

Natural hydrogen exploration in South Australia

Elinor Alexander

Director Geoscience and Exploration Branch

Energy Resources Division

Department for Energy & Mining



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HYDROGEN

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Will natural hydrogen be Australia's next gold rush?

...ing interest — and significant investment —

... gold rush, which could prove as exciting as back in discovered shimmering flecks in a waterhole near uing interest from domestic and international miners

... as a novel 21st century focus with players targeting

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Gold hydrogen takes to the stage in Australia, but questions remain

Gold hydrogen is garnering attention in Australia as a potential competitor to blue and even green hydrogen, but critics say that gold hydrogen comes with considerable methane emissions and may not be volumetrically significant.



A presentation on May 19 by Geoscience Australia on gold hydrogen was named winner of the best technical presentation at this year's Australian Petroleum Production & Exploration Association (APPEA) conference in Brisbane.

magazine.com/2022/02/02/natural-hydrogen-exploration-boom-snaps-up-one-third-of-south-australia/

Natural hydrogen exploration 'boom' snaps up one third of South Australia

South Australia has found itself at the heart of a 21st-century gold rush, though this time for naturally occurring hydrogen. Since February 2021, 18 exploration licenses have been granted or applied for in the state by six different companies searching for natural hydrogen.

FEBRUARY 2, 2022 BELLA PEACOCK

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Underground salt caverns (pictured) have been posited as a potential place to store hydrogen, but it seems hydrogen may already be abundant in gas form under our feet. Explorations companies are newly scrambling to find out.

Image: Guilhem Vellut, flickr

South Australia's new 'gold' rush is hydrogen

Exclusive

South Australia's new 'gold' rush is hydrogen



Angela Macdonald-Smith Senior resources writer

Jan 31, 2022 - 5:00am

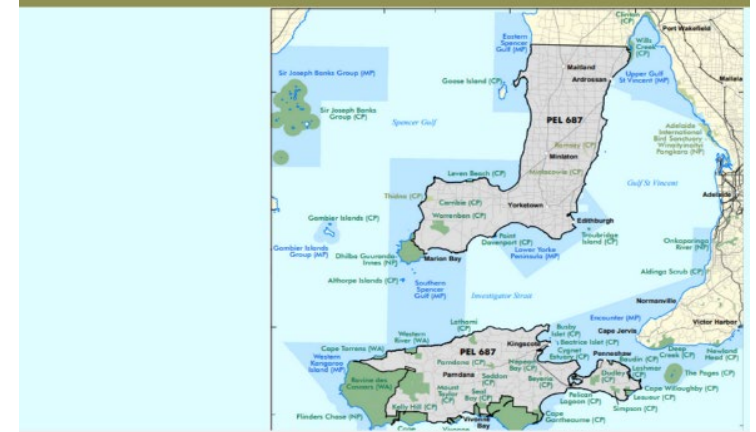
Acreeage covering almost a third of South Australia has been snatched up by entrepreneurial explorers in search of "gold" hydrogen deposits that they believe could easily undercut the cost of manufacturing the clean fuel.

In less than 12 months, six companies have taken up or applied for 18 exploration licences targeting so-called "gold" hydrogen, named for its natural occurrence and sustainable profile, covering 32 per cent of the entire state, according to consultancy EnergyQuest.

FUTURE OF ENERGY OPERATIONS MARKETS INSIGHT & STRATEGY RESEARCH

One third of South Australia pegged for native hydrogen exploration

AUSTRALIA'S government is pushing hard to get the cost of hydrogen down to A\$2 per kilo by 2030 but some little known frontiersmen in South Australia believe they can cut that by 75%.



Future Of Energy > Hydrogen

07 December 2021

Out in the dry of the state, there could be a best estimate prospective resource of 1.3 billion kilos of hydrogen (1.3 billion tonnes), based on a basement interval of 86 metres and is currently being appraised by a new company which suggests if converted to electricity could power one million homes for 40 years.

Comments

Share

Native, or native, hydrogen is the latest buzzword picking up steam in the Australian energy industry, though as yet commercial concentrations are yet to be found. However, since February, the state government has awarded 18 petroleum licenses for six companies looking

Why South Australia #1?

SA was put on the map of natural hydrogen occurrences in 2019-21 scientific papers (e.g. Zgonnik's comprehensive global review in 2020, Moretti et al. 2021) as a result of shows in drillholes and possible fairy circles.

Regulatory changes to enable natural hydrogen exploration have also attracted national and global interest.

Mali - Bourabougou Field is the world's only hydrogen producer – used for local electricity generation over the last 7 years.

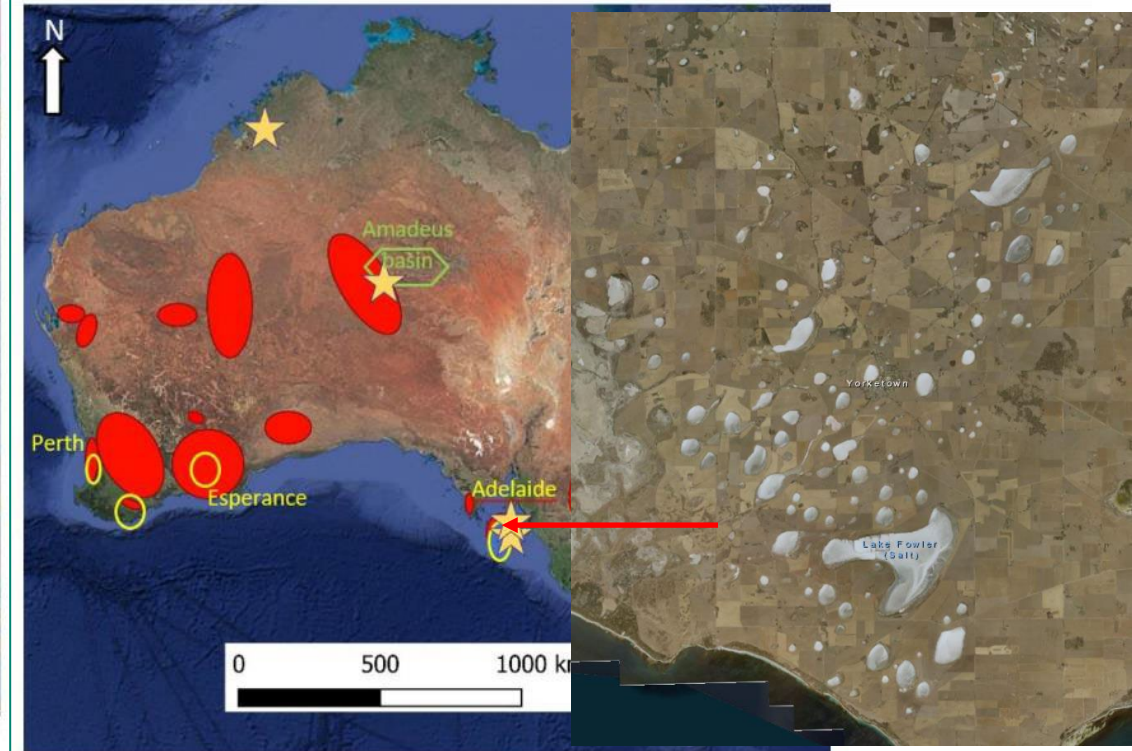
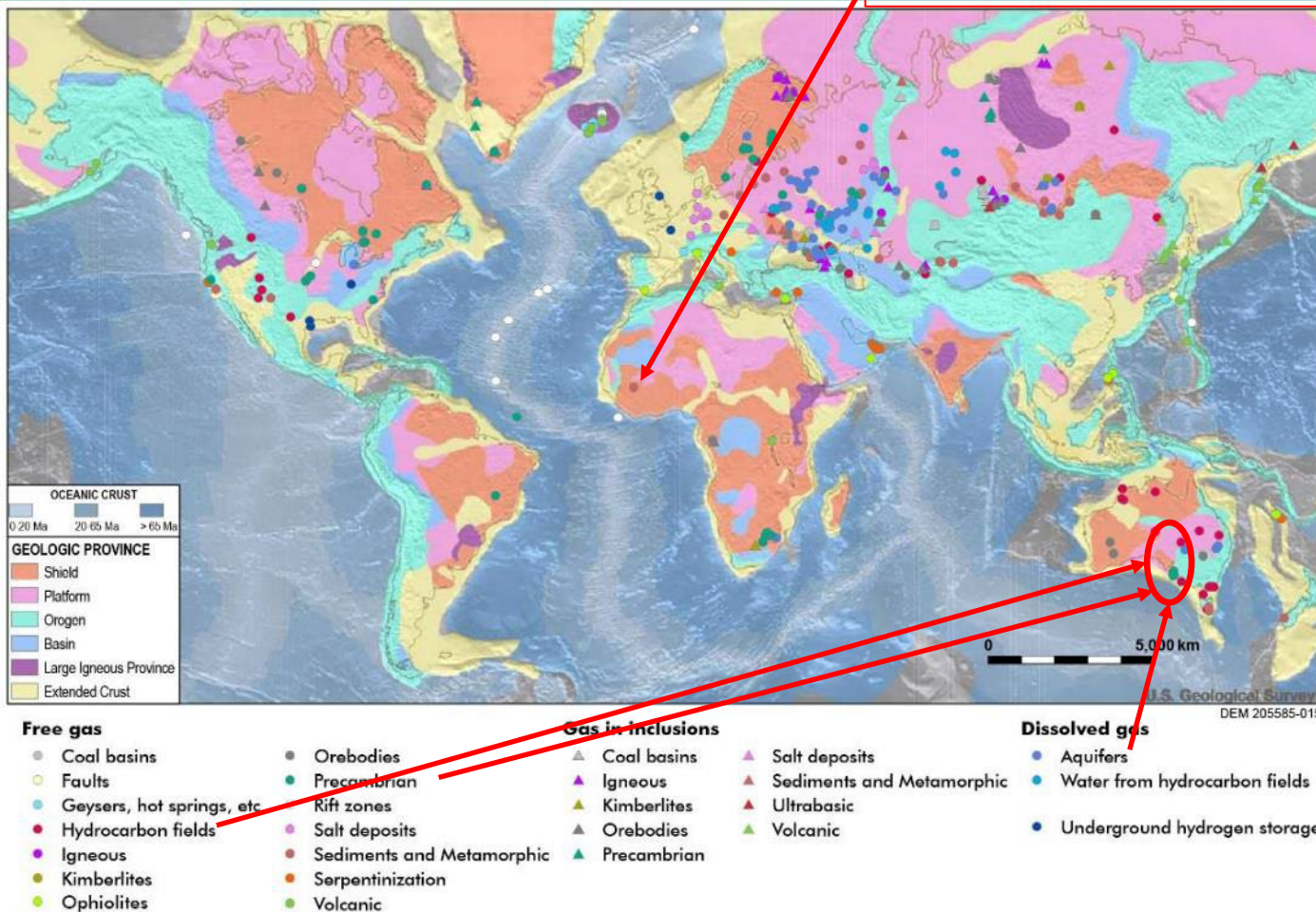


Figure 5. Location of the areas with many circular depressions in Australia (red areas). The yellow stars are the location of the wells that found H₂, the yellow circles highlight the areas where depressions that look like fairy circles can be observed and where statistic has been done in this study.

Moretti et al. (March 2021)



Why South Australia #2?

- Licensing, regulatory and investment frameworks are in place.
- Natural hydrogen exploration become possible in February 2021 via regulatory changes to include hydrogen as a 'regulated substance' – joining petroleum, CO₂, H₂S, He, N and substances produced with petroleum.
- DEM's online historical records revealed significant hydrogen contents from Government analyses of gas samples from 3 old, relatively shallow drillholes:
 - **1915 – Robe 1 (25.4%) TD 1372m – Limestone Coast**
 - **1921 – American Beach Oil 1 (64.4-80%) TD 292m – Kangaroo Is**
 - **1931 – Ramsay Oil Bore 1 (51.3-68.6%) TD 548m – Yorke Peninsula**
- SA has potential hydrogen source rocks – e.g. iron-rich and uranium-rich rocks in Archaean-Proterozoic basement provinces.
- Salt lakes on Yorke Peninsula and Kangaroo Island have been postulated to be fairy circles caused by hydrogen seeps (e.g. Moretti *et al.*, 2021).
- Easy access to free online data and reports.

Cores, cuttings and rock samples available to view and sample at the DEM Tonsley Drill Core Storage Facility.



“Collecting gas from the Ramsay Oil Bore 1 near Minlaton in 1931. The well reached ~548m, and a small gas flow of almost pure hydrogen was recorded.”

Legislative framework

Have **yourSay** on the
Hydrogen and Renewable Energy Act

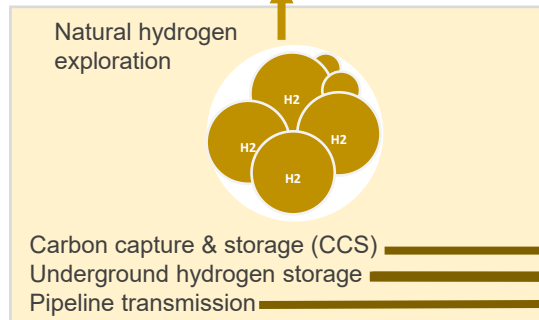
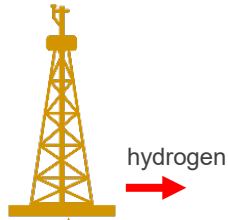


Petroleum & Geothermal Energy Act 2000

Provides a single window into government for natural hydrogen.

Includes underground storage and transmission pipelines for all 'colours' of hydrogen.

Natural (gold, white) hydrogen

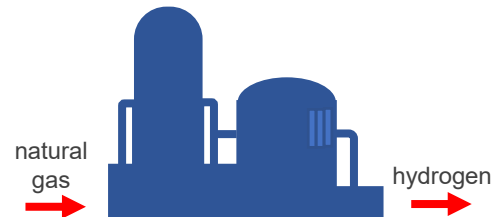


Hydrogen and Renewable Energy Act

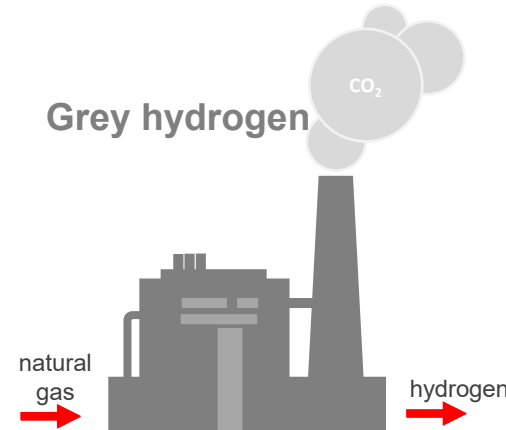
- covers all manufactured/generated hydrogen

- **public consultation open until 10 February 2023**

Blue hydrogen



Grey hydrogen



Green hydrogen



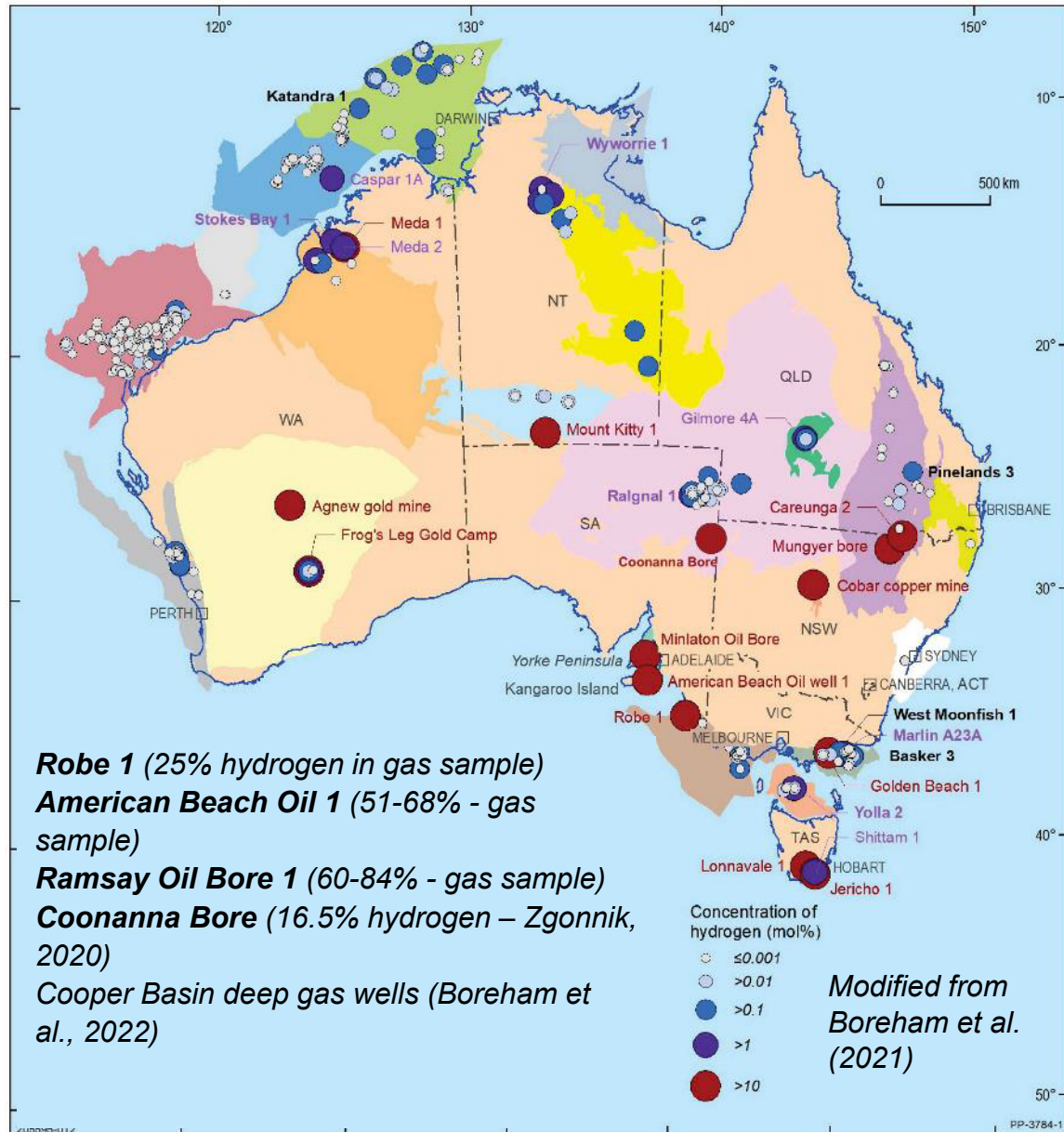
Potential SA natural hydrogen sources and indications



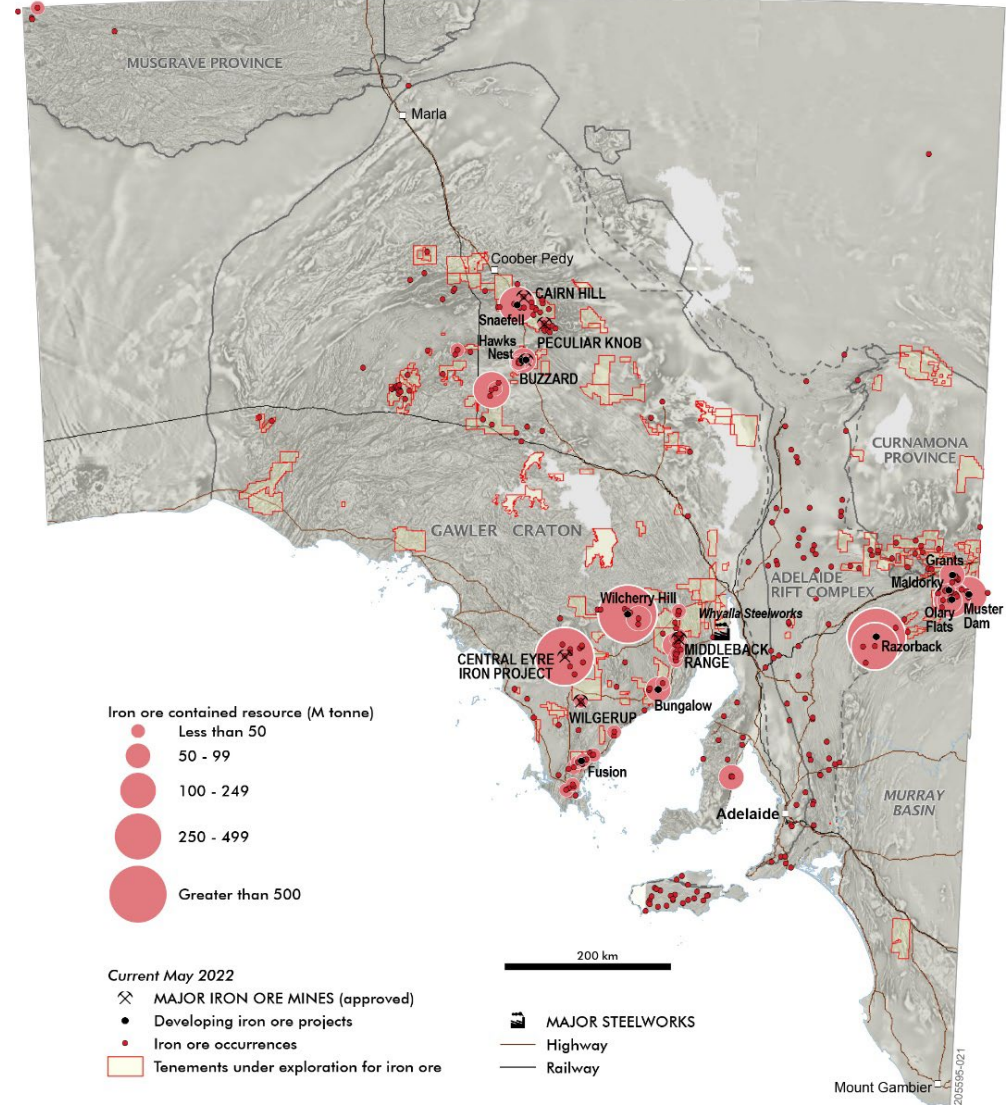
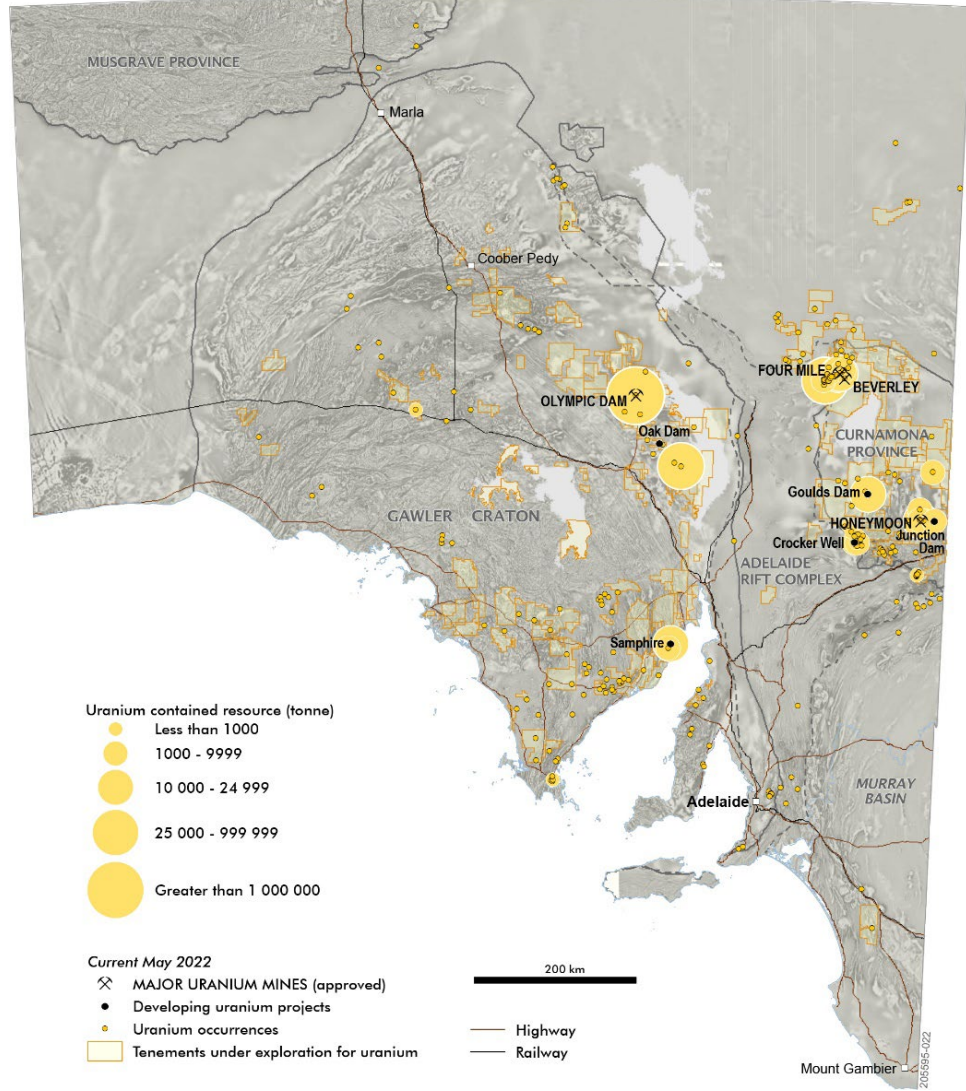
- Ancient basement complexes which contain iron and/or uranium rich rocks** e.g. Archaean greenstone and Precambrian basement terranes, 'hot' granites' - generate hydrogen via:
 - radiolytic processes (radioactive decay breaks bonds in water)
 - oxidation of Fe²⁺-rich minerals (serpentinization).
- fractured and seismically active source areas** - deep-seated faults can both channel migrating hydrogen up from deep sources to surface and introduce water downward for further chemical reaction with exposed iron-rich rocks. Cataclasis can generate hydrogen too.
- Hydrogen indications in drillholes.**
- Sedimentary cover may reservoir and trap migrating hydrogen particularly if **aquifer systems and /or seal rocks like salt** are present.
- Biogenic and abiogenic (thermal) **decomposition of organic matter** (e.g. Boreham et al. 2022 – over mature source rocks in the Cooper Basin).

Surficial hydrogen seeps? Seeps can be blind or coincident with visible sub-circular topographic depressions on the metre to kilometre scale (**'fairy circles'**).

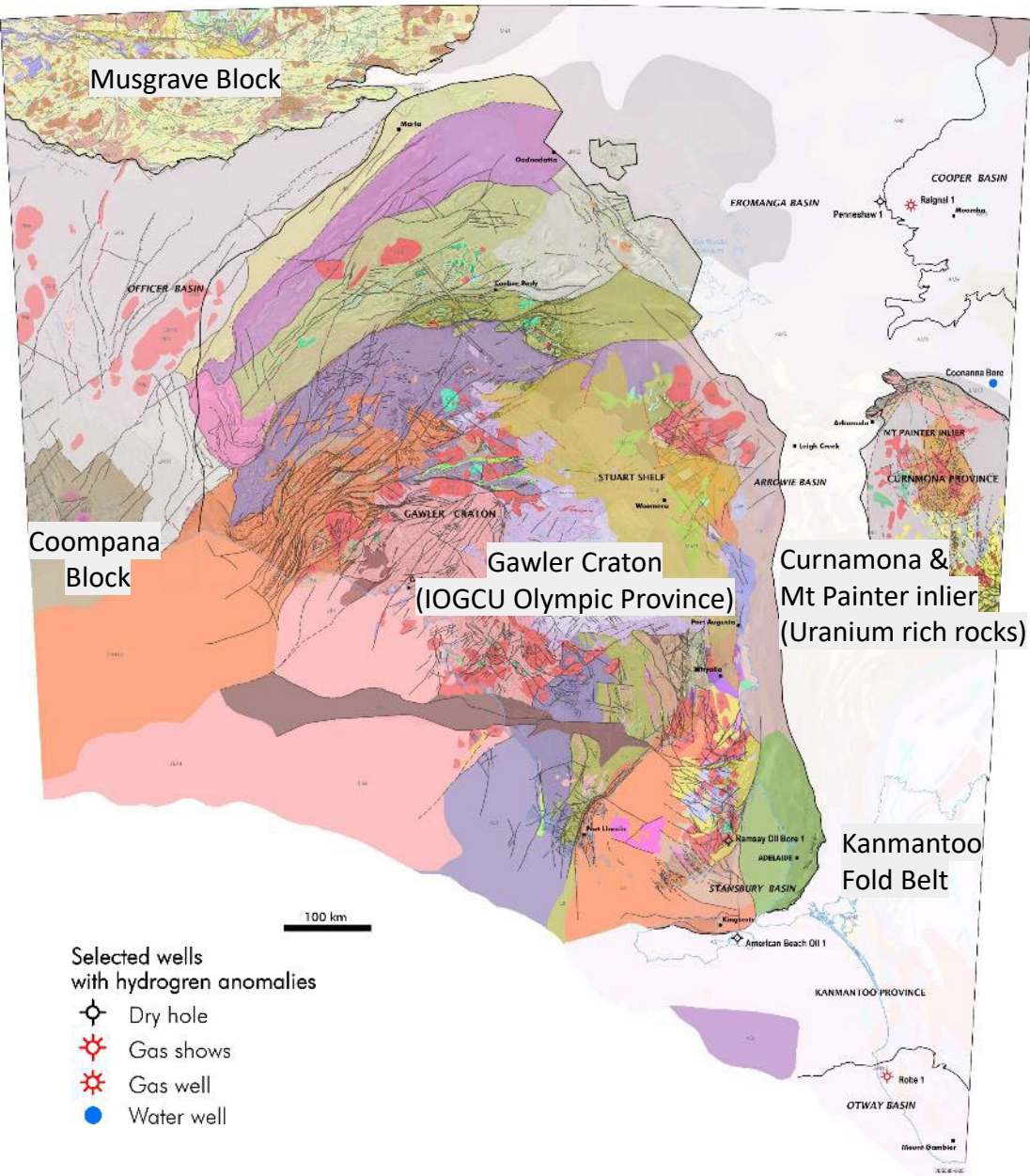
Thanks to Dr Betina Bendall (DEM-ERD) for her input to this overview



Uranium and iron mines and occurrences



Prospectivity – screening basement provinces



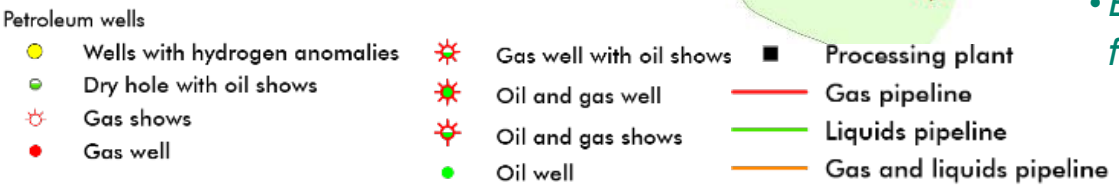
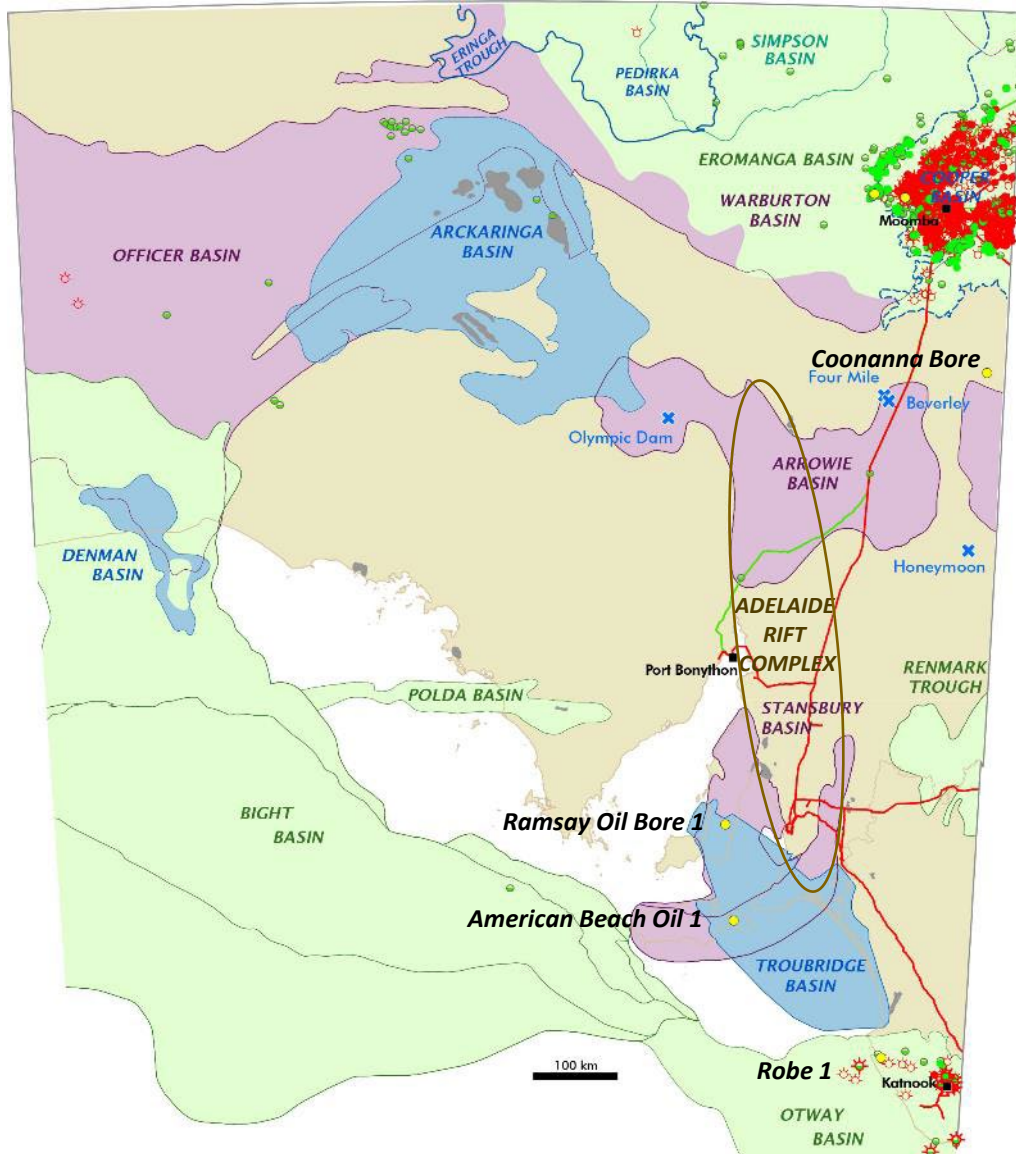
	Province				
	Coompana	Musgrave	Gawler	Curnamona & Mt Painter inlier	Kanmantoo Fold Belt
Hydrogen play elements					
Gabbros, mafics, ultramafic intrusives	Green	Green	Green	Green	Green
Iron-rich granitoid/intrusives	Green	Green	Green	Green	Green
Uranium-rich rocks			IOCGU*	Green	Green
Banded iron formations			Green	Green	Green
Ferruginous duricrusts		Green	Green	Green	Green
Structural complexity/deep active faults			Green	Green	Green
Hydrogen shows			Ramsay Oil Bore 1. Fairy circles on Yorke Peninsula?		American Beach Oil Bore 1. Fairy circles on KI?

* Iron Ore Copper Gold Uranium deposits

Thanks to Dr Betina Bendall (DEM-ERD) for her input to this overview



Prospectivity – screening basins



	Basin				
	Adelaide Rift Complex/ Arrowie Basin	Officer Basin	Stansbury Basin	Cooper/ Eromanga basins	Otway Basin
Hydrogen play elements					
Mafic intrusives/extrusives (source and seal)					
Iron stones					
Salt/anhydrite, aquifers (seal)					
Deep Faults					
Over-mature source rocks					
Hydrogen shows			Ramsay Oil Bore 1. Fairy circles?	Coonana 1, Ralgna 1 etc.	Robe 1 (mantle derived CO ₂ in Caroline 1, Nangwarry 1)

Boreham et al. 2022 at H-NAT:

- Free H₂ generated when dry gas generation is complete (Ro>3.5, >250C).
- Deep troughs in the Cooper Basin are potential sweet spots for hydrogen generated from over-mature coals and shales (Gidgee Energy in PEL 678, Nappamerri Trough).
- Estimated free hydrogen is 615-240 TCF – however the fate of the free hydrogen following primary migration is unknown.

Exploration methodologies

Axiom Sensing WHALI (White Hydrogen Autonomous Logging) Instrument - continuously monitoring natural hydrogen seeps in WA.

https://www.linkedin.com/company/axiom-sensing?trk=organization-update_share-update_actor-text



Soil gas sampling

E. Dugamin, L. Truche & F.V. Donzé (2019)



USGS 2022 “there is a growing acknowledgement that geoscientists have not looked for native H₂ in the right places with the right tools” (Mendenhall Fellowship Research Opportunity Nov 2022 - Detection and quantification

of natural hydrogen flux from the subsurface)

Screening

- Company exploration reports, well completion reports, maps, geophysical surveys, datasets, historical records (SARIG, PEPS).
- Satellite imagery/Google Earth to identify possible seeps.
- Source rocks – solid geology: mafics, granites, iron and uranium.
- Seals - subsurface salt, but can shales seal hydrogen? Aquifers?
- Cores – fluid inclusions, mineralogical studies.
- Analyses of existing gas samples (e.g. Boreham et al, 2021, 2022).

Field work

- Environmental approvals, stakeholder engagement, access notifications.
- Soil gas measurements (e.g. Frery et al. 2022, Truche et al. 2019).
- 24/7 monitoring of fairy circles/seeps (Moretti et al, 2021).

Surveys

- Geophysical – aeromagnetic, gravity, radiometric, resistivity surveys, magnetotelluric surveys, seismic.

Drilling

- Well bore design, engineering, drilling operations etc
- Specialised hydrogen detection equipment on the rig (e.g. Buru’s Currajong 1 and Rafael 1).

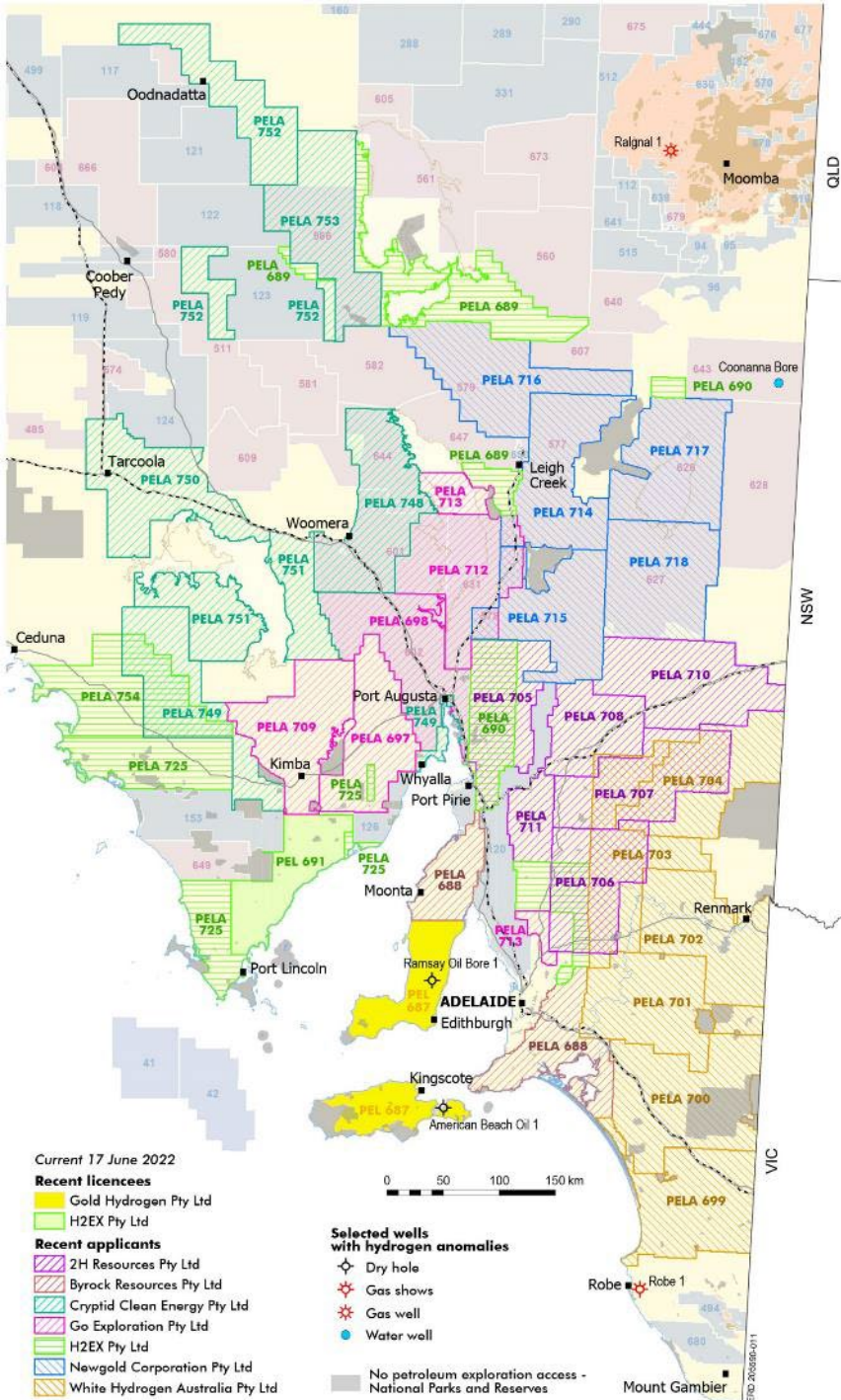


Natural Hydrogen Energy LLC (Zgonnik) – USA’s 1st hydrogen exploration well HoartyNE3, Nebraska. Now a JV with Australia-based Hyterra.

Hydrogen exploration status

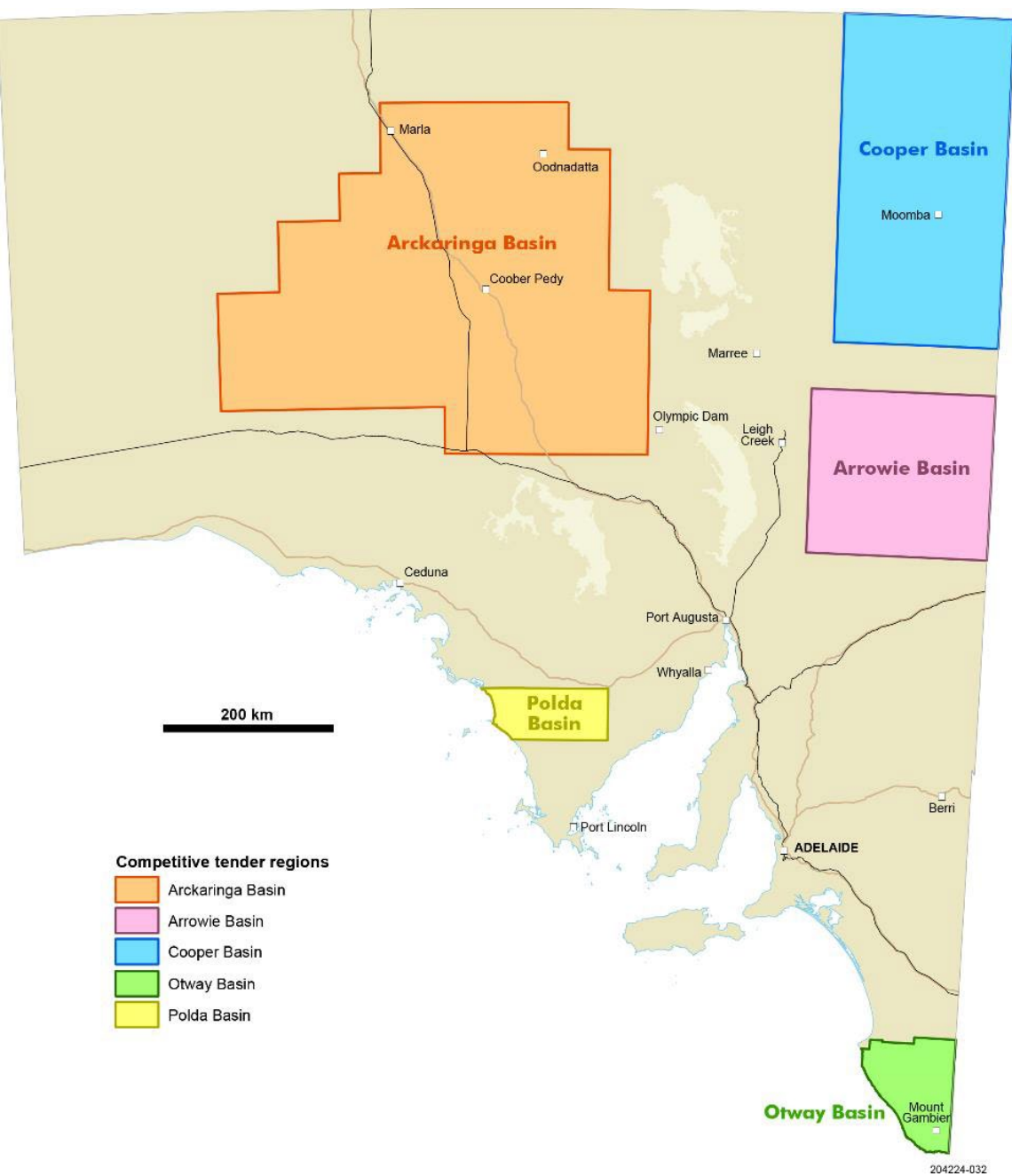
- In February 2021 the definition of a ‘regulated substance’ was expanded to include “*hydrogen, hydrogen compounds and by-products from hydrogen production*’.
- Companies can apply to explore for natural hydrogen via a Petroleum Exploration Licence (PEL) and transmit hydrogen via a Pipeline Licence.
- 35 PEL applications have since been lodged by 7 companies targeting natural hydrogen.
- 1st PEL was granted in July 2021 to Gold Hydrogen Pty Ltd (yellow).
- 2nd PEL was granted to H2EX in June 2022 (green).
- More PELs are currently being offered to applicants, once granted licence documents, including the work program, can be accessed via DEM’s online licence register.

A diversity of natural hydrogen plays will be tested by explorers.





New competitive tender regions



- On 10 November 2022 three additional Competitive Tender Regions (CTRs) were gazetted in addition to the existing Cooper and Otway CTRs.
- All Competitive Tender Regions now apply to all three categories of exploration licence: petroleum (regulated substances include natural hydrogen, helium, CO₂), geothermal and gas storage.
- Explorers and service companies now have the option to nominate release areas for vacant acreage in these regions.
- Acreage will be awarded by selecting the highest scoring 5 year exploration work program + financial and technical capacity of applicant.
- The new CTRs do not affect current licences and applications.
- ‘Over the counter’ applications may currently be lodged at any time elsewhere in the State not already under licence.

Conclusions

- It is early days for natural hydrogen exploration in Australia and globally.
- South Australia has prospective geology and evidence of natural hydrogen occurrences.
- Regulatory, licensing and investment frameworks are in place, enabling grant of Australia's first exploration licences targeting natural hydrogen.
- Upcoming company exploration activity in SA will test a diversity of natural hydrogen plays.



Government
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