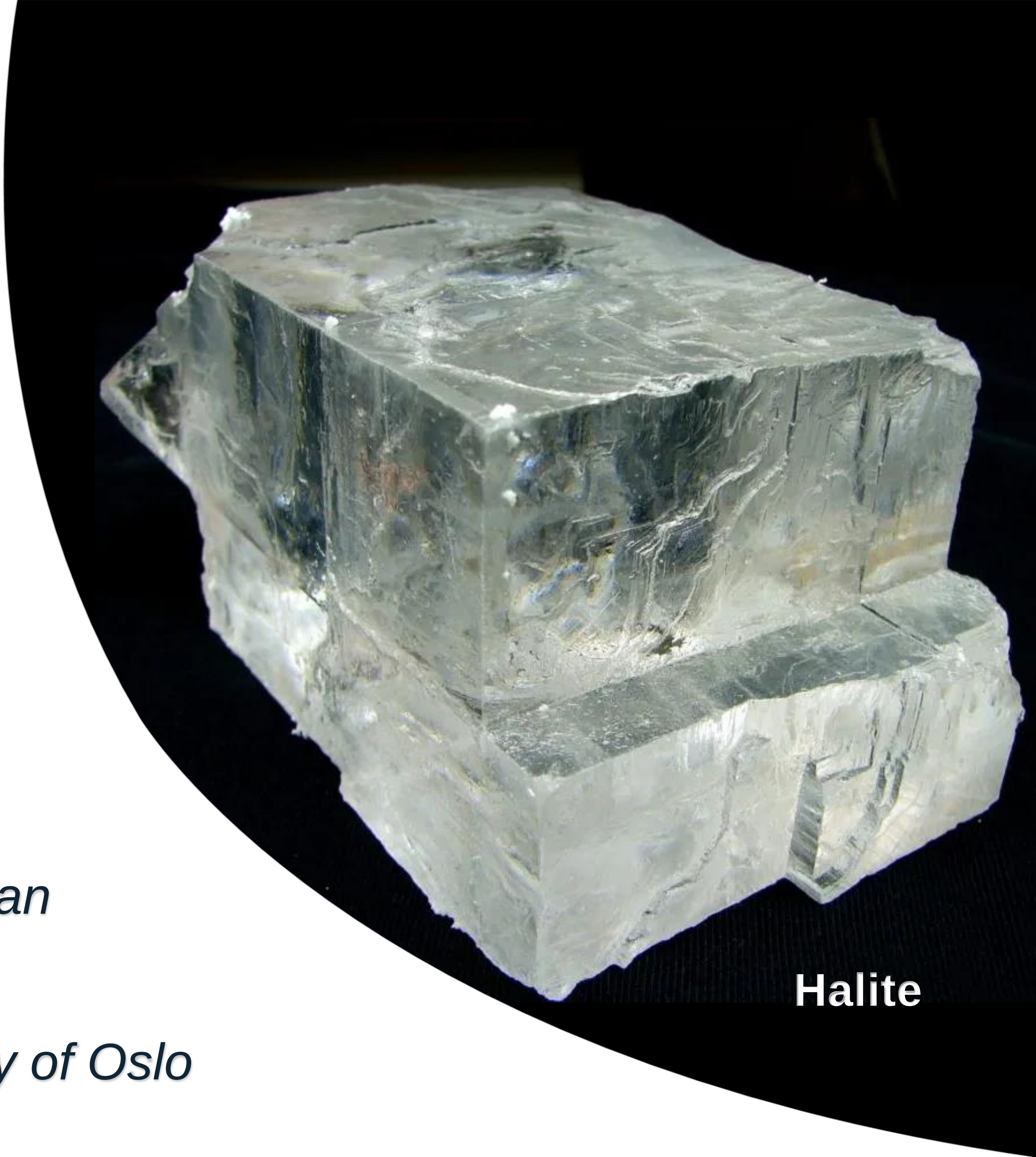
The race to Net-Zero by utilizing Australia's salt basins for holistic energy technologies

Lead Author: Dr. Rachelle Kernen

Co-Authors: Kathryn Amos, Ingrid Anell, Sian Evans, Leticia Rodriguez-Blanco

The University of Adelaide & The University of Oslo



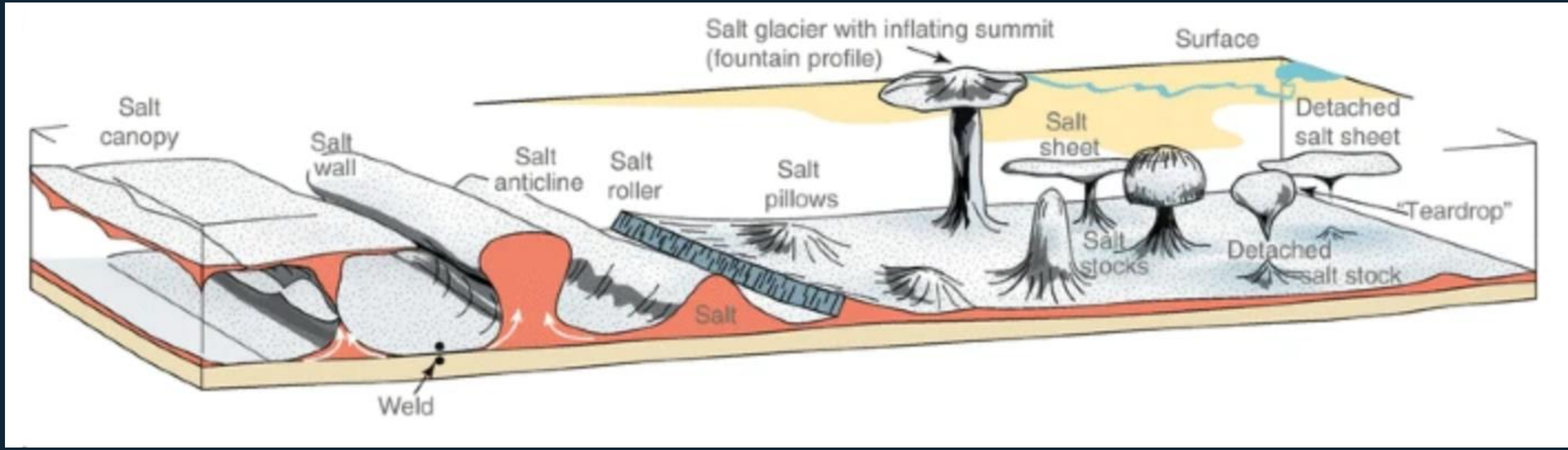
Acknowledgement of Country

I want to acknowledge the Aboriginal and Torres Strait Islander peoples of Australia. I acknowledge the traditional custodians of the lands on which I live, where the university is located, where I conduct my field research, and places I visit. I pay my respects to the ancestors and Elders past and present. I am committed to honoring Australian Aboriginal and Torres Strait Islander peoples' unique cultural and spiritual relationships to the land, water, sea, and sky and their rich contribution to society.

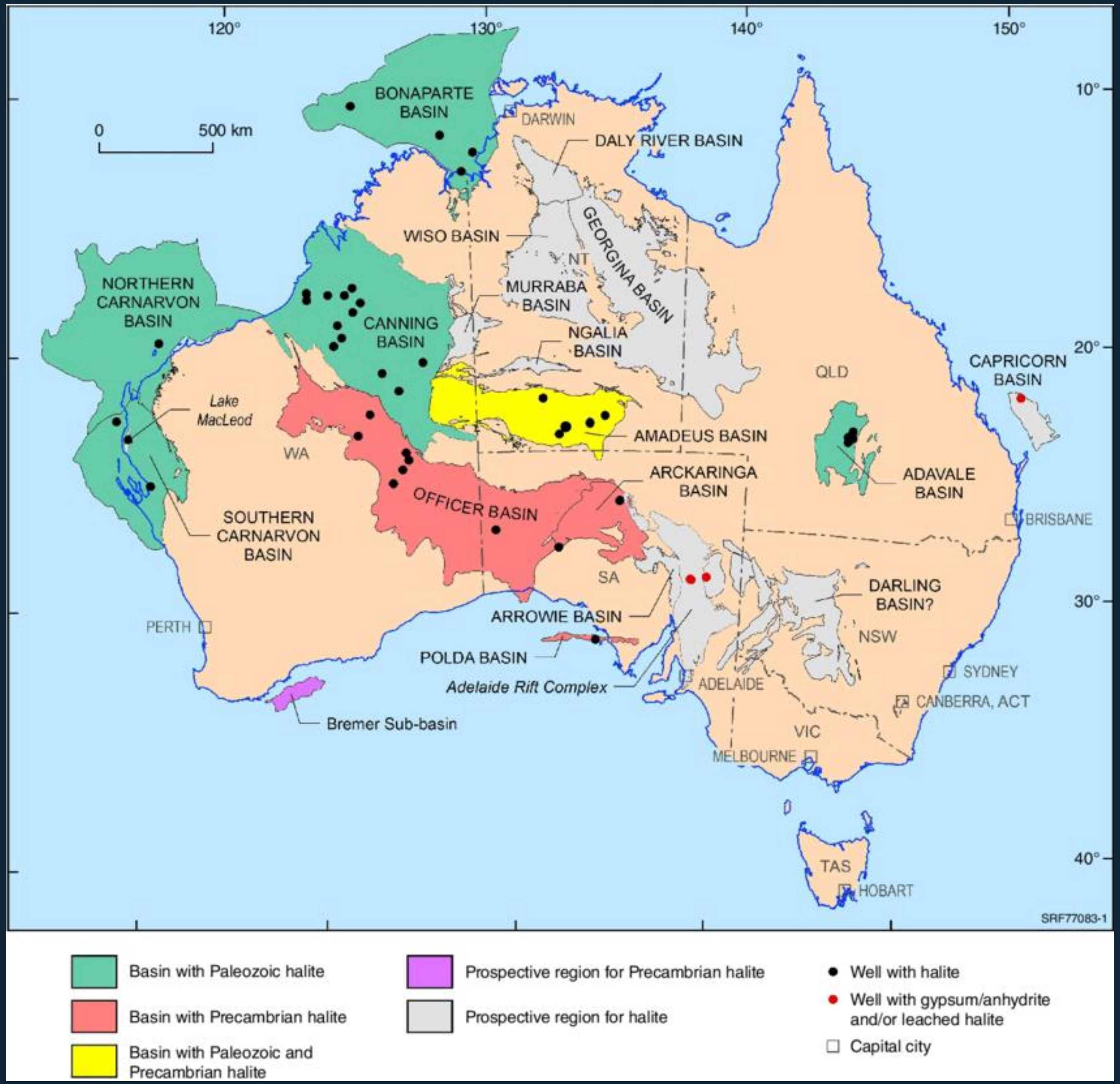
Wilpena Pound
Ikara-Flinders Ranges National Park
South Australia

Introduction to Salt Basins

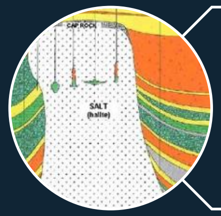
- Globally recognized
- Significant for petroleum systems and gas storage (caverns) outside of Australia
- Exciting potential for energy transition applications within Australia
- Many research gaps allow for development of new topics



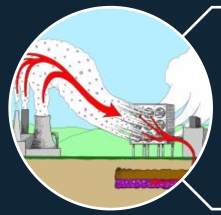
Australian Salt Basins



Bradshaw et al., 2023



Salt Caverns



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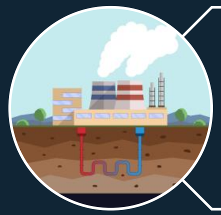
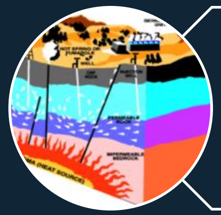


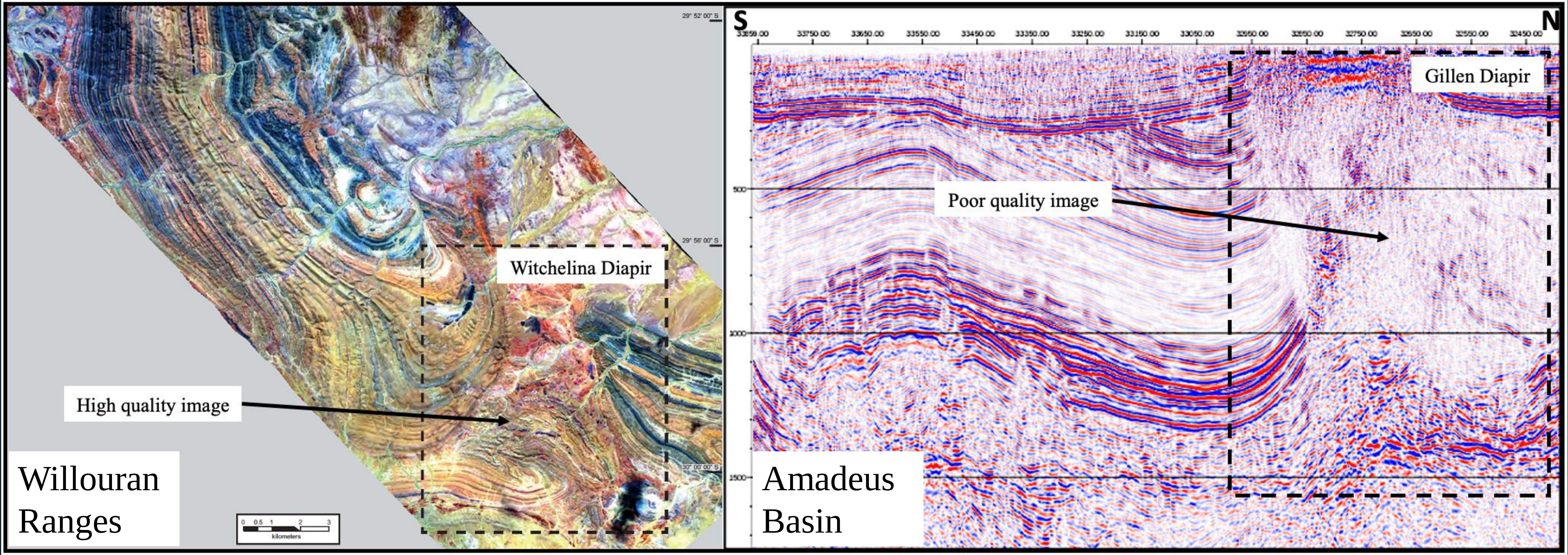
Geothermal Energy

Critical Minerals



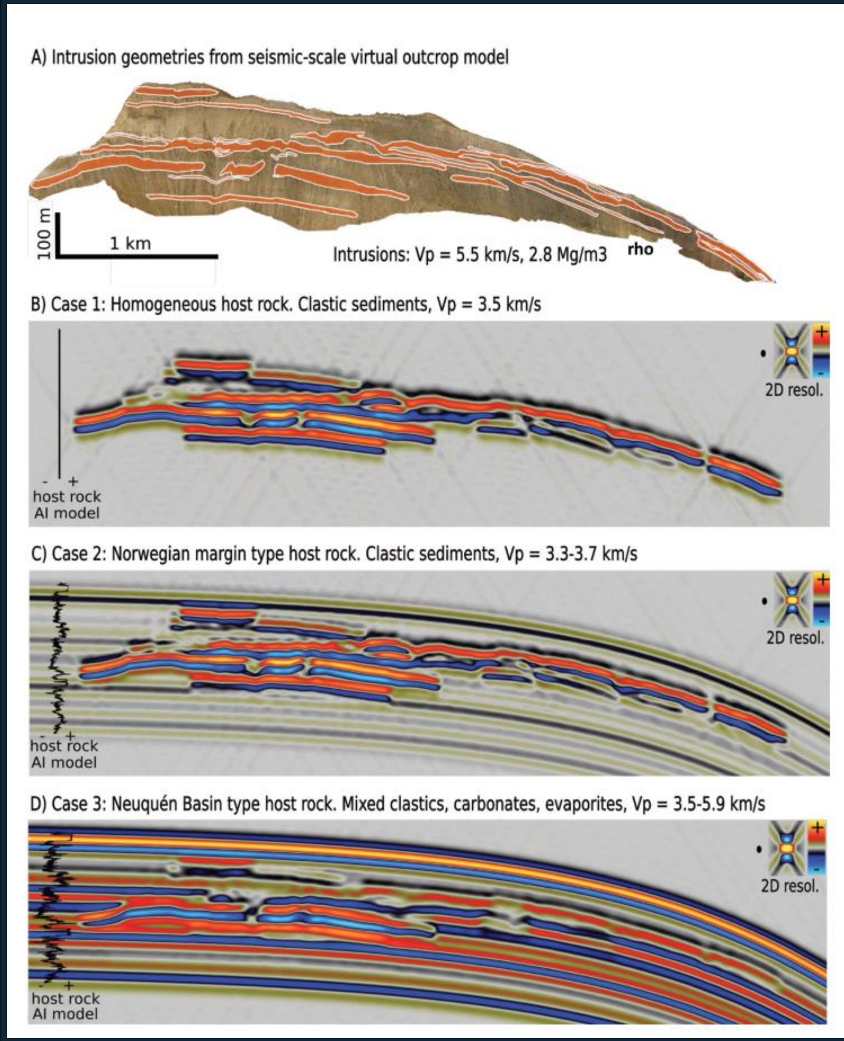
Natural Hydrogen

Outcrop Analogues – Inputs for Seismic Interpretation, Geophysical re-processing



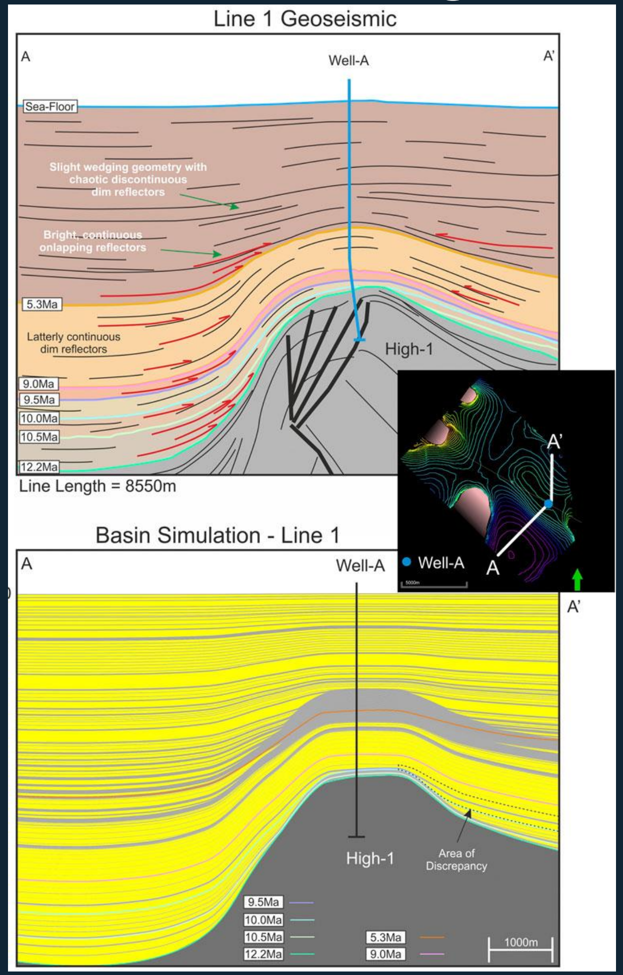
Outcrop Analogues – Inputs for Modelling

Synthetic Seismic



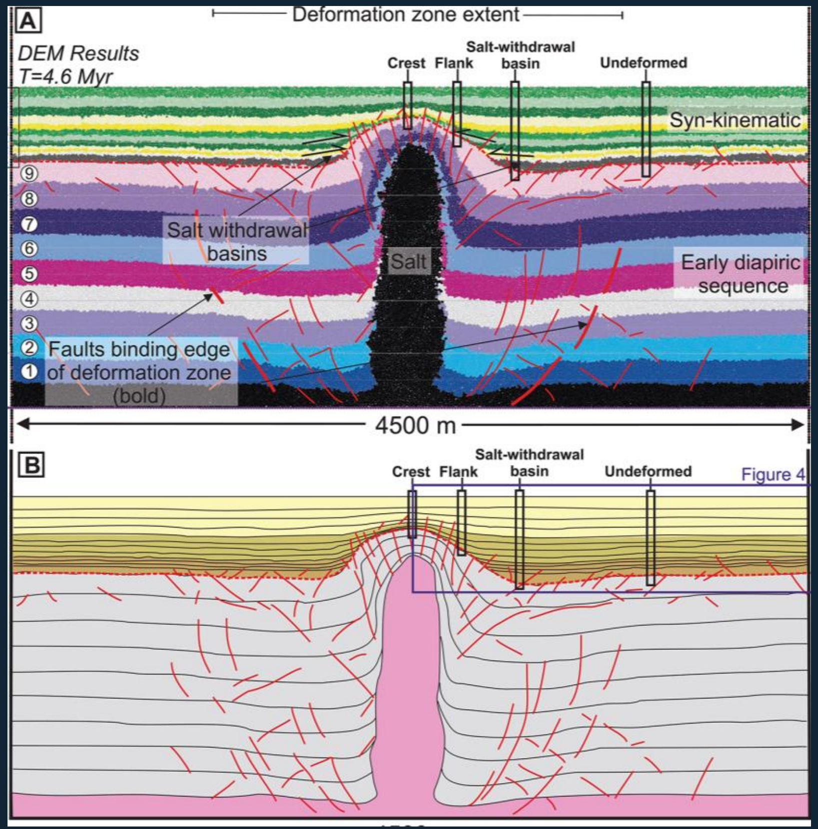
Planke et al., 2018

Forward Stratigraphic Modelling



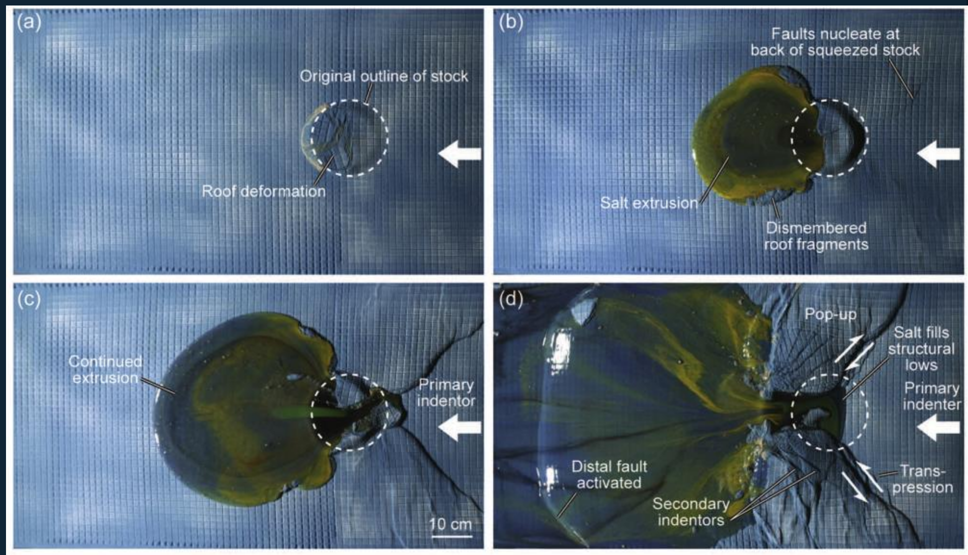
Christie et al., 2020

Numerical Modelling



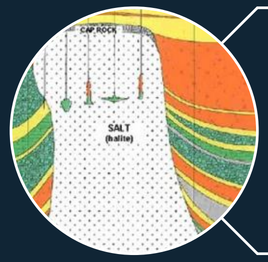
Cumberpatch et al., 2021

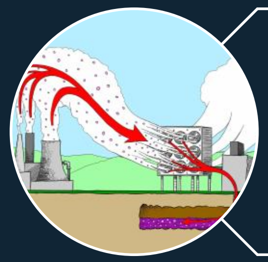
Physical Modelling



Dooley et al., 2018

Energy Storage


Salt Caverns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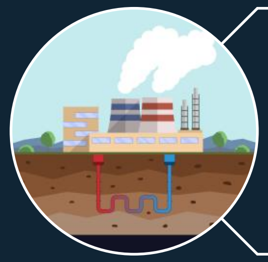
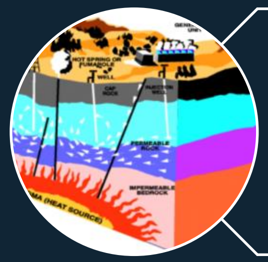
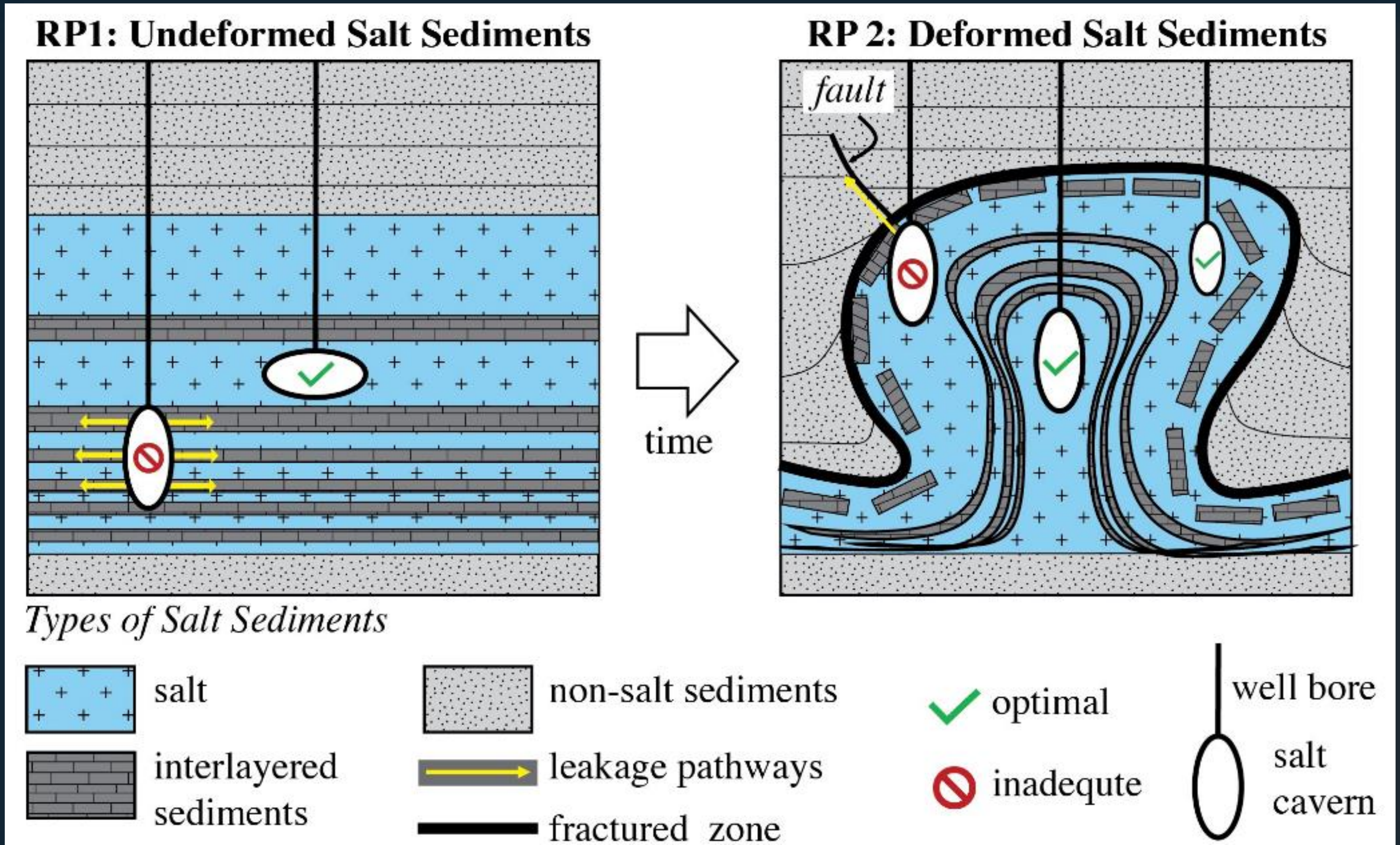

Geothermal Energy


Critical Minerals


Natural Hydrogen

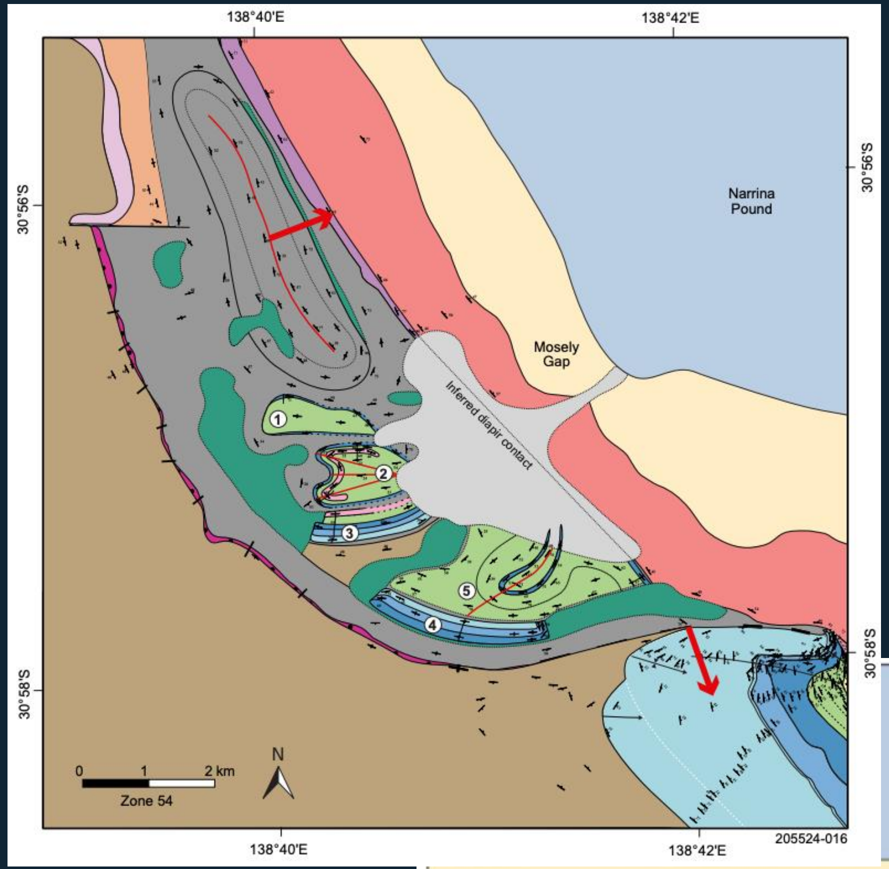
Energy Storage

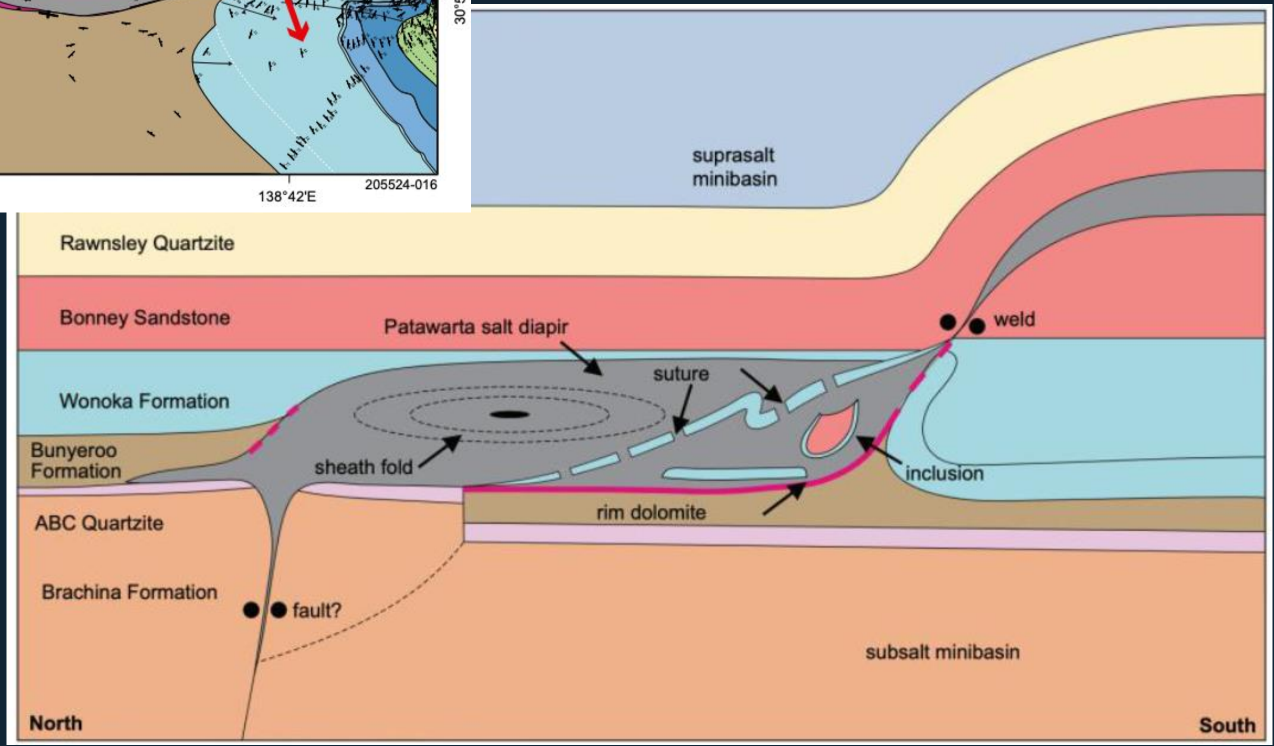


Kernen et al., 2024

- Undeformed salt sediments or layered evaporite sequences in sedimentary basins are found in abundance across Australia (approximately 15 basins)
- Deformed salt sediments or diapiric bodies are also common across Australia
- Need outcrop studies because there has not been an investment in high quality 3D geophysical datasets across Australia's salt basins

Energy Storage





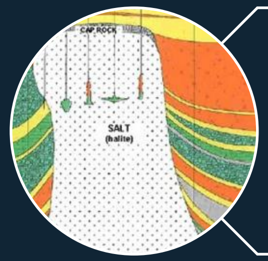
Kernen et al., 2021

Number of caverns per country (top 5 + the Netherlands)	
United States of America	781
Germany	337
Canada	207
United Kingdom	163
France	70
The Netherlands (11th)	9
Total number of caverns	1678

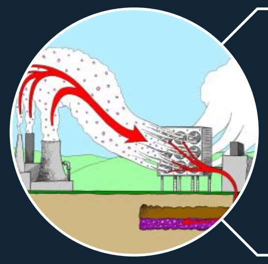
Storage product	Number of caverns
Natural gas	770
LPG	628
Crude oil	202
Unknown	53
Diesel	6
Helium	6
Hydrogen	6
Nitrogen	4
CAES	3

Country	Caverns in bedded salts	Caverns in domal salt	Unknown
Armenia	-	19	-
Canada	207	-	-
China	23	-	-
Denmark	-	7	-
France	-		70
Germany	134	189	14
Iraq	5	-	-
Mexico	-	13	-
Morocco	2	-	-
The Netherlands	2	7	-
Poland	2	18	-
Portugal	-	-	6 in salt walls
Russia	3	-	7
Turkey	-	-	6
United Kingdom	145	-	18
United States of America	468	313	-
Total (% of total number of caverns)	991 (~59%)	566 (~34%)	121 (~7%)
Incidents normalised to total number of caverns per salt type (in %)	~2%	~9%	~16%

Carbon Capture (Utilization) & Storage



Salt Caverns



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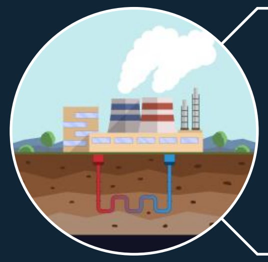
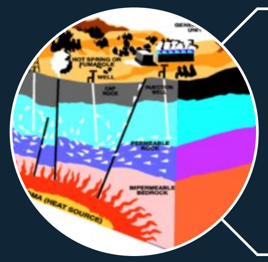


Geothermal Energy

Critical Minerals



Natural Hydrogen

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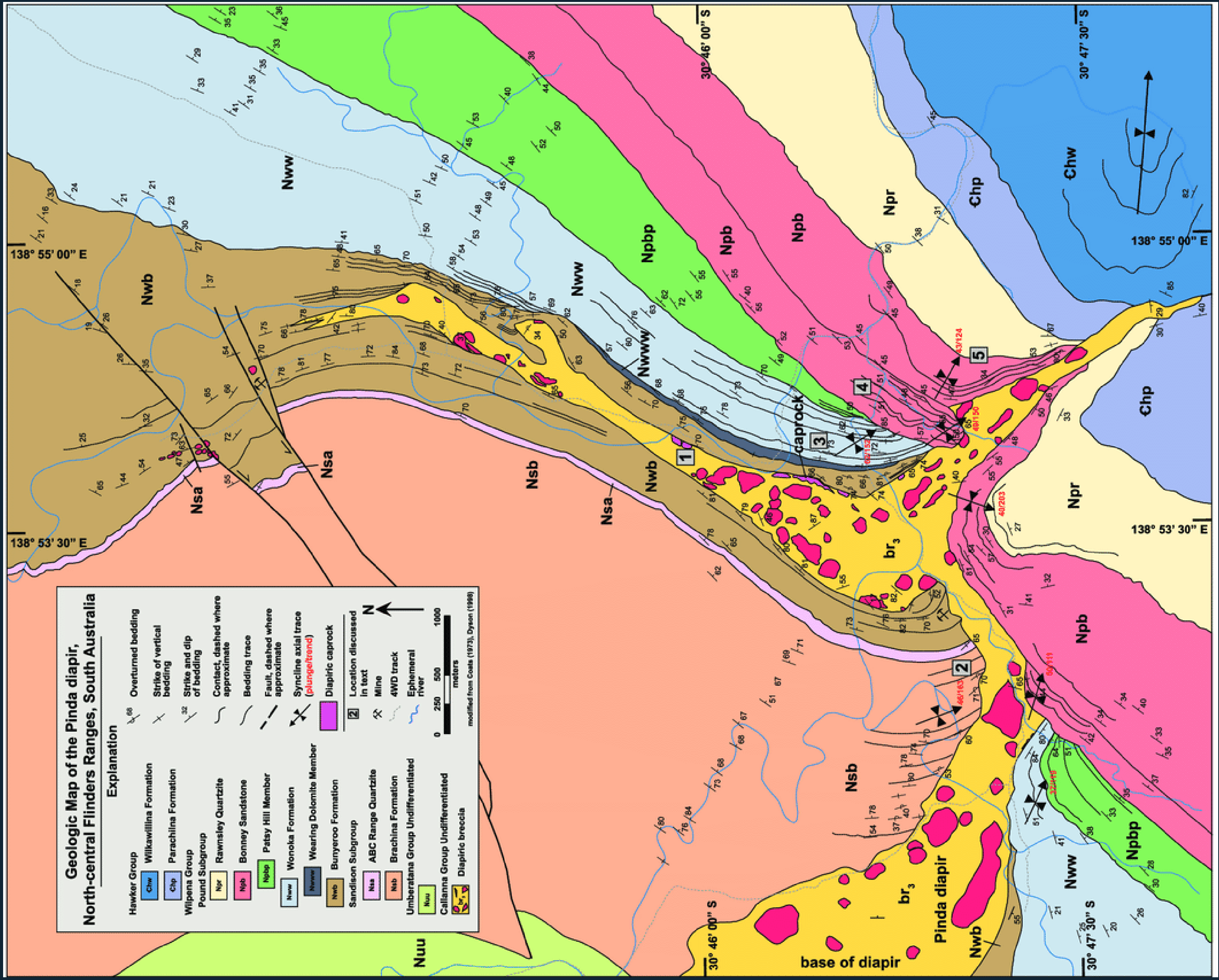
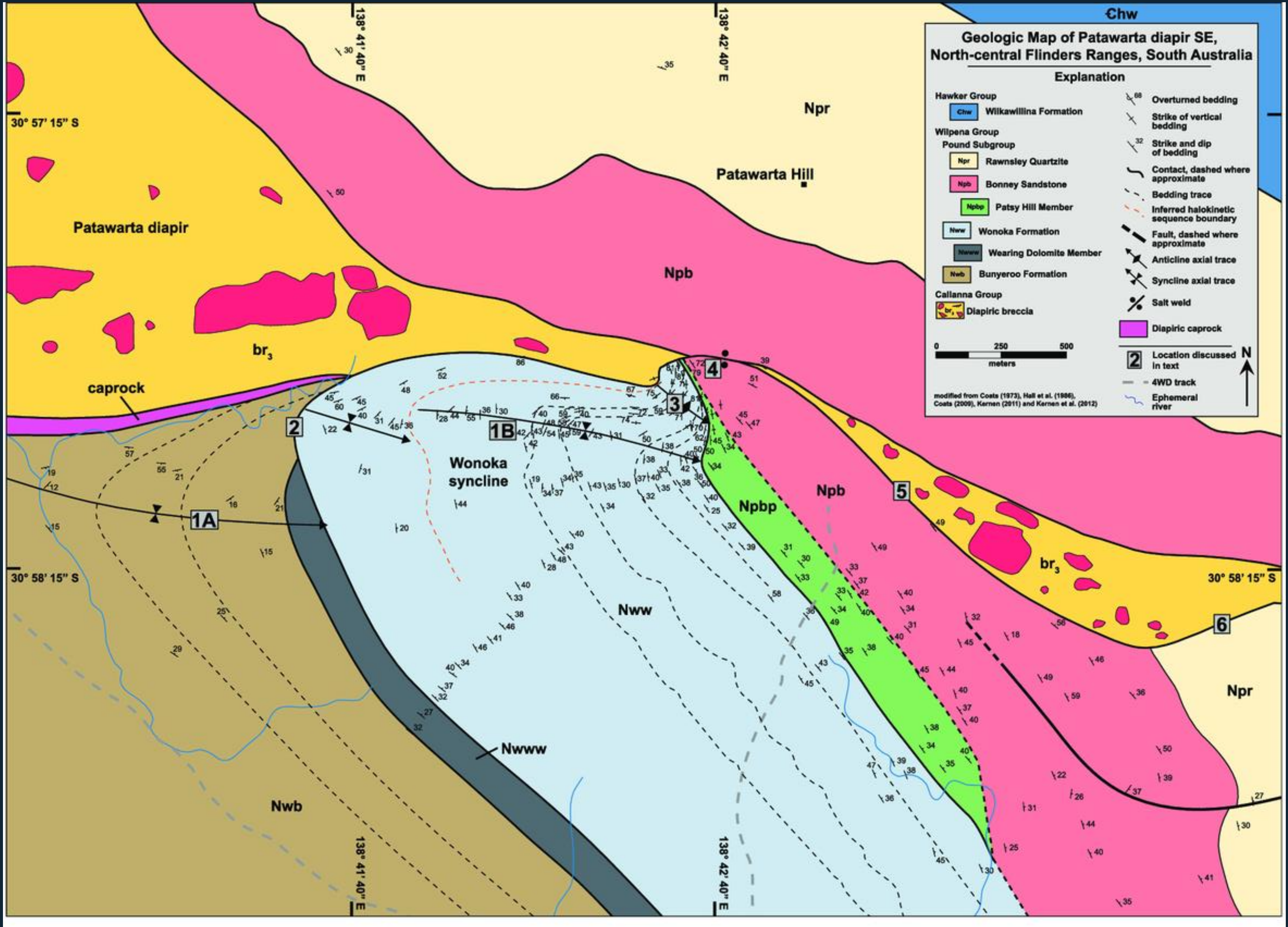
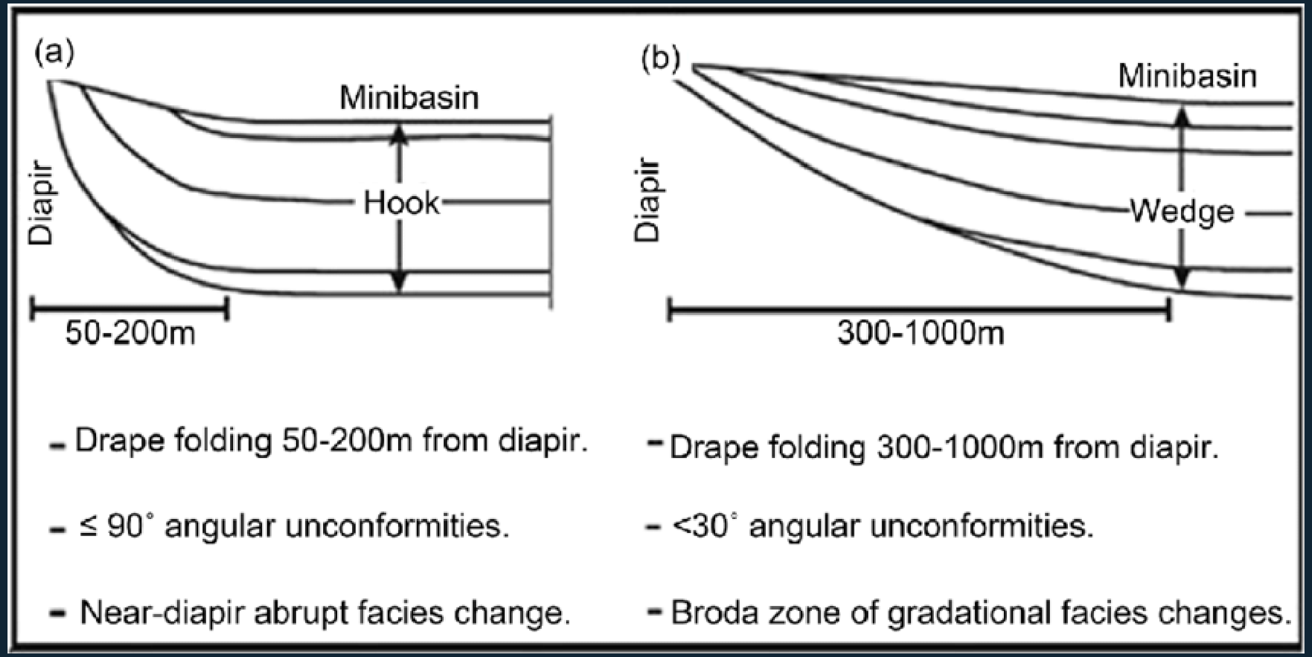


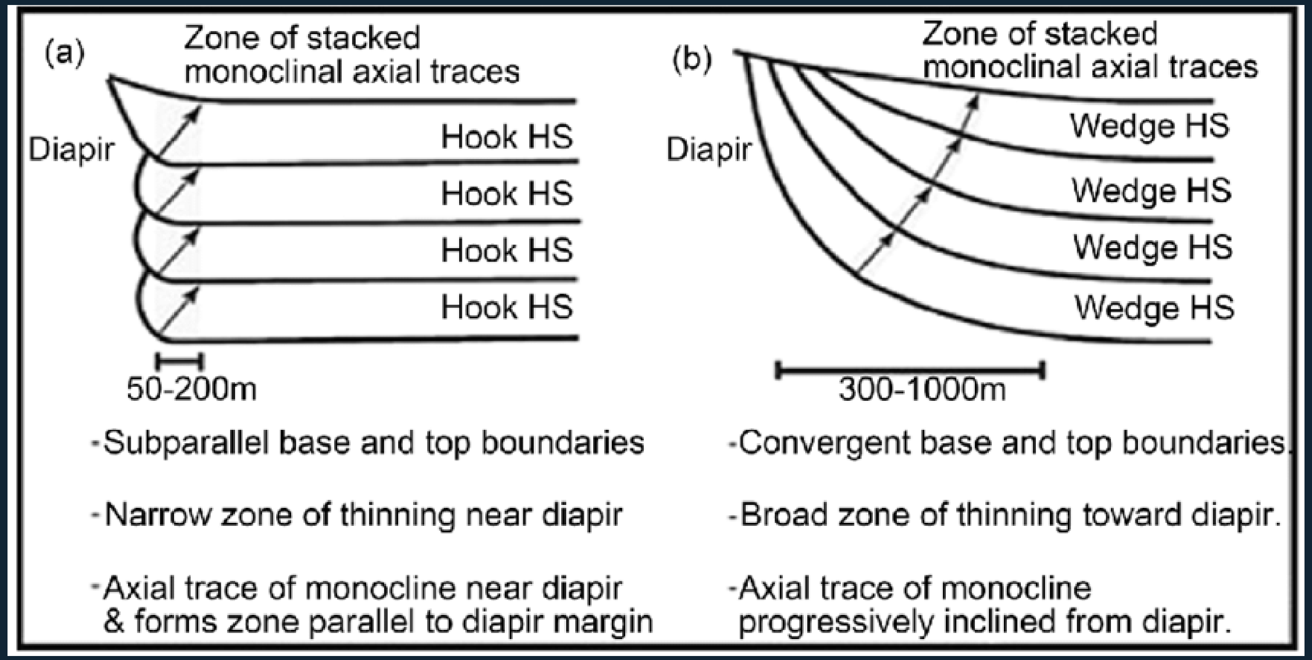
Hearon et al., 2015



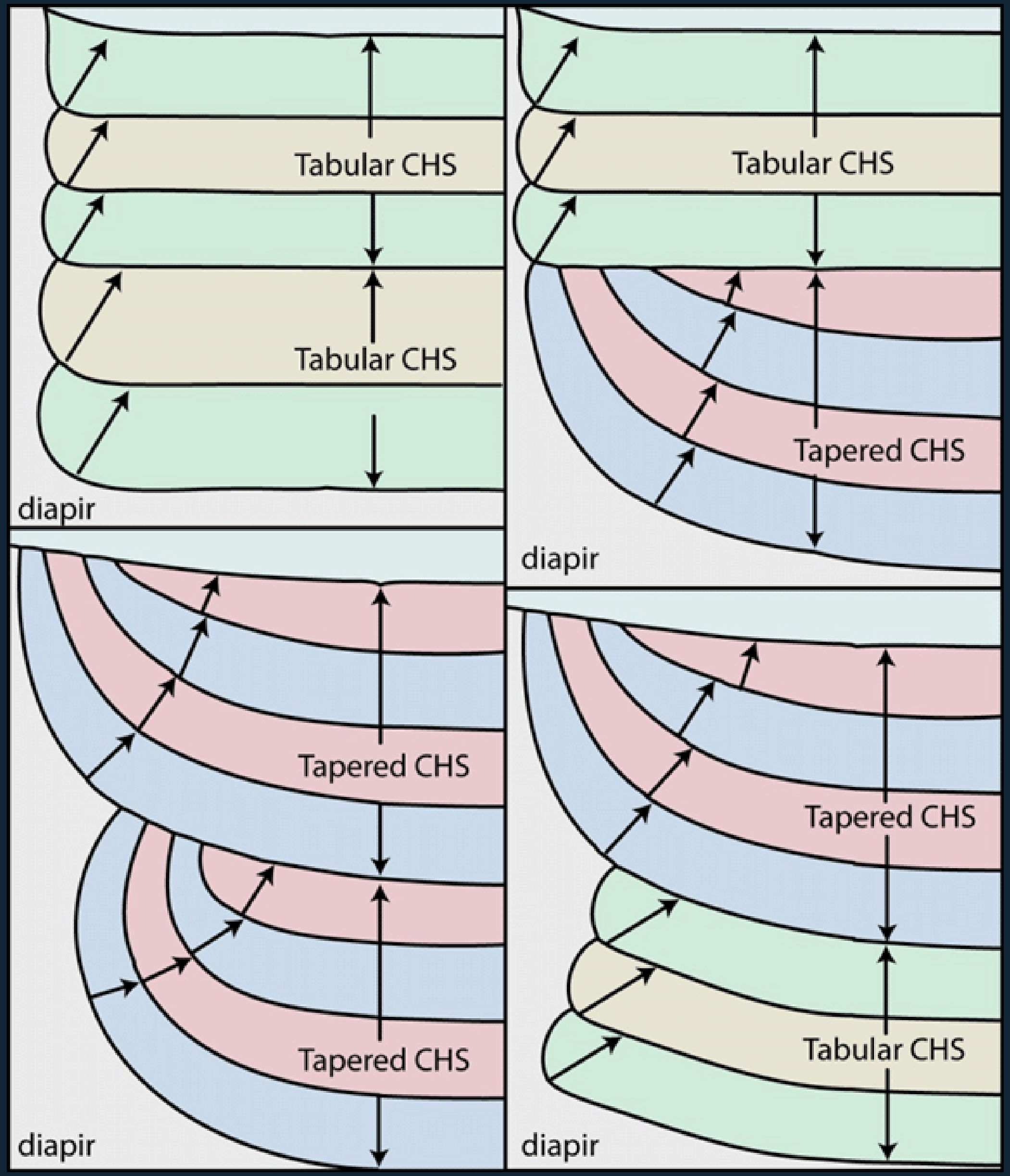
Kernen et al., 2012

Carbon Capture (Utilization) & Storage





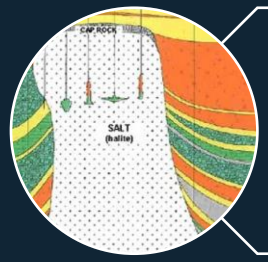
Giles and Rowan, 2012



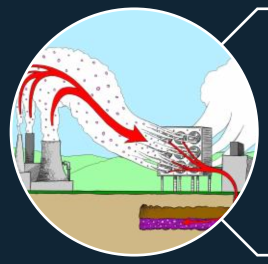
Giles and Rowan, 2012

- Continuation of petroleum geology studies
- Field analogues are key to characterize lateral facies changes and structural geology adjacent to and above diapiric bodies

Geothermal Energy



Salt Caverns



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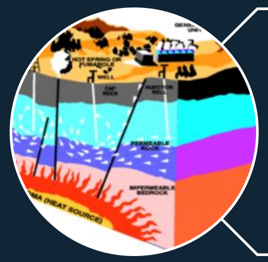
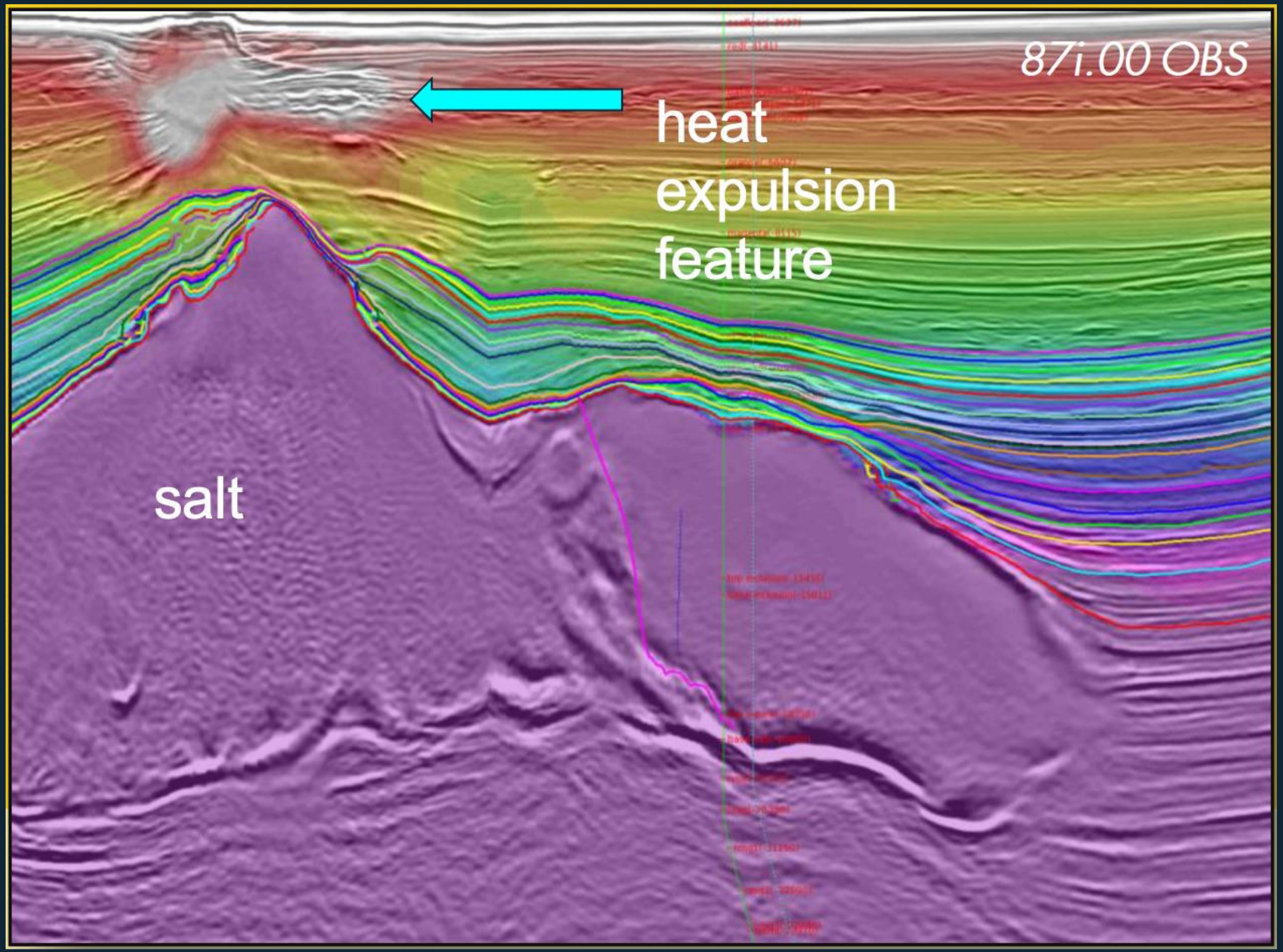
Geothermal

Critical Minerals

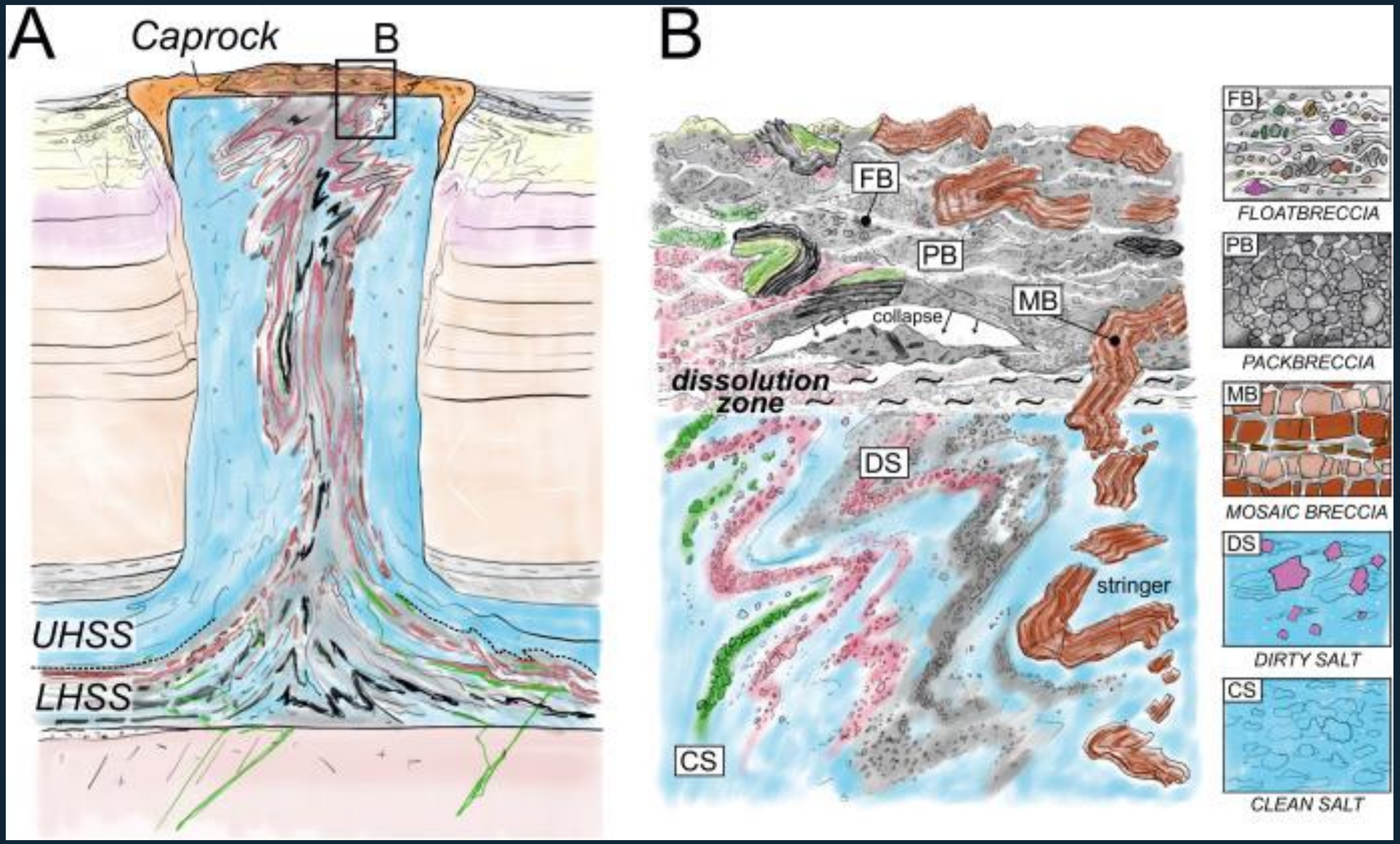


Natural Hydrogen

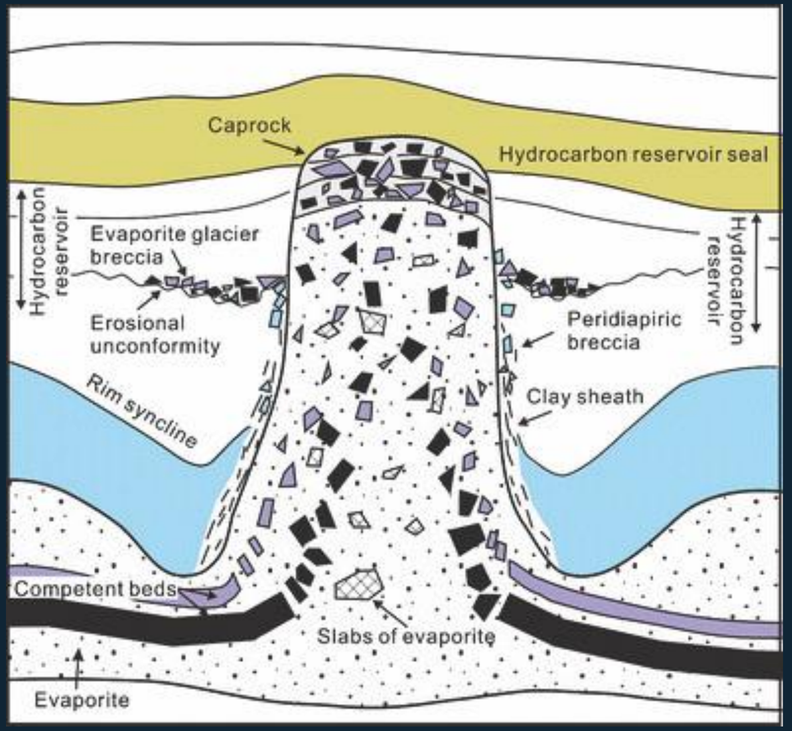
Geothermal Energy



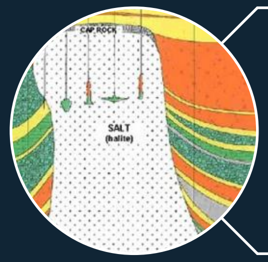
Kernen et al., 2014



Zavada et al., 2021



Critical Mineral Exploration



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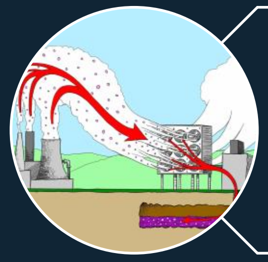

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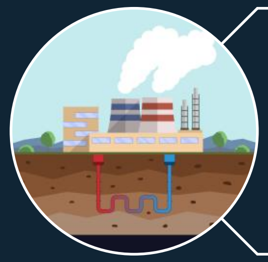
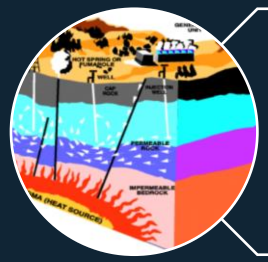


Geothermal Energy

Critical Minerals



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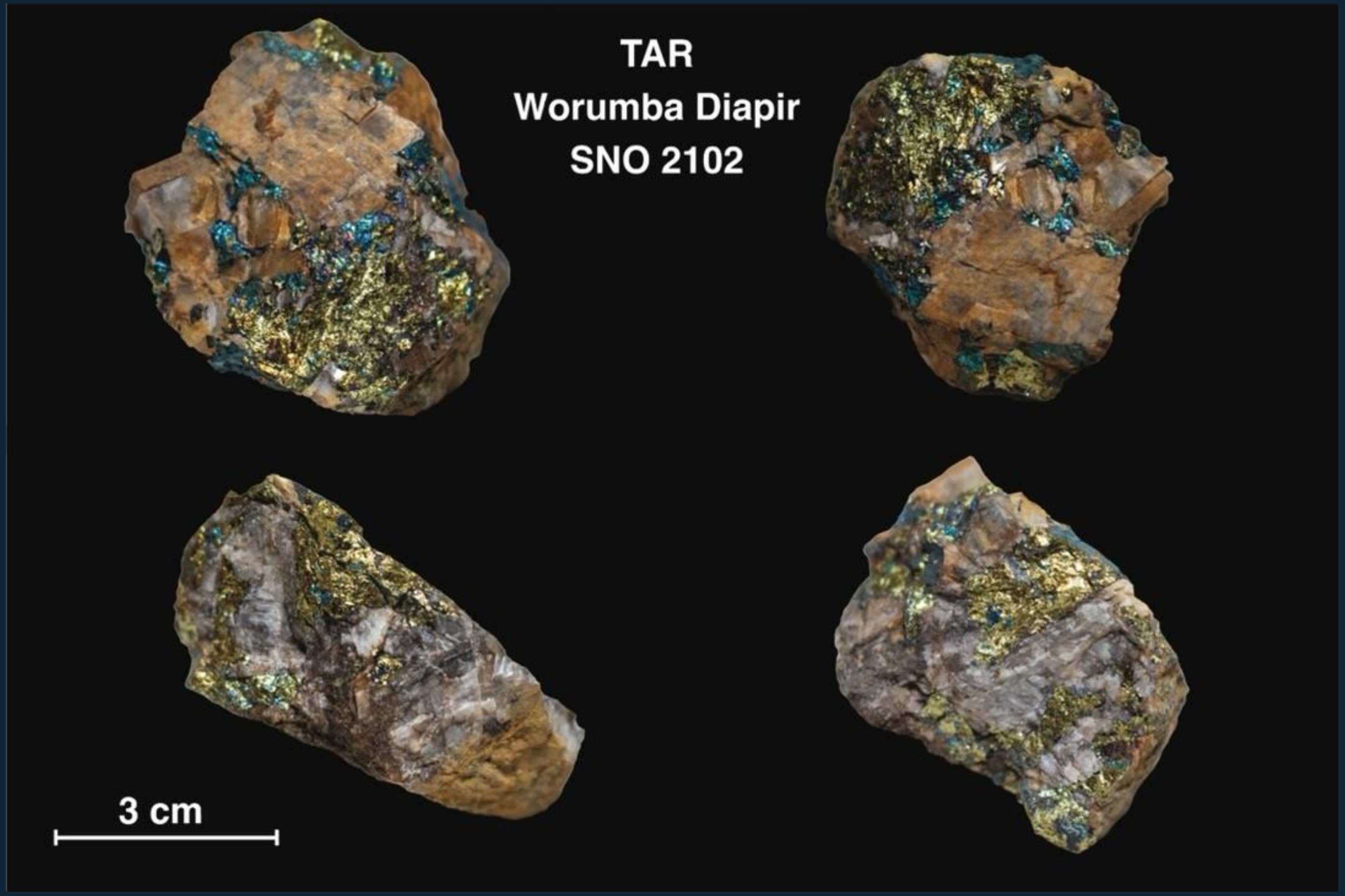
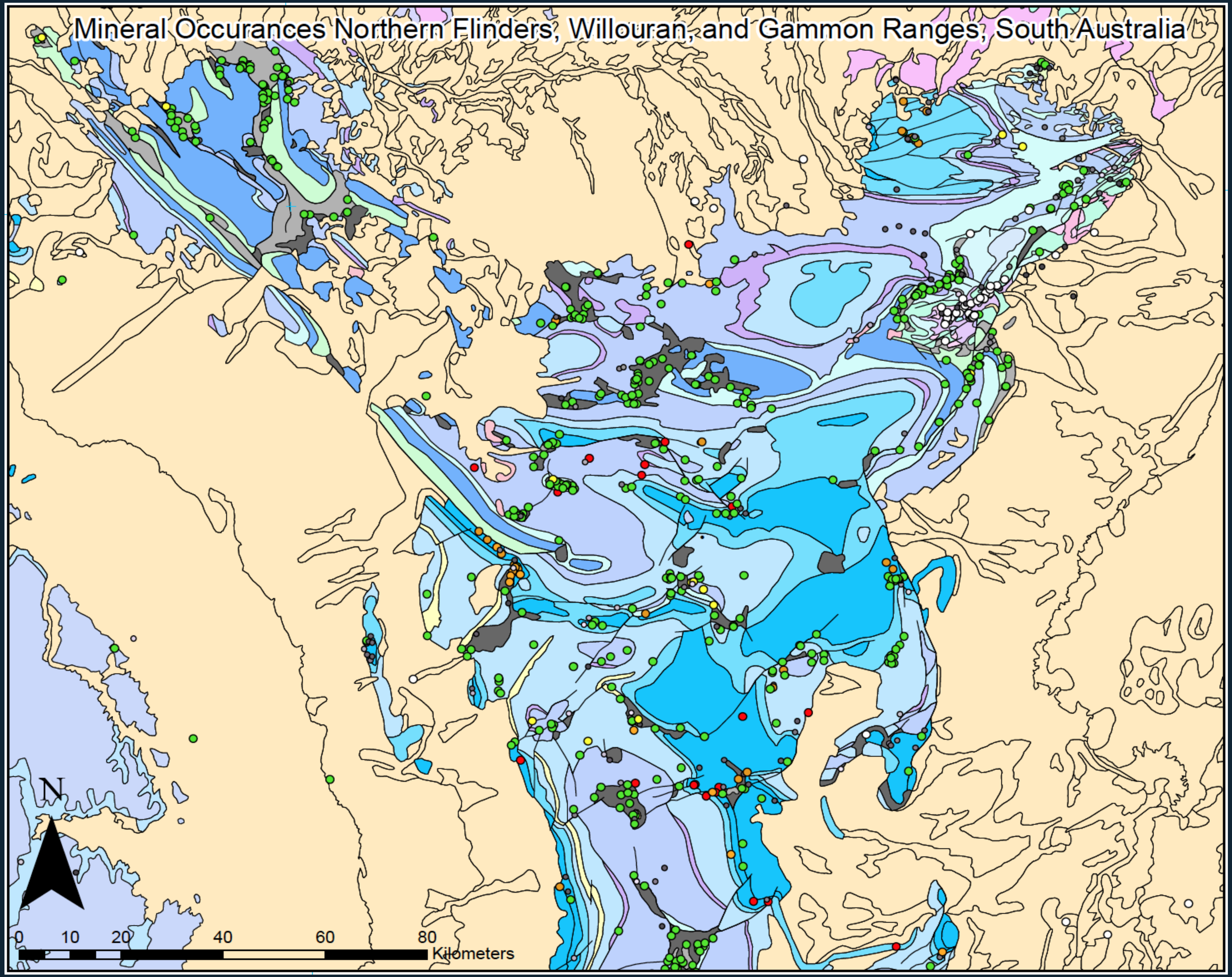
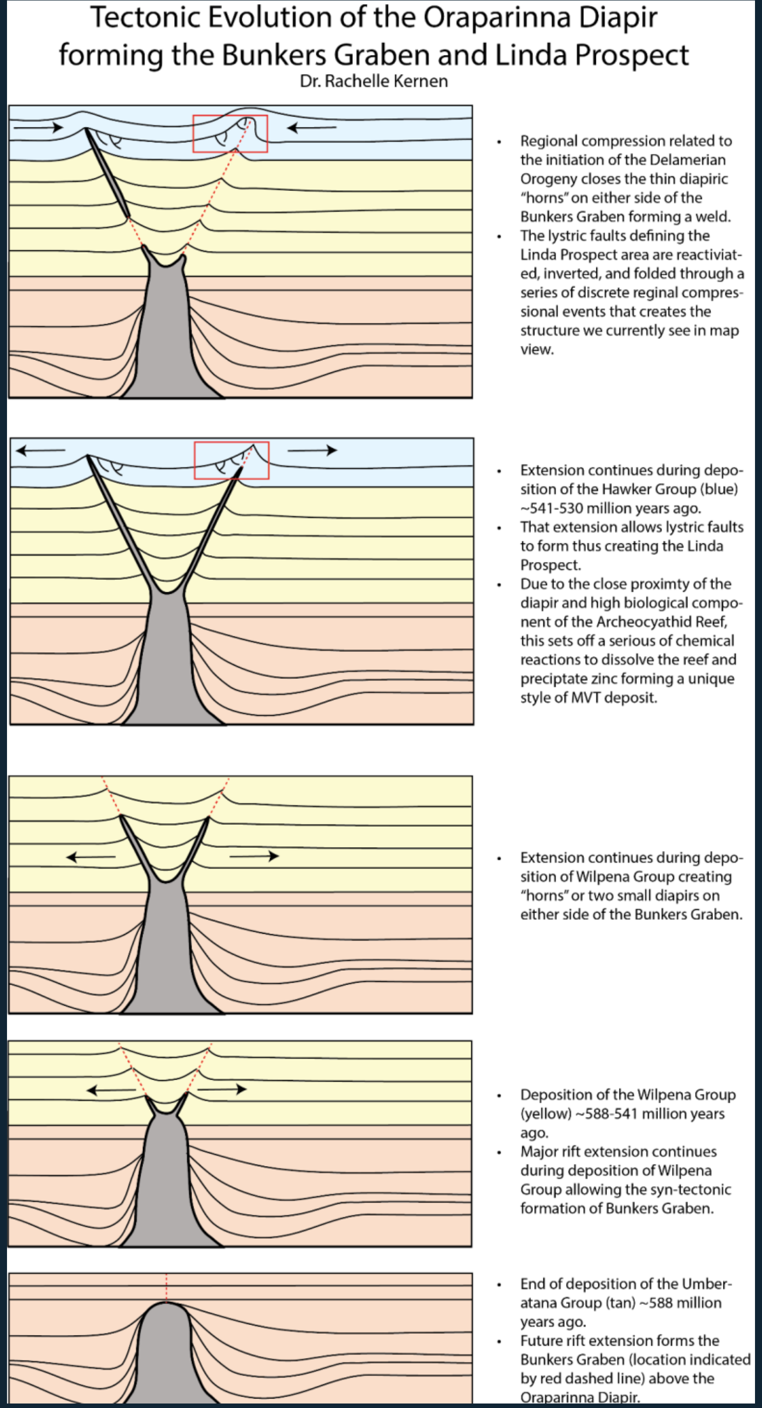
Critical Minerals



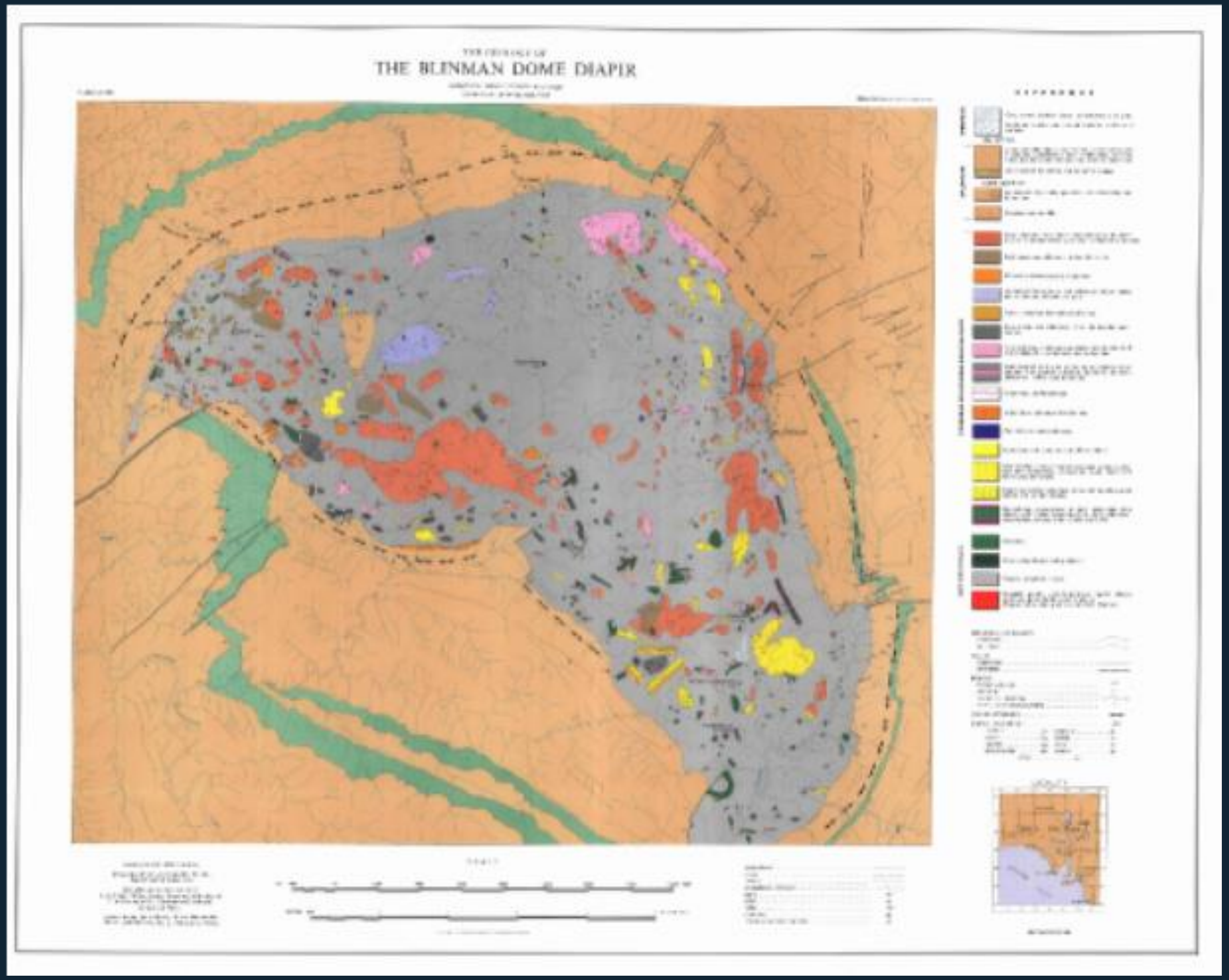


Copper (green), Gold (yellow), Lead/Zinc (orange), Manganese (red), and Uranium (white)

Critical Minerals



Kernen unpublished



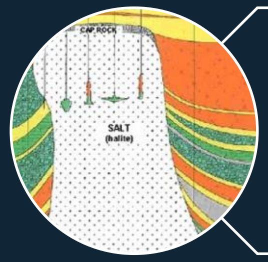
Coats, 1964

Joanne Weissgerber

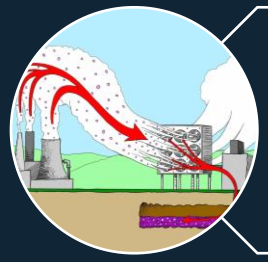
Kat Mazi-Ward

Dianne Amos

Natural Hydrogen Exploration



Salt Caverns



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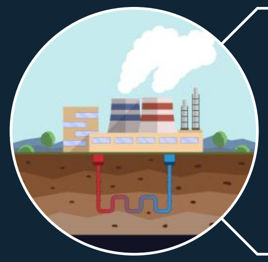
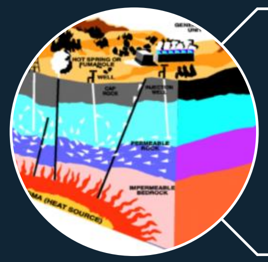


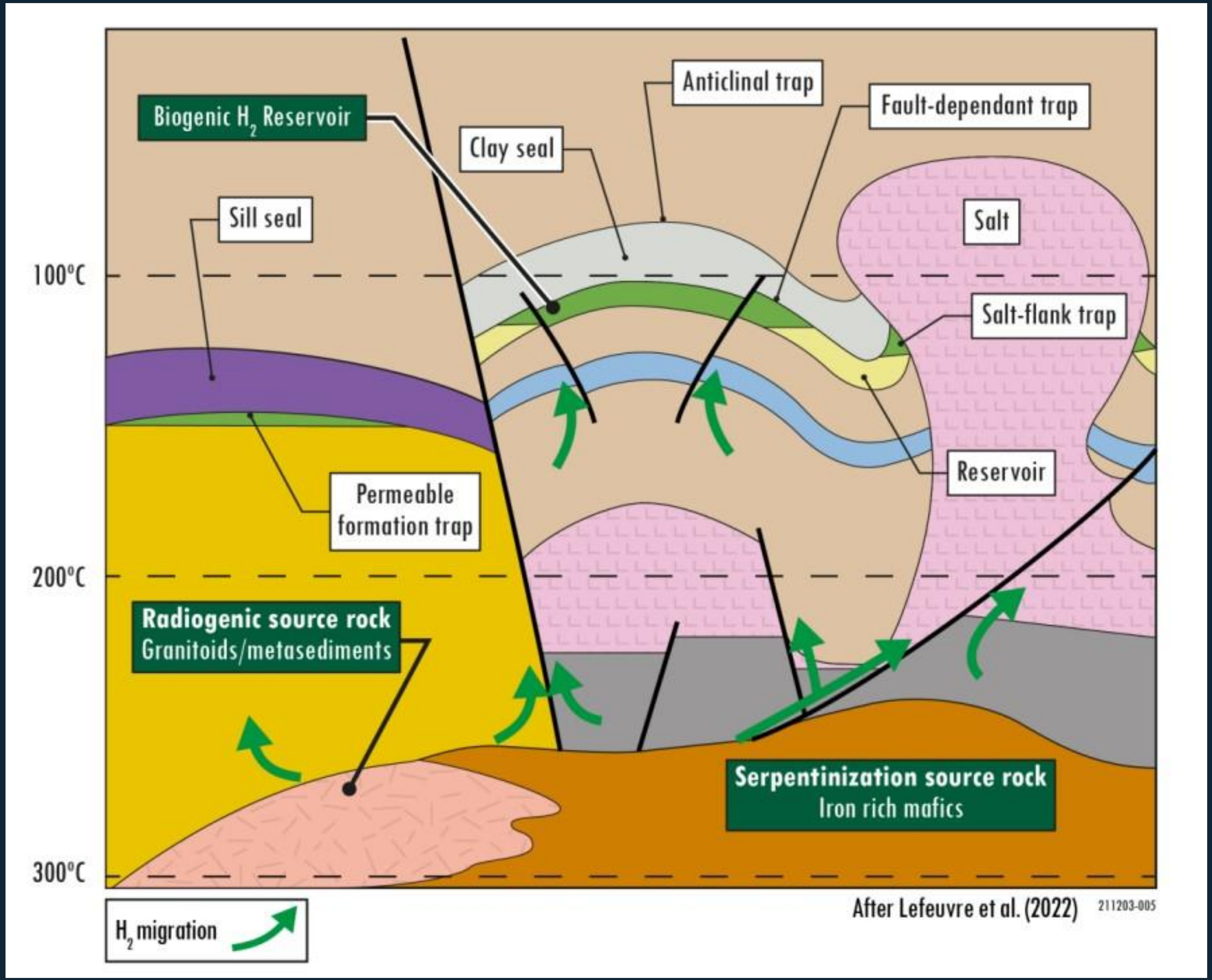
Geothermal Energy

Critical Minerals



Natural Hydrogen

Natural Hydrogen Exploration



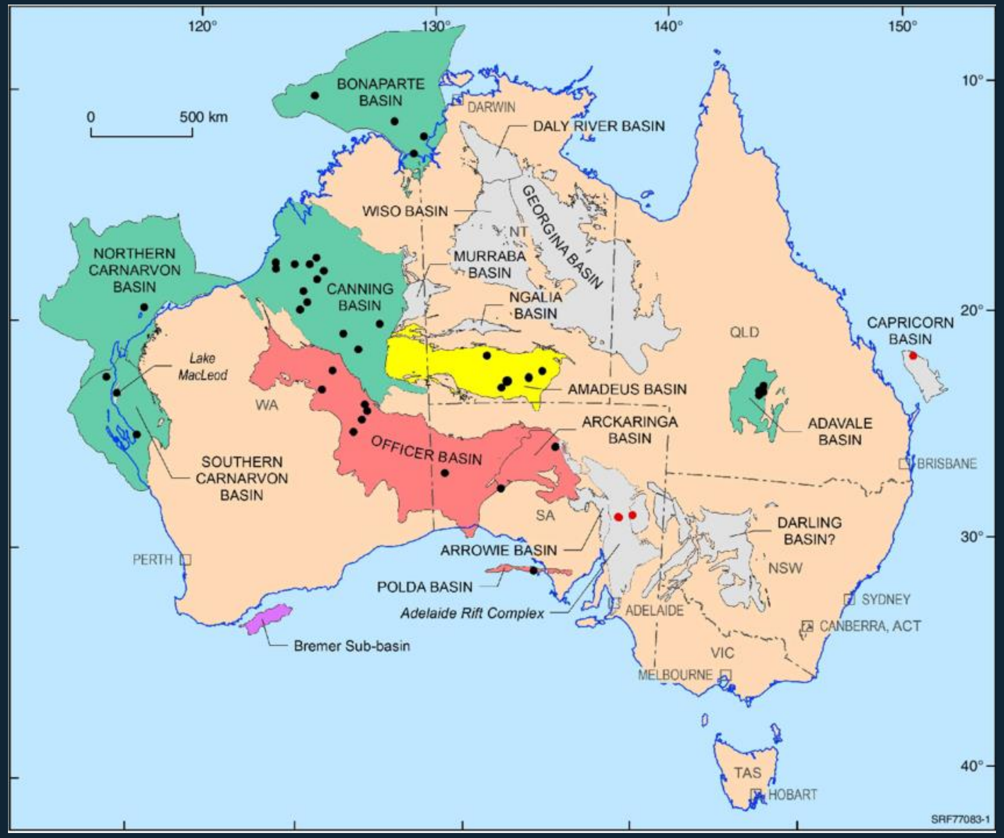
- Early biodegradation of interbedded organic shales or coal where trapped hydrogen is within the crystalline halite or potash fluid inclusions
- Production by radiolysis associated with sylvite and carnallite
- Migration from an underlying basement source

Conclusions

Location within Australia	Research type	Salt caverns	CO_2 storage	Geothermal energy	Mineral deposits	Natural hydrogen
Willouran Ranges	Outcrop	✓	✓	✓	✓	✓
Flinders Ranges		✓	✓	✓	✓	✓
Gammon Ranges		×	~	✓	✓	✓
Amadeus Basin	Subsurface	✓	✓	✓	✓	✓
Officer Basin		✓	✓	✓	✓	✓
Polda Basin		✓	✓	✓	✓	✓
Canning Basin		✓	✓	✓	✓	✓
Adavale Basin		✓	✓	✓	✓	✓

- Australia’s salt basin outcrops provide rare and exceptional sedimentological, stratigraphic, and structural parameters that can be used as analogues for improved interpretation of sparse or poor-quality subsurface datasets globally.
- These analogue studies provide the opportunity to improve computational and physical models for subsurface application and develop a predictive framework for characterizing the sustainable development potential of salt basins.
- To maximize the valuable resources offered by salt basins in the energy transition, we must consider the integrated potential of these systems and how they can co-exist within an individual basin.
- Considering all sustainable geo-energy systems and the fundamental role of salt basin research in enabling these applications will decarbonization be possible and have enough impact to reach net zero by 2050.

Research Priorities



Key opportunity - utilizing Australia’s world-famous outcrops

- Develop models based on outcrops and apply to subsurface
- Synthetic seismic & physical modelling

Research foci

- Improve understanding of diapiric bodies
- Substantial implications both for cavern storage viability and critical minerals
- Integrate knowledge from Quaternary evaporates and ancient deposits to improve characterization

Current Sponsors for ARC Industry Fellowship

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- HILT CRC sponsored PhD project beginning Q3 2024
- Funded collaboration with CNRS 2024
- Active field analogue investigations: Enorama Diapir, Blinman Diapir, Worumba Diapir, Bunkers Graben in Central Flinders Ranges

Thank you!

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