CO_2 Atlas Assessment of Geological Storage Potential

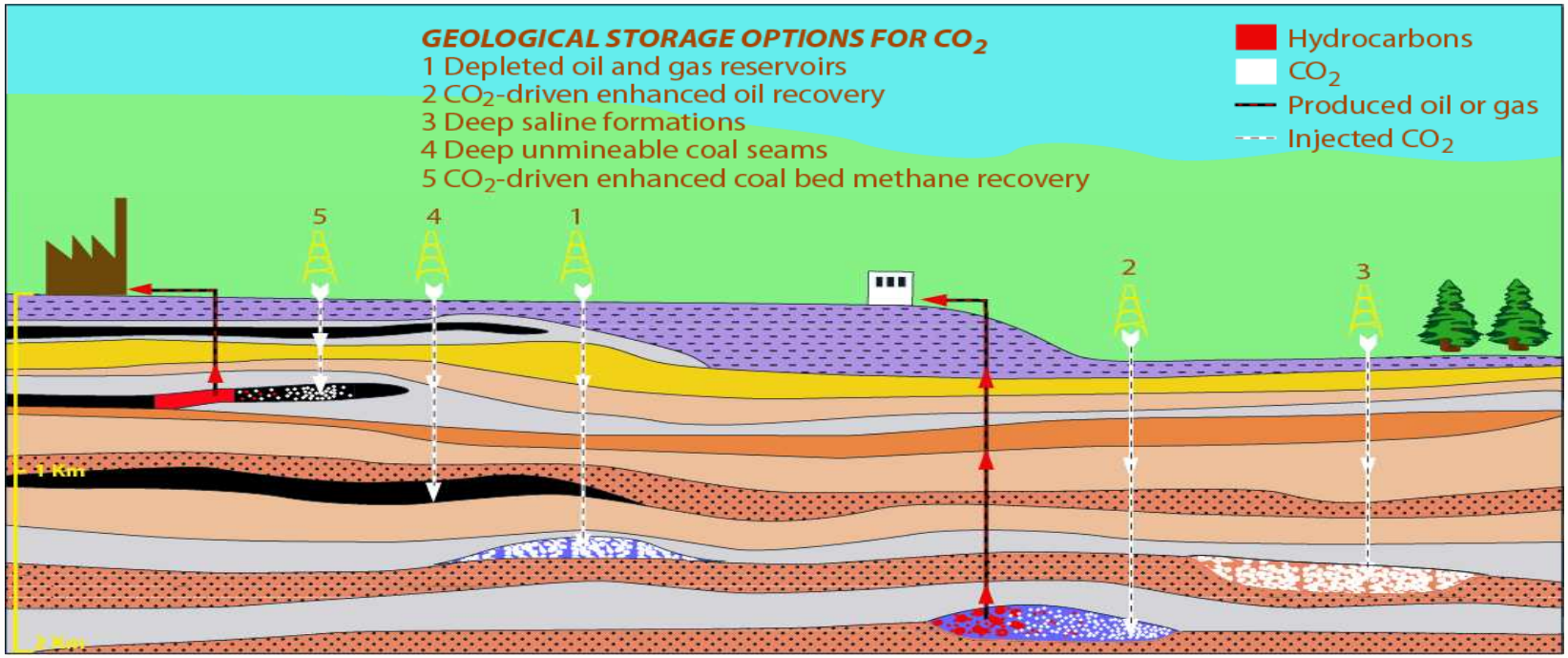
by

M. Cloete

08/04/2010, Gaberone

Introduction

The aim of a CO2 storage atlas is to identify the availability of geological sites that are both safe and practical for the storage of CO2 with a view of one day mitigating industrial greenhouse gas emissions



Theoretical global capacity ($GtCO_2$) : DSF = 9500 (91%);

DGR = 700 (6%); DOR = 120(1%); UMCS = 140 (1%)

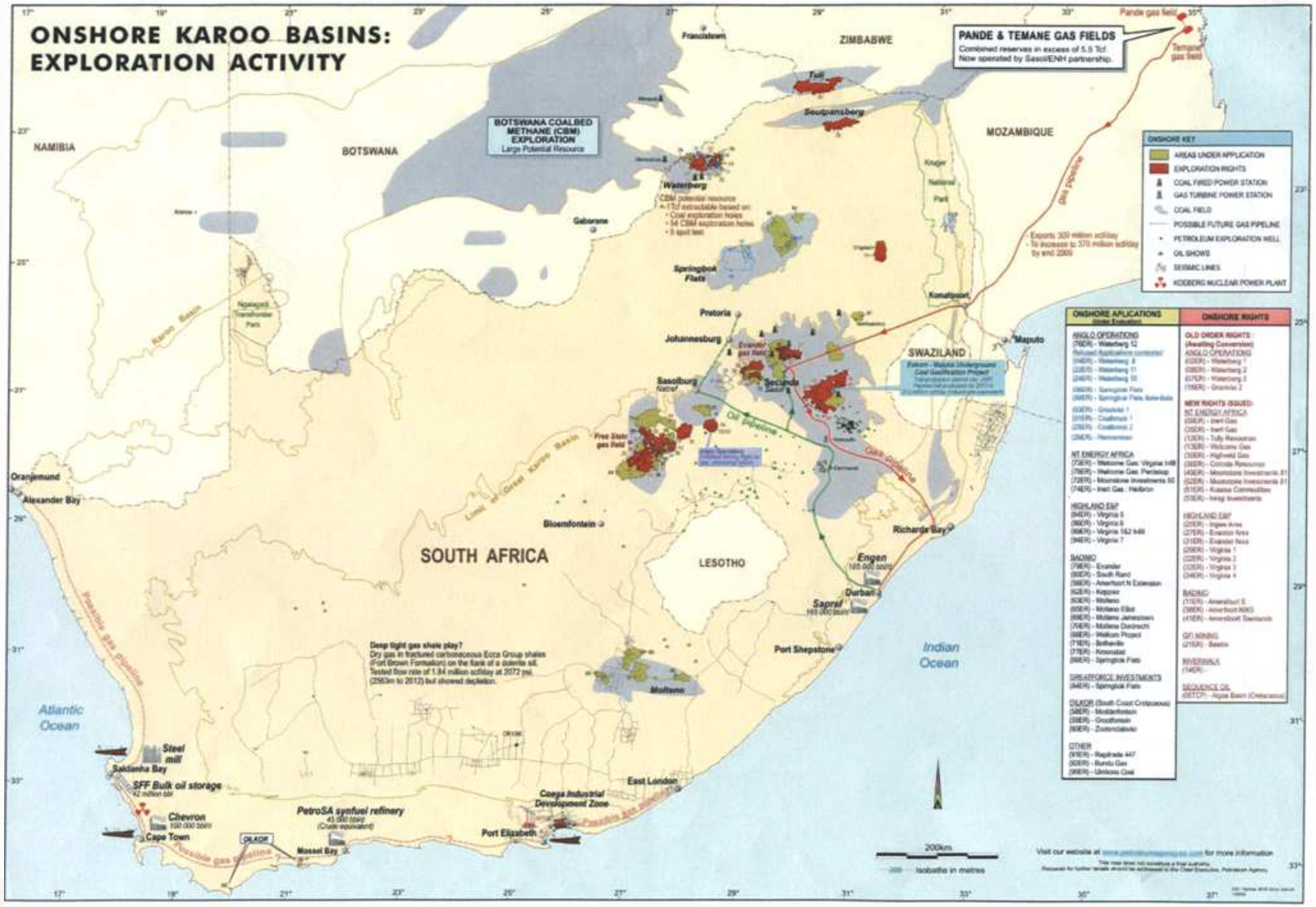
Presentation Layout

- Project work plan
- Data availability
- Criteria for assessing storage suitability of sedimentary basins
  - Screening
  - Ranking
- Standards & data certainty of estimated CO_2 storage capacities

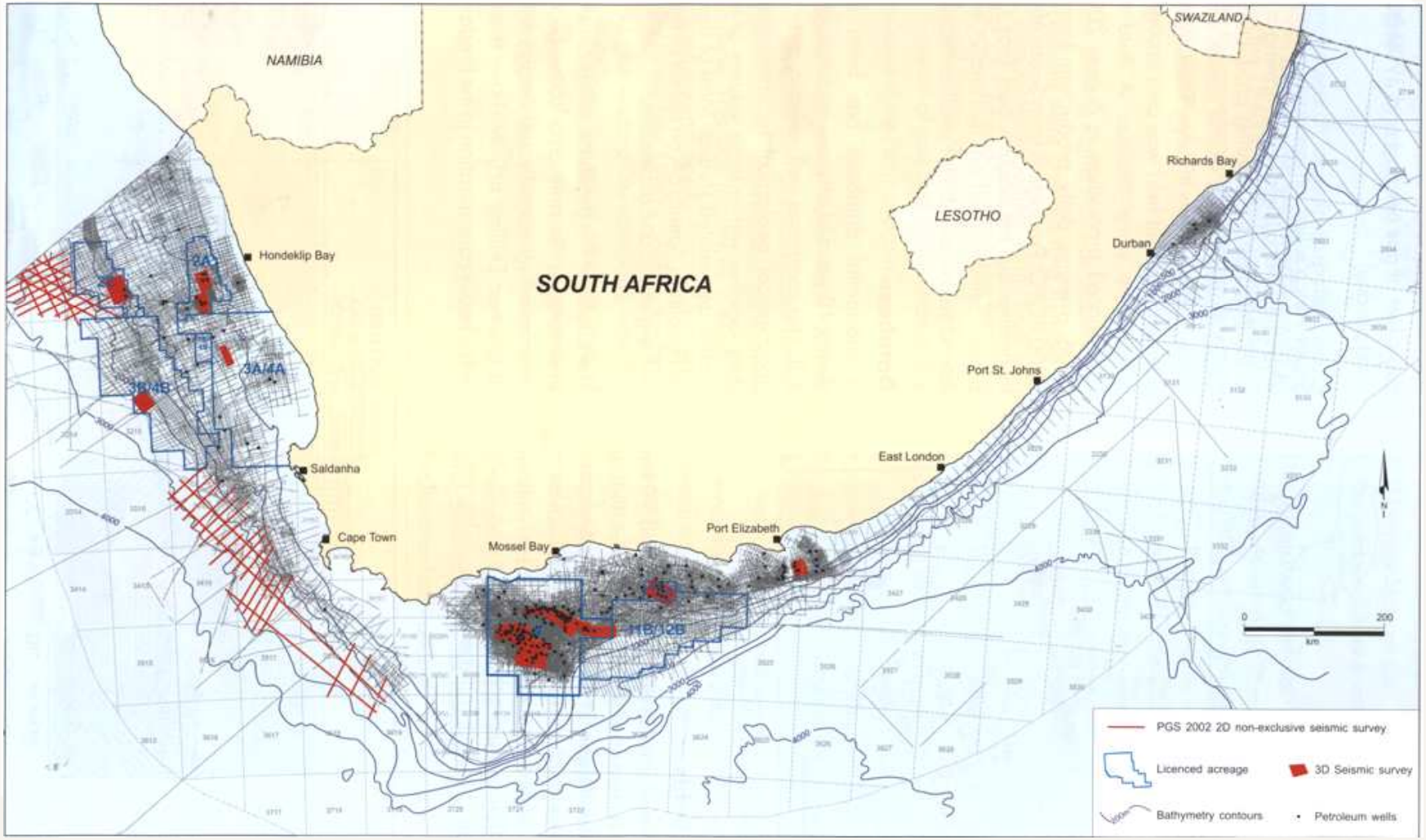
S.A. CO_2 GEOLOGICAL STORAGE ATLAS WORKPLAN (PHASE 1)

Breakdown of Phase 1 into sub-phases	Completion (weeks)
1.1 Document the stratigraphic, deep borehole and seismic data of all on- & offshore basins and rank them according to geological criteria	13
1.2 Document requisite information on physical and hydraulic properties of storage rocks, test methods and storage calculation formulae	21
1.3 Locate drill core of select stratigraphic boreholes, conduct fill-in petrographic and geotechnical tests	31
1.4 Delineate formations with best CO2 storage prospectivity and estimate storage capacities	41
1.5 Compile atlas brochure depicting the CO2 geological storage potential of basins in South Africa	56
1.6 Compile final technical report on Phase 1 with proposal whether to continue with Phase 2.	65
1.7 Editorial handling and printing of atlas & technical report	77

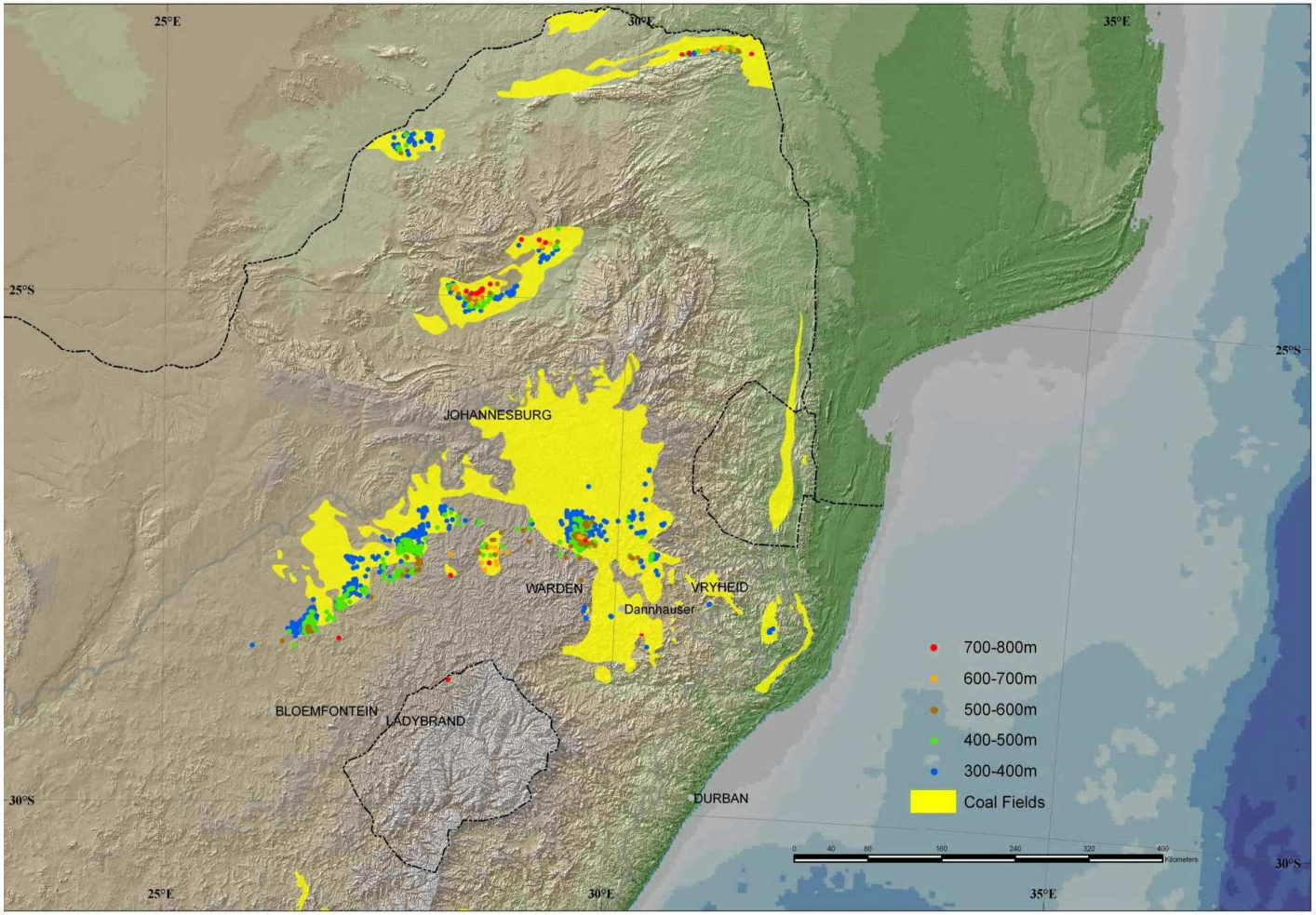
Data availability: Energy-related exploration activities in SA (PASA)



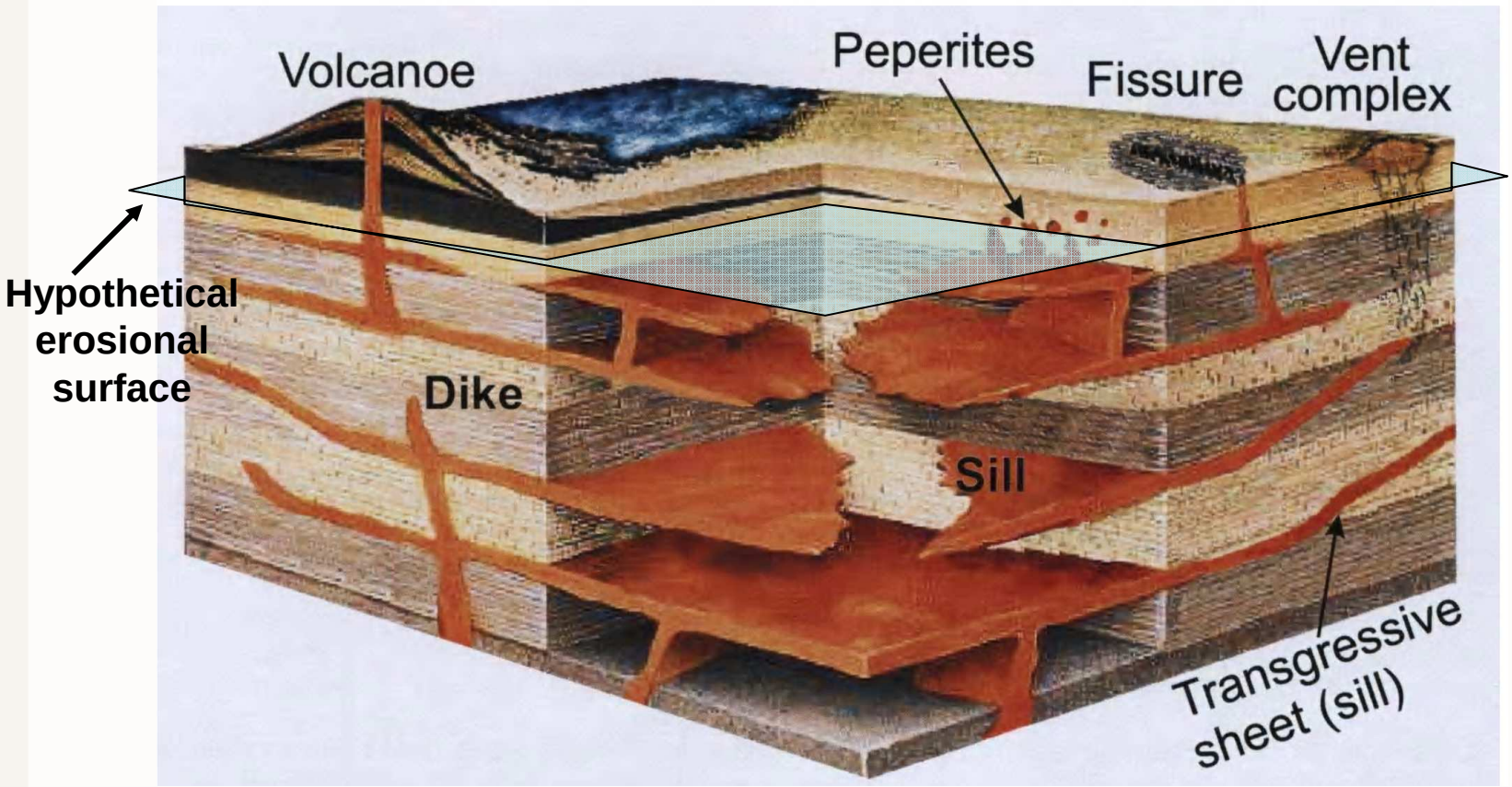
Data availability: extent of offshore seismic data and exploration wells (Petroleum Agency SA, 2007).



Data availability: distribution of deep coals in the Karoo Supergroup (from the Council for Geoscience's borehole database)



Sketch showing a connected (dolerite) sill complex and associated extrusive features, hydrothermal vent complexes and volcanoes (after Planke, 2005).



Criteria and classes for assessing the CO_2 storage suitability of sedimentary basins (modified after Bachu 2003, Gibson-Poole et al., 2006)

Item	Criterion	Classes				
		1	2	3	4	5
1	Tectonic setting	Very unstable eg subduction	Unstable eg synrift, intramontane	Intermediate eg foreland arc	Mostly stable passive margin	Stable, eg cratonic
2	Basin size	Very small <1,000 km^2	Small, 1,000 – 5,000 km^2	Medium 5,000 - 1,000	Large 5000 – 25,000 km^2	Very large >50,000 km^2
3	Basin depth	Very shallow (< 300 m)	Shallow (300 – 800 m)		Deep (>3,500 m)	Intermediate 800 – 3500m
4	Reservoir-seal pairs	Poor		Intermediate		Excellent
5	Fault intensity	Extensive		Moderate		Limited

Criteria and classes for assessing the CO_2 storage suitability of S. Afr. sedimentary basins (modified after Bachu 2003, Gibson-Poole et al., 2006)

Item	Criterion	Classes				
		1	2	3	4	5
6	Dolerite dykes/sheets	Extensive		Moderate		None
7	Geothermal gradient	Warm basin (>40ºC)		Moderate basin (>40ºC)		Cold basin (>40ºC)
8	Hydrocarbon potential	None	Small	Medium	Large	Giant
9	Maturity*	Unexplored	Exploration	Developing	Mature	Over mature
10	Coal	None	Very shallow (<300 m)	Very Deep (>1,500m)	Deep (800 – 1,500 m)	Shallow (300 - 800 m)

* = criteria not entirely geological

Criteria and classes for assessing the CO_2 storage suitability of S. Afr. sedimentary basins (modified after Bachu 2003, Gibson-Poole et al., 2006)

Item	Criterion	Classes				
		1	2	3	4	5
11	Coal rank	Anthracite	Lignite		Sub-bituminous	Bituminous
12	On/offshore*	Deep offshore		Shallow offshore		Onshore
13	Economic activities	Large scale mining	Active mining	Conirmed (no mining)	Potential	None
14	Infrastructure*	None	Minor		Moderate	Extensive
15	Distance from CO_2 sources*	>1,000 km	500 – 1,000km		300 – 500km	>300 km

* = criteria not entirely geological

Comparative ranking of each basin for storage suitability based only on geological (i.e. no economic criteria - 9, 12, 14 and 15).

Basin/area	Geological Suitability	Rank
Outeniqua Basin	0,78	1
Northern Karoo	0,76	2
Orange Basin	0,75	3
Durban/Zululand Basin	0,73	4
Tshipse Basin	0,71	5
Katberg/Molteno-Indwe	0,69	6
Ellisras (Lephalale)	0,67	7
Springbok Flats Basin	0,67	8
Onshore Zululand Basin	0,67	9
Onshore Algoa Basin	0,65	10
Durban-Lebombo	0,62	11
Southern Karoo	0,60	12
Tuli Basin	0,56	13

Storage suitability of basins based on geological criteria, excluding the presence of coal and coal rank.

Basin/area	Suitability: Geol – coal	Rank
Outeniqua Basin	0,91	1
Durban/Zululand Basin	0,84	2
Orange Basin	0,84	3
Onshore Zululand Basin	0,78	4
Onshore Algoa Basin	0,76	5
Northern Karoo	0,71	6
Katberg/Molteno-Indwe	0,71	7
Southern Karoo	0,69	8
Tshipse Basin	0,64	9
Durban-Lebombo	0,64	10
Springbok Flats Basin	0,60	11
Ellisras (Lephalale)	0,60	12
Tuli Basin	0,56	13

CSLF-T-2005-09
August 2005

Phase I Final Report from the Task Force for Review and Identification of Standards for CO_2 Storage Capacity Measurement

CSLF-T-2007-04
June 15, 2007

Phase II Final Report from the Task Force for Review and Identification of Standards for CO_2 Storage Capacity Estimation

CSLF-T-2008-04
21 April 2008

Comparison between Methodologies Recommended for Estimation of CO_2 Storage Capacity in Geological Media
by
the CSLF Task Force on CO_2 Storage Capacity Estimation
and
the USDOE Capacity and Fairways Subgroup of the Regional Carbon Sequestration Partnerships Program

- Phase III Report -

All definitions and standards of the SA CO_2 Storage Atlas will be aligned to CSLF recommendations and other authoritative publications

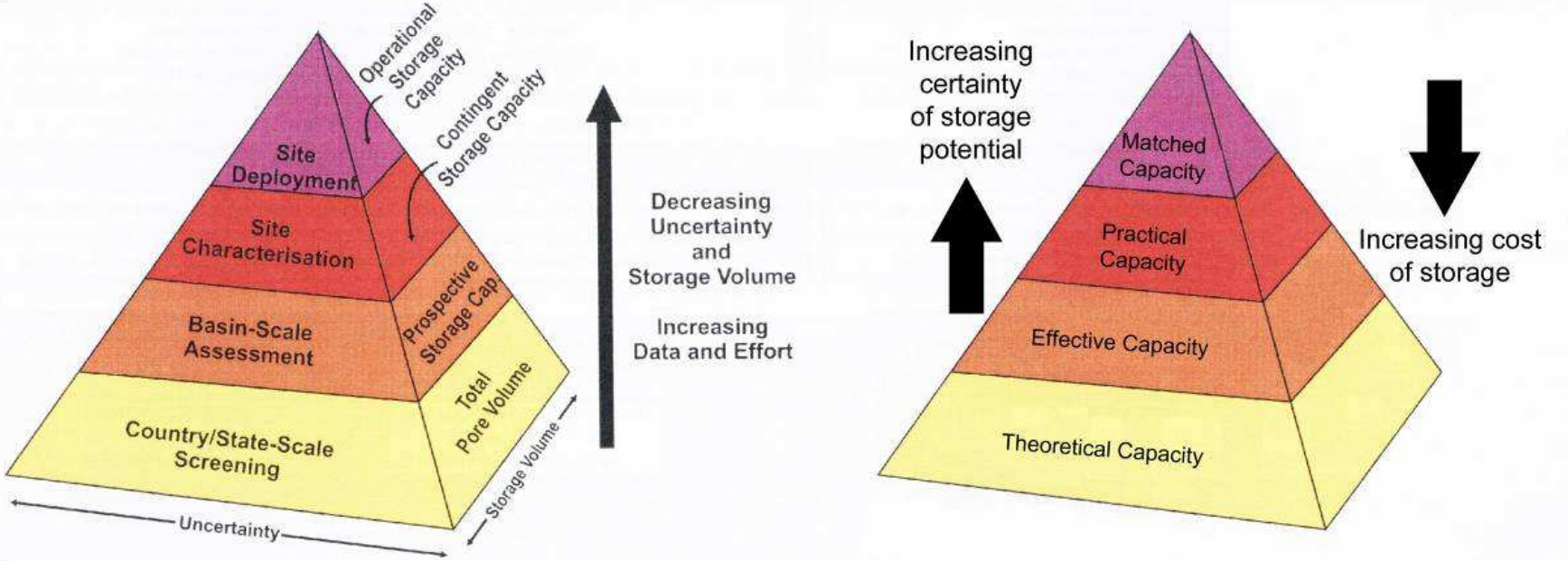
CO_2 Storage Capacity Estimation Formulae

- **Deep saline aquifers:** $M_{CO2} = A\, h_g\, \varphi_{tot}\, \rho\, E$ **(1)**
- **Coal beds** $M_{CO2} = A\, h_g\, C\, \rho\, E$ **(2)**
- **Oil and gas reservoirs** $M_{CO2} = A\, h_n\, \varphi_e(1-S_w)\, B\, \rho\, E$ **(3)**

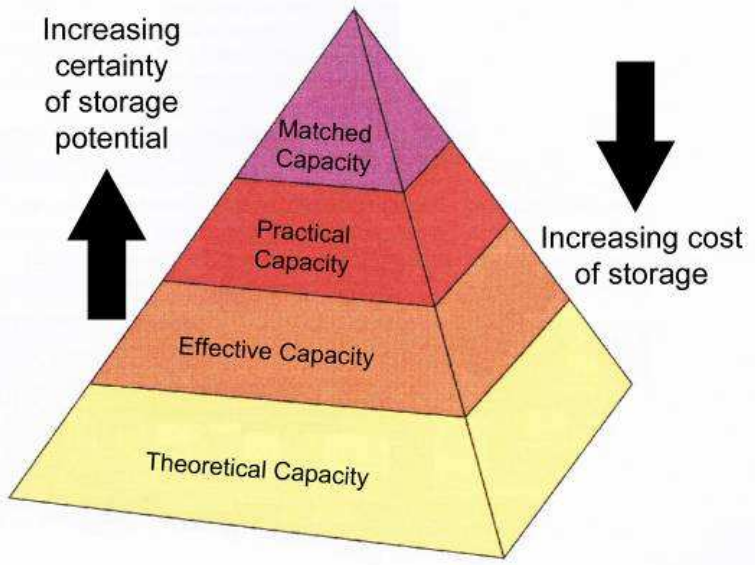
Symbols:

M_{CO2}	= Mass estimate of CO_2 storability
A	= Geographical area of formation
h_g	= Gross thickness of formation
φ_{tot}	= Average porosity of formation
ρ	= CO_2 density at storage pressure and temperature
E	= Storage efficiency factor
C	= Concentration of CO_2 standard volume per unit of coal volume
h_n	= Net thickness of formation
φ_e	= Effective porosity of formation
S_w	= Average water saturation within the storage volume
B	= Formation volume factor (converts standard oil or gas volume to sub-surface volume)

Certainty of CO2 storage capacity



Techno-Economic Resource-Reserve pyramid for CO2 storage capacity in geological media (CSLF, 2008). The pyramid shows the relationship between Theoretical, Effective, Practical and Matched capacities.

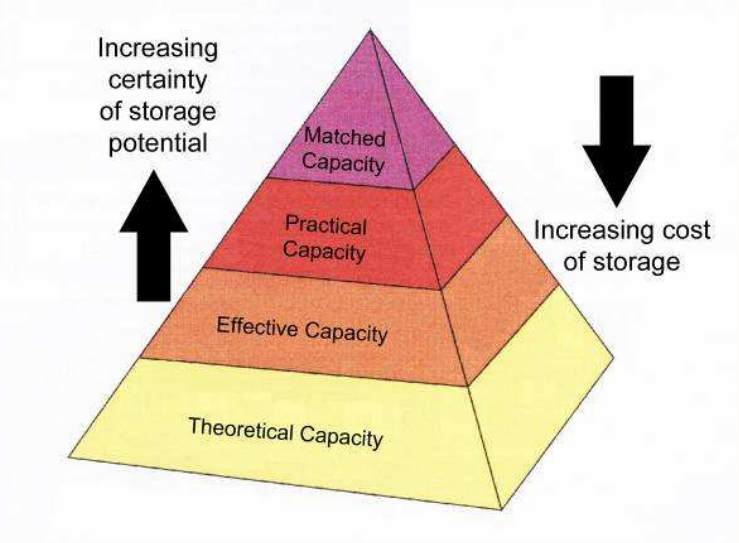


Theoretical Storage Capacity

Assumes entire pore volume is accessible to store CO2, or CO2 adsorbed at 100% saturation in the entire coal mass. This unrealistic as there always will be physical, technical, regulatory and economic limitations that prevent full utilization of this storage capacity.

Effective Storage Capacity

Represents a subset of the theoretical capacity and is obtained by applying a range of technical (geological and engineering) cut-off limits to a storage capacity assessment. This estimate usually changes with the acquisition of new data and/or knowledge.



Practical Storage Capacity is that subset of the effective capacity that is obtained by considering technical, legal and regulatory, infrastructure and general economic barriers to CO2 geological storage - prone to rapid changes

Matched Storage Capacity is that subset of the practical capacity that is obtained by detailed matching of large stationary CO2 sources with geological storage sites that are adequate in terms of capacity, injectivity and supply rate.

The difference between matched and practical storage capacities represents **Stranded storage capacity** that cannot be realized because of lack of infrastructure and/or CO2 sources within economic distance.

Confidence indicator				
Subsurface Heterogeneity	Complex subsurface, numerous structures at spacings of < 3 km, highly discontinuous formation properties at < 3 km spacing, typical of tectonically deformed areas	**5**	**3**	**1**
	Moderate heterogeneous subsurface, structure and anisotropy present but repetitive at 3 – 16 km spacing; possible to interpolate rock properties for up to 16 km	**7**	**5**	**3**
	Structural complications are infrequent and range of rock properties can be projected over areas > 16 km	**9**	**7**	**5**
		Borehole density avg. > 1 borehole/ 3 km^2; seismic survey spacing avg. > 1 line per 16 linear km	Borehole density avg. > 1 borehole/ 23 km^2; seismic survey spacing avg. > 1 line per 80 linear km	Borehole density avg. > 1 borehole/ 260 km^2; seismic survey spacing avg. > 1 line per 160 linear km
		Data Density		

Conclusions

- Geological screening and ranking of the sedimentary basins provide an objective means for assessing which basins have the best storage potential.
- Data availability is very important as it allows for better storage estimates to be made, i.e. greater certainty of estimates and greater confidence.
- Atlases need to produce a storage potential estimate for the country or region which has been assessed
- Atlases need to make recommendations on knowledge gaps and provide a list of research projects that will address the most serious deficiencies
- Atlases need to advise decision makers on whether to proceed or not with the exploration for CO_2 storage space.

Thank you

Definitions for ‘unmineable’ coal

- CSLF consider coal to be suitable for CO2 storage (i.e. unmineable) when at average geothermal gradients it occurs at a depth of no deeper than 800 m and upwards to where groundwater is protected by regulation (p19, Phase II Report).

- In the USA coal is not considered for CO2 storage if shallower 152 m. However, at intermediate depths (152-305m), only coal beds less than 1.1. m and greater than 0.52 m were considered as potential targets for CO2 storage.