The Search for Natural Hydrogen

Some Worldwide Exploration Highlights

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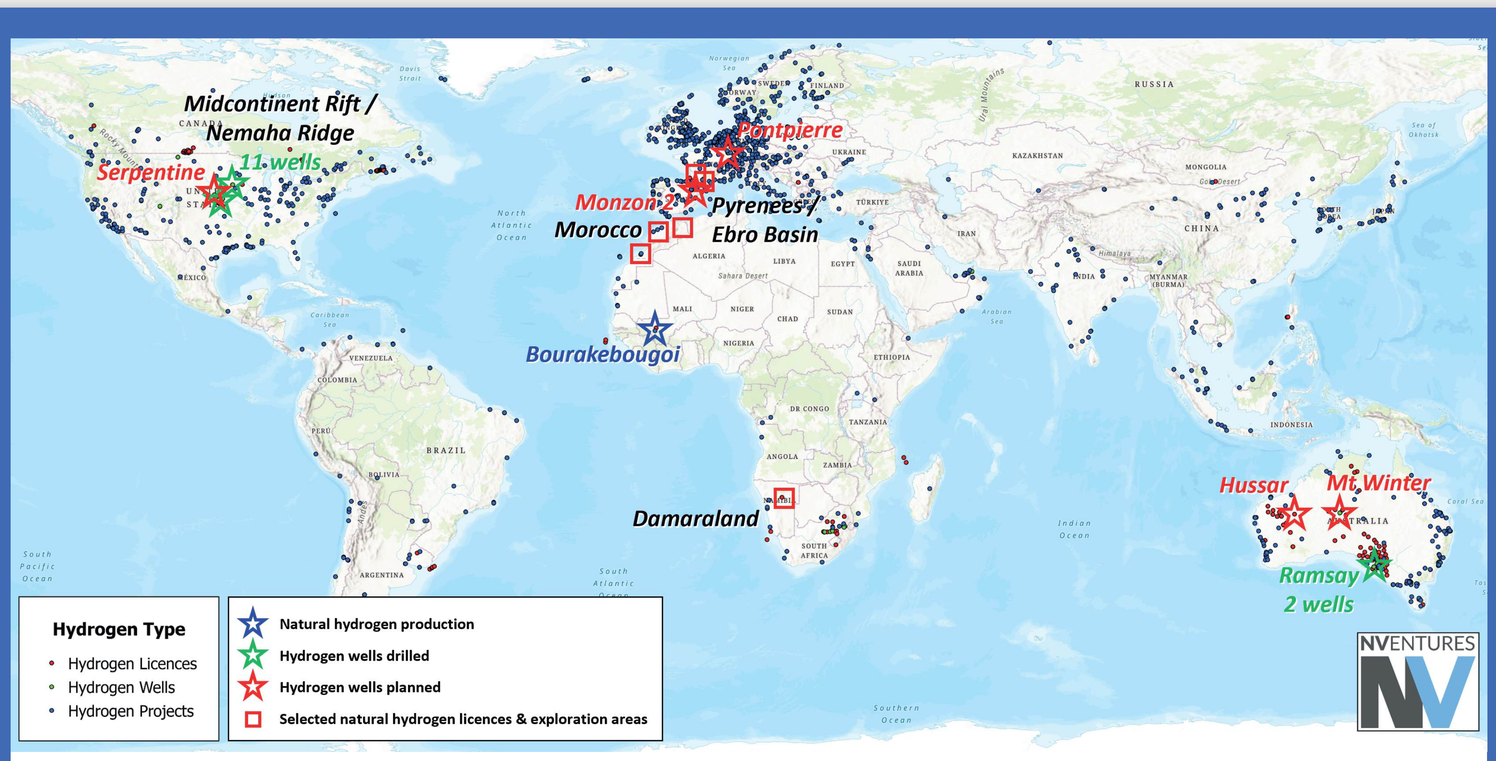
Areas such as South Australia & several states of the midcontinental USA, which combine a supportive licensing regime with favourable geology for natural hydrogen generation & entrapment have, over the past three years, seen the transition from initial funding & early exploration to drilling. Following the first dedicated exploration well, Hoarty NE3 in late 2018, twelve hydrogen exploration & appraisal wells have been drilled; ten on the US Midcontinent Rift / Nemaha Ridge play and two at Ramsay on the Yorke Peninsula, South Australia.

Within the next one to two years exploration drilling is expected to extend into new areas, with wells planned or in permitting in the USA, Australia (Western Australia & Northern Territories), France (Lorraine) & Spain – with others proposed in Morocco & Canada.

NVentures have over 25 years of experience providing coverage – with a strong geotechnical base - of the hydrocarbon exploration sector, more recently extending into the hydrogen & new energy sectors. As hydrogen exploration expands around the world & understanding of hydrogen generative & resource models mature, NVentures continue to document & provide in-depth reporting covering all aspects of the business, including:

- Prospective areas attracting industry interest - hydrogen system models, gas shows / seeps & natural hydrogen indicators.
- Licensing & licence rounds - plus supporting legislation.
- Sector focused exploration & development companies – with geotechnical analysis of projects & work programmes.
- Detailed reviews of key hydrogen exploration wells, including planned wells & key legacy wells.



As of June 2025 a total of thirteen hydrogen exploration / appraisal wells have been drilled (11 in the US mid-continent & 2 in South Australia), with five permitting. More than forty companies are involved in active natural hydrogen exploration, including stimulated hydrogen production. This map locates licenced areas, with active exploration programmes (red dots), hydrogen exploration / appraisal wells (green) & other natural hydrogen projects (blue).

The Midcontinent Rift & Nemaha Ridge – Kansas, Nebraska & Iowa

Mesoproterozoic rift (c. 1,080 Ma) with up to 8 km syn-rift fill (Keweenawan Supergroup) - basalt lavas dominant in the lower part & arkosic clastics in the upper part - intruded by gabbro & ultrabasic sills.

- Trends south-west from Lake Superior to central Kansas - 1,500 km x 80 km wide.
- NE Iowa Igneous Complex (NEIIC) is a major ultramafic intrusion with olivine cumulates (dunites) & troctolites believed to be linked to the rift system.
- Rift cuts through early Proterozoic (1,600 – 1,800 Ma) Mazatzal accretionary wedge - amphibolite grade metamorphics - gneiss, gabbro & peridotite.
- Sharp fault-bounded contacts between the two provinces define strong gravity & magnetic anomalies.

The Nemaha Ridge is a granite-cored high formed by transpressional movement (principally early Pennsylvanian) along the eastern margin of the Midcontinent Rift. Rejuvenated by the Laramide Orogeny (55 Ma).

- Plunges SSW across eastern Kansas: top basement > 200 m in north to 3,000 m at the Oklahoma border.

The Natural Hydrogen Play

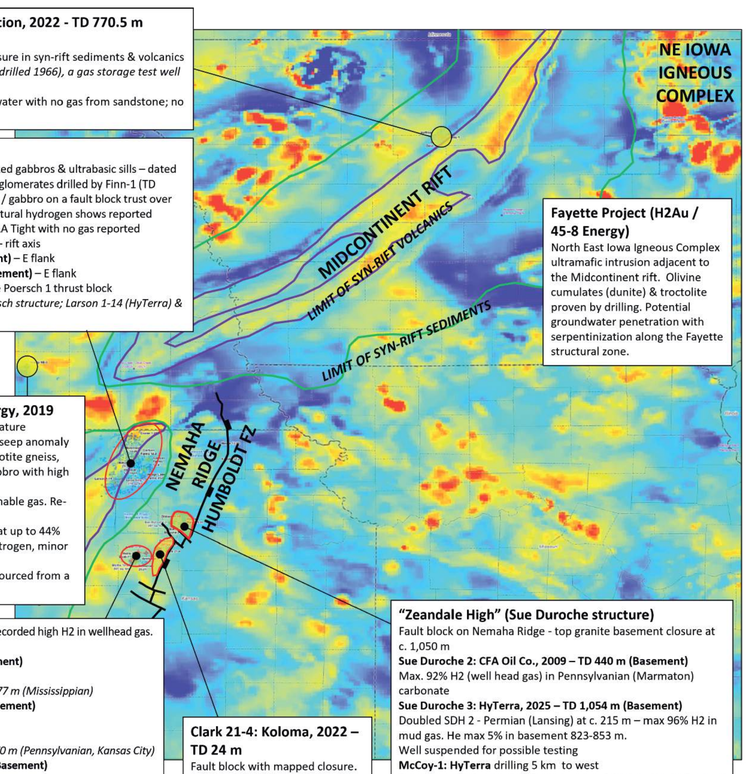
Serpentinization - variously inferred to be of pre-rift Mazatzal peridotites, syn-rift ultrabasics within the Midcontinent Rift & / or ultramafic intrusions such as the NEIIC.

- Prove hydrogen rich gas from several wells & soil gas surveys on the Nemaha Ridge.
- Circular anomalies interpreted as hydrogen seeps ("fairy circles") in Salina Basin – target of Hoarty NE3 – Possible natural seep play.
- Conventional fault block traps with reservoir in fractured basement & Upper Palaeozoic carbonates & sandstones.

Van Deist 14-3:Twin Rivers Exploration, 2022 - TD 770.5 m (Basement)
Vincent Dome – structural high with dip-closure in syn-rift sediments & volcanics
Effective re-drill & deepening of Hoffman 3 (drilled 1966), a gas storage test well with 96.3% H2 in mud gas. Not tested
Van Deist well tested at 661 m, recovering water with no gas from sandstone; no test in basement. P&A Tight

Midcontinent Rift Play (NE Kansas)
Syn-rift basalts intruded by partially serpentized gabbros & ultrabasic sills – dated 1.1 Ga - overlain by arkosic sandstones & conglomerates drilled by Finn-1 (TD 1,208 m). Poersch 1 encountered thick basalt / gabbro on a fault block trust over syn-rift sediments (TD 3,435 m). No legacy natural hydrogen shows reported
Koloma drilled three H2 wells in 2023 – all P&A Tight with no gas reported
- **Balsmeier 21-32 - TD 1,849 m (Basement)** – rift axis
- **Carlson Farms 54-4 0 TD 1,301 m (Basement)** – E flank
- **Hedge Lawn Farms 25-6 - TD 1,402 m (Basement)** – E flank

Top End Energy plan well Serpentine 1 on the Poersch 1 thrust block
Two permitted wells also located on the Poersch structure; Larson 1-14 (HyTerra) & Vethauer 5-5 (Koloma)



Fayette Project (H2Au / 45-8 Energy)
North East Iowa Igneous Complex ultramafic intrusion adjacent to the Midcontinent rift. Olivine cumulates (dunite) & troctolite proven by drilling. Potential groundwater penetration with serpentinization along the Fayette structural zone.

Hoarty NE3: Natural Hydrogen Energy, 2019
Located at the centre of a circular surface feature interpreted as a potential natural hydrogen seep anomaly
Basement drilled 1,065 m to TD 3,440 m - biotite gneiss, quartzite & serpentinized amphibolite & gabbro with high H2 in mud gas
- Swab tested 1,075-3,437 m –flowed flammable gas. Re-entered for ESP test in 2023
- Gas samples from both tests analysed H2 at up to 44% with helium at 1.1 to 12.8% + dominant nitrogen, minor CH4 & CO2 (HyTerra, March 2025)

No proven conventional trap – gas may be sourced from a naturally recharging seep

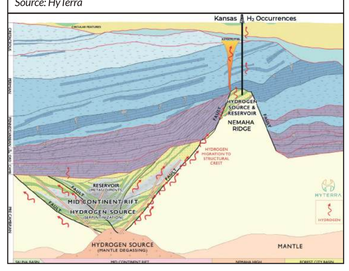
Four wells drilled by CFA Oil Co. 1981 – 1985 recorded high H2 in wellhead gas. Two doubled / offset by recent drilling:
Smith 11-27: Koloma, 2022 - TD 997 m (Basement)
P&A Tight-no gas reported
*Doubled / deepened **Heins** 1 -H2 21-80%. TD 677 m (Mississippian)*
Blythe 13-20: HyTerra, 2025 - TD 1,615 m (Basement)
Tilted fault block structure
H2 & He seen from mud gas – samples taken
*Doubled / deepened **Scott 1**: H2 25-56%. TD 670 m (Pennsylvanian, Kansas City)*
Stenstrom 23-21: Koloma, 2022 – TD 969 m (Basement)
P&A Tight-no gas reported
Offset to Scott 1

Clark 21-4: Koloma, 2022 – TD 24 m
Fault block with mapped closure. Planned TD 823 m. P&A Tight – Basement objective not reached

"Zeandale High" (Sue Duroche structure)
Fault block on Nemaha Ridge - top granite basement closure at c. 1,050 m
Sue Duroche 2: CFA Oil Co., 2009 – TD 440 m (Basement)
Max. 92% H2 (well head gas) in Pennsylvanian (Marmaton) carbonate
Sue Duroche 3: HyTerra, 2025 – TD 1,054 m (Basement)
Doubled SDH 2 - Permian (Lansing) at c. 215 m – max 96% H2 in mud gas. He max 5% in basement 823-853 m.
Well suspended for possible testing
McCoy-1: HyTerra drilling 5 km to west
Pure Wave Hydrogen: Lily Rock prospect Permitted wells Downey Ranch 3-31 (HyTerra) & Dibben 31-19 (Koloma - expired)

Hoarty NE3, SE Nebraska – surface anomaly
Well location is at the centre

Midcontinent / Nemaha Natural H2 Play
Source: HyTerra



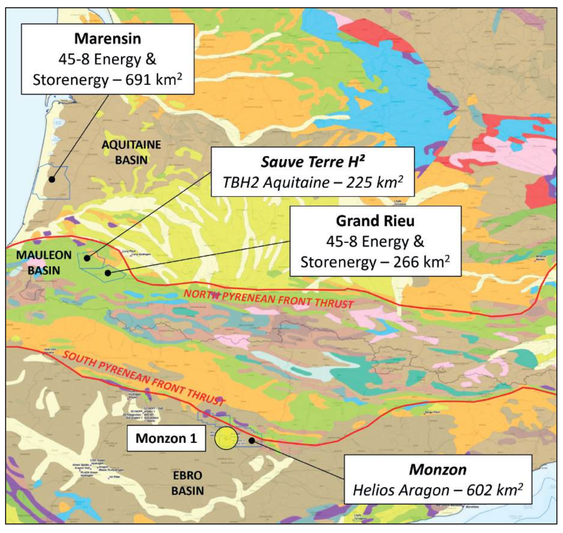
Pyrenees and the Ebro Basin

Crustal hyper-extension & rifting during the mid Cretaceous (Aptian-Cenomanian) resulted in mantle exhumation followed, during the late Cretaceous & early Tertiary, by collision, obduction & ophiolite emplacement during the Alpine (Pyrenean) orogeny.

Large, buried ultrabasic (lhertzolite) ophiolite bodies have been mapped on both the northern & southern flanks of the Pyrenees, including below & adjacent to several Mesozoic & Tertiary sedimentary basins, providing the potential for natural hydrogen gas in conventional reservoirs & traps. Ophiolites are located at 8 to 10 km below the north Pyrenean foothills.

The Natural Hydrogen Play

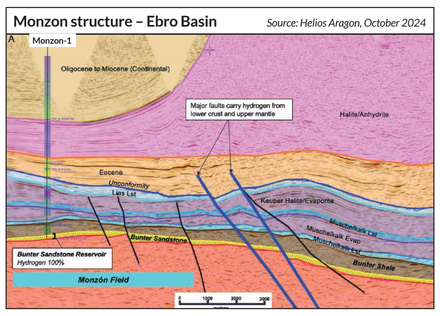
Serpentinization – fractured lhertzolites reacting with Pyrenean aquifer waters.



Evidence for a natural hydrogen system:

- In the Ebro Basin, Monzon 1 (1963) was drilled as a conventional hydrocarbon exploration well on a dip-closed structure. The well encountered hydrogen at up 25% in mud gas whilst drilling the Lower Triassic Bunter Sandstone (3,683-3,715 m).
- Natural hydrogen documented from surface seeps along the North Pyrenean Fault Zone, with soil gas anomalies in the Mauléon Basin (Aquitaine).
- 2D gravity / magnetic modelling of north Pyrenean ophiolites - consistent with partial serpentinization (up to 76%).

Monzon structure – Ebro Basin
Source: Helios Aragon, October 2024



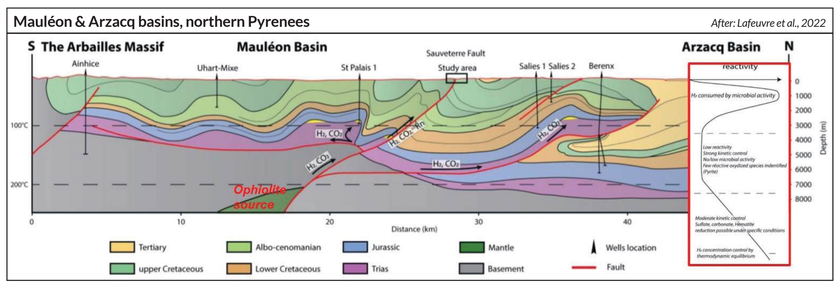
Reservoir objectives:

- Triassic Bunter Sandstone with salt top-seal.
- Jurassic / Cretaceous fractured carbonates.

Well targets:

- Extensional fault blocks, thrust anticlines.

Mauléon & Arzacq basins, northern Pyrenees
After: Lafeuvre et al., 2022



Africa – Morocco and Namibia

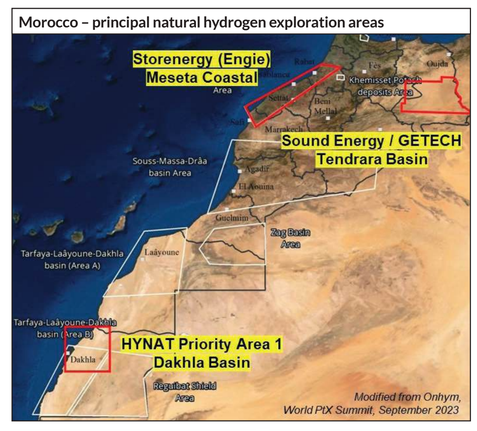
Although hosting the world's only natural hydrogen production at Bourakebougoi in the Taoudeni Basin, Mali, exploration in western Africa is at an early stage. As part of the national energy strategy, Moroccan state energy company ONHYM have put a considerable investment into early phase exploration, resulting in the signing of agreements to evaluate two high-graded areas with Hynat & Storenergy in 2024. In late 2024 Sound Energy & GETECH agreed to collaborate in hydrogen exploration throughout Morocco, including on Sound's Tarfaya Basin hydrocarbon licences.

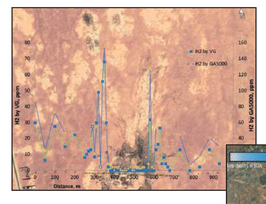
ONHYM initially high-graded two areas, the Meseta Coastal strip & the onshore Dakhla Basin, where fields of sub-circular depressions (SCDs) indicated potential hydrogen seeps. Extensive field work, including more than 1,500 soil gas sample points showed hydrogen anomalies linked to these SCDs, & also showed potassium & thorium anomalies from gamma spectroscopy for some.

Although the source system is currently unclear, both areas are located adjacent to shallow, potentially serpentinized mantle in the adjacent offshore.

Soil gas studies in SCD fields in Namibia (Darmaraland) show similar natural hydrogen anomalies, supporting the case for further exploration, with hydrogen source in this area linked to a Neoproterozoic banded iron formation.

Morocco – principal natural hydrogen exploration areas

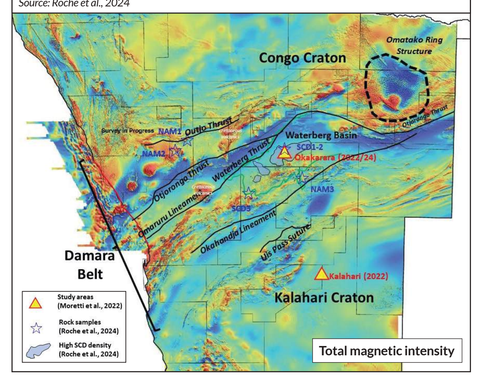




H2 soil gas abundance (ppm) across semi-circular depression (SCD)
Source: Onhym, September 2023

SCD fields in Damaraland, Namibia
Source: Roche et al., 2024

Structure & natural hydrogen indicators, Damaraland, Namibia
Source: Roche et al., 2024



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