An assessment of Queensland's CO_2 geological storage prospectivity — the Queensland CO_2 geological storage atlas

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Abstract

In 2008, the Queensland Government launched its Carbon Geostorage Initiative to assess Queensland's geological storage potential by identifying, characterising and evaluating sedimentary basins with potential for long-term, secure storage of CO_2 from current and future stationary CO_2 sources. As part of this initiative, 36 onshore basins have been assessed for their CO_2 geological storage prospectivity through injection into either: regional reservoir-seal intervals ('saline reservoirs' and aquifers); depleted oil and gas fields; or deep unmineable coal seams (Fig. 1). This comprehensive state-wide regional assessment is based on the technical (geological) suitability for geological storage, and does not consider factors such as potential interference with other resources, distance from emissions nodes or absolute storage volumes. Basins were assessed by evaluating the potential of their component reservoir-seal intervals to effectively inject, store and contain CO_2. Methodologies have been developed that allow the estimation of storage capacity volumes within highly prospective reservoir-seal fairways at a regional scale. These estimates reflect conservative values that are more reliable than previous theoretical estimates, which relied upon access to pore space at the physical limit of the pore rock volume to accept fluids. Results show that the greatest potential to store the large quantities of CO_2 required to make deep cuts in Queensland's stationary emissions is to use deep, regional reservoir-seal intervals in major hydrocarbon and/or groundwater bearing basins using structural traps or **migration assisted storage** (MAS) mechanisms. Depleted oil and gas fields and deep unmineable coal seams provide only limited opportunities for geological storage of CO_2 in Queensland.

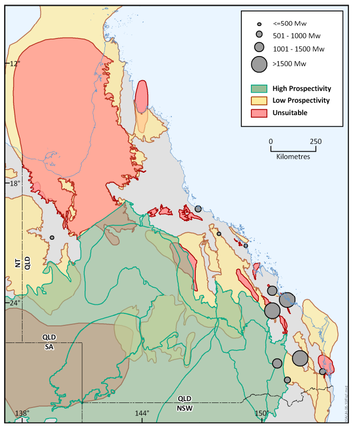

Figure 1: Geological storage prospectivity of onshore Queensland basins, and location of major emission hubs.

Migration Assisted Storage

The Bowen, Cooper, Eromanga, Galilee and Surat basins contain extensive, quartz-rich fluvial reservoirs sealed by fluvial-lacustrine or marine argillaceous rocks that have either produced hydrocarbons and/or are major groundwater aquifers, and are evaluated as having the highest prospectivity for CO_2 geological storage (Table 1). Maximum potential storage areas have been mapped in these basins based on the extent of highly prospective reservoir fairways (Fig 2), and are used together with specific reservoir data, calculated temperature and pressure gradients, and consideration of the percentage of the total rock volume affected by the CO_2 plume to estimate storage capacities using the MAS trapping mechanism. Capacities range from >46 Gt in the Eromanga Basin, to ~3 Gt in the Galilee and Surat basins, and <0.4 Gt in the Bowen Basin. Other basins are evaluated as having either low prospectivity or are unsuitable for geological storage.

Basin Name	Reservoir Unit	Average Net Thickness (m)	Average Porosity (%)	Median Kh (mD); Max Kh (mD)	Seal Unit	Seal Thickness (m)	Geothermal Gradient (C/km)	Storage Area (km2)	Seal Ranking: Seal Type	Seal Ranking: Bulk Seal Effectiveness	Seal Ranking: Faults through Seal	Res. Ranking: Porosity	Res. Ranking: Permeability	Res. Ranking: Depth at Base Seal Adequate	Total Score	CO_2 Storage Capacity (Mt)
Eromanga	Wyandra Sandstone (coastal)	10	21.8 (n=42)	[1]0.4 (n=222); 12,000	Wallumbilla Fm/Allaru Mudstone (marine mudstones)	400-700	38.8	314,383	C	3	2	3	3	3	14	20159
Eromanga	Adori Sandstone (fluvial-lacustrine)	18	19.8 (n=82)	403 (n=78); 8,091	Westbourne Formation (fluvial-lacustrine shale, siltstone, sst)	<160	38.8	314,383	C	2	2	3	3	3	13	6474
Eromanga	Hooray Sandstone (fluvial)	59	17 (n=1,984)	[1]4.5 (n=1834); 7,520	Cadna-owie Formation (shoreface mudstone to siltstone)	<130	38.8	314,383	C	2	2	3	3	3	13	5473
Eromanga	Hutton Sandstone (fluvial)	99	17 (n=1,984)	91 (n=2,321); 2,321	Birkhead Formation (fluvial-lacustrine siltstone and sandstone)	<110	38.8	314,383	C	2	2	3	3	3	13	12226
Eromanga	lower Poolowanna Formation (fluvial)	55	12 (n=525)	[1]6.4 (n=489); 2,700	upper Poolowanna Fm (fluvial-lacustrine siltstone & mudstone)	<100	38.8	314,383	C	2	2	3	3	3	13	2081
Surat	Precipice Sandstone (fluvial)	4 (n=9)	16.8 (n=1,654)	13 (n=1519); 7,908	Evergreen Formation (marine-lacustrine shale & siltstone)	50-100	28.0	39,491	C	3	3	3	3	3	15	1298
Surat	Basal Evergreen Unit (fluvial)	1.5 (n=7)	14.9 (n=37)	5.4 (n=32); 3,370	Evergreen Formation (marine-lacustrine shale & siltstone)	50-100	28.0	2,091	C	3	3	3	2	3	14	21
Surat	Boxvale Member (fluvial)	8.4 (n=4)	15.7 (n=475)	7.1 (n=426); 7,380	Evergreen Formation (marine-lacustrine shale & siltstone)	50-100	28.0	7,300	C	3	3	3	2	3	14	454
Surat	Hutton Sandstone (fluvial)	32.7 (n=3)	17.6 (n=2,649)	98 (n=2451); 13,600	Walloon Sub-group (fluvio-lacustrine siltstone & mudstone)	50-420	28.0	12,748	C	2	3	3	3	3	14	1198
Galilee - north	Betts Creek beds (fluvial)	54 (n=15)	14.8 (n=37)	29 (n=60); 5,852	Rewan Formation (fluvial-lacustrine siltstone & sst)	100-340	40.2	12,344	U	2	2	3	3	3	13	594
Galilee - north	Clematis Sst/Rewan Fm (fluvial)	247 (n=2)	19.4 (n=10)	no data	Moolayember Fm (fluvio-lacustrine)	50-717	40.2	4,616	C	2	3	3	3	2	13	534
Galilee - south	Clematis Sst/Rewan Fm (fluvial)	129.5 (n=6)	20.7 (n=29)	144 (n=46); 4,770	Moolayember Fm (fluvio-lacustrine)	50-411	40.2	22,106	C	2	2	3	3	3	13	982
Galilee - south	Colinlea Sandstone (fluvial)	21 (n=12)	20.4 (n=11)	245 (n=23); 5,738	Black Alley Shale (marine-deltaic shale & siltstone)	<55	40.2	25,191	C	2	2	3	3	3	13	1320
Bowen - Southern	Showgrounds Sandstone (fluvial)	5.1 (n = 21)	12.4 (n=1,634)	14 (n=1410); 9,577	Snake Creek Mudstone (lacustrine mudstone)	<25	34.9	5,347	C	3	2	3	2	3	13	191
Bowen - Southern	Tinowon Formation (fluvial)	13.1 (n=8)	12.3 (n=684)	1.6 (n=512); 9,440	Black Alley Shale (marine-lacustrine shale & siltstone)	<50	34.9	1,239	C	3	2	3	2	3	13	89
Bowen - Western	Aldebaran Sandstone (coastal-fluvial)	15.6 (n=8)	13.1 (n=432)	2.1 (n=302); 1,390	Intraformational & Ingelara Fm (marine shales)	>200	43.6	2,769	C	3	2	3	2	3	13	100
Cooper	Toolachee Formation (fluvial)	22	10.2 (n=1,163)	2.5 (n=1163); 7,100	Callamurra Member (fluvio-lacustrine mudstone/siltstone)	<180	38.8	15,188	C	3	2	2	3	3	13	172

Table 1: Ranking results and maximum theoretical storage capacity estimates for high prospectivity reservoirs in Queensland. C = conventional seal; U = unconventional seal; [1]Low median permeability reflects sampling from both reservoir and seal intervals.

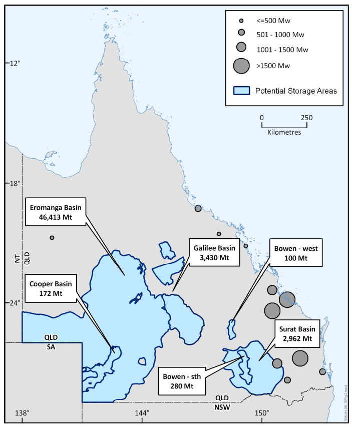

Figure 2: Maximum potential storage areas and estimated storage capacities for highly prospective basins in Queensland.

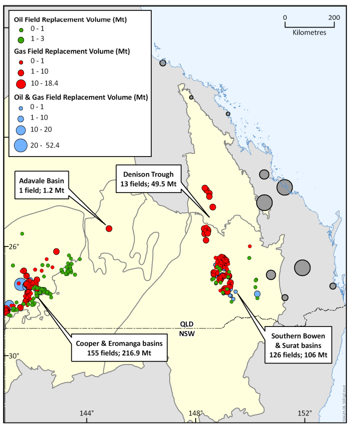

Figure 3: Maximum theoretical CO_2 replacement volume for petroleum fields in Queensland.

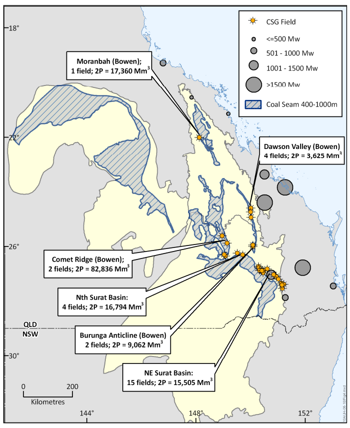

Figure 4: Location of producing CSG fields with 2008 2P gas reserves shown, and areas mapped where coal measures occur at depths of 400–1,000 m.

Other Storage Options

Other potential storage options are limited to petroleum fields once depleted, and deep unmineable coal seams. The maximum theoretical replacement volume for 295 petroleum fields in Queensland is estimated at <0.4 Gt based on June 2008 reserves and production data, with ~96% of this volume in gas pools, and 65% of this volume from just 25 fields in the Bowen, Surat, Cooper and Eromanga basins (Fig 3). However, most large fields are still producing and unlikely to be available for storage in the near future, and are under demand for natural gas storage, particularly for coal-seam gas (CSG) fields feeding into LNG plants. Although Queensland contains vast coal and CSG resources, storage of CO_2 in coal seams will be limited to depths of 400–1,000m (Fig 4), where injection rates are likely to be <1 mmscf/d. Storage in coal seams is thus unlikely to occur on a large-scale, and is most likely to be used where it is technically and economically feasible to enhance CSG production through CO_2 injection.

Conclusions

Geological storage assessments have often been undertaken at a country or regional scale using various levels of quality, coverage, and public availability of data, as well as using different standards. Our regional assessment of CO_2 geological storage in Queensland basins shows that sustainable, large-scale storage of CO_2 requires using MAS within regionally extensive reservoir-seal fairways. This study also highlights the importance of a prospectivity-based approach to regional assessments that uses reservoir-seal pairs as the primary evaluation units, and calculation of conservative maximum theoretical storage volumes based on the mapped extent of highly prospective reservoir-seal intervals and site-specific reservoir data.

References

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