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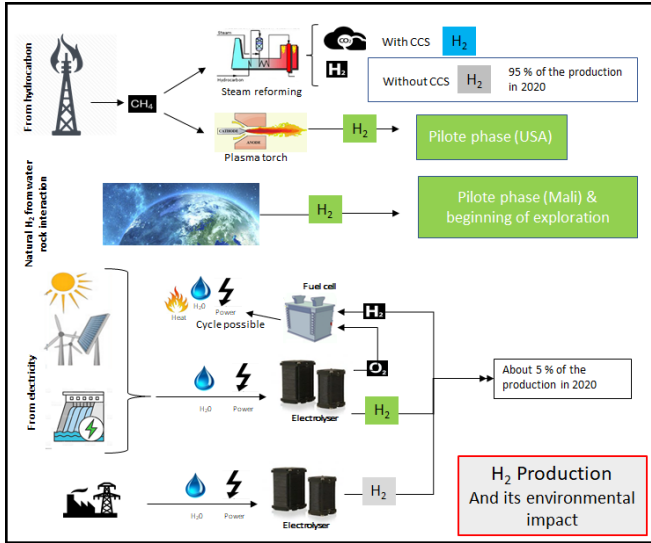


# Natural Hydrogen : the E&P starts

3/12/2021 : GERG  
Dr. Isabelle Moretti, E2S UPPA  
French Academy of technologies



## Hydrogen: Production mode and environmental impact



■ Today we have cheap  $H_2$  from HC and more expensive from electrolyser (roughly 2 vs 8 \$/kg)

■ Within the steam reforming

- 1/3 of the price is the gas,
- 1/3 the energy (to 800°C),
- 1/3 the cleaning

Natural  $H_2$  could be cheaper and cleaner

H<sub>2</sub> Production And its environmental impact

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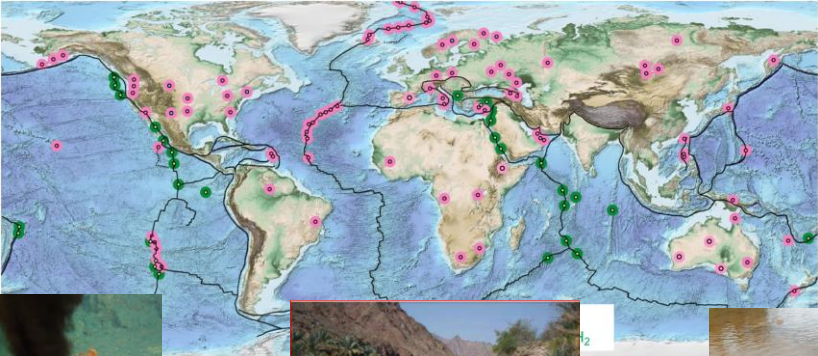
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## A long list of known emanations

+ along the Mid Oceanic Ridges and in ophiolitic context



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## Natural Hydrogen and Mid Oceanic Ridges

- Mid-oceanic ridges
  - East Pacific r.:  $H_2 \approx 60\%$  (Welhan & Craig., 1979)
  - Rainbow:  $H_2 \approx 50\%$  (Charlou et al., 2002)
  - Logachev:  $H_2 \approx 50\%$  (Douville et al., 2002)
  - Lost City:  $H_2 \approx 70\%$  (Kelly et al., 2005)
  - Ashadze :  $H_2 \approx 70\%$  (Charlou et al., 2008)

**Each vents:**  
flux~  $5-10 \times 10^6 \text{ m}^3 \text{ H}_2/\text{an}$   
(Charlou et al., 2008)

Probably thousands of vents  
Along 60 000 km  
of mid-oceanic ridges

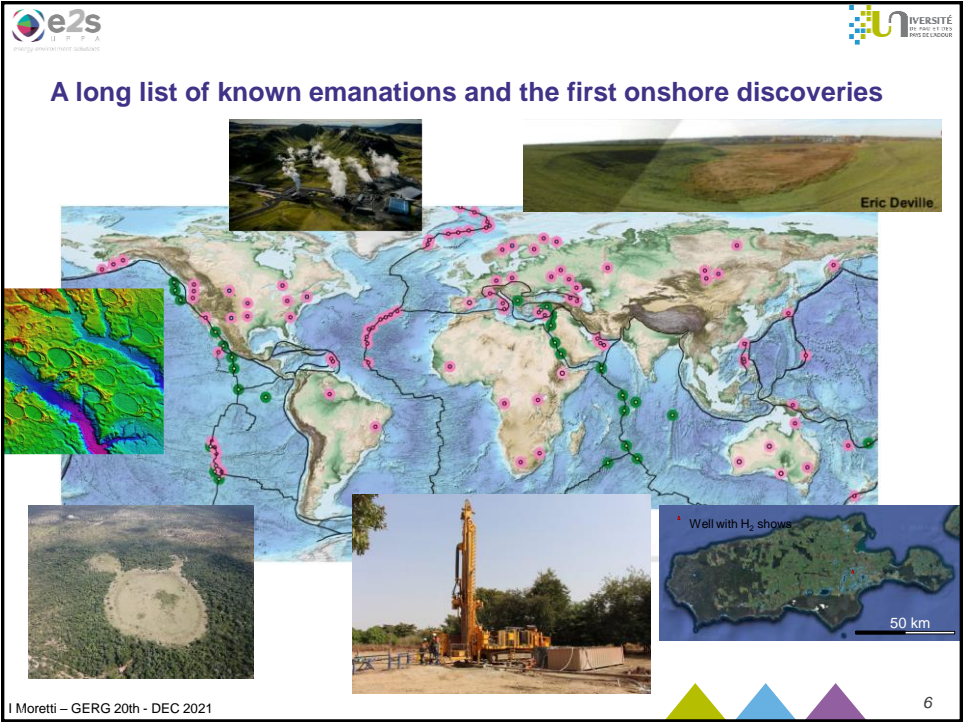
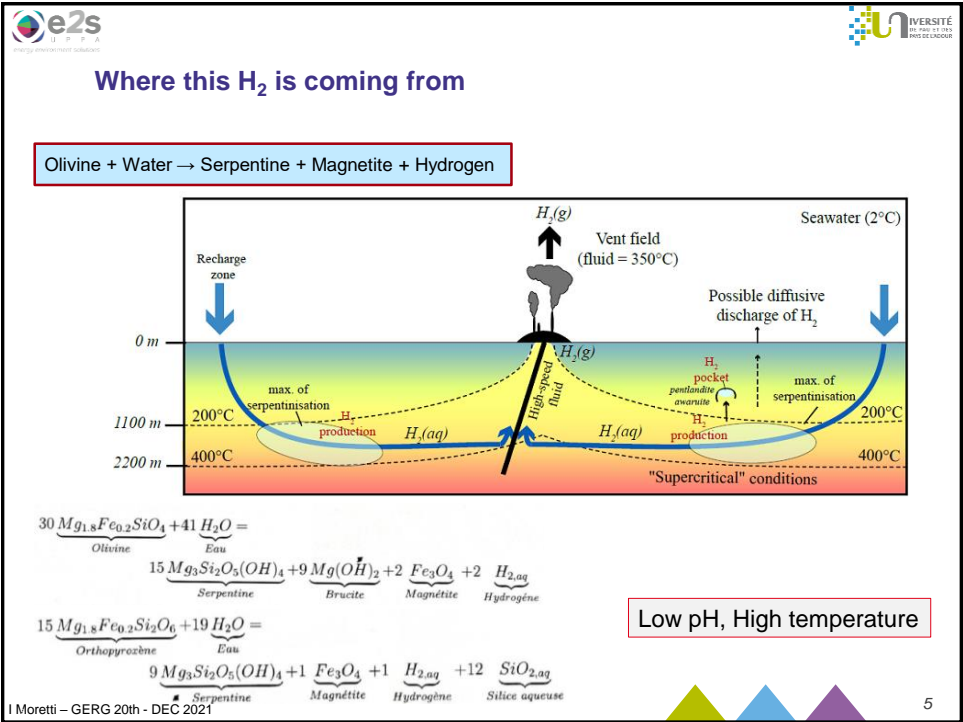
**White smoker**

**Rainbow**

**Lost city**

➤ Known for long time but not easy to produce

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## Mali: first production of pure natural H<sub>2</sub>

**NIARELA.NET** Actualité malienne ACCUEIL NORD-MALI POLITIQUE FAITS DIVERS SPC  
ECONOMIE INSOLITE INTERNATIONAL VIDEO

Des puits d'hydrogène naturel à Bourakébougou : bientôt le boom gazier au Mali ?

**A Pure HYDROGEN GAS WELL In an African Village**

**CONFIDENTIEL Afrique** Le premier continent RUBRIQUES • NOUS CONTACTER • QUI SOMMES-NOUS

Sénégol Monde: Philip Morris Manufacturing Sénégal apporte des précisions: COMMUNIQUÉ ... 25 janvier ...

### Mali: L'hydrogène de Bourakebougou fascine la communauté scientifique et fait la Une de La Tribune

L'intégration de l'hydrogène comme source d'énergie dans la transition énergétique va nécessairement bouleverser les modes de vie de la planète. Au Mali, plus précisément dans un village appelé Bourakébougou, niché à 40 km de Bamako (capitale du Mali), se joue une grande partie de l'avenir énergétique africain et mondial. Cette découverte majeure et historique de l'hydrogène naturel (production d'une électricité verte à 100%) a fasciné l'ensemble Professeur Alain Prudent, affilié au prestigieux Institut de Physique du globe de Paris et à l'université de Paris VII, directeur scientifique de GEVAL, qui a souligné l'importance et les opportunités de cette matière stratégique dans les colonnes du quotidien français La Tribune.

10 juillet 2019  
Mali à jour 10 juillet 2019  
A 08:00

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## Mali: what we learn

- H<sub>2</sub> accumulation seal exists: here dolerite
- No leakage above the producing structure
- 7 years of production: 1300m<sup>3</sup>/day and no pressure drop (4 bars) :
  - Either the tank is big (and the pipe is small...)
  - Either it recharges continuously

**Bougou-13 Well**

0 1000 2000 3000 4000

Shales

H<sub>2</sub> (ppm)

Dolerite

Marl

CH<sub>4</sub> (ppm)

Marl

Dolerite

**Bougou-19 Well**

0 5000 10000 15000 20000 25000

Metapelite

Breccia

H<sub>2</sub> (ppm)

Marble

10 x CH<sub>4</sub> (ppm)

**Laterite**

**Dolerite**

**Bourakebougou**

Bamako Dio

LEGEND

So<sub>1,2</sub>

Ni

Ba

So<sub>3</sub>

So<sub>1,2</sub>

Granites & migmatites (Archean & Proterozoic)

Dolerite Intrusion

St

F1&F2

Ni

Ba

1000

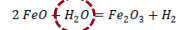
2000

3000

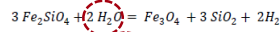
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**H<sub>2</sub> sources: mainly H<sub>2</sub>O – Water rock interaction**

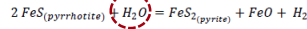
- Fe oxidation with geothermal hot fluids



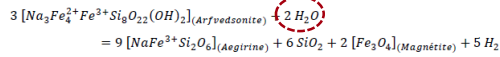
- Serpentinization



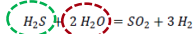
- Hydrothermal context but basic



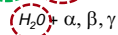
- Granite peralkaline



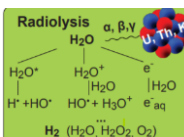
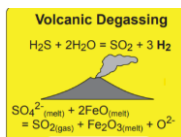
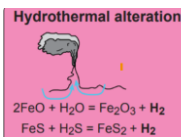
- Volcanic



- Radiolysis

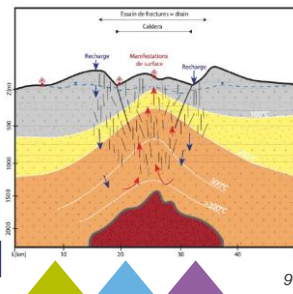


■ Open question:  $NH_3$



Modified from Klein et al., 2020 *Elements*, Vol. 16, pp. 19–24

A permanent flow, as for the geothermy



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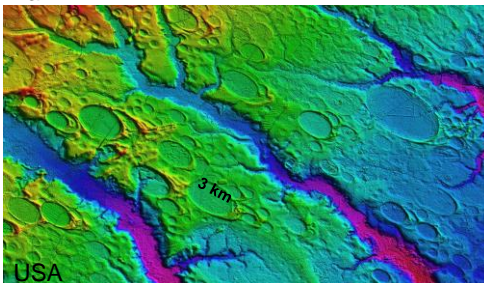
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**Mali: first production of pure natural H<sub>2</sub>**  
**Where will be the next ones ?**

## Where will be the next ones ?

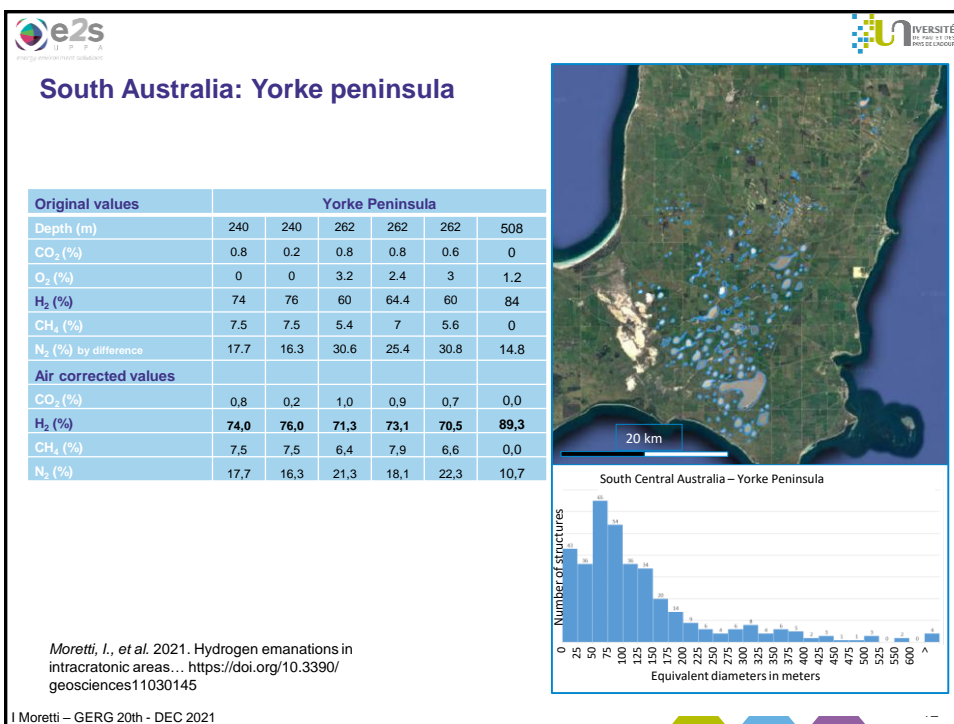
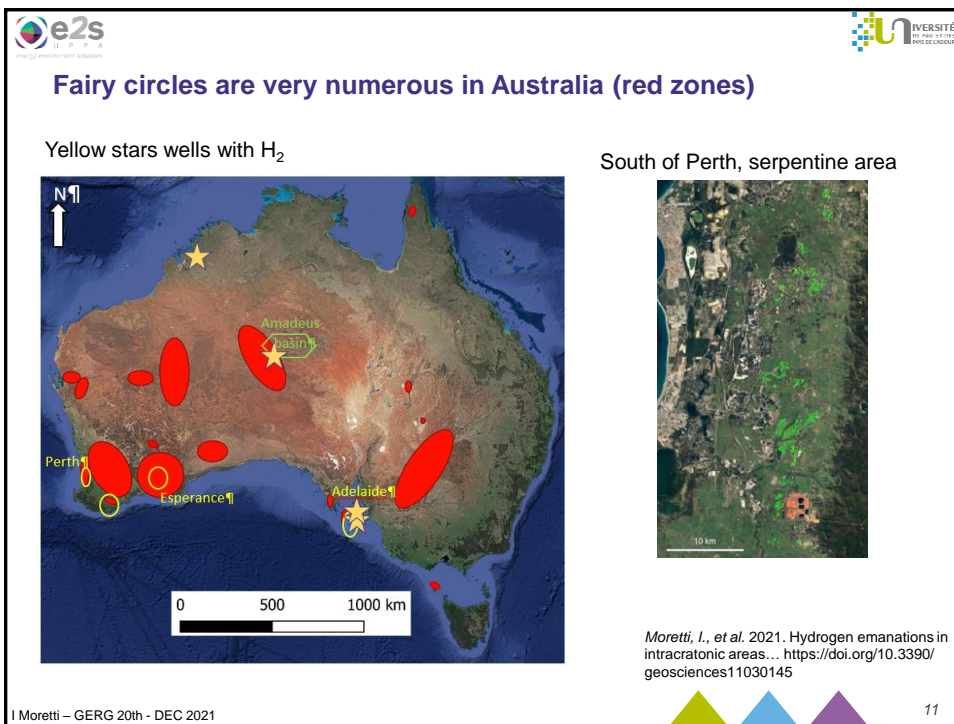


Brazil



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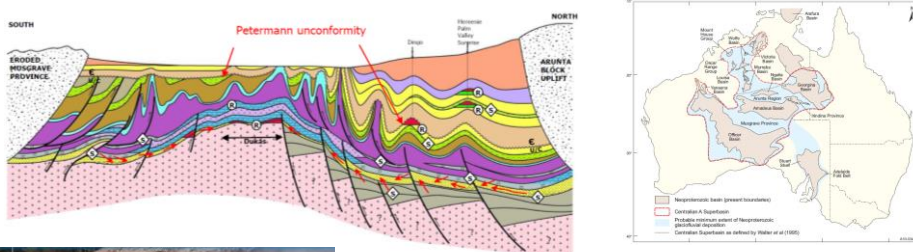

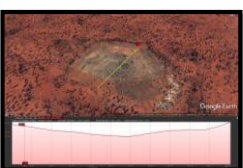
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## Amadeus basin, Australia: blend HC, He, H<sub>2</sub>

- Mt Kitty 1 gas:  
9% Helium  
11.5% Hydrogen
- Discovery by Santos

Johns, D.; Menpes, A.; Walshe, P.; Bache, F. Exploration of a Sub-Salt Play in the Southern Amadeus Basin, Central Australia—Searching for Big Gas in Proterozoic Réservoirs; Seapex Presentation; Seapex: Singapore, 2017.

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## Other examples of what is happening worldwide

- Mali: Hydroma, 20 new wells, certification of the reserves by Chapman (Canada)
- USA: NH2E start up drilled a first well in Kansas:
- France: 45-8 : Looking for both H<sub>e</sub> and H<sub>2</sub>
- Djibouti: ODDEG is looking for mix production Geothermy and H<sub>2</sub>
- Helios and Ascent will be drilling in Spain in 2021
- Pristine (USA) will be drilling in south and north America in the coming months ...


**H tech report** 15 Dec 2020

**Ascent Hydrogen Fund signs deal with Spain's Helios Aragon to explore and produce 'Gold Hydrogen'**

Sub-surface data of an area in Aragon, Spain, suggests wells may contain commercially extractable natural hydrogen.



**Energy** Actual | Chiffres | Notre stratégie | Nos projets | Investisseurs | Contact



**45-8 Energy, la première entreprise dédiée à l'exploration d'hélium en Europe**

Notre approche innovante consiste à co-valoriser, dans des contextes géologiques spécifiques, les ressources associées à l'hélium comme l'hydrogène natif.

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**H-NAT 2021** by **IC Corp**

POTENTIAL • EXPLORATION • PRODUCTION

Conference & Exhibition

**June 2-3, 2021 | Digital Event**

**1<sup>st</sup> Natural Hydrogen**

**Worldwide Summit**



**The first H Natural forum took place in June**

<https://www.hnatsummit.com/>

**H-Nat Summit : first opportunity** for all stakeholders to introduce or learn about this **new promising market**, showcase their **latest H2 discoveries, exploration activities, products & services**, build partnerships, establish and grow business relationships, raise financing, assemble teams...

H-Nat Summit opens up a fresh competitive **playing field** for conventional energy players. Alongside them, **new businesses and entrepreneurs** from **various sectors** was also showing interest in this promising **new market**, with start up, research groups, monitoring or academic partnerships already in place to ensure they do not miss the H<sub>2</sub> opportunity.

**This first forum** has been an **opportunity** for all stakeholders to showcase their **latest products & services**, build partnerships, establish and grow business relationships, raise financing, assemble teams... 750 attendees


Second edition is expected to take place in June 2022.  
AAPG included the topic in their International meetings of 2022 (ICE- April Cartagena-Colombia; May Budapest-Hungria)

**Side event at the COP 26 organized by the Glasgow Uni**









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**To conclude...**

**Exploration of H<sub>2</sub> is starting, it is a very promising way to go real green H<sub>2</sub>... and a new decarbonized resources for couple of countries**



| To finalize   | To test  | Just to use and to improve  |
|---|--|---|
| <br>U: mobility, aircraft<br><br><br>T: by boat/ H2 liquefied<br><br><br>P: by photocatalysis<br><br><br>P: from biomass through syngas<br>P: from Iron industry wastes | <br>U: mobility, boat<br><br><br>T: by boat with organic solvent<br><br><br>T: by pipe blend H2/gas nat<br><br><br>P: Photobioreactor<br><br>P: plasma torch Technology | <br>U: mobility, car, train, bus<br><br><br>P & U P2G<br><br><br>P & U : Reversible electrolyzer<br><br><br>S: Subsurface<br><br><br>P : Acalin Electrolyzer<br>P : PEM Electrolyzer<br><br>P: H2 natural |

TRL

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## To know more

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