Society of London

Natural hydrogen: the new frontier

Geological hydrogen could revolutionise our low-carbon future.

NATURAL HYDROGEN IN ARAGON

- There are a variety processes which produce natural hydrogen, the Helios project in Aragón relies on:
  1) alteration of ultra mafic minerals by water, probably a process of serpentisation or another form of metasomatic alteration of the shallow mantle
  2) migration and subsequent
  3) entrapment in Bunter aged sandstones
  4) sealed by salt rich shales and thick salt

- The combination of a regional and potent source, the Tethys oceanic crust in close proximity to the surface, linked by deep seated faults and thrusts, seismically mapped traps and robust seals have allowed the subsurface accumulation of hydrogen which has been recorded in wells drilled in the 1960's, interpreted from satellite spectral data analysis and ground-truthed in a 2022 surface geochemical survey

- **This perhaps is the first example in Europe of a complete "hydrogen system"**

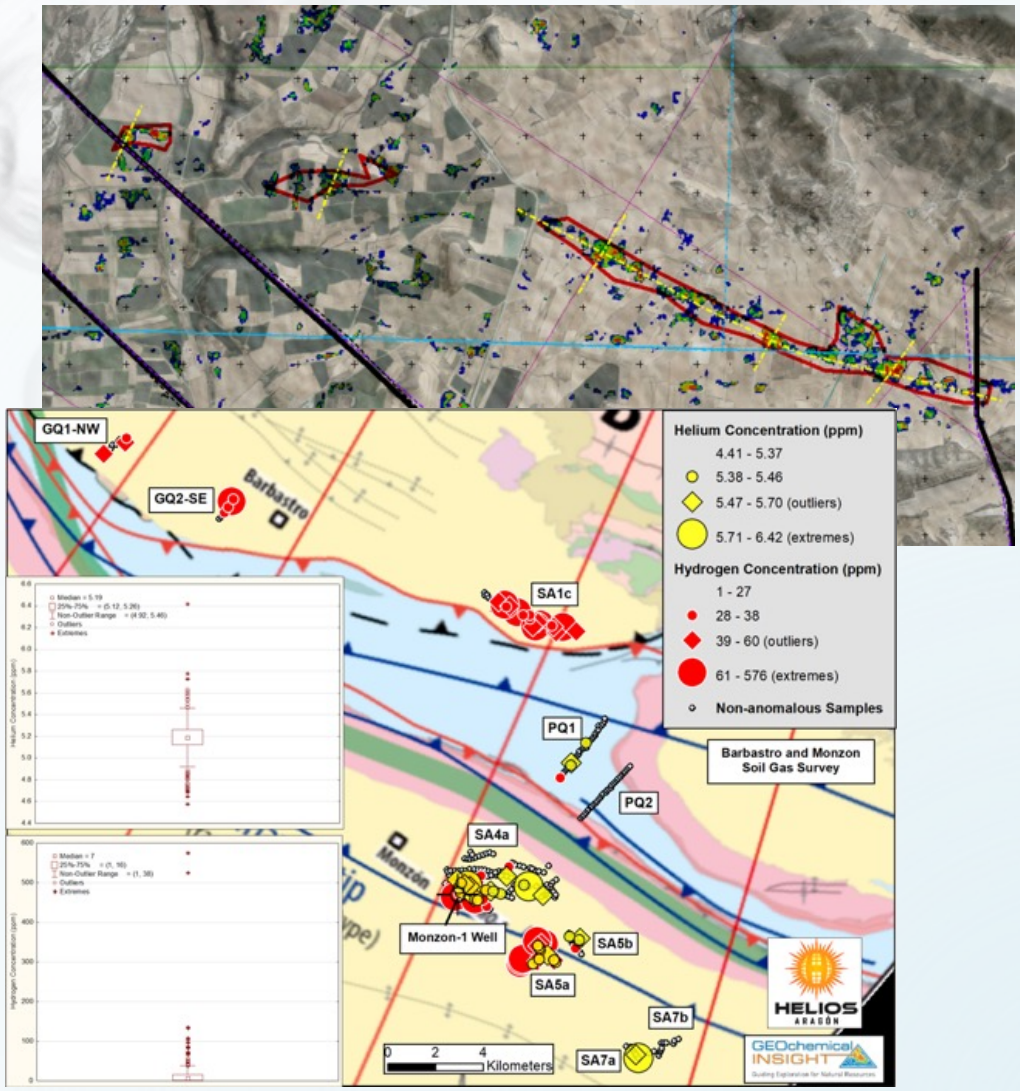
NATURAL HYDROGEN SURVEYS

Satellite spectral data survey (undertaken by Dirt Exploration)

- Hydrogen generates three strong and characteristic emission lines at 656nm which are readily detectable by satellite. Using European Space Agency Sentinel-2A and 2V data (@786km orbit)anomalies were recorded and mapped
- Data collected over winter to avoid excess water vapour and aerosol opacity
- Output is essentially a plot of rock and/or vegetation plus hydrogen. Areas of interest were high-graded

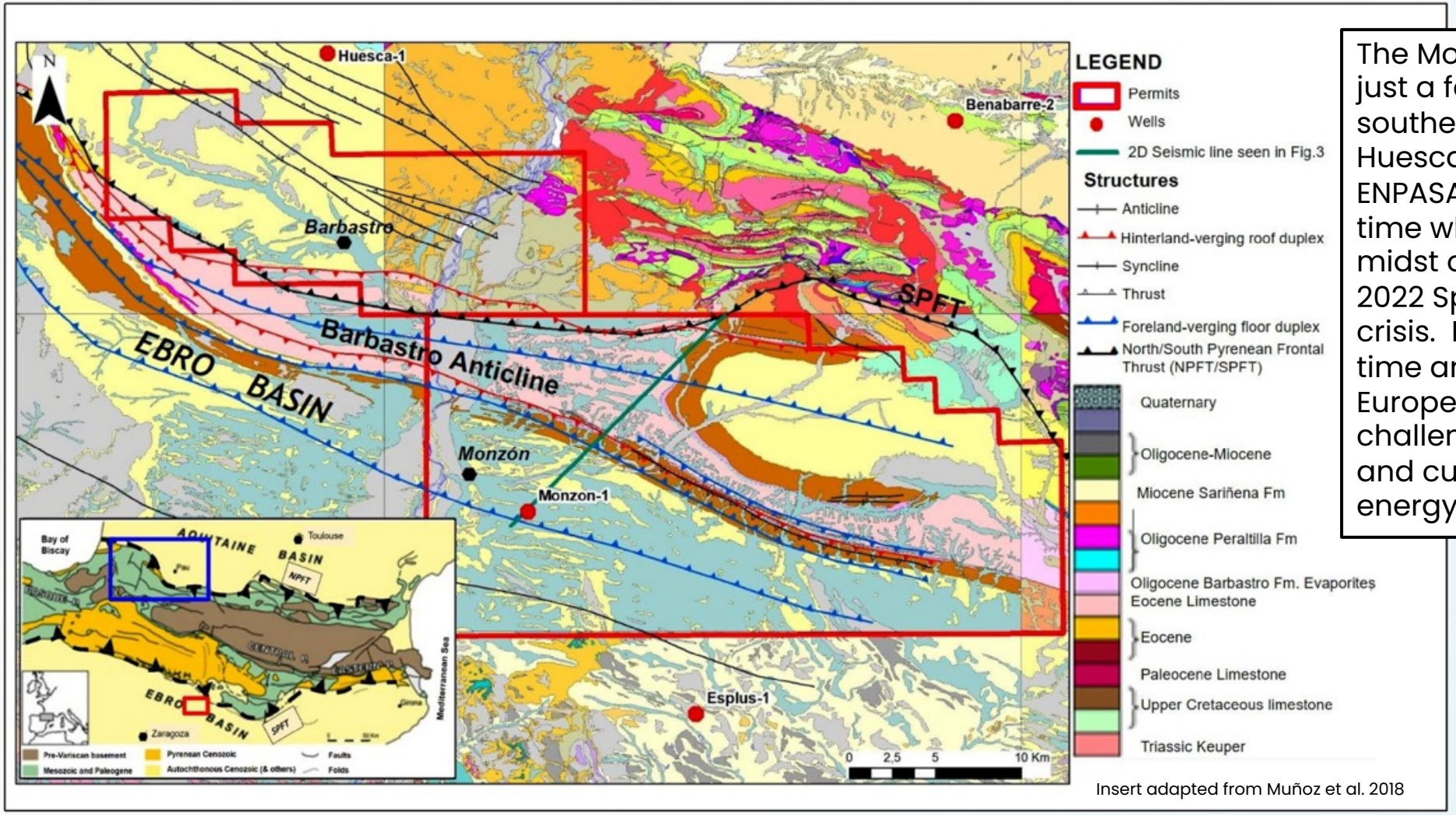
Geochemical soil survey (analysed by Geochemical Insight)

- 359 samples from 8 sites across mapped prospects and the Monzón discovery
- Significant hydrogen and helium anomalies recorded over prominent subsurface features (bounding faults and gas-chimney on seismic) and at the Monzón-1 well
- High hydrogen readings are found at 4 of the 5 satellite-derived hydrogen anomalies



GEOCHEMCIAL SURVEY

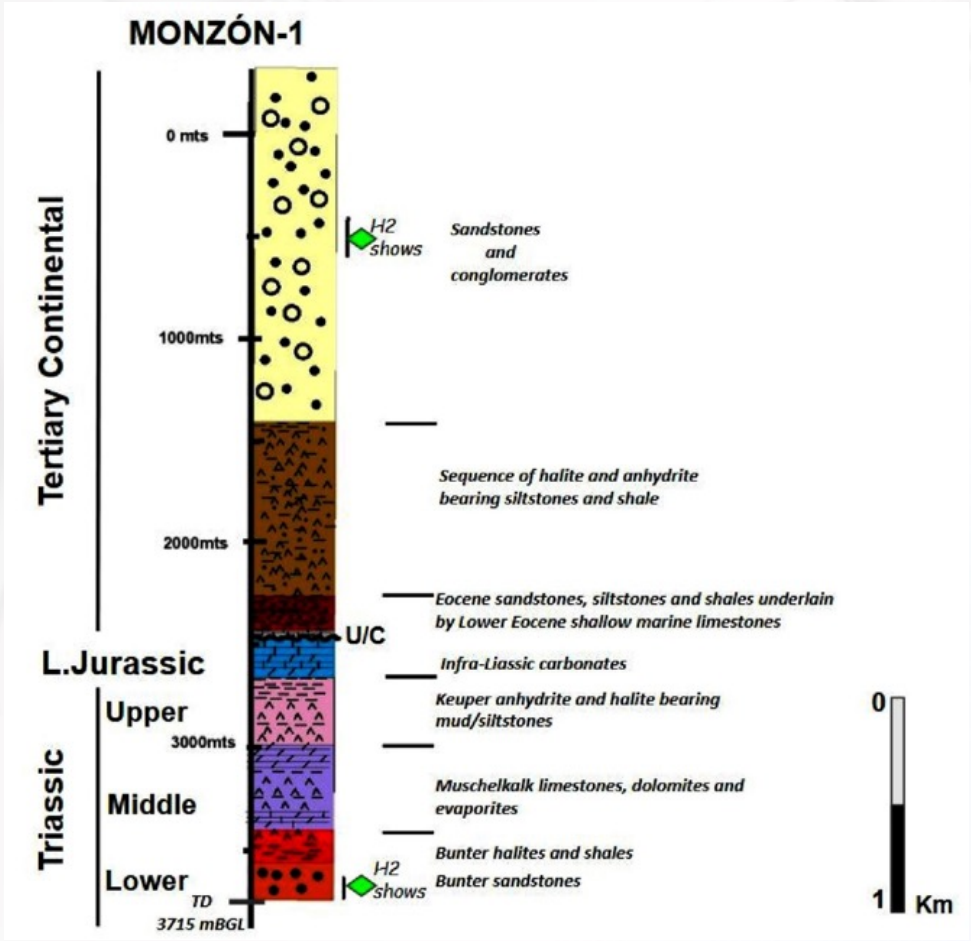
GEOLOGICAL SETTING



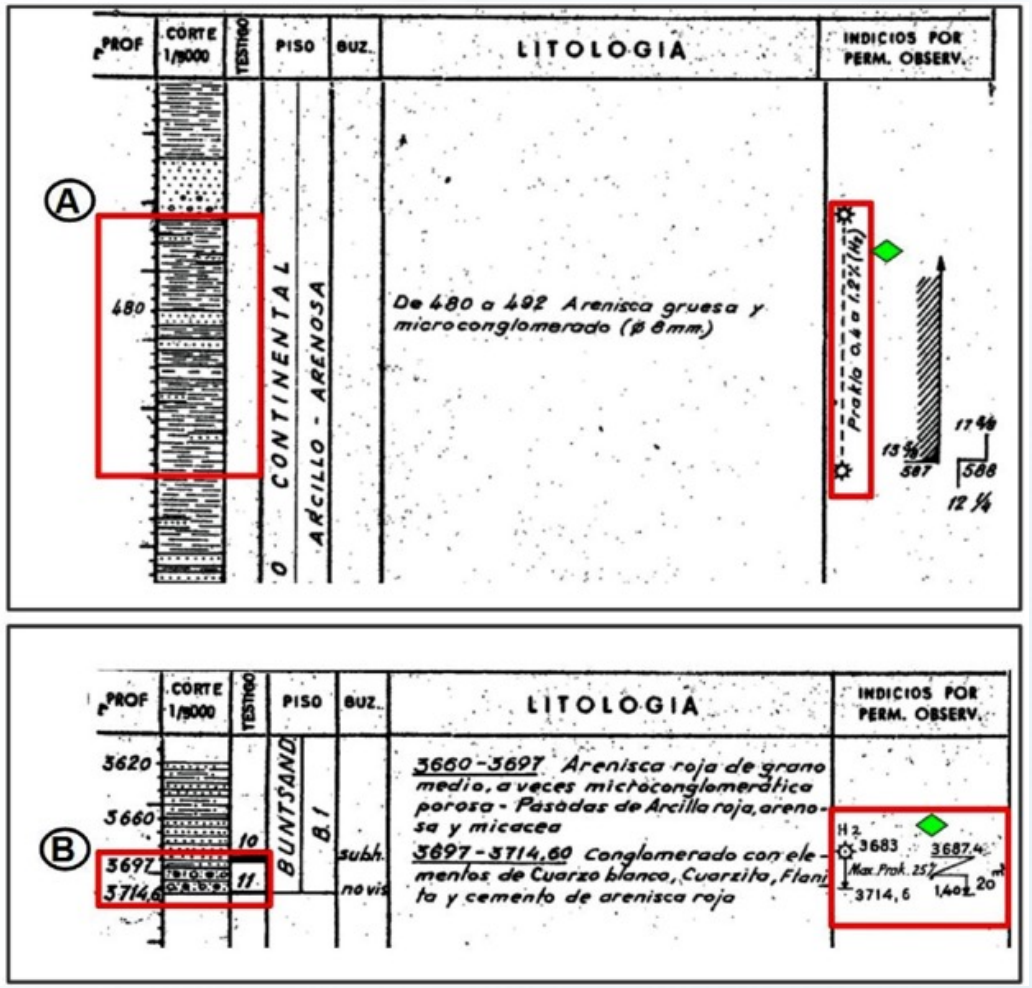
Insert adapted from Muñoz et al. 2018

The Monzón-1 well was drilled just a few kilometres southeast of Monzón in Huesca province, Aragón by ENPASA in 1963. This was a time when Spain was in the midst of an energy crisis. In 2022 Spain faces a similar crisis. Natural hydrogen this time around could help meet Europe's combined challenges of rapid transition and curtailment of imported energy

MONZON-1 WELL

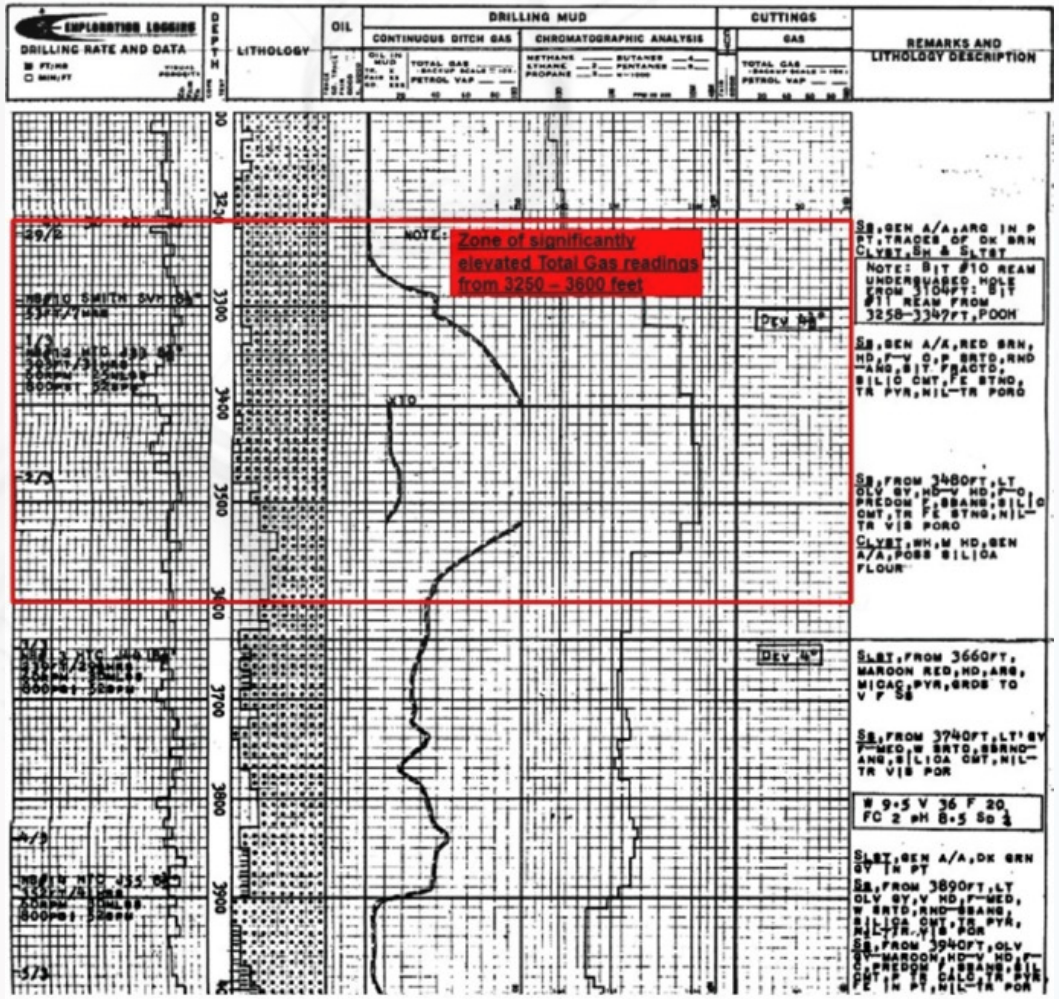


Well section and hydrogen shows



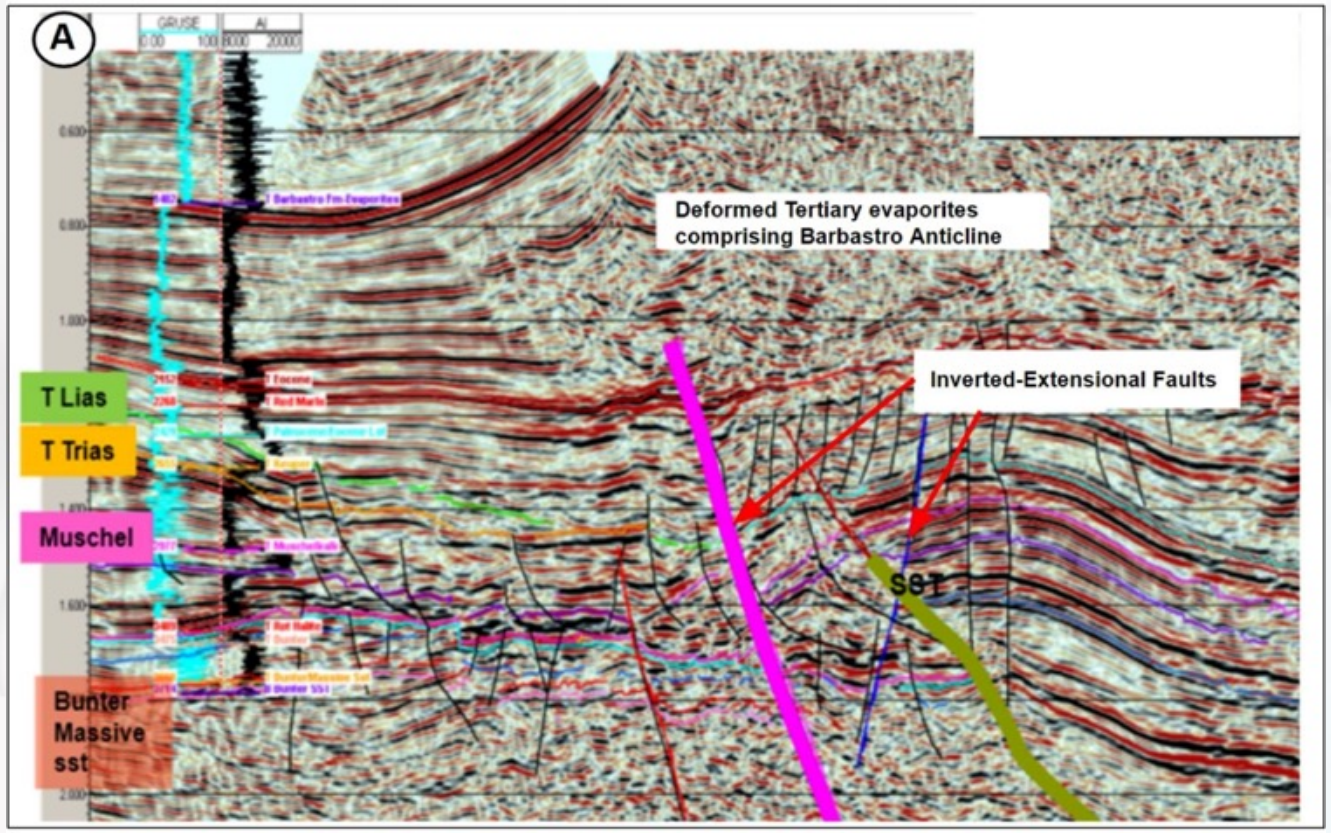
Hydrogen shows (100% of gas) from the composite log (ENPASA, 1963)

HYDROGEN DRILLING ANALGOGUE

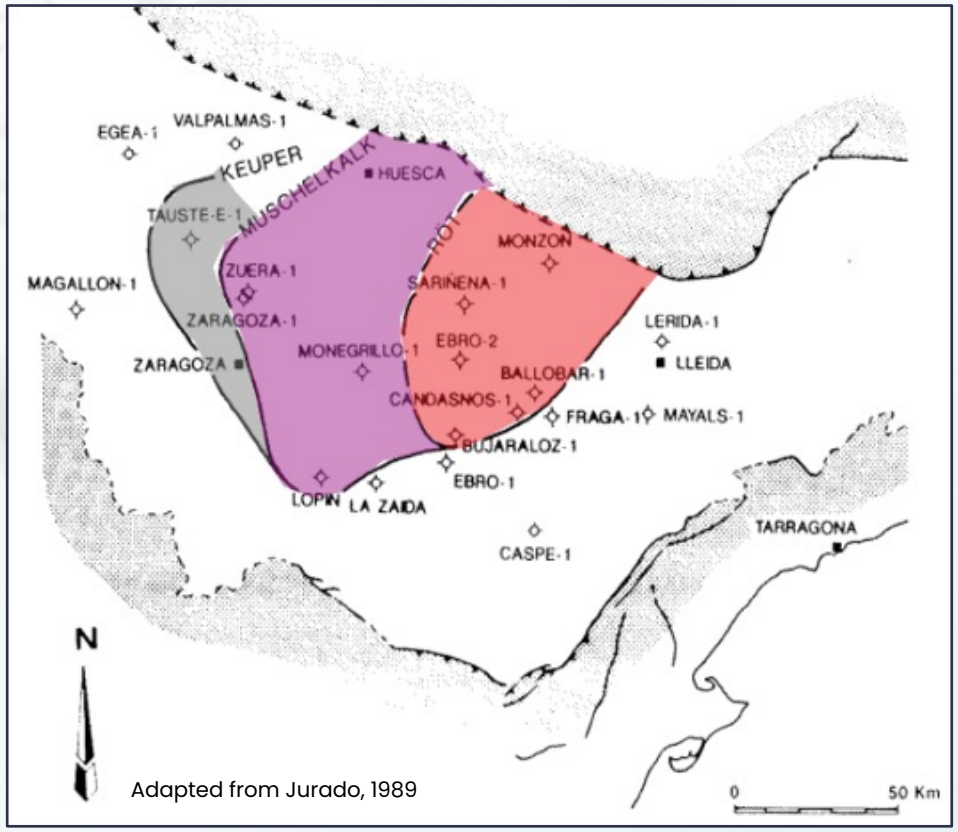


- Hydrogen accumulations have been hard to recognize as they were not expected and hydrogen (and helium) was not routinely monitored or measured
- The two gases are commonly used as the carrier gas, a Flame Ionizer Detector would use hydrogen for the flame
- Natural hydrogen was not of interest to most companies or countries until very recently and still few governments can appreciate the possibility of naturally occurring commercial hydrogen – very much as the early explorers in the North Sea did not believe that there would be commercial hydrocarbons
- HAPL have examined other well examples and the mud-log interpreted by Exploration Logging in the early 1980's here shows a well intersecting significant shows of hydrogen between 3230-3600 feet, with a maximum of 200 gas units recorded at 3480 feet

TRAP AND SEAL



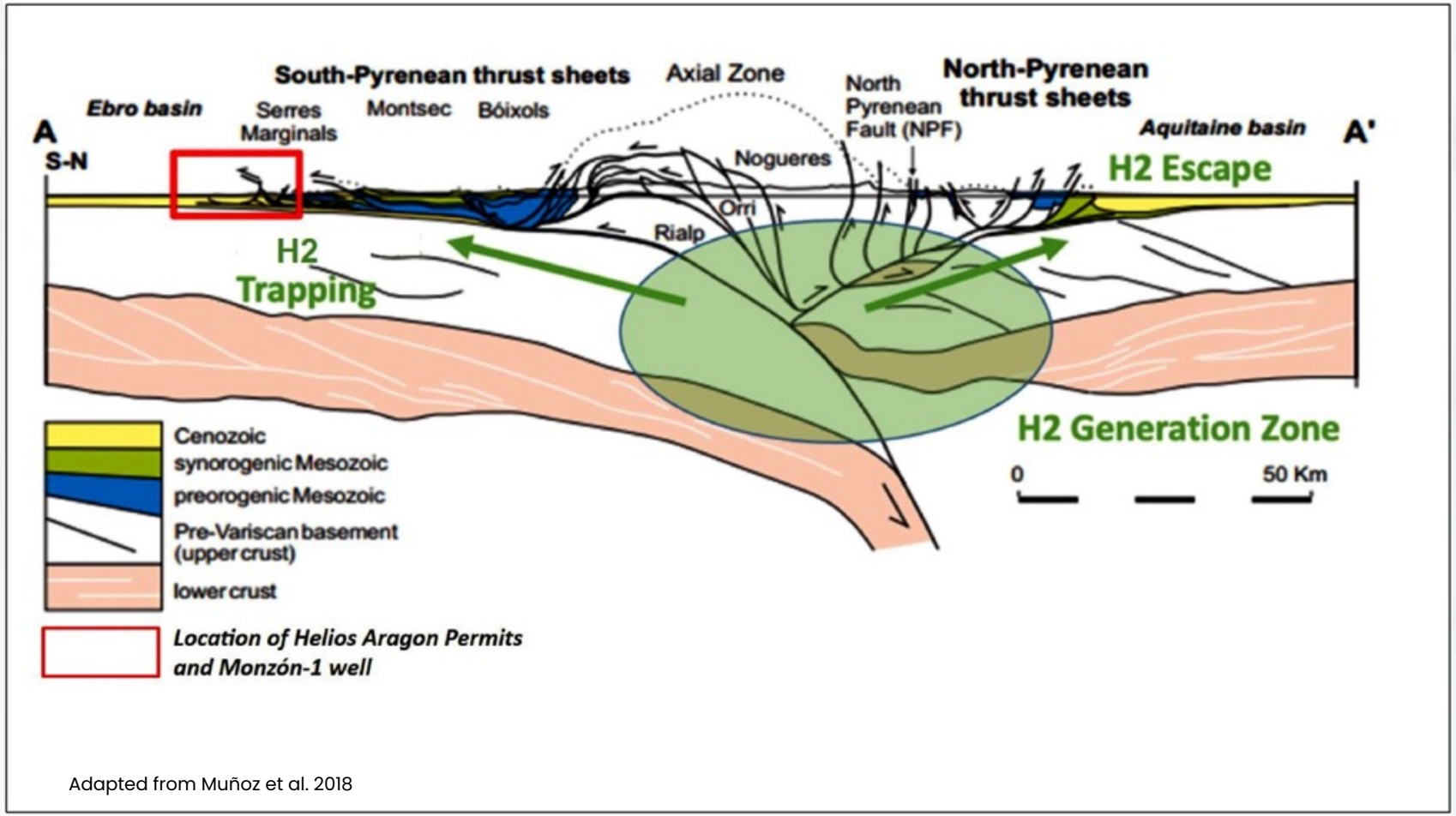
Location of the Monzón well on a modern vintage NE-SW oriented 2D seismic line. Note the presence below the Barbastro Anticline of a major, deep-seated basement inversion fault system which bounds the Monzón structure to the north



Extensive Triassic evaporites in the Ebro Basin

- Extent of Keuper, Muschelkalk and Bunter deposits
- All are, or contain thick salt, halitic/gypsiferous shales or shale
- Monzón structure overlain by all three halite zones

HYROGEN GENERATION AND MIGRATION



Adapted from Muñoz et al. 2018

- There is an notable symmetry across the Pyrenees
- The location of Monzón-1 well in the South Pyrenees is almost identical geologically to that where hydrogen emanations are recorded in the North Pyrenees. The difference being the greater sedimentary cover to the south in the Ebro basin, including a thick salt section
- Also worth considering is the “locked” paleo-Tethys ocean floor below the Ebro basin – marine sediments and submarine volcano-clastics of Ordovician age were encountered in the Ballobar well, to the south of Monzón-1

THE HYDROGEN SYSTEM

Summary

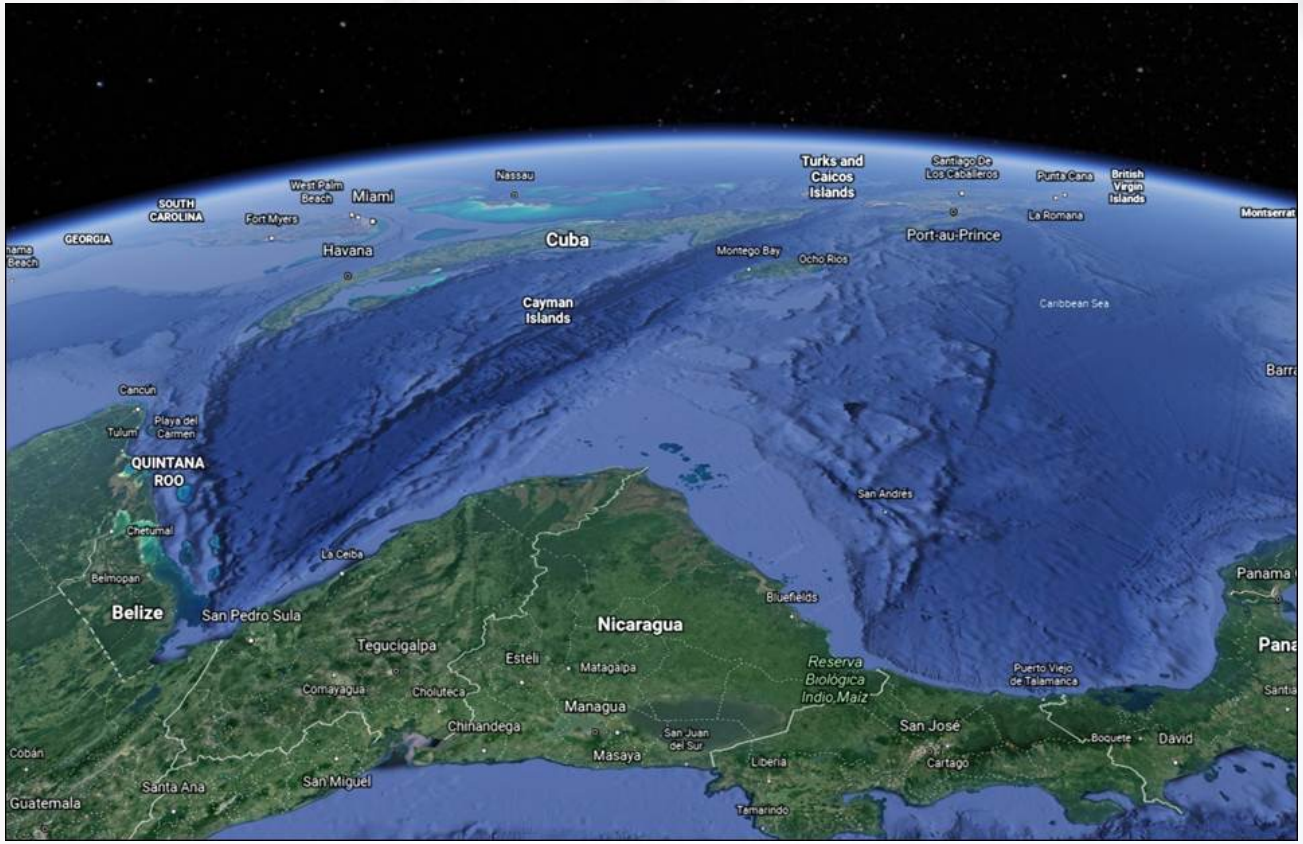
- **Source** - wet mantle interaction, the Tethys ocean floor
- **Charge** - continuous metasomatic alteration of iron rich / ocean floor mantle rocks
- **Migration** - deep seated faults and thrusts
- **Reservoir** - highly porous and permeable Bunter desert sandstones – a key reservoir in the North Sea
- **Structuration** - successive compressive stresses related to the closure of Tethys and the rotation of the Iberian Peninsula
- **Trap** – pop-up fault blocks, antiformal structures
- **Seal** – Keuper salt-rich marls and halite

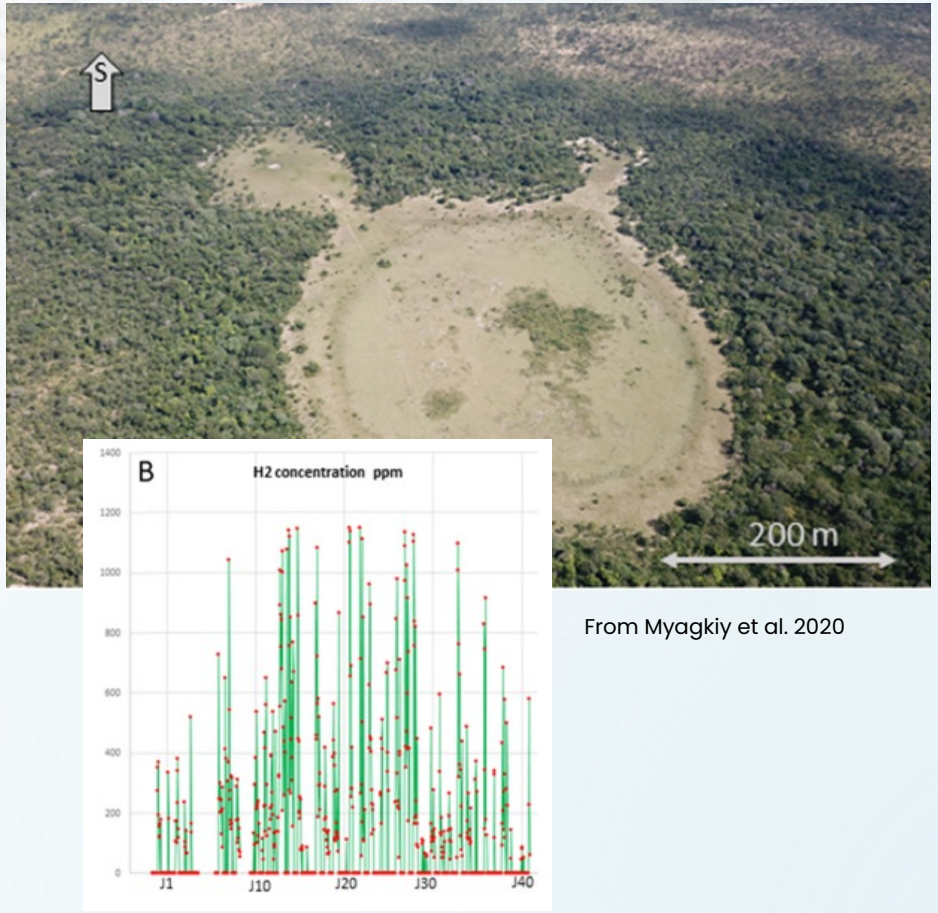
Way forward

- **Appraisal well** in 2024 and **first production** for local industry as early as 2028 of low emission and the lowest cost hydrogen

HYDROGEN PROSPECTIVITY

Do suitable hydrogen systems exist in Latin America and the Caribbean?





From Myagkiy et al. 2020

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Thank you

Q&A