Geological Assessment & Storage Capacity: an International Perspective

Storage Retention Time of CO_2 in Sedimentary Basins: Examples from Petroleum Systems

UNFCC
SBSTA 20th
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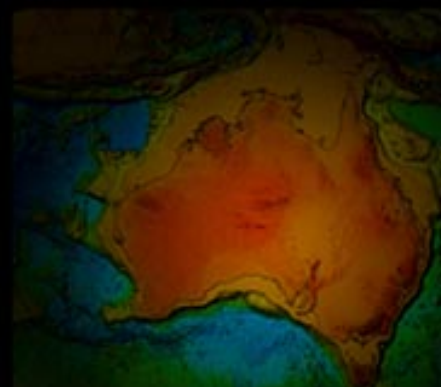
Dr John Bradshaw
Chief Scientist CCS

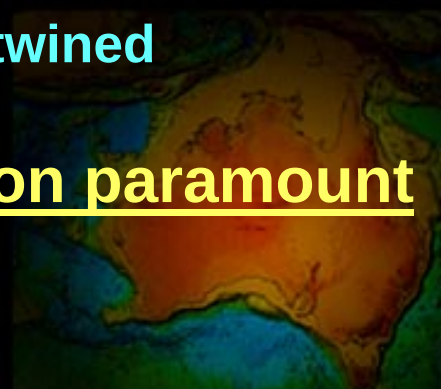


Australian Government
Geoscience Australia

Main messages – Geological storage

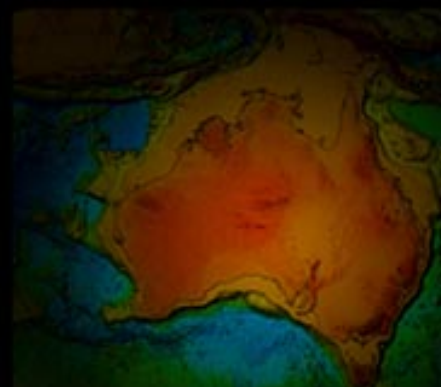
- **Lots of technical advice available**
  - **i.e. don't rely on uninformed "layman's" perspective – "alarmist"**
- **Natural Petroleum Systems highly instructive**
  - **"The present is the key to the past"**
  - ***"The past is the key to our future"***
- **Need Prospect risk assessment on technical criteria across the "world"**
  - **Consistent approach**
- **Leakage is not a major issue**
  - **Choose appropriate sites**
  - **Policy issues vs technical aspects must be intertwined**

- **<u>Regulations, technical advice & site selection paramount</u>**



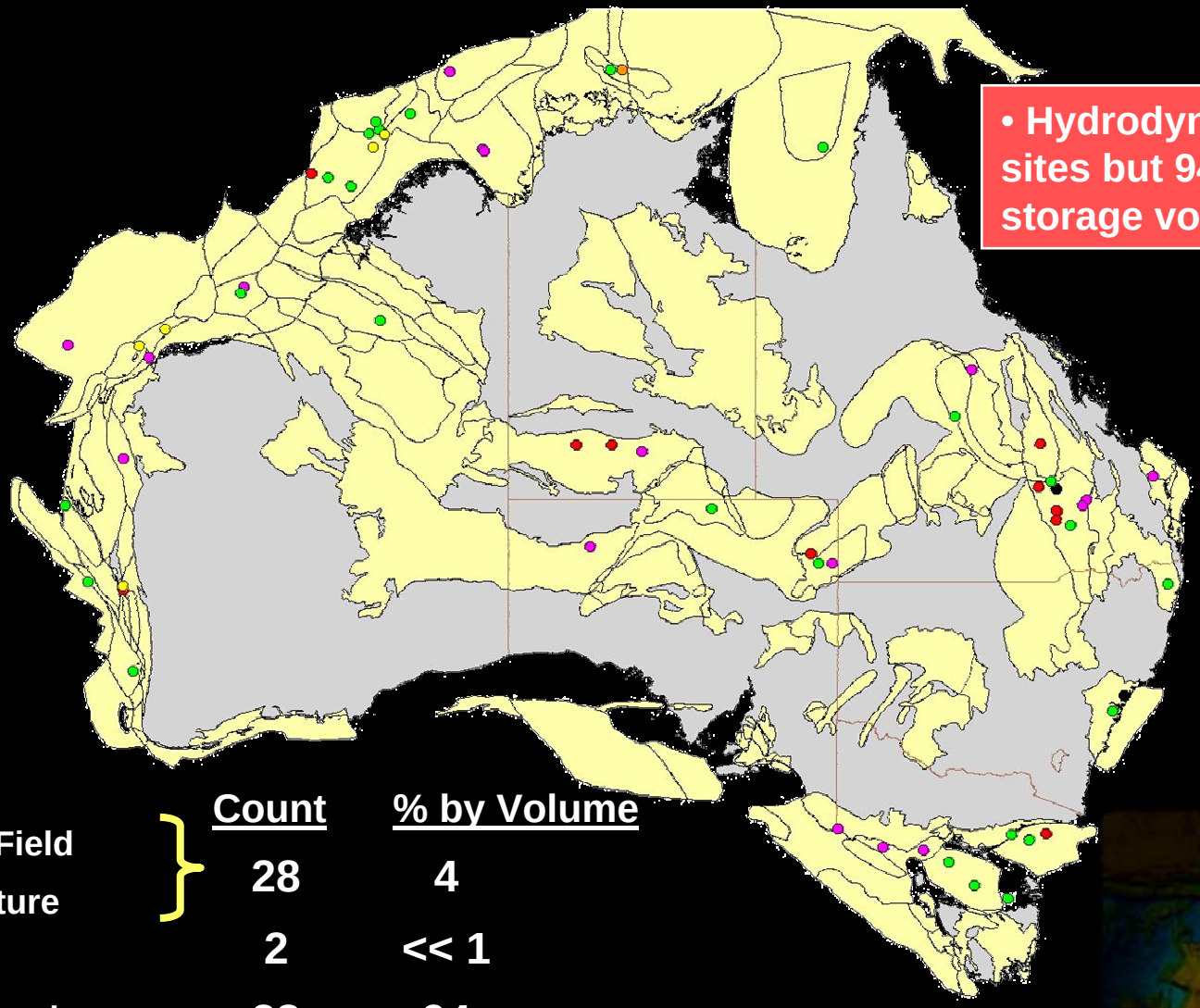
Talk Outline

- Geological Assessment Case Study
  - Australia
- CO_2 Storage Prospectivity
  - Australia, APEC (China) & World
- Source Sink Matching & Storage Capacities
- Storage Retention Time
  - Natural Petroleum & CO_2 Systems



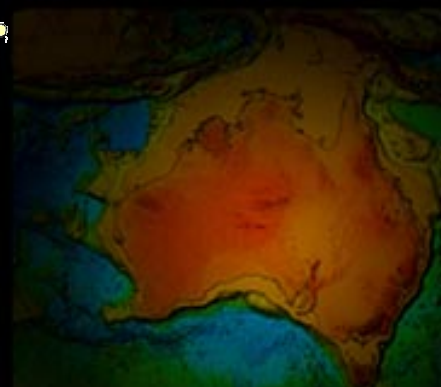

Australian Case Study

65 Potential Storage Sites

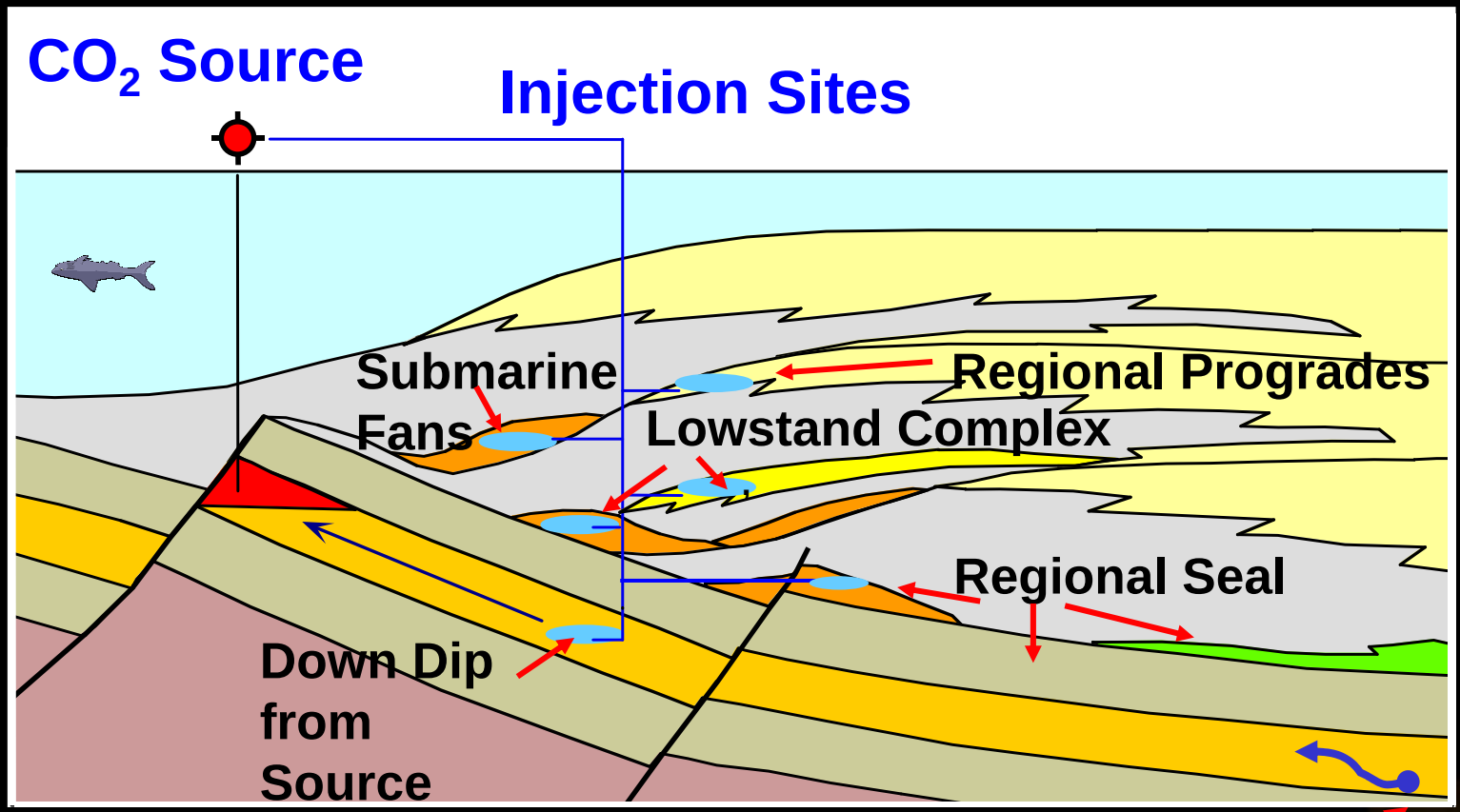


- Hydrodynamic 43 % of sites but 94% of CO_2 storage volume

	Count	% by Volume
Depleted Field	28	4
Dry Structure		
ECBM	2	<< 1
Hydrodynamic	28	94
Stratigraphic	7	2
Sub-Unconformity		

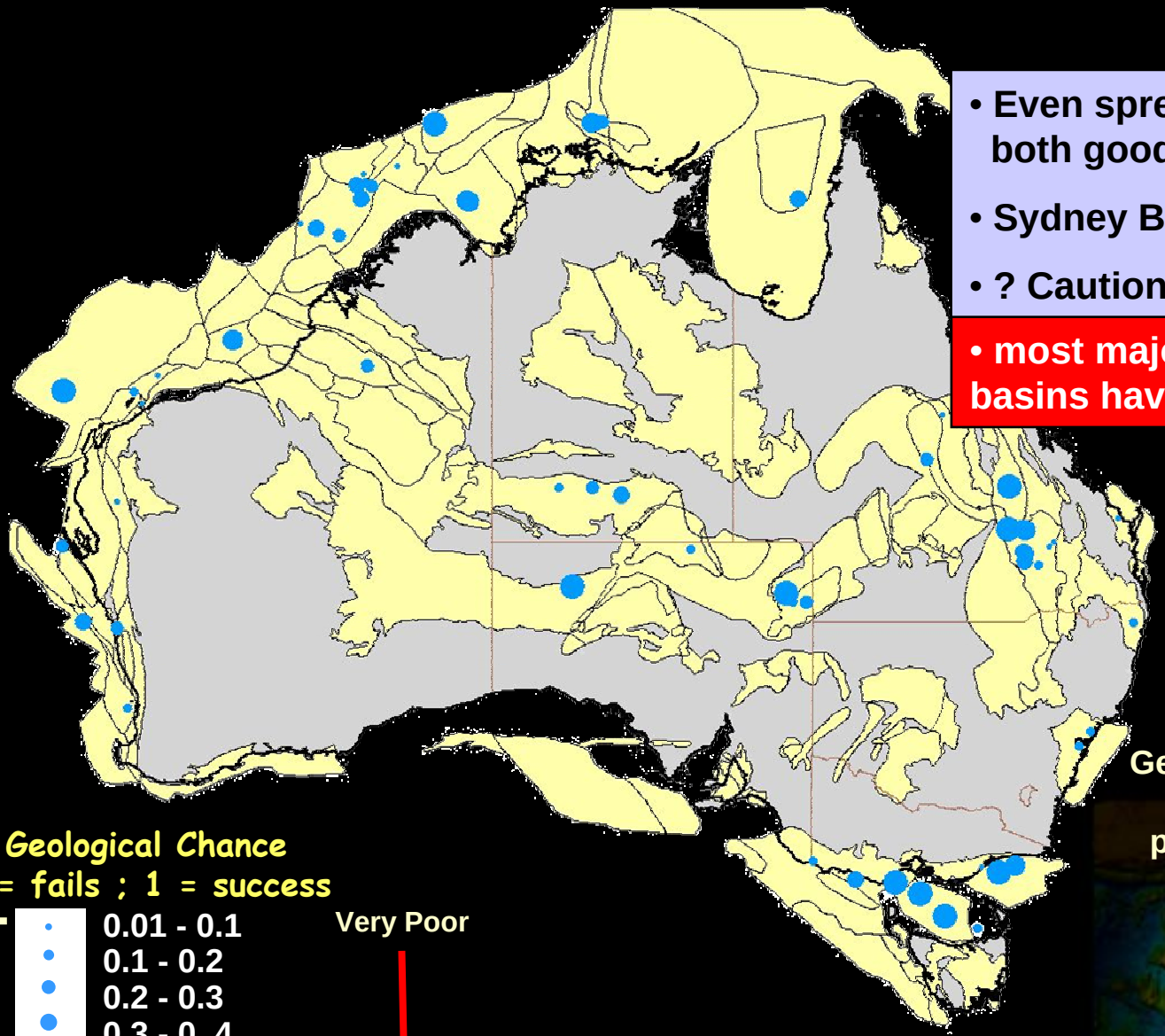


Conceptual Storage Sites



- Each Geological Setting has a unique set of technical risks !

1. Geological Chance



- Even spread of sites - both good and bad
- Sydney Basin - not viable
- ? Caution : Trap Type?
- most major petroliferous basins have viable sites

Geological Chance
0 = fails ; 1 = success

Selection for this map

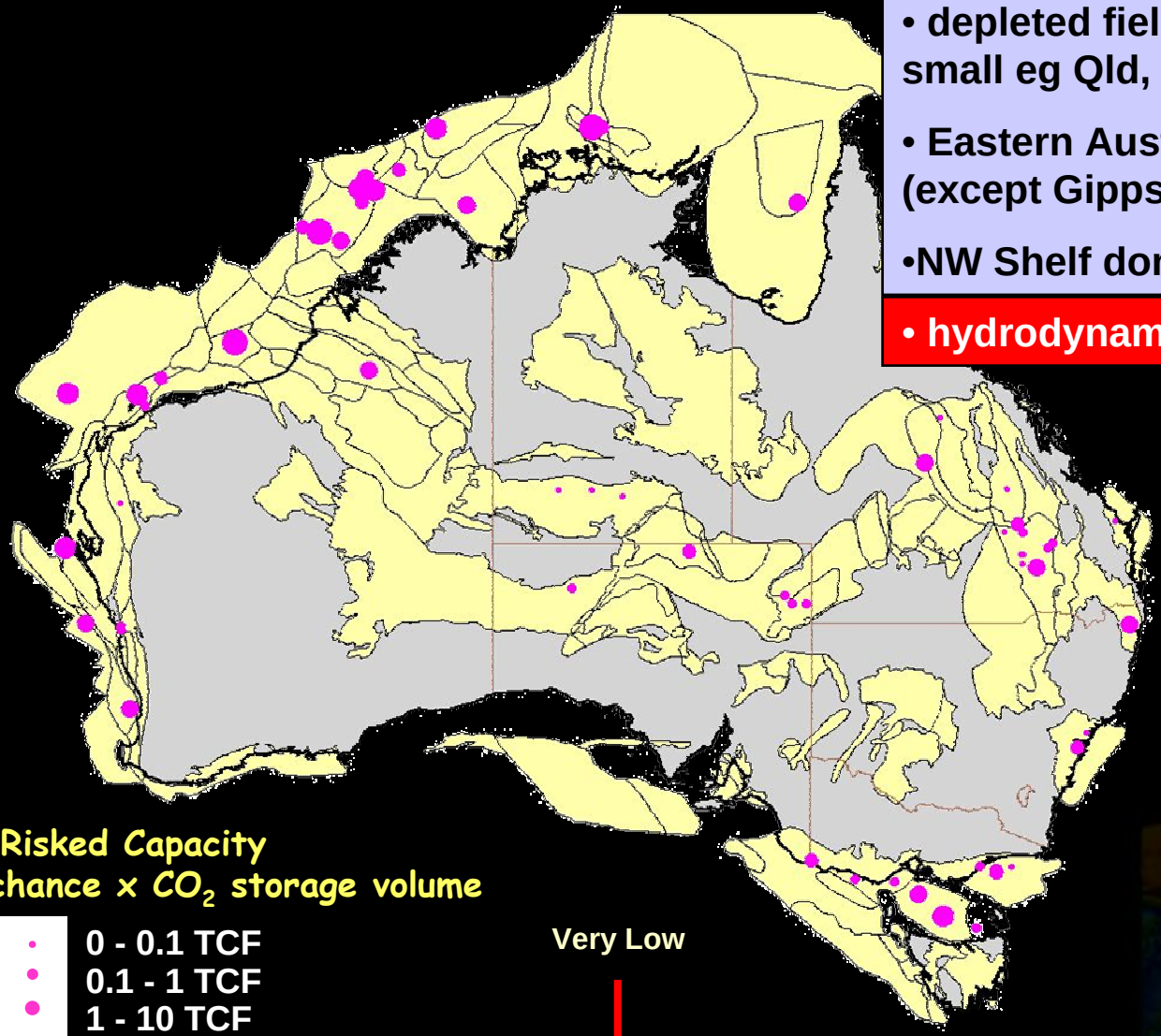
	0.01 - 0.1
	0.1 - 0.2
	0.2 - 0.3
	0.3 - 0..4
	0.4 - 0.5
	>0.5

Very Poor

Very Good

Geological Chance
=
product of 5 site risk factors

2. Risked Capacity



- depleted fields dominantly small eg Qld, Moomba, Amadeus
- Eastern Australia problem ? (except Gippsland & Bass)
- NW Shelf dominantly large
- hydrodynamic traps huge

Risked Capacity
= Geologic chance x CO_2 storage volume

Selection for this map

0 - 0.1 TCF
0.1 - 1 TCF
1 - 10 TCF
10 - 100 TCF
100 - 1000 TCF
1000 - 4600 TCF

Very Low

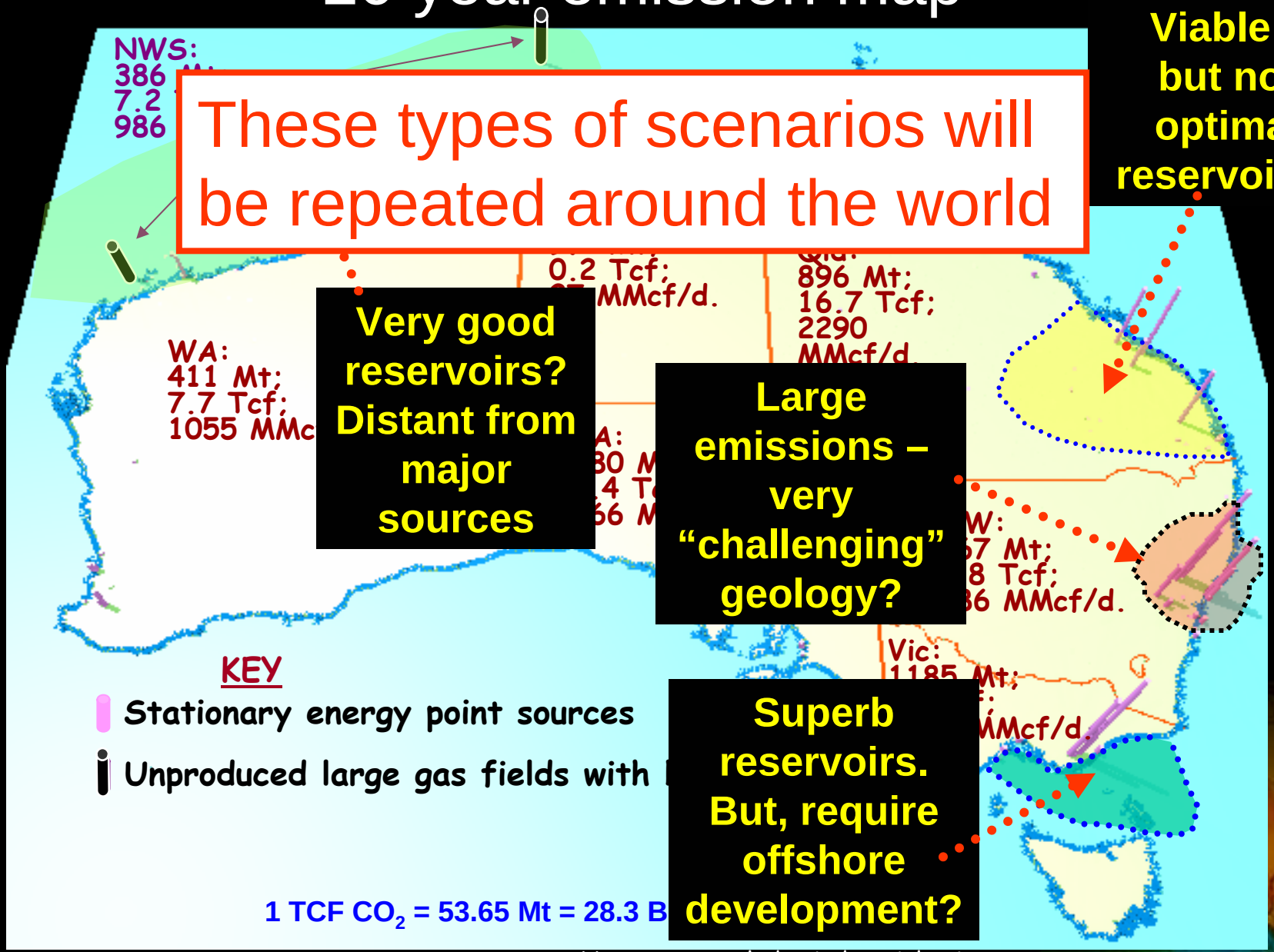
Enormous

Risked Capacity =
Site Risk x CO_2
Storage Volume

1 TCF CO_2 = 53.65 Mt = 28.3 BCM

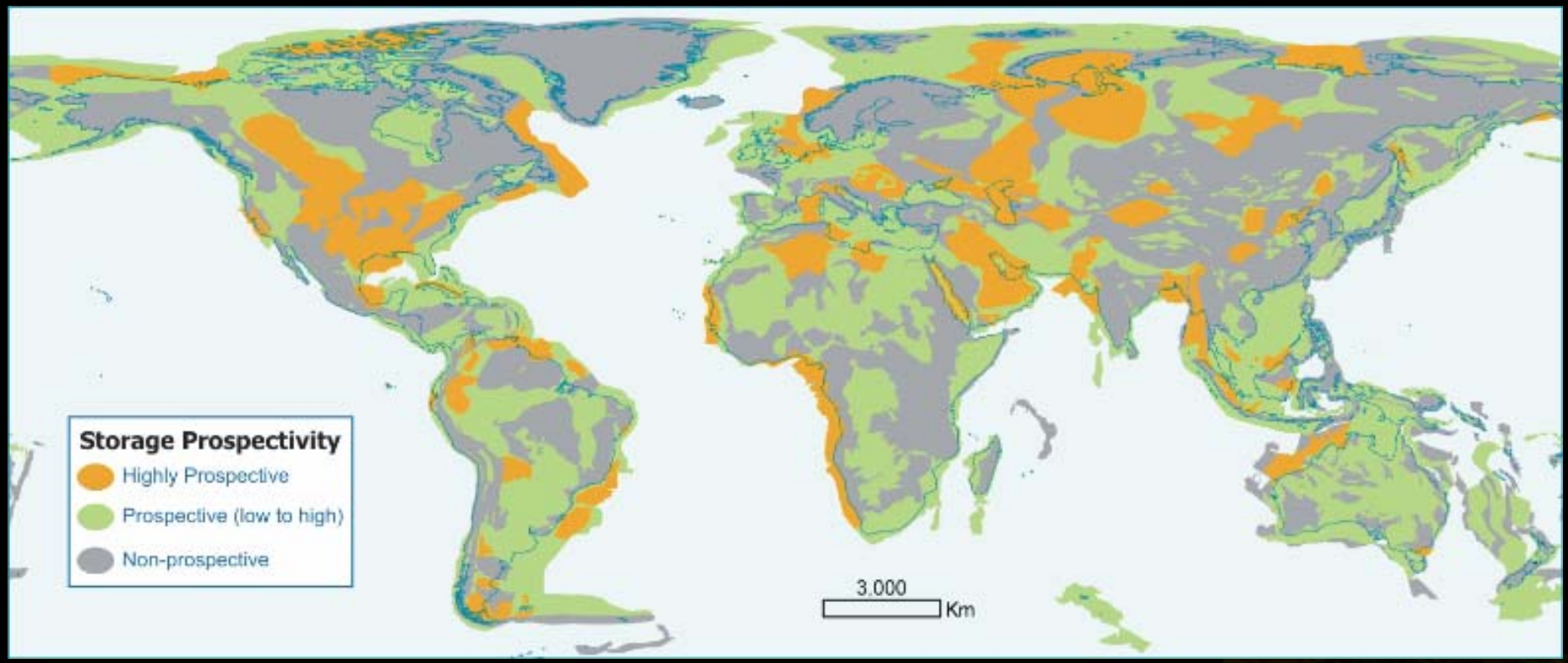
Summary of Emissions, Economics & Geological Risk

20 year emission map



Note: map excludes industrial point sources

World Map of CO_2 Storage Prospectivity



- Highly Prospective
- Prospective – High to Low
- Non-Prospective

•From Bradshaw & Dance 2004

World Map of CO_2 Storage Prospectivity

Remember : ***("this is a geologists map")***

Like any Prospectivity map,
this is a map of where to begin to look for CO_2 storage space

Not a map of where it actually is?

Highly Prospective

Prospective – High to Low

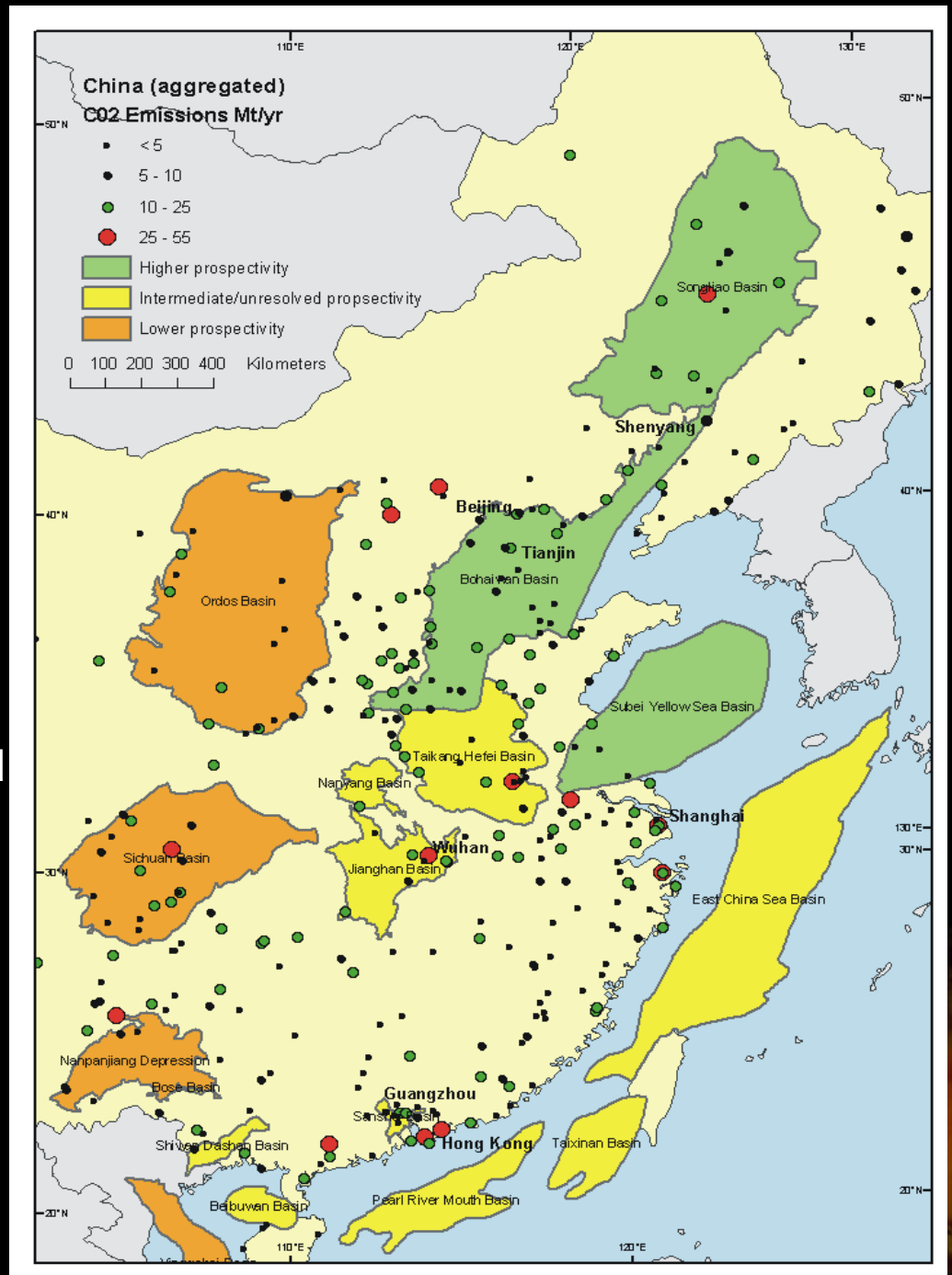
Non-Prospective

•From Bradshaw & Dance 2004

CHINA Stationary CO_2 emissions and basins

Tentative ranking of prospectivity for CO_2 Storage

- Higher Prospectivity
- Intermediate / unresolved Prospectivity
- Lower Prospectivity

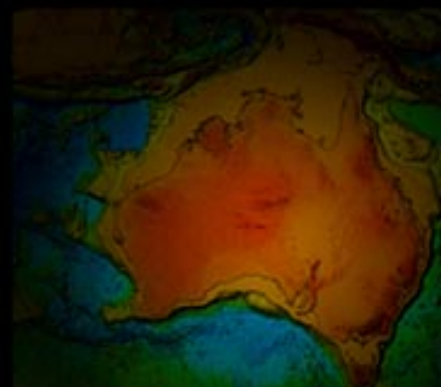


What does Source Sink Matching tell us?

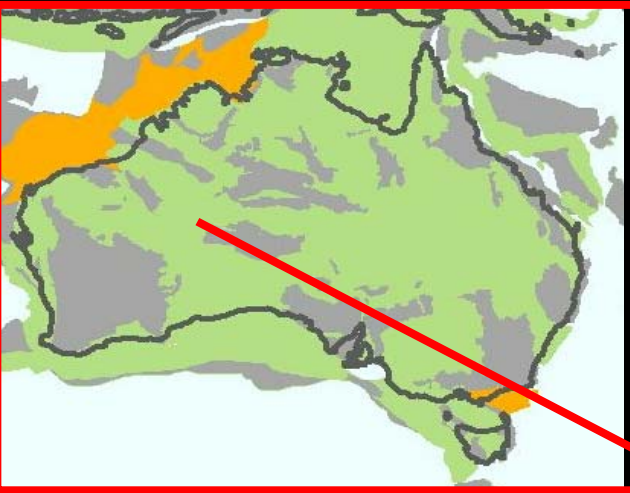
Especially about realistic capacity estimates

&

Economics

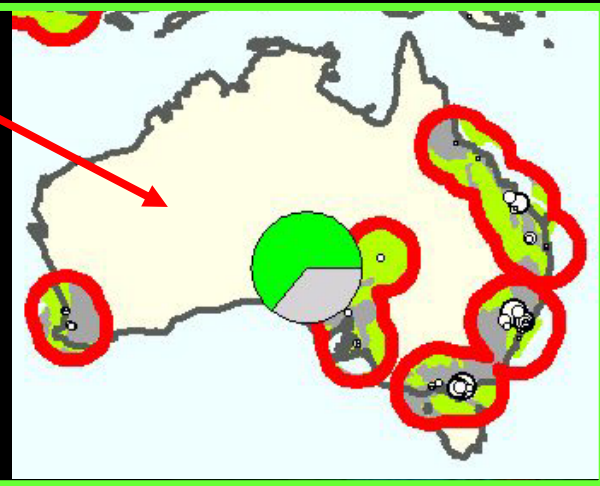


Total Capacity vs Sustainable Rates

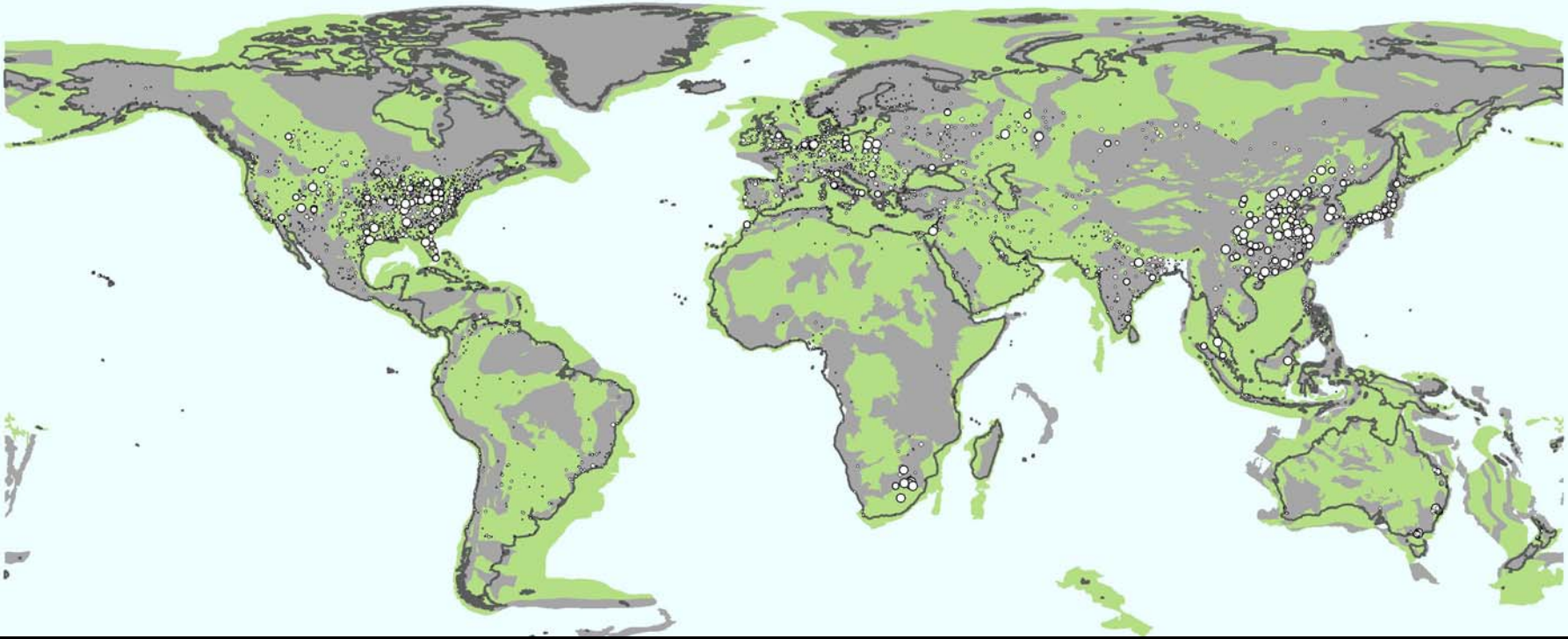


Total Pore Volume of best sites (not all sites)	**> 4100 Gt CO_2 (never quoted)**
Risked Pore Volume of best sites	**: 740 Gt CO_2**
Or	**1600 Years of current emissions for Australia**

Sustainable Rate "Source sink matching "	**: 100 – 115 Mt CO_2 / year (25% of a years emissions)**
	or
Cost Curve Rate	**: 40 – 180 Mt CO_2 / year (depending on CO_2 cost)**



World Regional Storage Opportunities

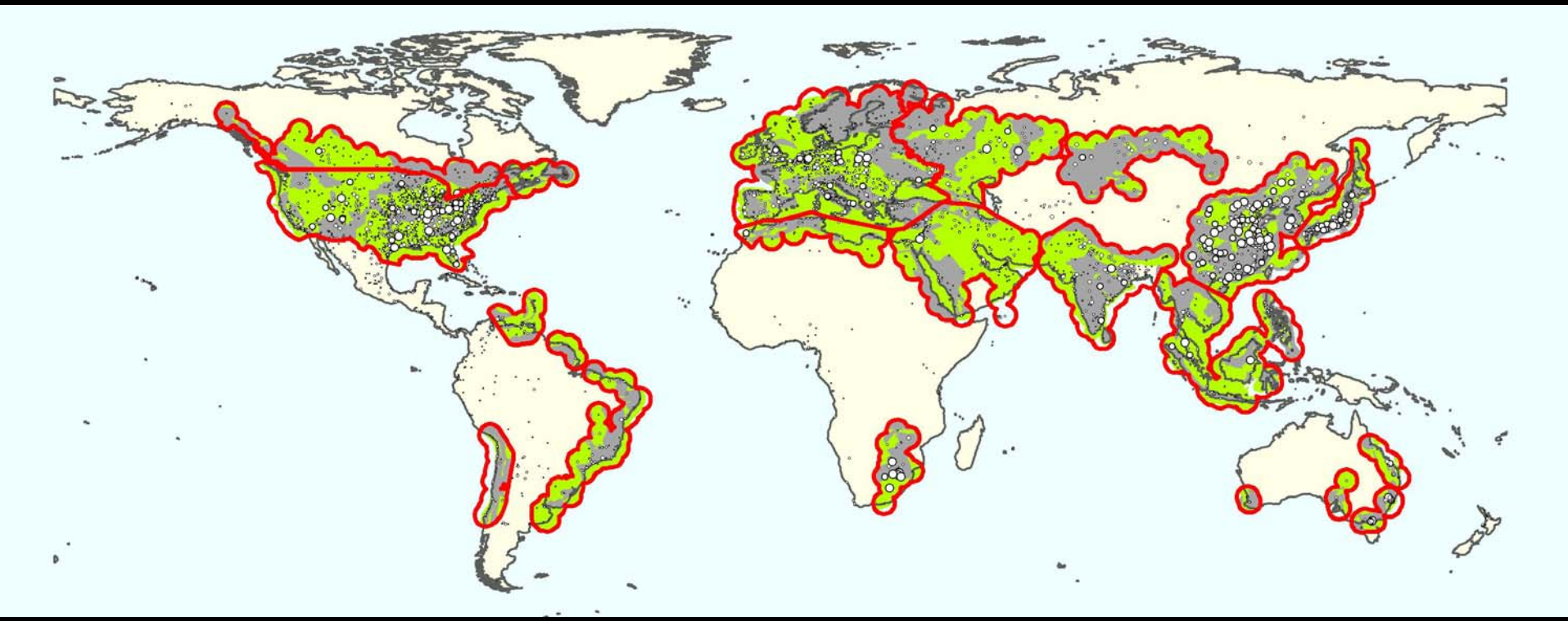


- **Emission sources**

Prospective basins

Non- Prospective provinces

World Regional Storage Opportunities



Emission regions (300km buffer)

Prospective basins

Non- Prospective provinces

Storage Capacity versus years of storage: Australia and China

	Australia		China	
Total Emissions (Gt CO2)	0.5		3.3	
	Total Capacity (Gt CO2)	Storage Years	Total Capacity (GT CO2)	Storage Years
ECBM	4	8		
EOR			?	
Oil & Gas Fields			7.8	2
Coal Beds	?		12	4
Saline Reservoirs	740	1480	1435	435

Not available for 40 years

? Significant injectivity concerns + sterilisation issues?

China estimates from : ZHANG HONGTAO et al: 2005 GCEP Conference Note : based on surface area calculation

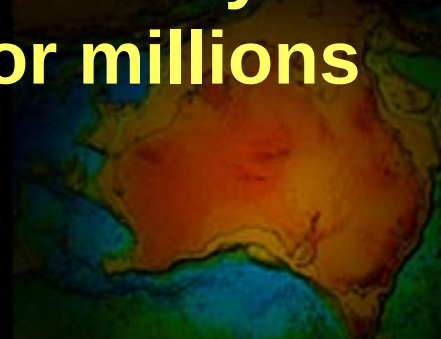
Temporary or Permanent ?

- **Yes & Yes**

- **Geological characteristics of storage sites - highly variable?**
  - **Operator, regulations, safeguards, emissions type, rates of injection, etc – all affect the answer**

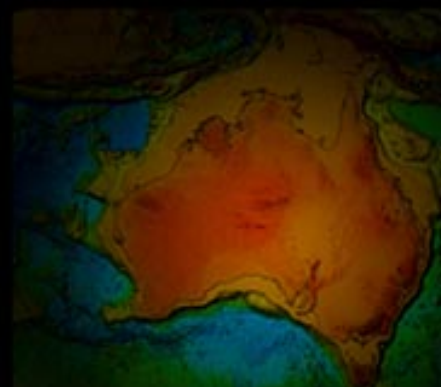
How do geoscientists respond?

- **Yes it could leak, …….**
- **…….. if inappropriate sites are chosen**
- **By analogy to oil and gas accumulations,**
  - **if appropriate sites are chosen it can stay in the deep geological sub-surface for millions of years**

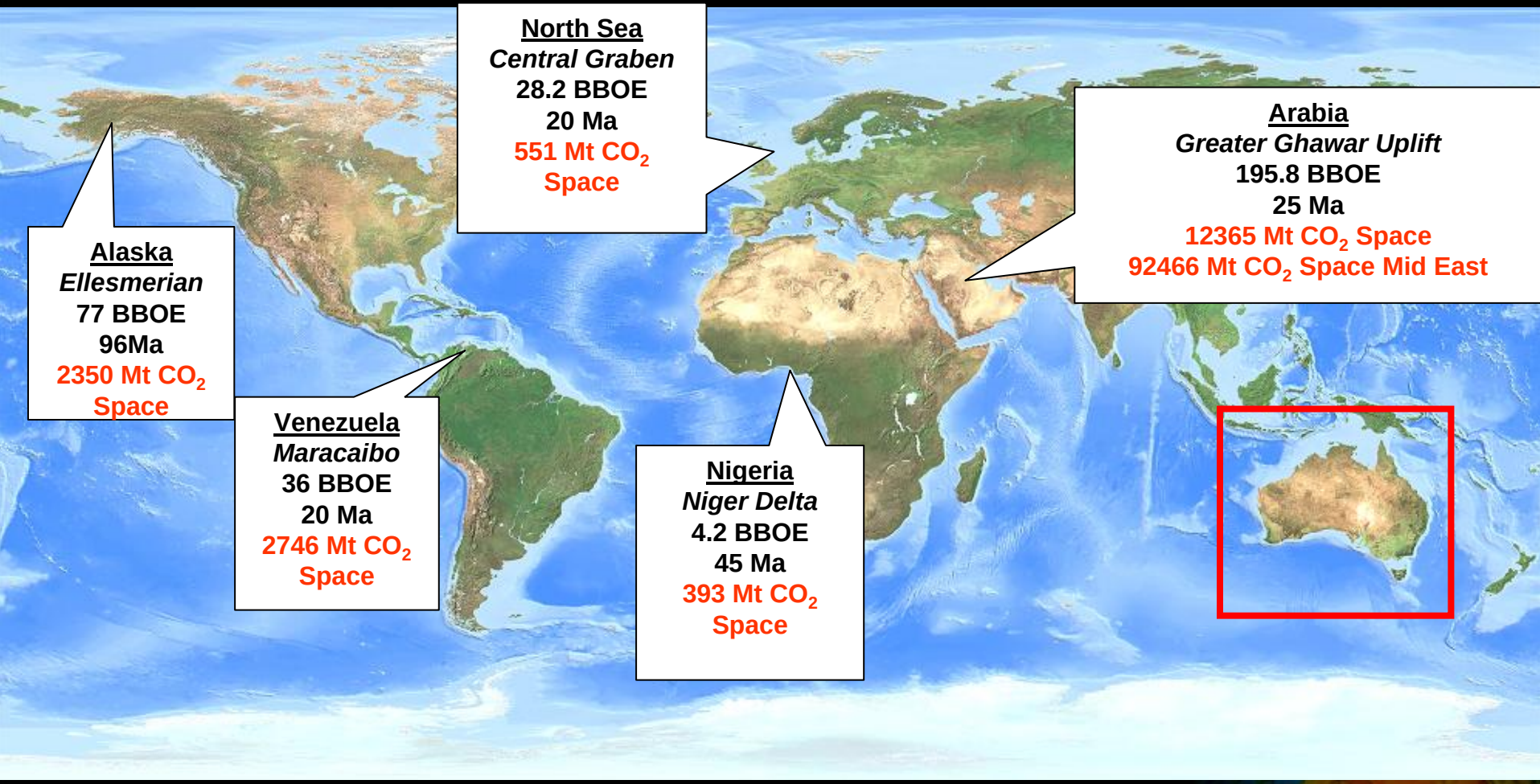


Oil & Gas Accumulations

- 1000's of billions of barrels of hydrocarbons have been stored in the deep geological subsurface along with co-produced and inorganically derived CO_2
- Storage times generally up to 10s to 100s of millions of years and longer
- Where is the "proof"?
- Answer : Petroleum Systems

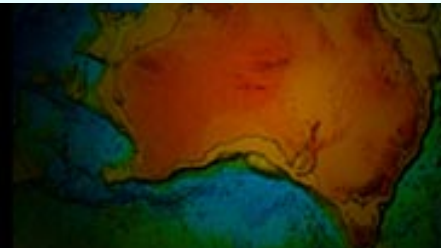


Storage Times & In Place Volumes of Major Petroleum Provinces



BBOE = Billions of barrels of oil equivalent

Ma = millions of years



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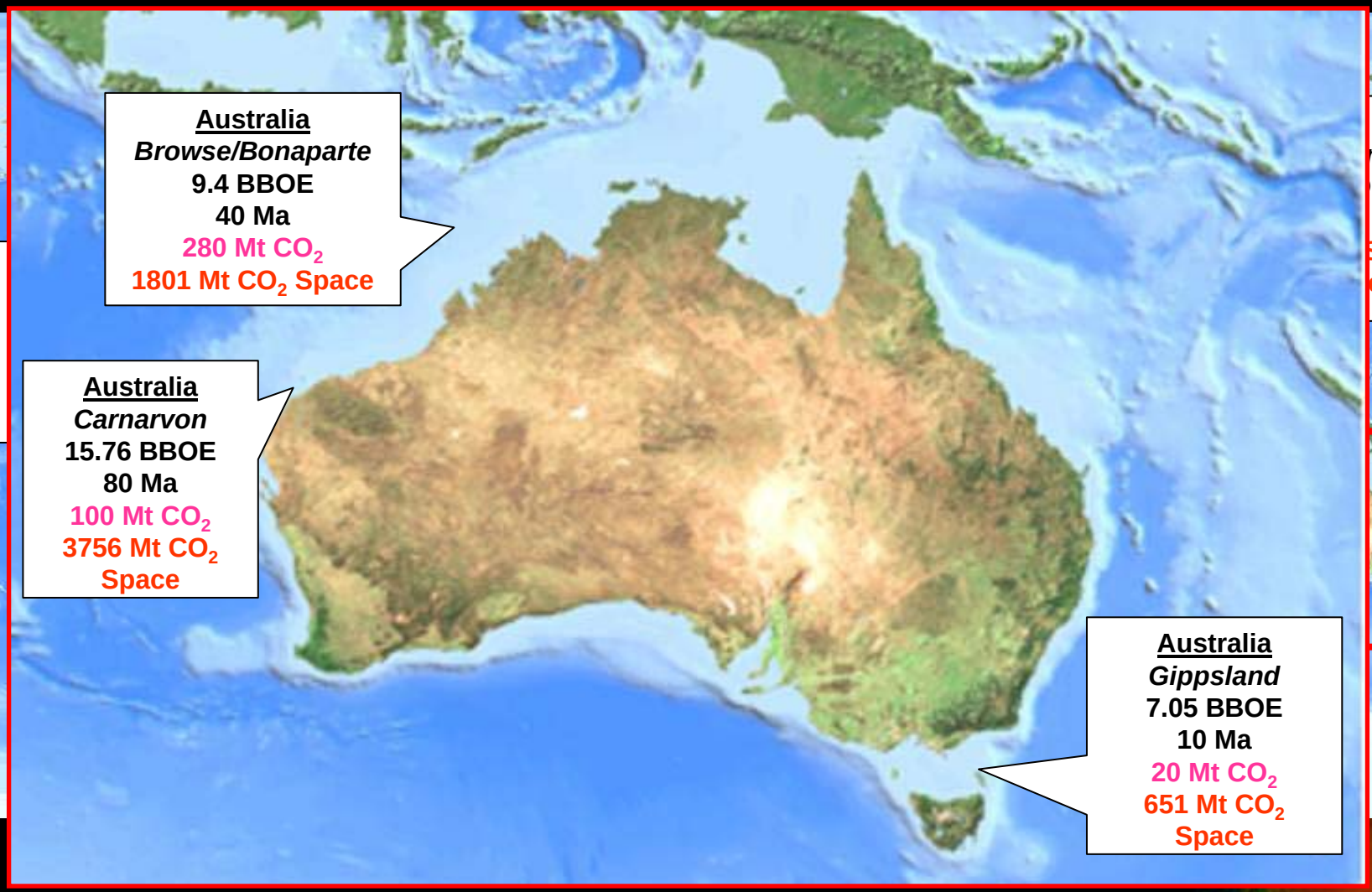

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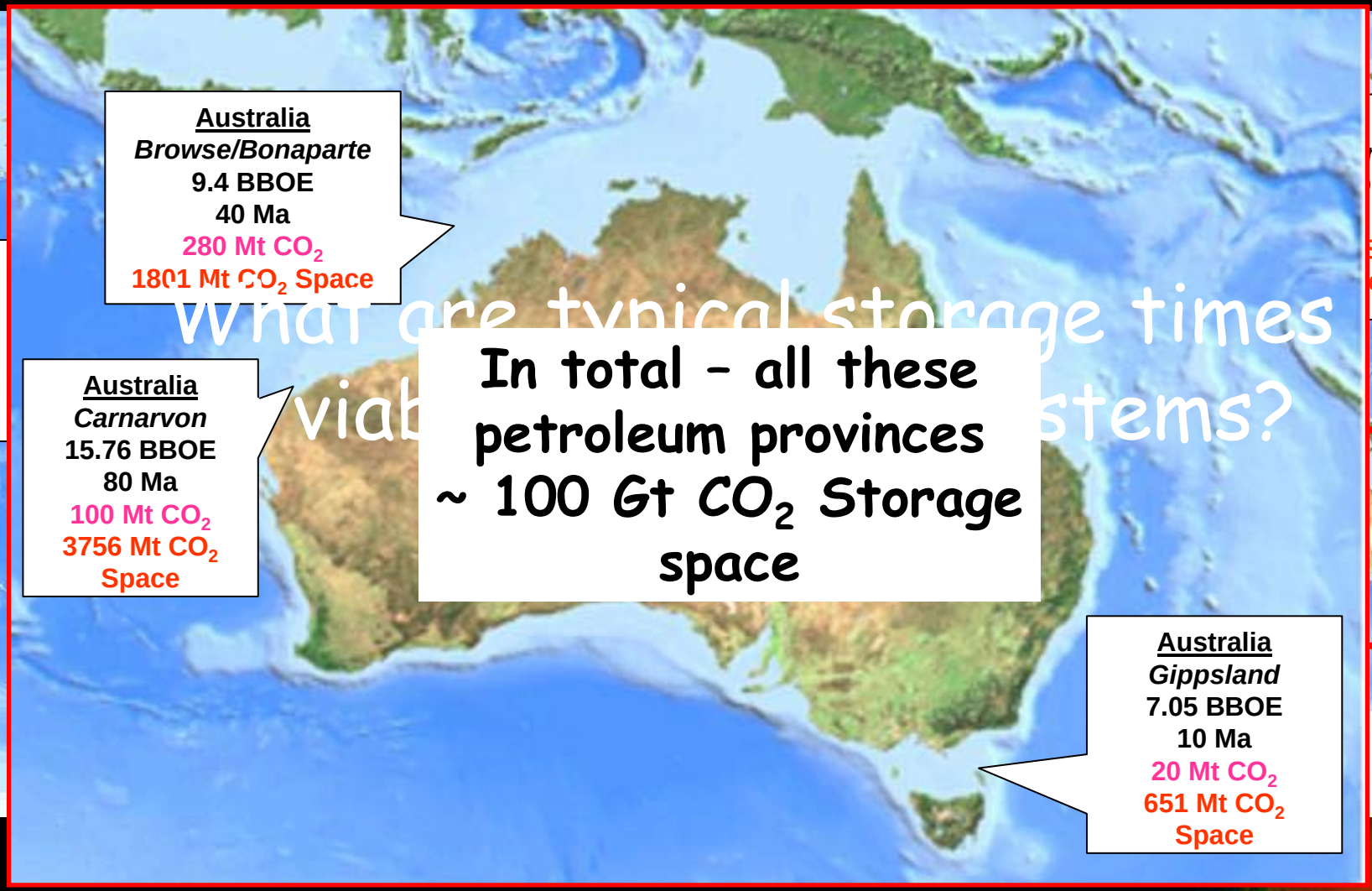

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Petroleum Systems

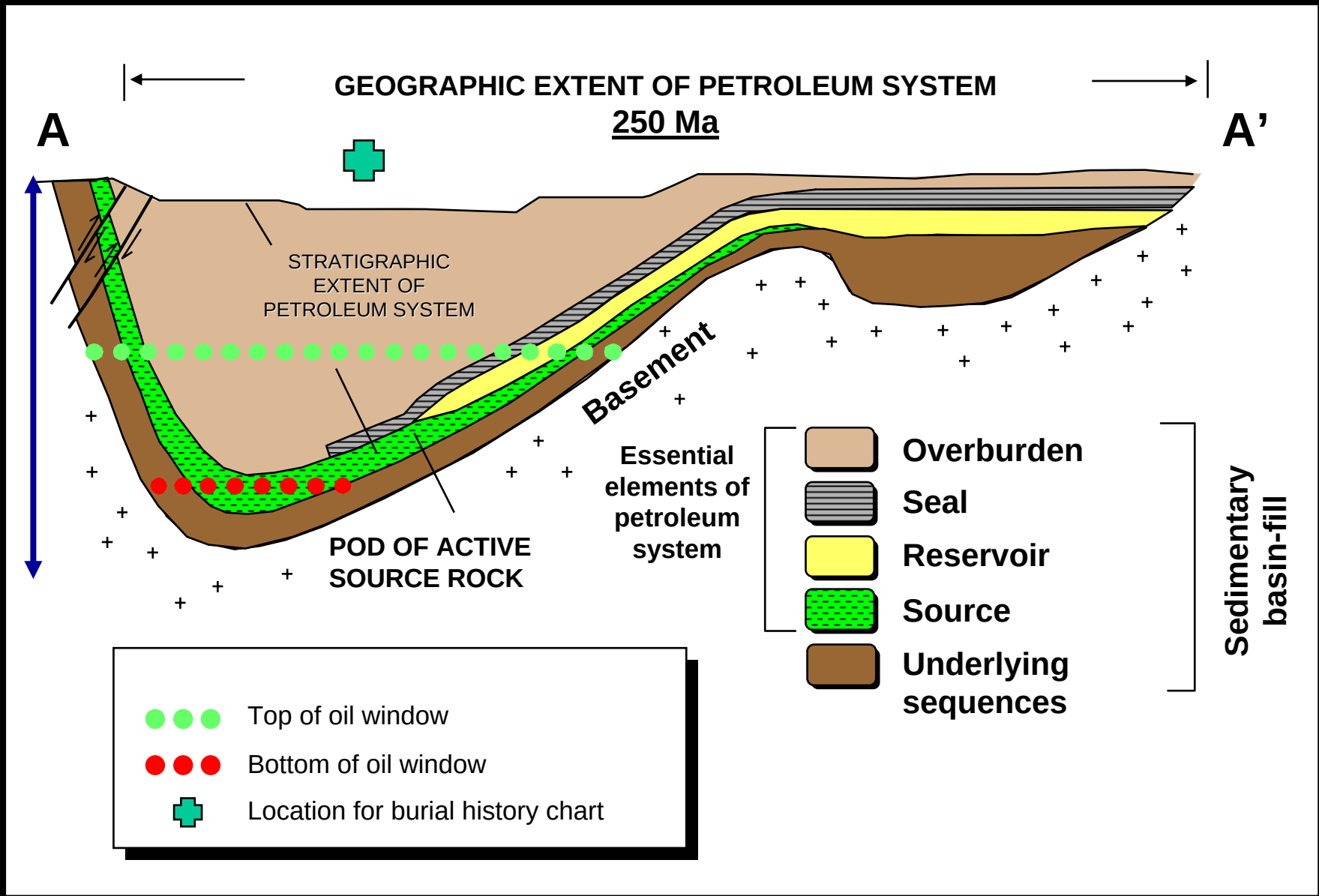
- Timing ("sequencing") of events is critical
- If events occur out of order, then system process fails
  - Eg hydrocarbon generates and migrates before a structural trap forms

BUT

For CO_2 storage

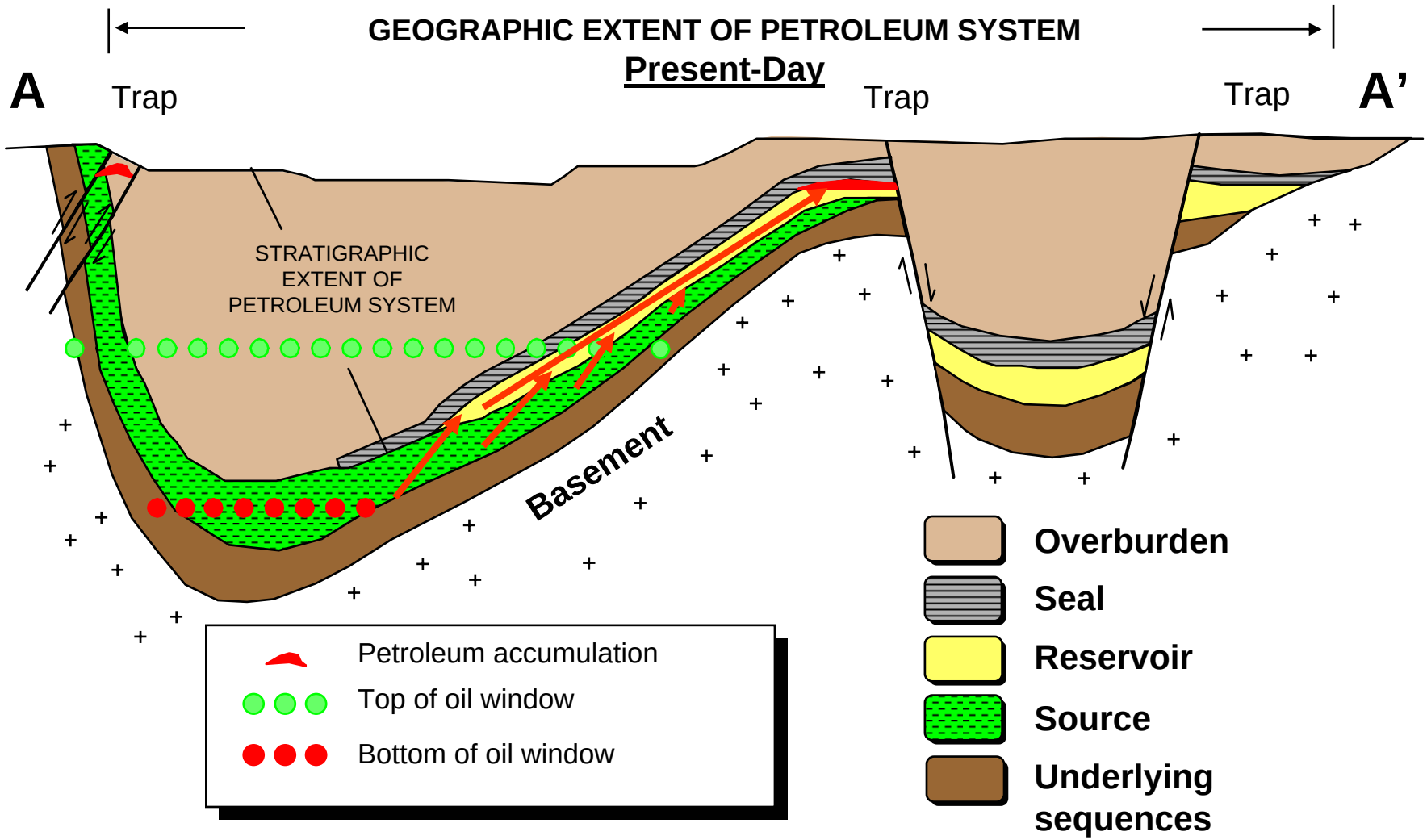
We will control the timing, location, and sequencing

Geological Cross Section – 250 Ma



AAPG: Magoon, L.B, and Dow, W.G: The Petroleum System-from source to Trap: AAPG Memoir 69.

Geological Cross Section – Present Day



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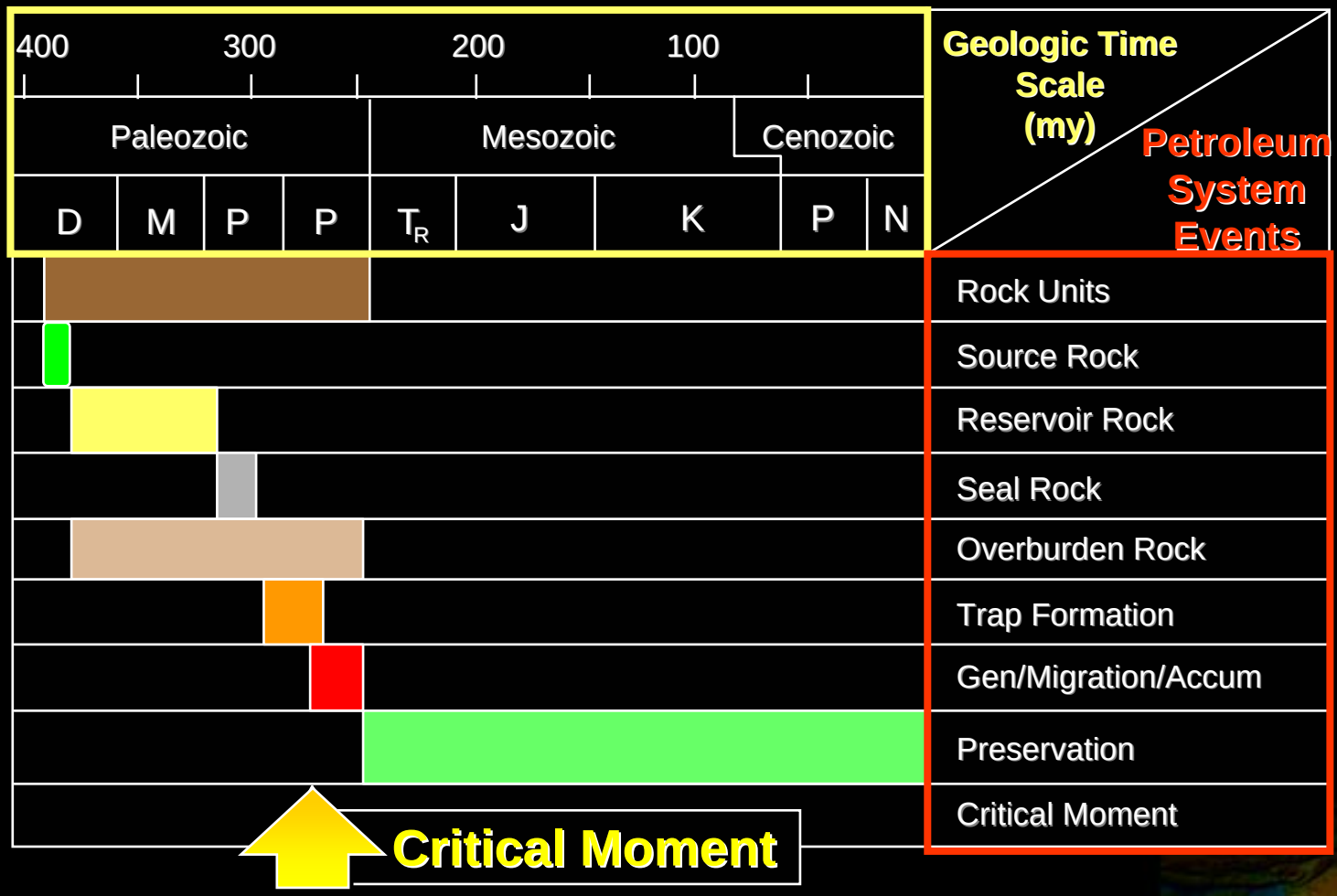
Event Chart



Time of Expulsion and Migration.
(Trap must already exist)

AAPG: Magoon, L.B, and Dow, W.G: The Petroleum System-from source to Trap: AAPG Memoir 69.

Event Chart

400 300 200 100

Geologic Time Scale

250 My

Paleozoic | Mesozoic | Cenozoic

D M P P T_R J K P N

Petroleum System Events

Geological Timescale

Rock Units

Source Rock

Reservoir Rock

Seal Rock

Overburden Rock

Elements

Need these in correct stratigraphic order

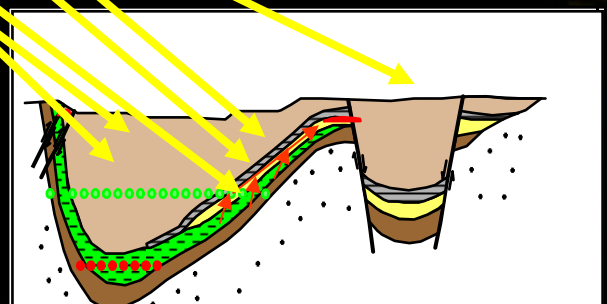
Gen/Migration/Accum

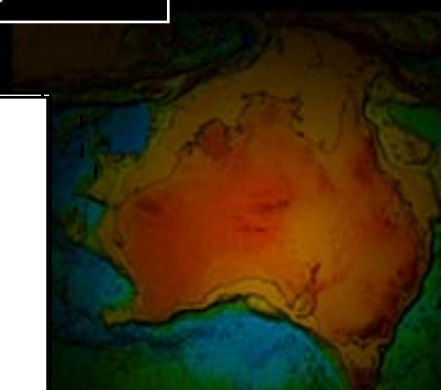
Preservation

Critical Moment

Processes

Critical Moment





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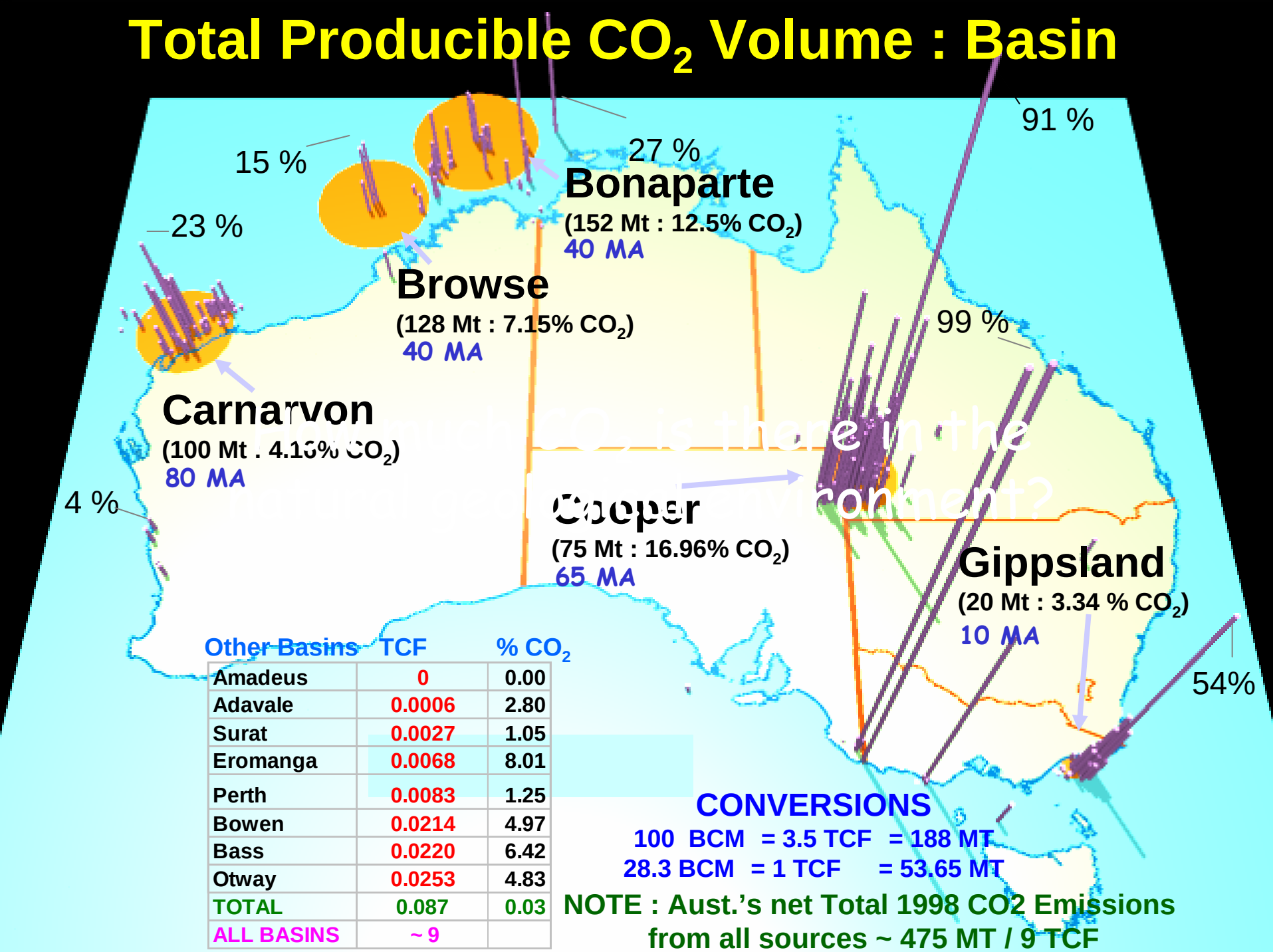
Total Producible CO_2 Volume : Basin



Other Basins	TCF	% CO_2
Amadeus	0	0.00
Adavale	0.0006	2.80
Surat	0.0027	1.05
Eromanga	0.0068	8.01
Perth	0.0083	1.25
Bowen	0.0214	4.97
Bass	0.0220	6.42
Otway	0.0253	4.83
TOTAL	0.087	0.03
ALL BASINS	~ 9	

CONVERSIONS

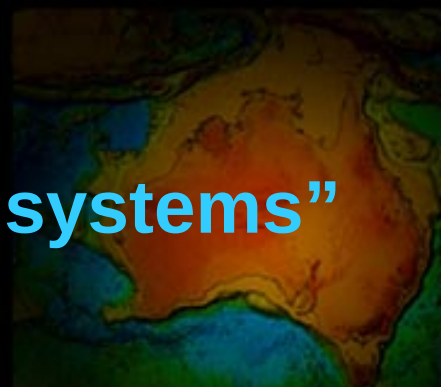
100 BCM = 3.5 TCF = 188 MT

28.3 BCM = 1 TCF = 53.65 MT

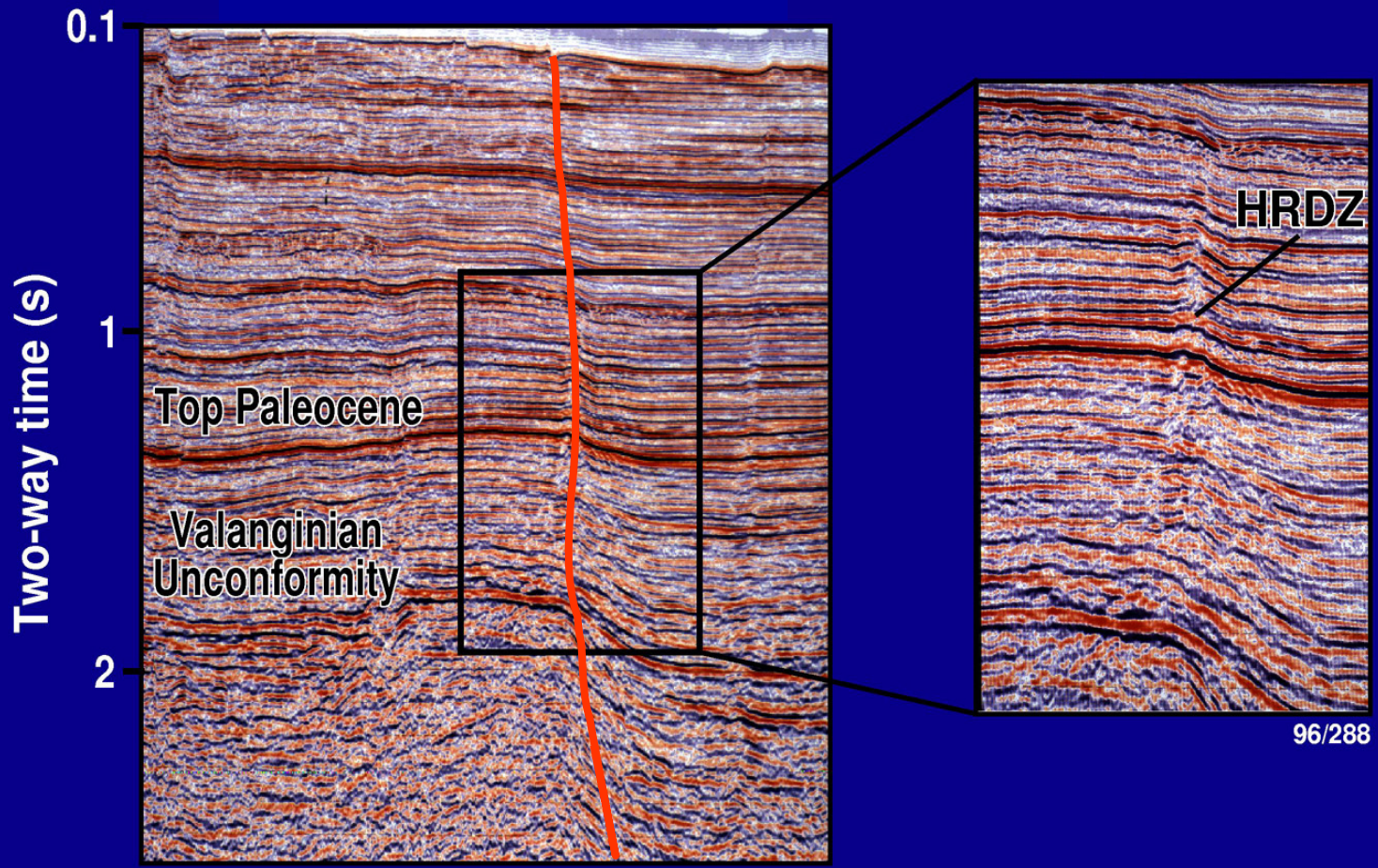
NOTE : Aust.'s net Total 1998 CO2 Emissions from all sources ~ 475 MT / 9 TCF

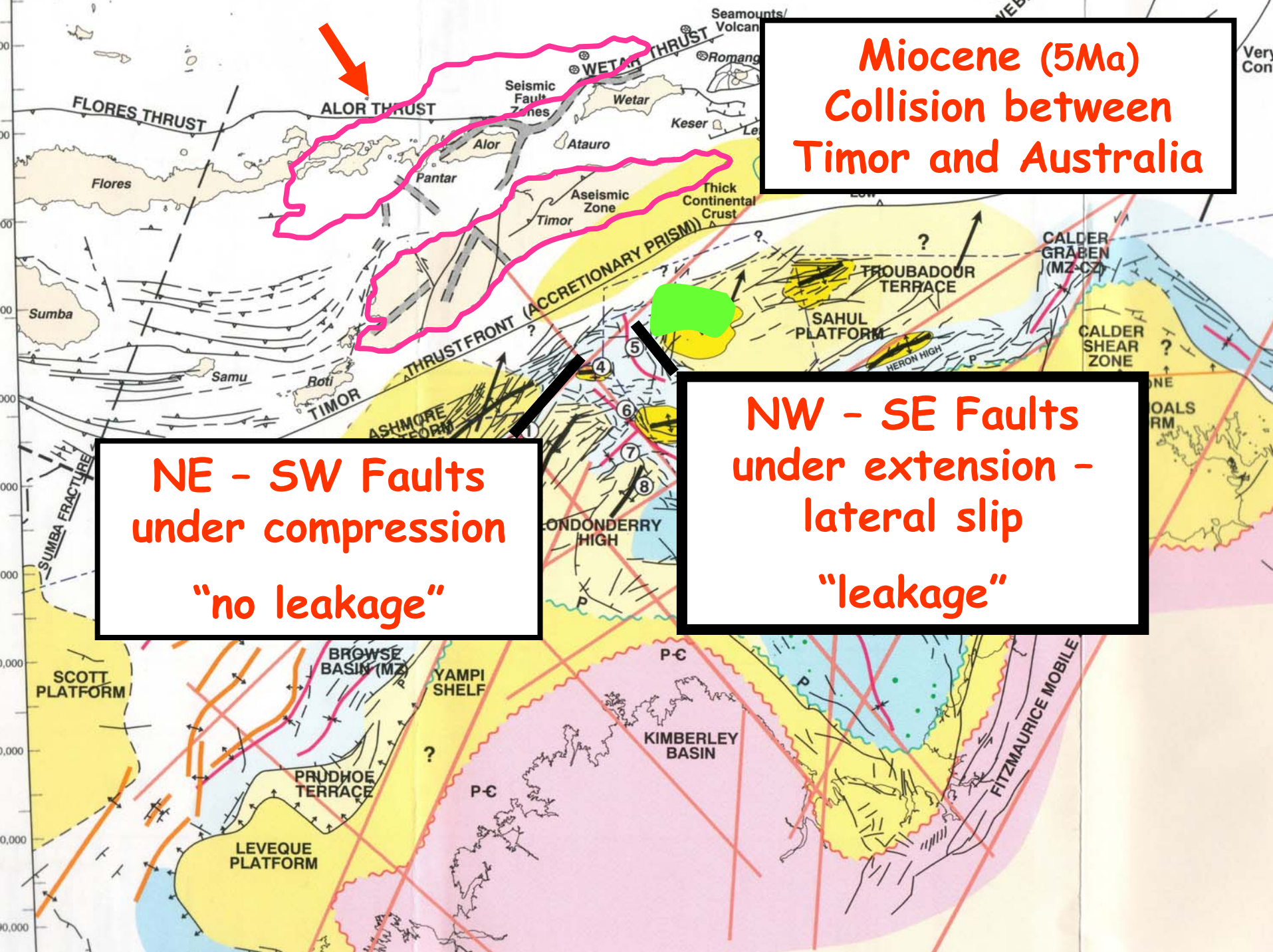
What about leakage in Petroleum Systems ?

- **Some fields have been destroyed over geological time ("catastrophic release")**
  - **Due to major plate tectonic events (example)**
  - **Significant escape from a viable trap is episodic not constant (otherwise not trapped)**
- **Leakage does occur naturally**
  - **Natural analogues – often "leaky systems" studied**



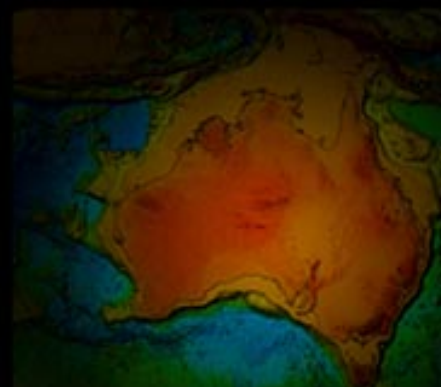
Hydrocarbon leakage and mineralisation




Miocene (5Ma)
Collision between
Timor and Australia
NE - SW Faults
under compression
"no leakage"
NW - SE Faults
under extension -
lateral slip
"leakage"
FLORES THRUST
ALOR THRUST
WETAR THRUST
Seismic
Fault
Zones
Wetar
Alor
Atauro
Keser
Pantar
Flores
Aseismic
Zone
Thick
Continental
Crust
Timor
THRUST FRONT (ACCRETIONARY PRISM))
Sumba
Samu
Roti
TIMOR
TROUBADOUR
TERRACE
CALDER
GRABEN
(MZ-CZ)
SAHUL
PLATFORM
HERON HIGH
CALDER
SHEAR
ZONE
SUMBA FRACTURE
LONDONDERRY
HIGH
SCOTT
PLATFORM
BROWSE
BASIN (MZ)
YAMPI
SHELF
P-€
KIMBERLEY
BASIN
FITZMAURICE MOBILE
PRUDHOE
TERRACE
LEVEQUE
PLATFORM

What about well leakage ?

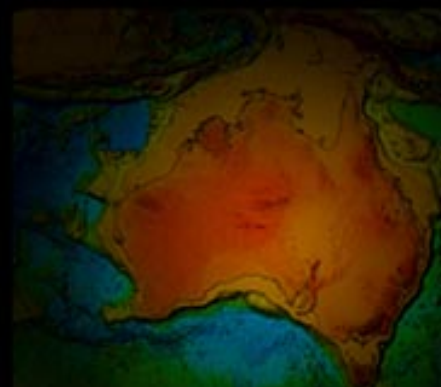
- **Largely an engineering issue**
  - **put in perspective**
- **Can remediate & plan**
  - **not a major cost in life of project**

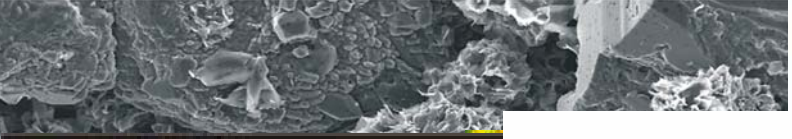


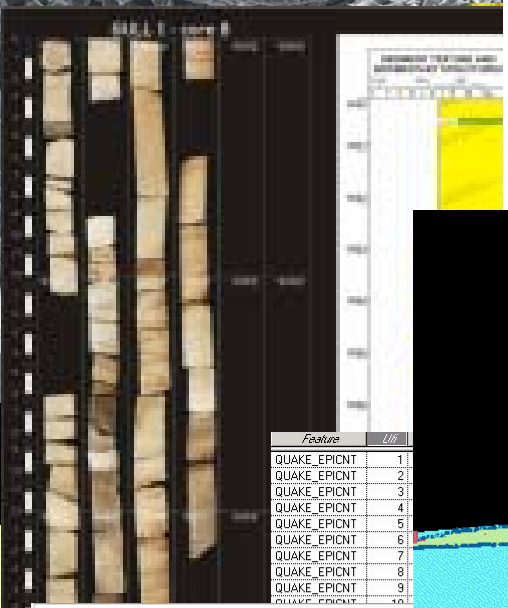
So what is needed?

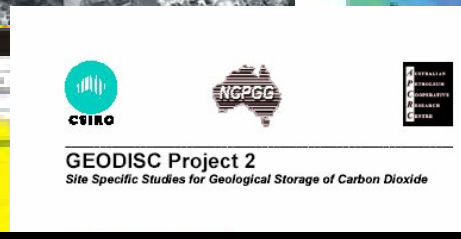
- **Prospect risk assessment on technical criteria across the "world"**
- **Focus on deep saline reservoirs**
- **Takes time and commitment**
- **<u>Regulations, technical advice & site selection paramount</u>**

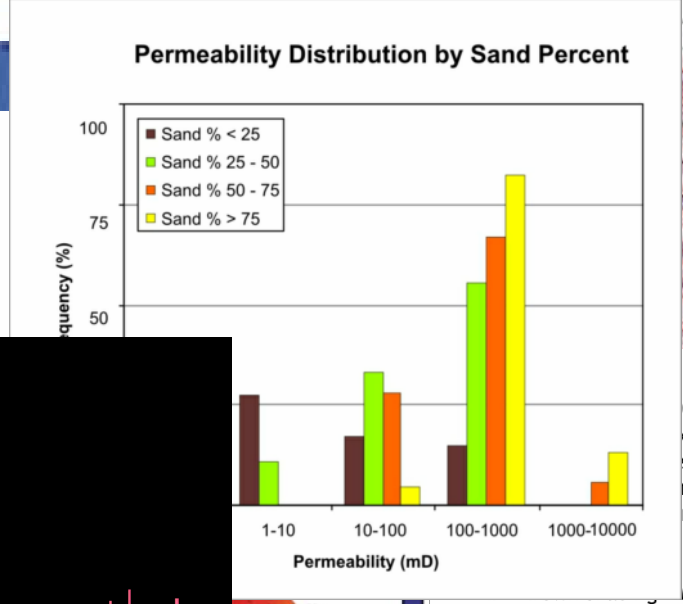
- **How do we do it?**

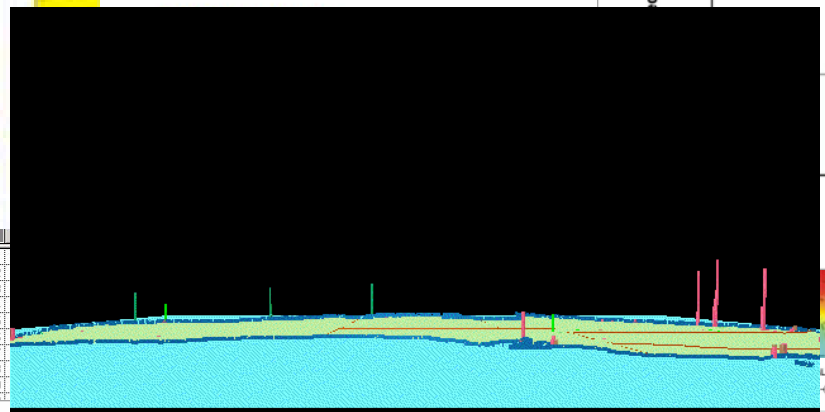


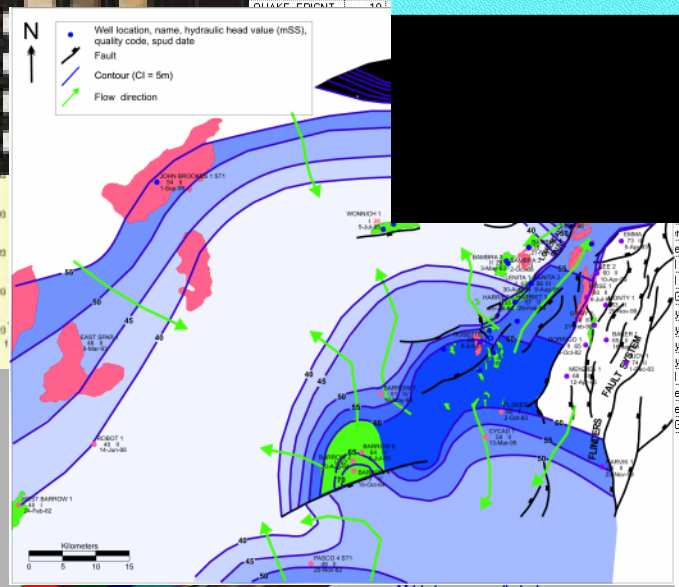


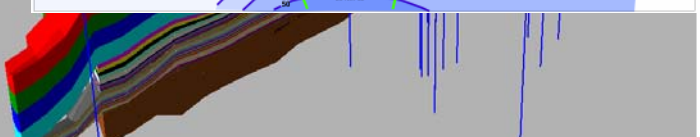


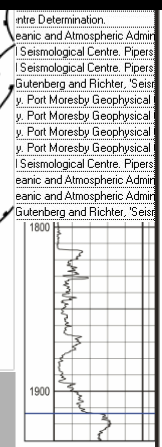


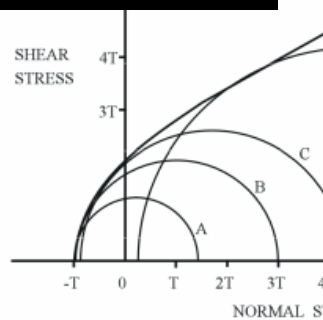




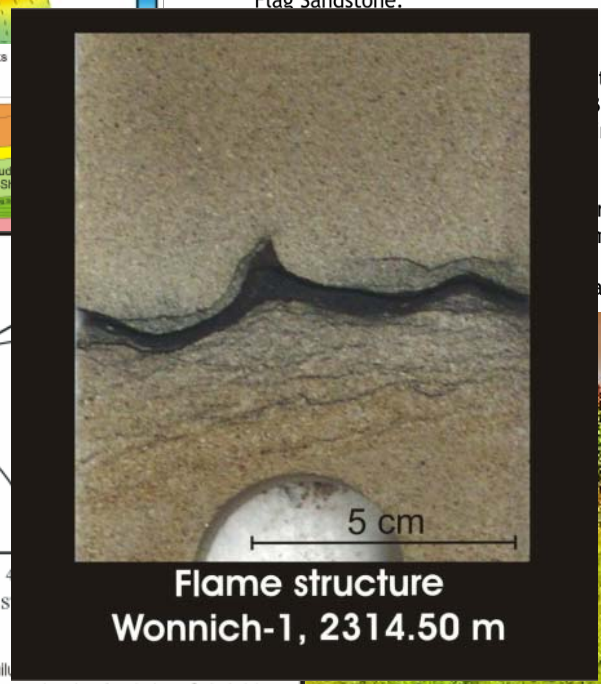








Mohr diagram with Mohr circles for different fail
fracturing; B: maximum stress difference for pure extension fracturing; C: hybrid extensional-shear failure. T denotes the tensile strength of the rock.
After Etheridge (1983).



SS.
horizontal scale.
nce boundary.
nsgressive surface.
mum flooding surface.
main Flag Sandstone

Muderong Shale regional seal or intraformational seals within the Flag Sandstone.


Offshore South Perth Basin
Investigation