

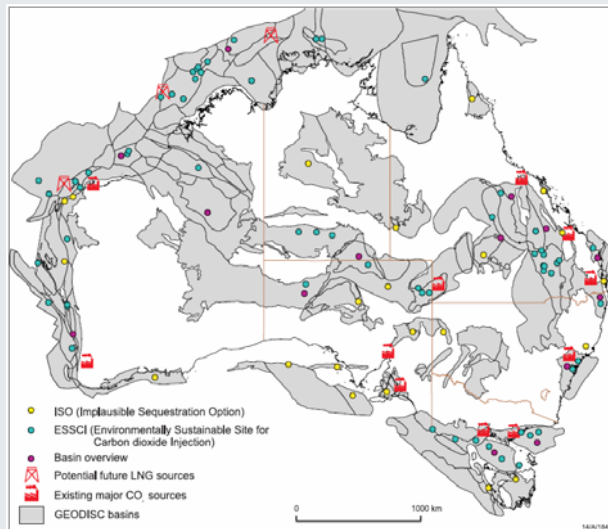


Regional Assessment of Australia's Storage Potential

Rick Causebrook – Geoscience Australia

Geoscience Australia's Involvement in CCS Studies

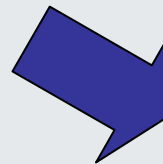
Australian High Level Storage Potential Studies



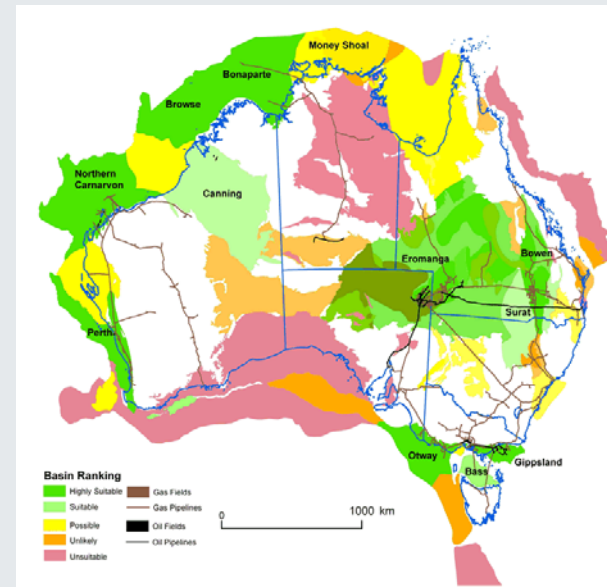
GEODISC 2000

(APCRC)

Increasing
world-wide
development of
methodologies



In between we
have also
conducted
many detailed
Regional
Studies



Carbon Storage Task
Force 2009

Access to Data

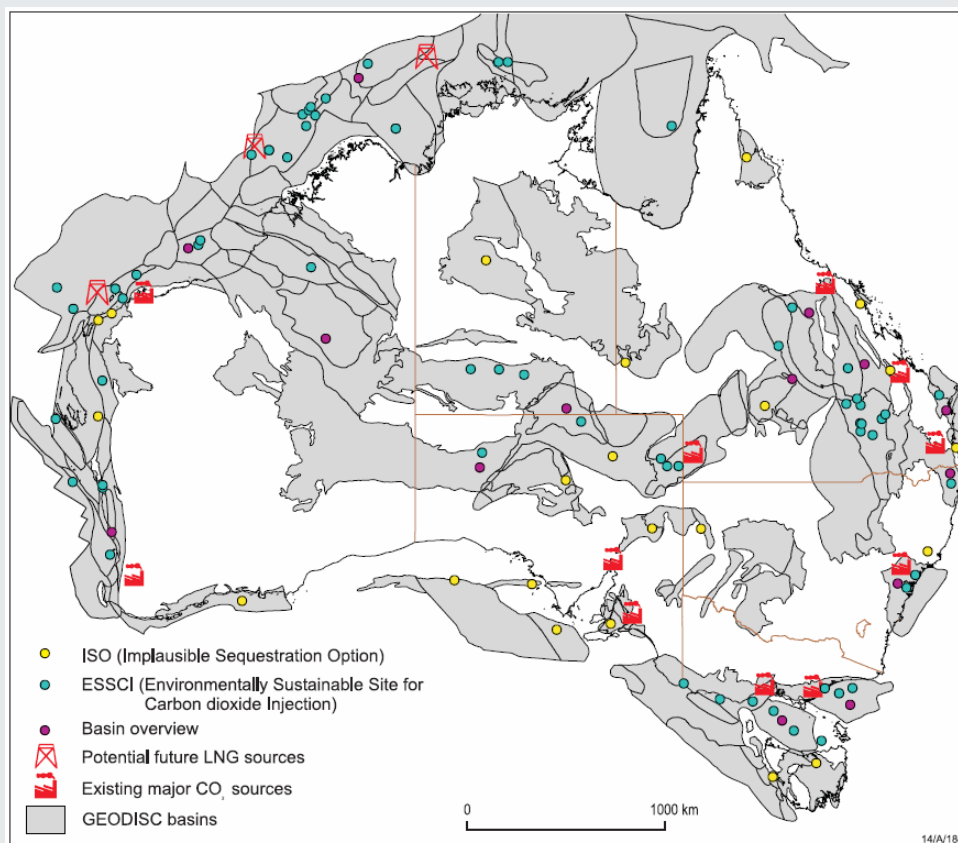
These regional studies could not have completed successfully without access to a considerable amount of exploration data.



In Australia data and samples submitted under Commonwealth and State legislation is held for public use at Geoscience Australia and by State Geological Surveys

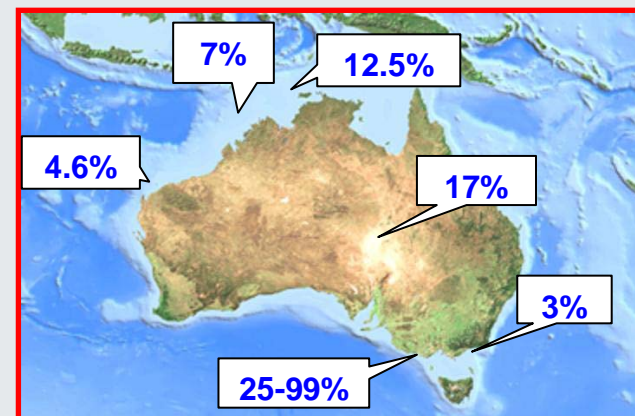
Mapping the storage potential of Australia's sedimentary basins

- The first significant attempt



GEODISC (APCRC) 1999-2003

CAGS Technical Workshop – Canberra 19th-21st January 2010



- First review of sedimentary basins & creation of portfolio of storage options
- Carried out under the APCRC
- 48 basins (out of >300)
- 65 sites (out of 102) viable and ranked based on capacity, injectivity, technical & economic viability, containment, existing resources
- Disparity between sources & sinks
- Theoretically >1600 years of storage
- Realistically 100-115Mt/y

GEOSCIENCE AUSTRALIA

Carbon Storage Task Force GHG Storage Project 2009

Reasons behind study

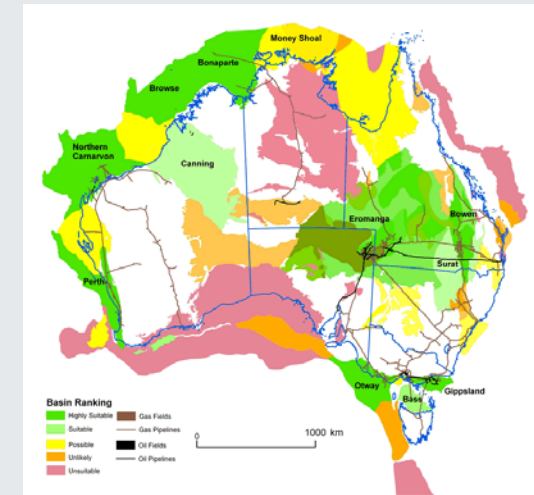
- [Carbon Storage Task Force](#)
- Established by Australian Government in October 2008 under the:
- [National Low Emissions Coal Initiative](#)
- to develop the
- [National Carbon Mapping and Infrastructure Plan](#)

Geological Storage Assessment Participants

- Geoscience Australia
- Department of Primary Industries Victoria
- Department of Employment, Economic Development and Innovation , Queensland
- Department of Mines and Petroleum, WA
- Department of Primary Industries, NSW
- Department of Primary Industries and Resources, SA

Carbon Storage Task Force Basin Ranking and Capacity

- Updated high level assessment completed 2009
 - Development of prospectivity and capacity assessment methodologies
 - New information from recent regional and basin studies
 - Basins summarised and ranked using publicly available data (OPA)
- Outcomes
 - Basins ranked
 - Eliminated small eastern basins & other poor, but convenient, sites
 - Identified and documented prospective and non-prospective basins
 - Scientific rationale for recommendations regarding priorities for future study and data acquisition programmes



Process

1. Critical Geologic Inputs

- Distribution of top and fault seal (containment)
- Criteria - Seismic activity, Size, **Depth***, Type, **Fault seal***, Hydrogeology, Geothermal gradient, Hydrocarbon potential, Basin maturity, Coal and CBM, **Reservoir***, **Seal integrity***, **Reservoir/Seal pairs***, Onshore/offshore, Climate, Accessibility, Infrastructure, CO₂ sources, Knowledge level & Data availability
- Basin outlines - single agreed set
- Key boundary issues
 - 800 m top aquifer (supercritical phase change)
 - 3500 m top of basal aquifer (generous)
 - 250 m bathymetric contour
- Distribution of oil & gas fields

2. Just geology – nothing discounted on economic, resource conflict, commercial, logistical issues

Process continued

- Development of project
 - Easily updated- common platform ArcGIS v9.2
- Ranking of basins
 - Modified after Bachu (2003)
 - ‘zeroed’ on non geologic factors – just the rocks
 - Weighted heavily toward seal and reservoir-
containment is the priority at this scale
 - 5 colour class code
- Capacity- using DOE 2008 simple formula
 - Efficiency set between 0.5-5%
 - Order of magnitude calculation
 - Input parameters ‘Monte Carlo’

“Modified Bachu” Ranking Criteria

Basin Ranking Criteria		Note: Any changes to the definition of Criteria should be made in this table only					
	Basin Criterion	Classes					Weighting
		1	2	3	4	5	
1	Tectonics (Seismicity)	High	High/Medium	Medium	Medium/Low	Low	0.00
2	Size	Small (<5000km ²)	Medium (5000-25000km ²)	Large (25000-50000km ²)	Very Large (>50000km ²)		0.06
3	Depth	Shallow (<1,500m)	Deep (>3,500m)	Intermediate (1,500 - 3,500m)			0.10
4	Type	Non-marine	Non-marine and marine	Marine			0.04
5	Faulting intensity	Extensive	Moderate	Limited			0.14
6	Hydrogeology	Poor (fractured rock system, short flow system)	Intermediate (faulted-fractured rock system, intermediate flow)	Good (regional, long-range flow systems; topography or erosional flow)			0.04
7	Geothermal	Warm basin (>40°C/km)	Moderate (30-40°C/km)	Cold basin (<30°C/km)			0.05
8	Hydrocarbon potential	None	Small	Medium	Large	Giant	0.05
9	Maturity	Unexplored	Exploration	Developing	Mature	Over-mature	0.05
10	Coal and CBM	None	Shallow (200-800m)	Deep (>800m)			0.00
11	Reservoir	None	Potential	Poor	Good	Excellent	0.16
12	Seal	None	Potential	Poor	Good	Excellent	0.18
13	Reservoir/Seal Pairs	None	Poor	Good (Single)	Excellent (Multiple)		0.03
14	Onshore / offshore	Deep offshore (>200 m)	Shallow offshore (<200 m)	Onshore			0.00
15	Climate	Harsh	Desert	Tropical	Subtropical	Temperate	0.00
16	Accessibility	Inaccessible	Difficult	Acceptable	Easy		0.00
17	Infrastructure	None	Minor	Moderate	Extensive		0.00
18	CO ₂ sources	None	Few	Moderate	Major		0.00
19	Knowledge level	Limited	Moderate	Good	Extensive		0.05
20	Data availability	Poor	Moderate	Good	Excellent		0.05

After Bachu 2003

“Modified Bachu” Basin Ranking Schema

Weightings:-					0.00	0.04	0.10	0.04	0.14	0.04	0.05
State	Onshore	Basin Name	Total Score	Ranking	Seismicity	Size	Depth	Type	Fault seal	Hydrogeology	Geothermal gradient
VIC	Offshore	Gippsland Basin	0.92	1	4	3	3	2	3	3	2
WA	offshore	North Perth Basin	0.82	2	4	4	3	2	2	3	2
SA	Onshore	Eromanga Basin	0.79	3	4	4	3	1	3	3	1
WA	offshore	Northern Carnarvon Basin	0.78	4	5	4	3	2	1	2	2
SA	Onshore	Cooper Basin	0.69	5	5	3	3	2	2	3	1
WA	offshore	Browse Basin	0.68	6	5	4	3	3	2	1	2
QLD	Onshore	Bowen	0.67	7	4	3	3	2	2	3	3
WA	offshore	Northern Bonaparte	0.65	8	5	4	3	2	1	3	2
SA	Offshore	Otway Basin	0.63	9	3	3	3	1	1	3	3
NT	offshore	Money Shoal	0.62	10	3	4	3	2	3	2	3
QLD	Onshore	Galilee	0.62	11	5	4	3	2	3	3	1

Input for Monte Carlo Simulation for Capacity Estimation

Parameter	Unit	Score (P90)	Score (P50)	Score (P10)	Distribution
Area of storage region	km ²	10000	16000	30000	Triangular
Gross thickness of saline formation	m	200	500	900	Triangular
Average porosity of saline formation over thickness interval	%	19	22	25	Triangular
Density of CO ₂ at average reservoir conditions	t/m ³	0.5	0.6	0.7	Triangular
E-storage efficiency factor (% of total pore volume)	%	4	4	4	
Calculated storage potential	gigatons	31.0	48.8	78.3	

Basin assessment

Offshore Gippsland Basin

SOUTHEASTERN VICTORIA, OFFSHORE

Reservoir:

Top Latrobe, Curlip, Admiral formations, Golden Beech, Intra-Latrobe, Intra-Seaspray groups, and Intra-Golden Beach Subgroup

Seal:

Lakes Entrance Formation, basal Halibut Group and Kipper Shale

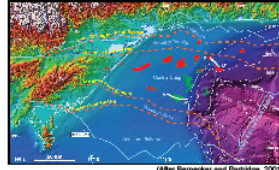
HYDROCARBON POTENTIAL
CATEGORY 1 and 2* (OGRA 2006)

Crude oil MMBL 278.28
Condensate MMBL 130.92
LPG MMBL 174.85
Sales gas Tcf 7.35

*Data from entire basin

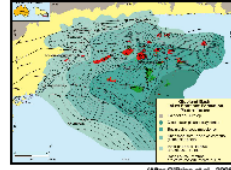


STRUCTURAL ELEMENTS



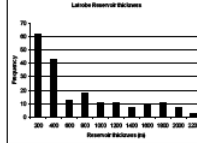
(After Berner and Patridge, 2001)

REGIONAL SEAL AREA

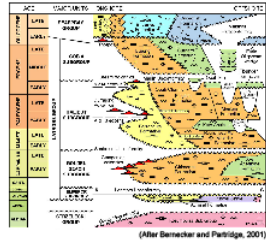


(After O'Brien et al., 2005)

RESERVOIR THICKNESS



STRATIGRAPHY

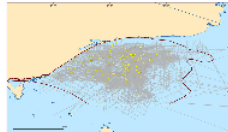


(After Berner and Patridge, 2001)

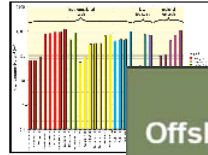
OIL AND GAS FIELDS



WELLS AND SEISMIC COVERAGE

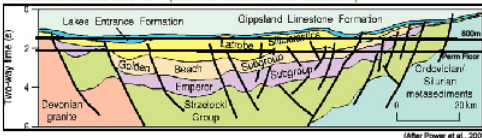


TOP SEAL POTENTIAL



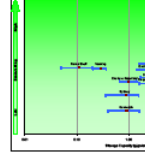
(After)

REGIONAL CROSS SECTION (LOCATION IN OIL AND GAS FIELDS MAP)



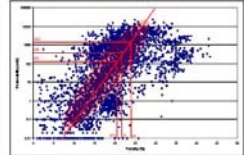
(After Power et al., 2001)

BASIN RANKING VS. CAP

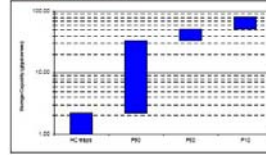


Offshore Gippsland Basin

POROSITY VS. PERMEABILITY



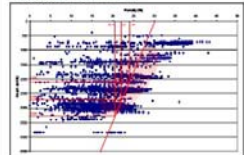
STORAGE CAPACITY



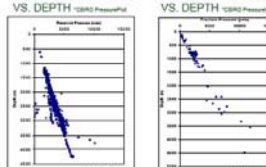
BASIN RANKING

Category	Description	Score	Weighting
Tectonics (Sediment)	Medium/Low	4	0.00
Size	Large	3	0.08
Depth	Intermediate	3	0.10
Type	Non-marine and Marine	2	0.04
Faulting intensity	Limited	3	0.14
Hydrogeology	Good	3	0.04
Geothermal	Moderate	2	0.08
Hydrocarbon potential	Good	5	0.08
Maturity	Over mature	5	0.08
Coal and CBM	Deep	3	0.00
Reservoir	Excellent	5	0.10
Seal	Excellent	5	0.18
Reservoir/Seal Pair	Excellent	4	0.03
Obstacle/Obstacle	Shallow Obstacle	2	0.00
Climate	Temperate	5	0.00
Accessibility	Excellent	3	0.00
Infrastructure	Extensive	4	0.00
CO ₂ sources	Major	4	0.00
Knowledge level	Extensive	4	0.08
Data availability	Excellent	4	0.05
Overall Ranking			1

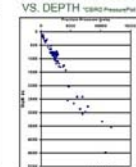
POROSITY VS. DEPTH



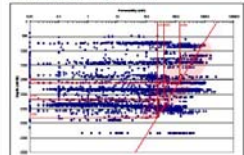
RESERVOIR PRESSURE VS. DEPTH



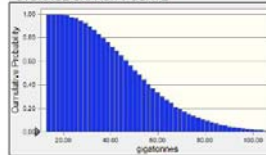
FRACTURE PRESSURE VS. DEPTH



PERMEABILITY VS. DEPTH



STORAGE CAPACITY CURVE



STORAGE CAPACITY ESTIMATE

Parameter	Unit	Score (P90)	Score (P50)	Score (P10)	Order/Basis
Area of storage region	km ²	10000	10000	10000	Triangular
Gross thickness of saline formation	m	200	500	800	Triangular
Average porosity of saline formation over thickness interval	%	10	22	28	Triangular
Density of CO ₂ at average reservoir conditions	tonnes/m ³	0.5	0.6	0.7	Triangular
Storage efficiency factor (% of total pore volume)	%	4	4	4	
Calculated storage potential	gigatonnes	31.0	48.6	78.3	

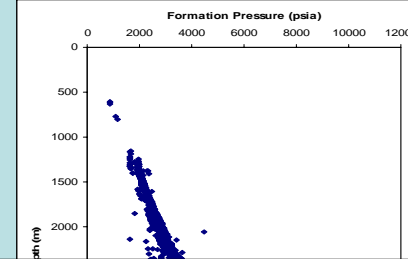
POTENTIAL INJECTION PARAMETERS

Parameter	Unit	Shallow	Mid-Depth	Deep
Depth base seal	m	850	2000	2400
Formation thickness	m	500	700	600
Injection depth	m	2100	2700	3300
Porosity	%	24	22	20.5
Absolute permeability	mD	1400	400	120
Formation pressure	psia	3200	3600	4700
Fracture pressure	psia	5400	7010	8810

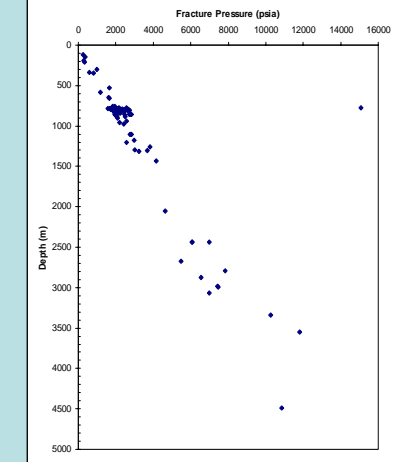
Storage capacity estimate

Parameter	Unit	Score (P90)	Score (P50)	Score (P10)	Distribution
Area of storage region	km ²	10000	16000	30000	Triangular
Gross thickness of saline formation	m	200	500	900	Triangular
Average porosity of saline formation over thickness interval	%	19	22	25	Triangular
Density of CO ₂ at average reservoir conditions	t/m ³	0.5	0.6	0.7	Triangular
E-storage efficiency factor (% of total pore volume)	%				
Calculated storage potential	gigatons	3			

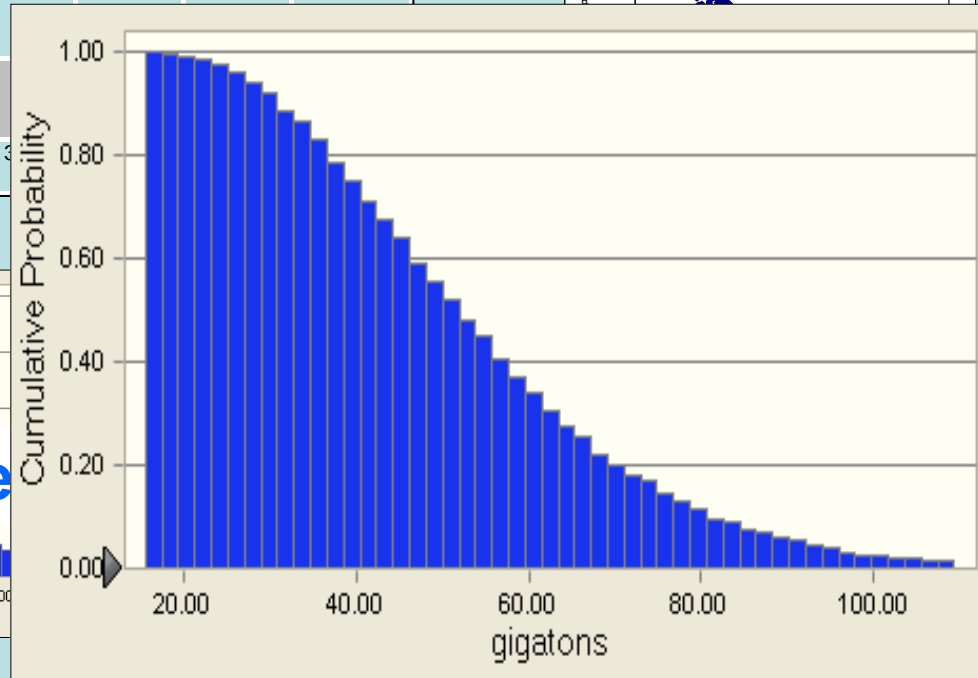
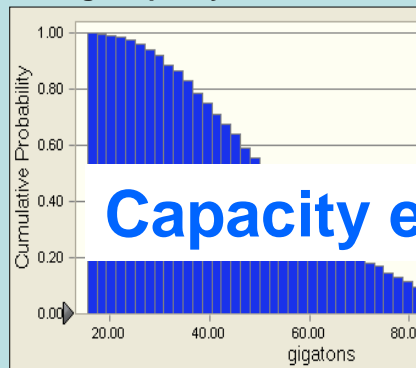
Reservoir pressure vs. depth



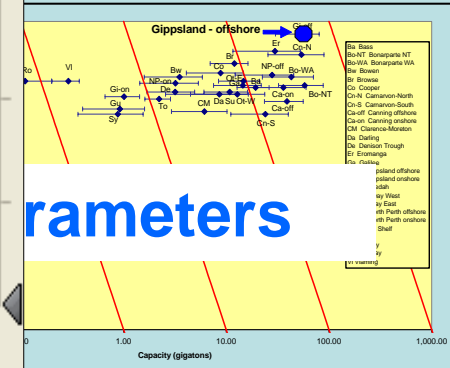
Fracture pressure vs. depth



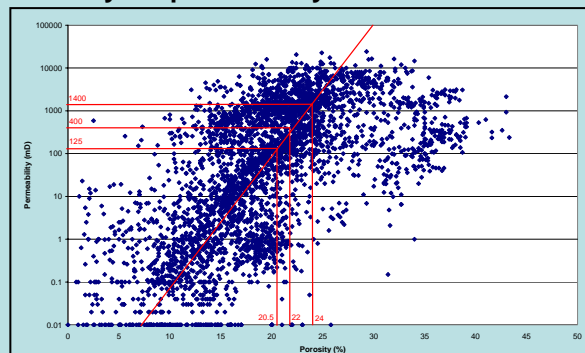
Storage capacity curve



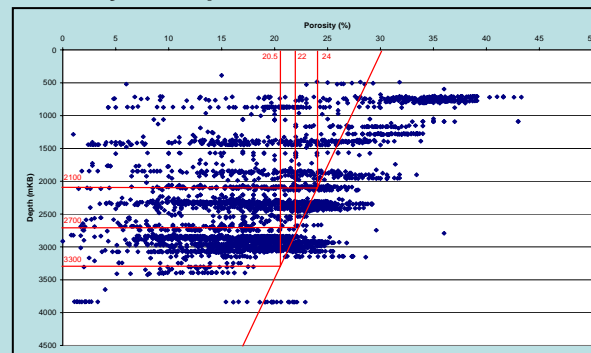
g vs. capacity



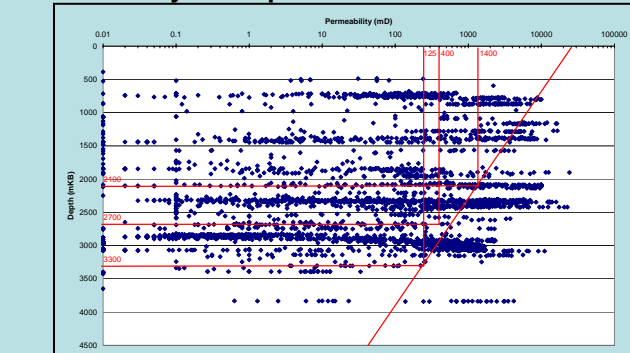
Porosity vs. permeability



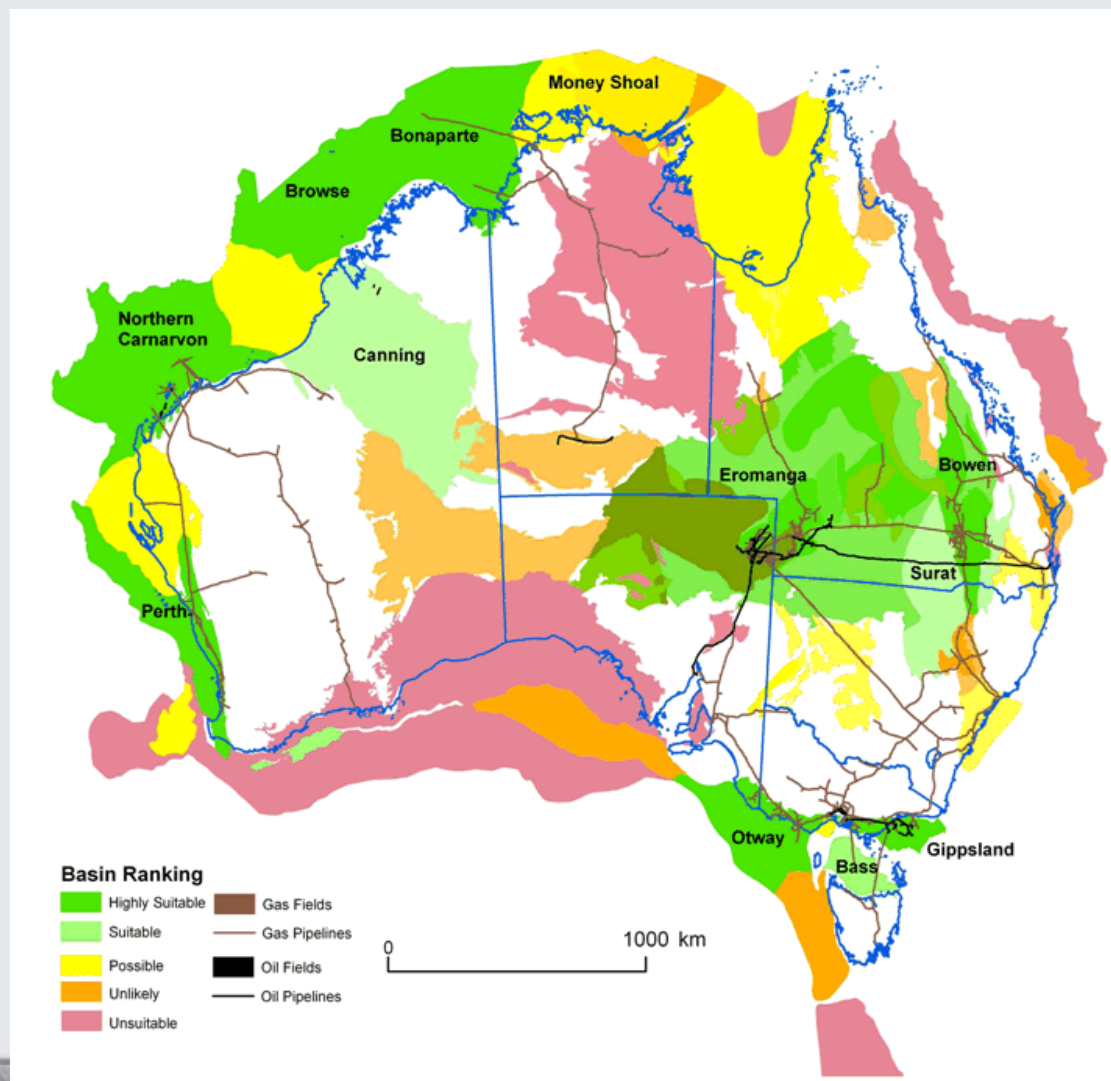
Porosity vs. depth



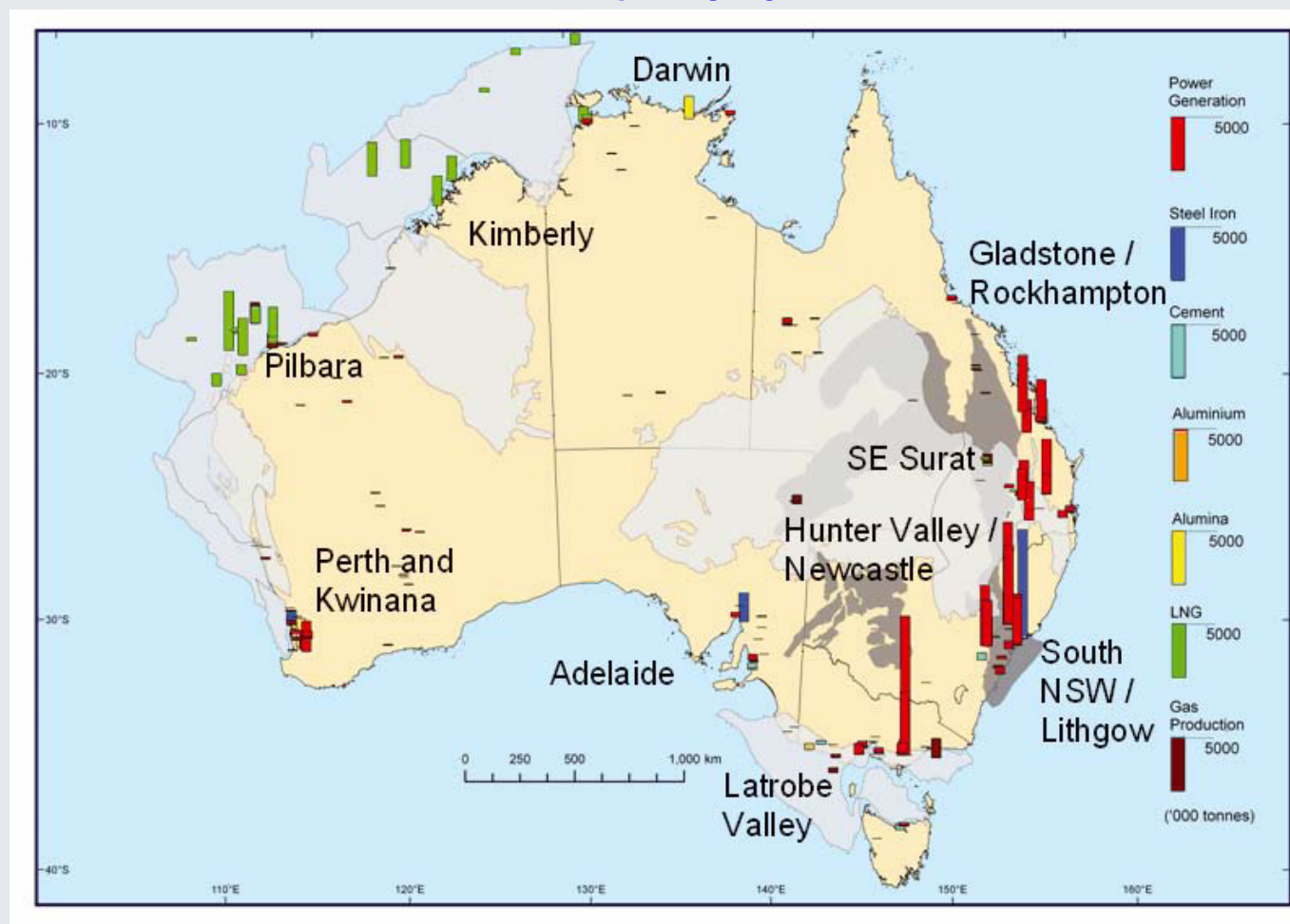
Permeability vs. depth



CCS Prospectivity of Australian Basins

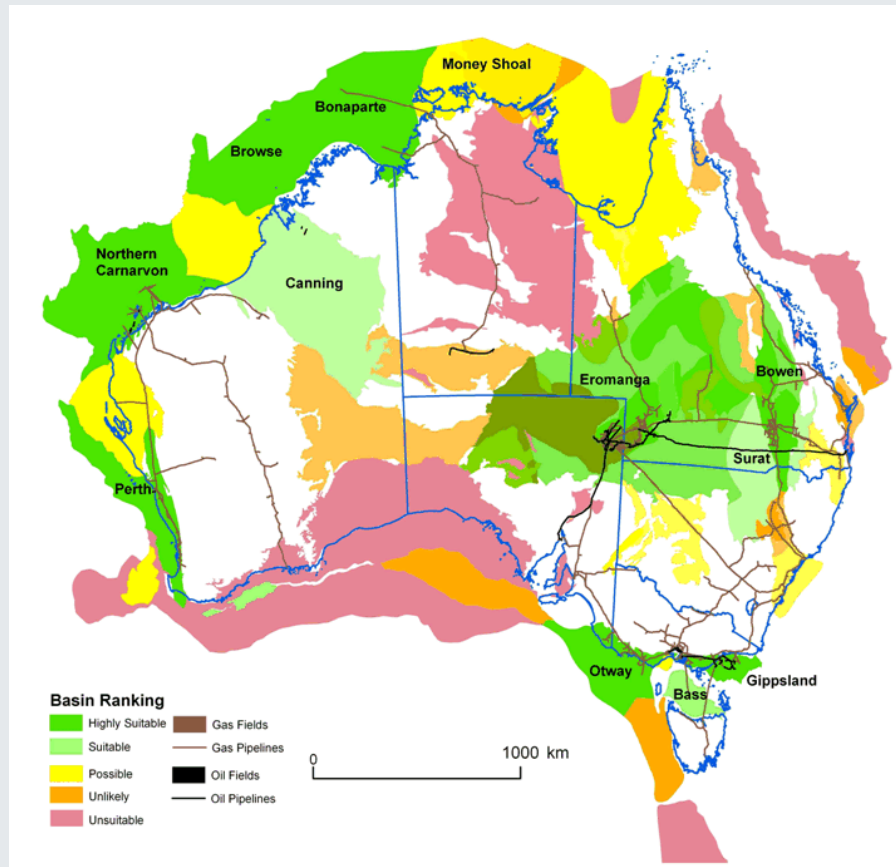


Geographical distribution of emissions by industry estimated for 2020

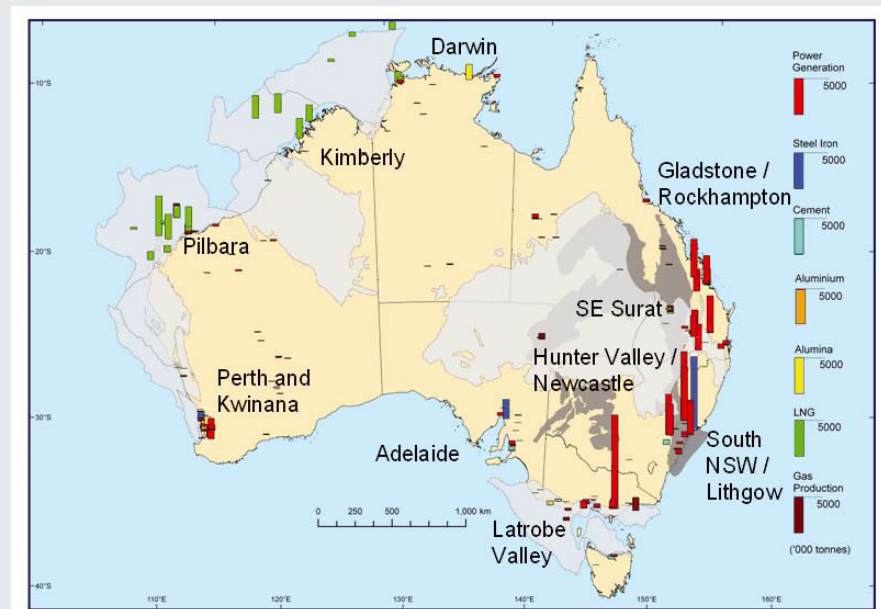


Carbon Storage Taskforce 2009, *National Carbon Mapping and Infrastructure Plan – Australia: Concise Report*, Department of Resources, Energy and Tourism, Canberra.

Australia's Storage Prospectivity as understood in 2009



Geographical distribution of emissions by industry estimated for 2020

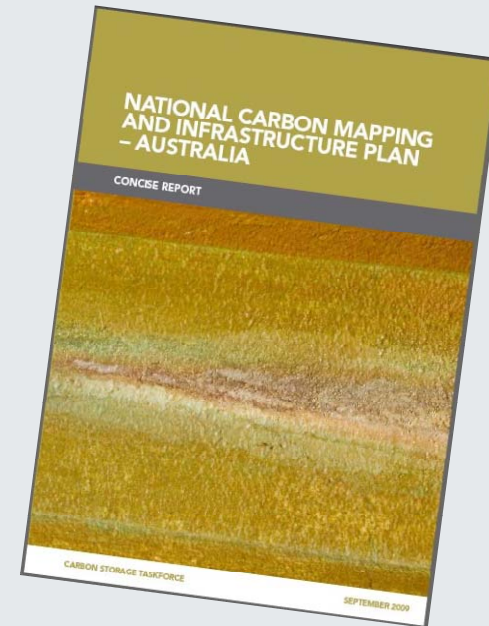


Engineering and economic analyses

- These basin analyses formed the input to high level engineering and economic assessments involving conceptual pipeline length and well number to transport and inject an industrial scale volume > ~40 Mtpa for 25yrs

National Carbon Mapping and Infrastructure Plan-Australia

- Concise report delivered to the Minister of Resources and Energy in September 2009
- Released publically December 2009
- http://www.ret.gov.au/resources/resources_programs/nleci/cst/Pages/default.aspx



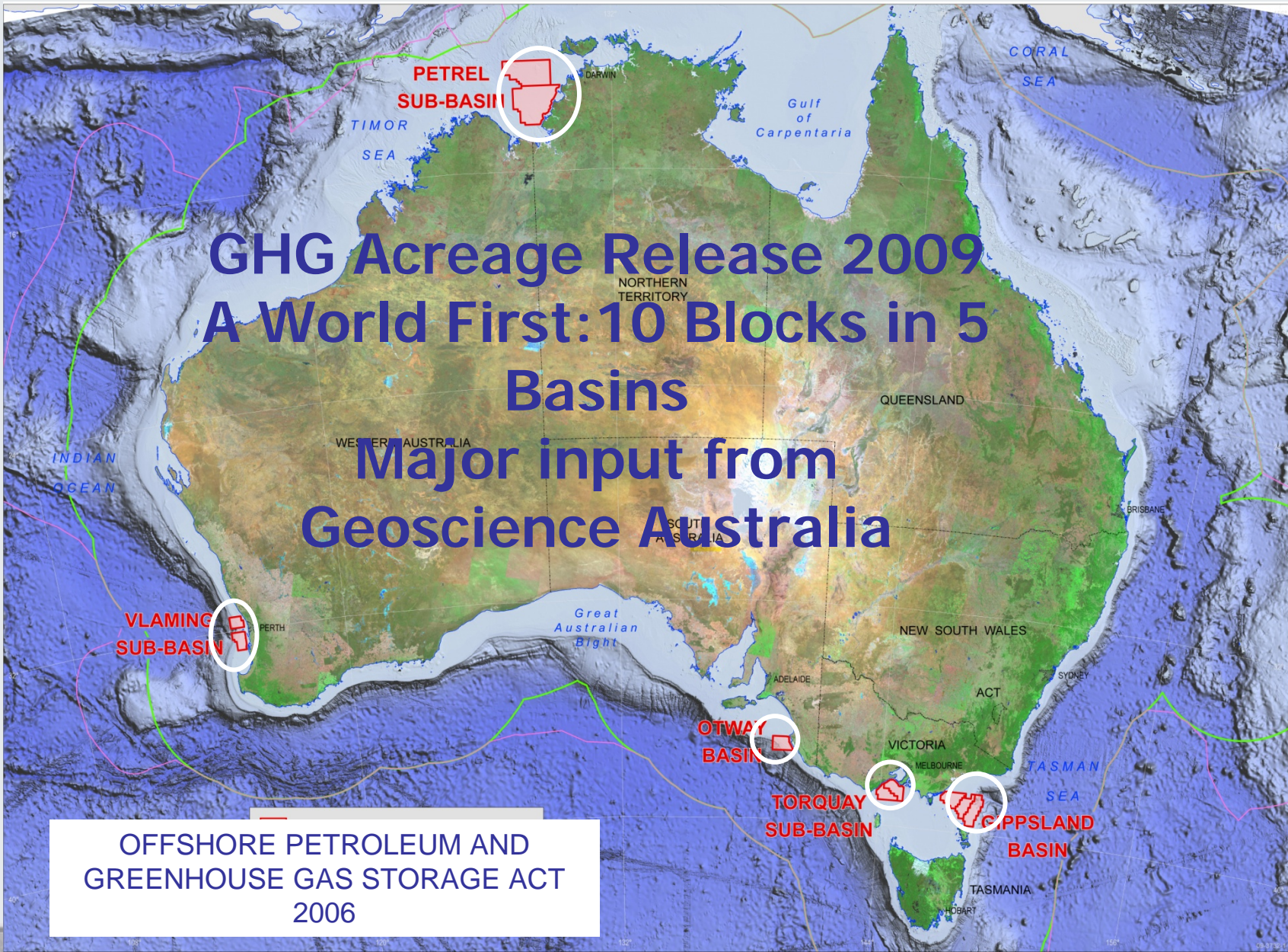
Conclusions on Storage Capacity

- There is high confidence that the east of Australia has aquifer storage capacity for 70 -450 years at a storage rate of 200 Mtpa, and that the west of Australia has capacity for 260-1120 years at 100 Mtpa, with the possibility that a far greater capacity will be defined as basins and their CO₂ storage behaviour become better known.

Carbon Storage Task Force 2009, National Carbon Mapping and Infrastructure Plan – Australia: Concise report, Department of Resources, Energy and Tourism, Canberra.

National Carbon and Infrastructure Plan

- Element 1: Pre-Competitive Exploration Programme:
 - Recommended acquisition of strategic data by State and Commonwealth Governments to encourage exploration.
- Element 2: Exploration:
 - Acreage release under OPGGSA 2006
- Element 3: Demonstration:
 - Encouragement of significant scale (>1Mtpa) projects



A map of Australia with various offshore basins highlighted in red and labeled. The basins are: PETREL SUB-BASIN (off the northern coast), VLAMING SUB-BASIN (off the southwestern coast), OTWAY BASIN (off the southern coast), TORQUAY SUB-BASIN (off the southern coast), and GIPPSLAND BASIN (off the southeastern coast). The map also shows the Gulf of Carpentaria, Timor Sea, Indian Ocean, and Tasman Sea. Major cities like Darwin, Perth, Adelaide, Melbourne, Sydney, and Hobart are marked. The text 'GHG Acreage Release 2009' and 'A World First: 10 Blocks in 5 Basins' is overlaid in large blue letters. Below this, 'Major input from Geoscience Australia' is written in white. At the bottom left, a white box contains the text 'OFFSHORE PETROLEUM AND GREENHOUSE GAS STORAGE ACT 2006'. At the bottom right, 'GEOSCIENCE AUSTRALIA' is written in large letters.

GHG Acreage Release 2009

A World First: 10 Blocks in 5 Basins

Major input from
Geoscience Australia

OFFSHORE PETROLEUM AND
GREENHOUSE GAS STORAGE ACT
2006

Questions?

