

Update on the CO2CRC Otway Project

Lincoln Paterson (CO2CRC/CSIRO)

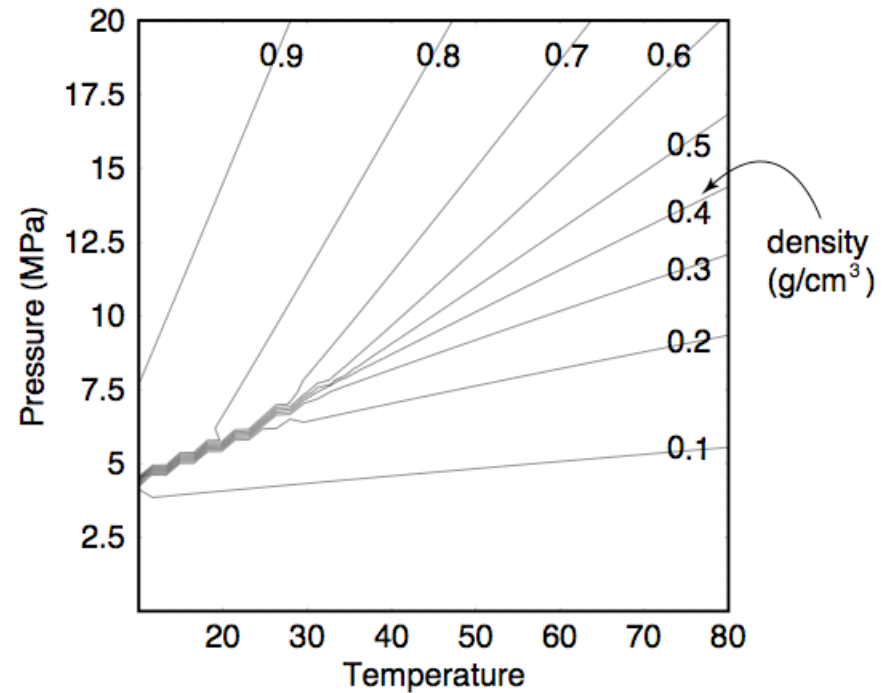
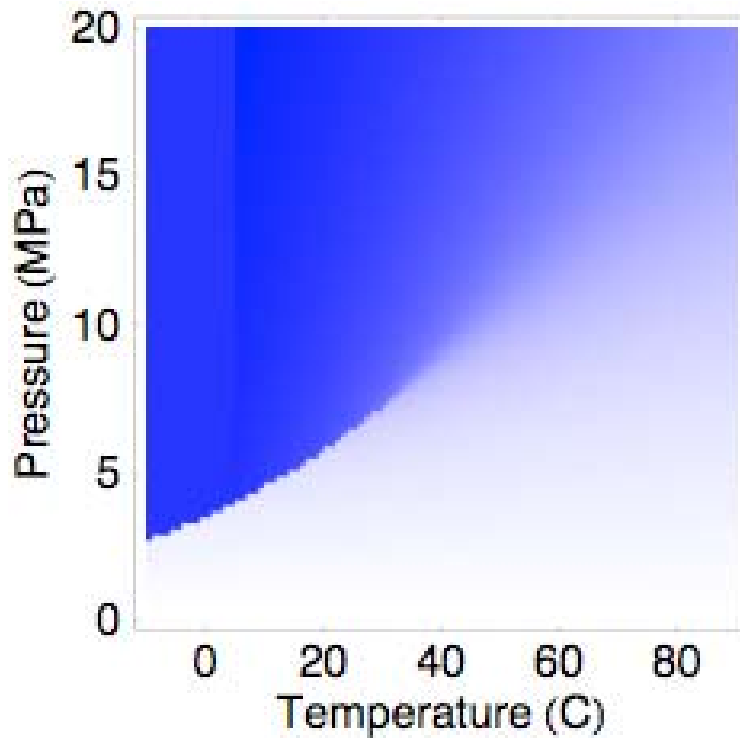
Craig Dugan (Process Group)

12 August 2009

CO2CRC Otway Project

- The CO2CRC Otway Project is the country's first demonstration of the deep geological storage of carbon dioxide (CO₂), the most common greenhouse gas.
- The project initiated development of regulation and approval processes.
- The nearby Buttress reservoir provides the source of carbon dioxide.
- Injection commenced in March 2008. Since then over 60,000 tonnes has been injected into the Waarre C formation approximately 2 km deep.

Carbon dioxide density



Viscosity

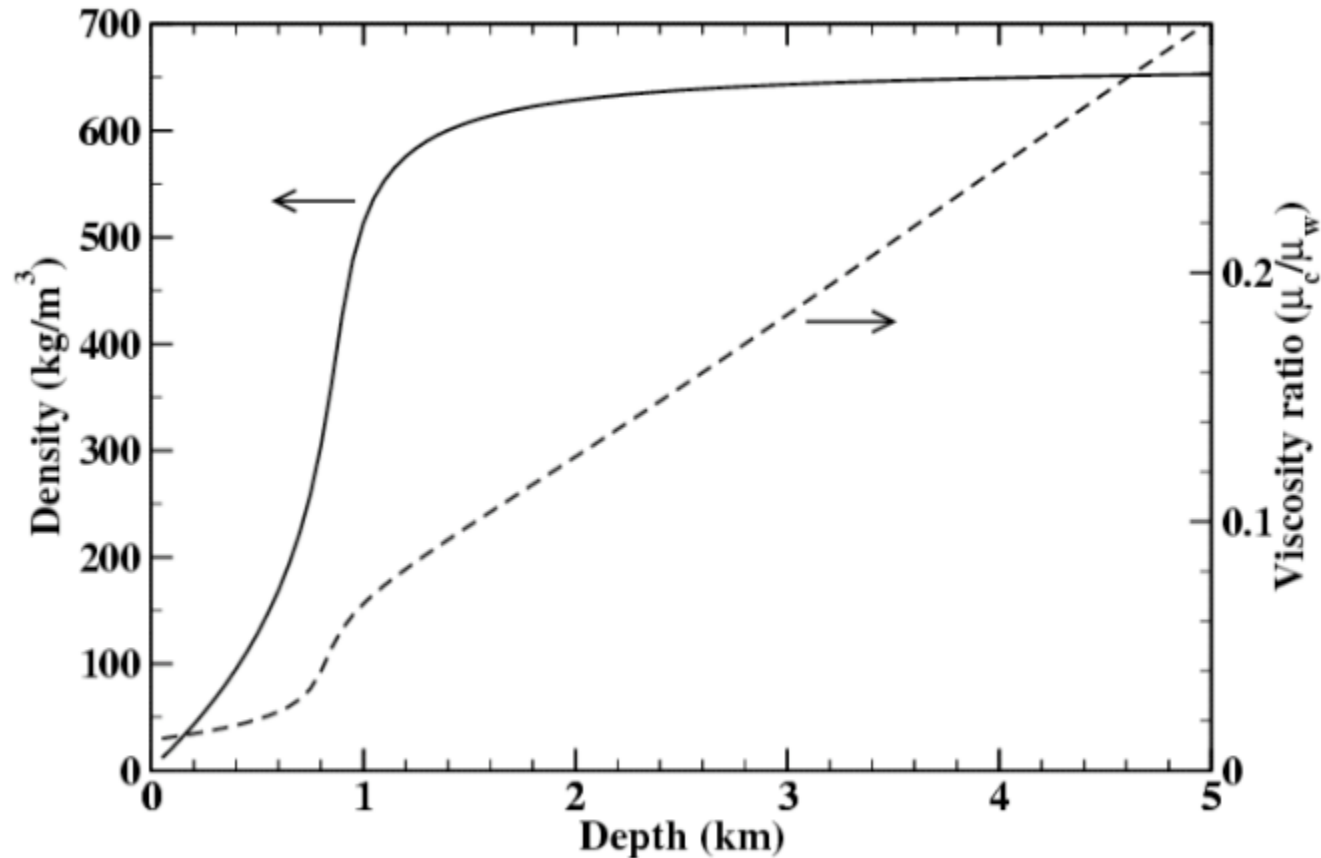
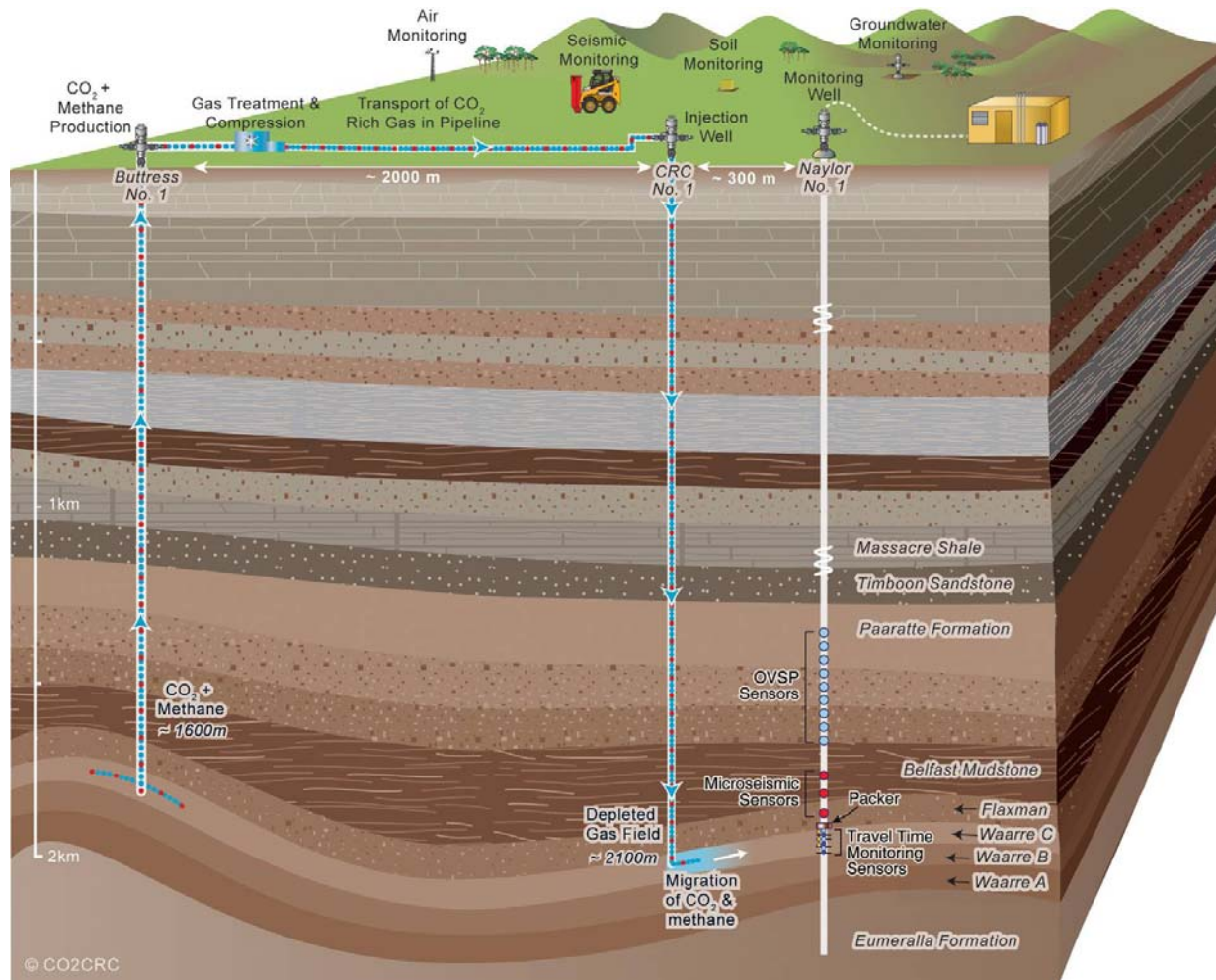


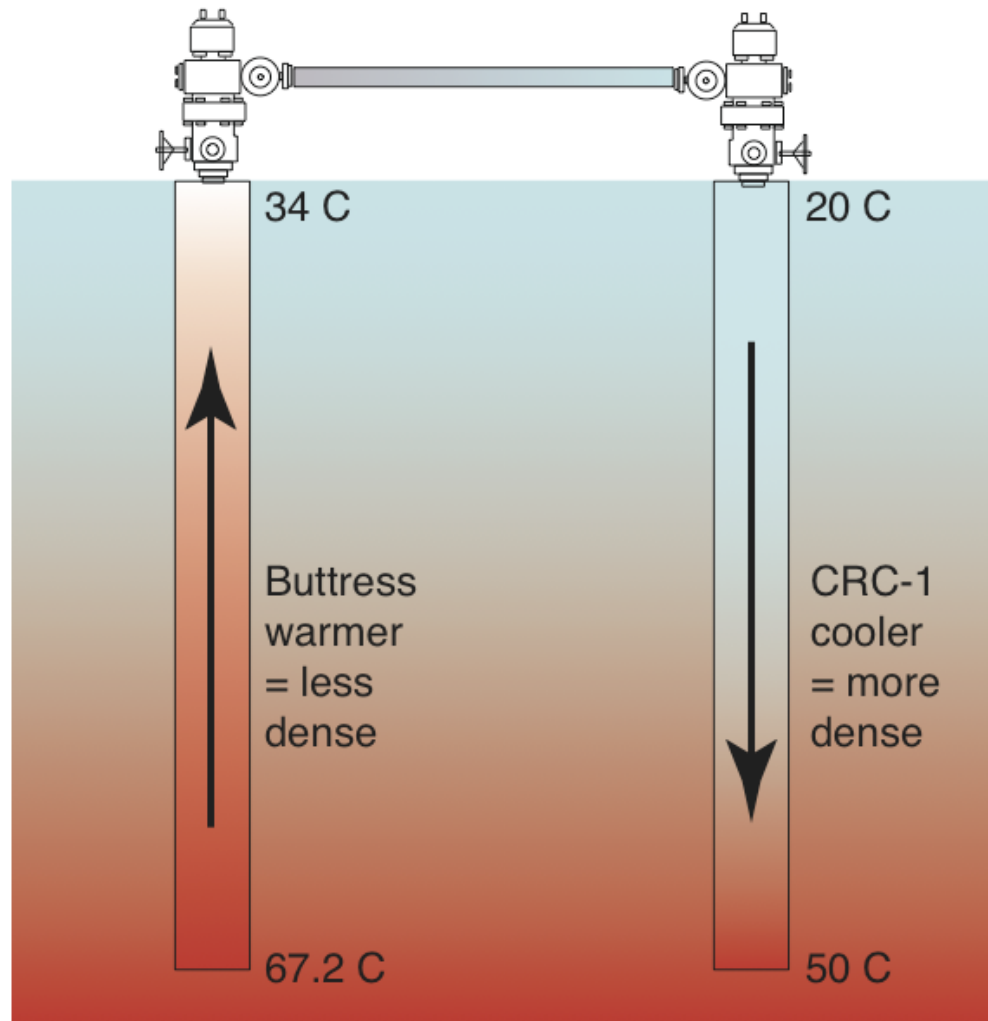
Figure 2: CO₂ density and viscosity at subsurface conditions, surface temp. 15 C, 30 C/km and 10 MPa/km.

Ennis-King & Paterson 2002 SPE 77809

CO2CRC Otway Project



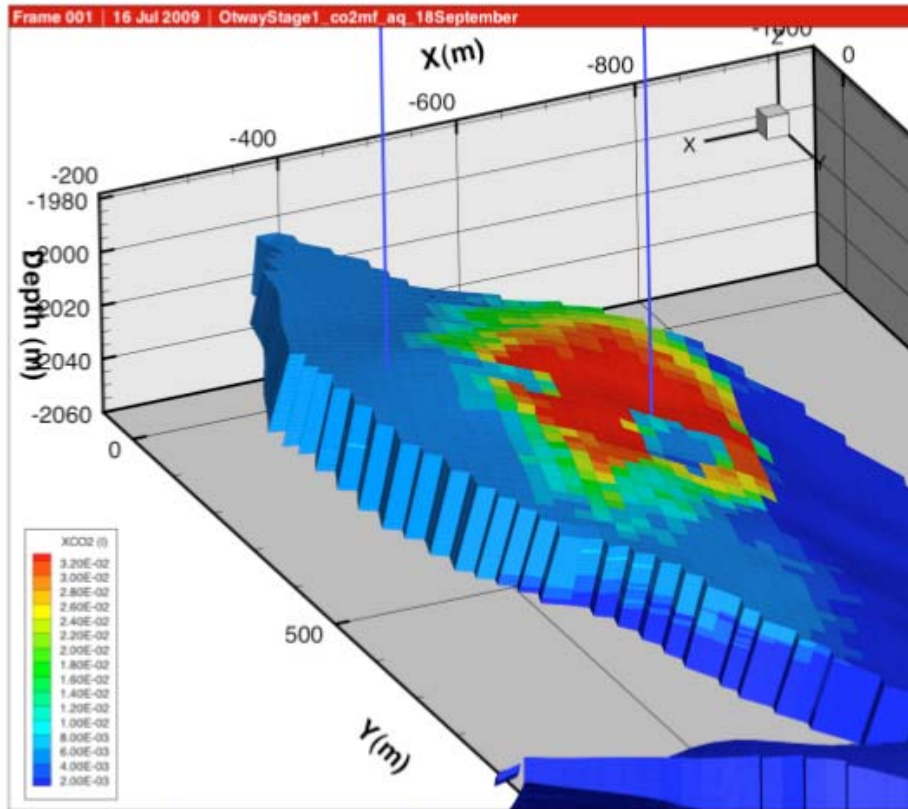
Buttress-Naylor system



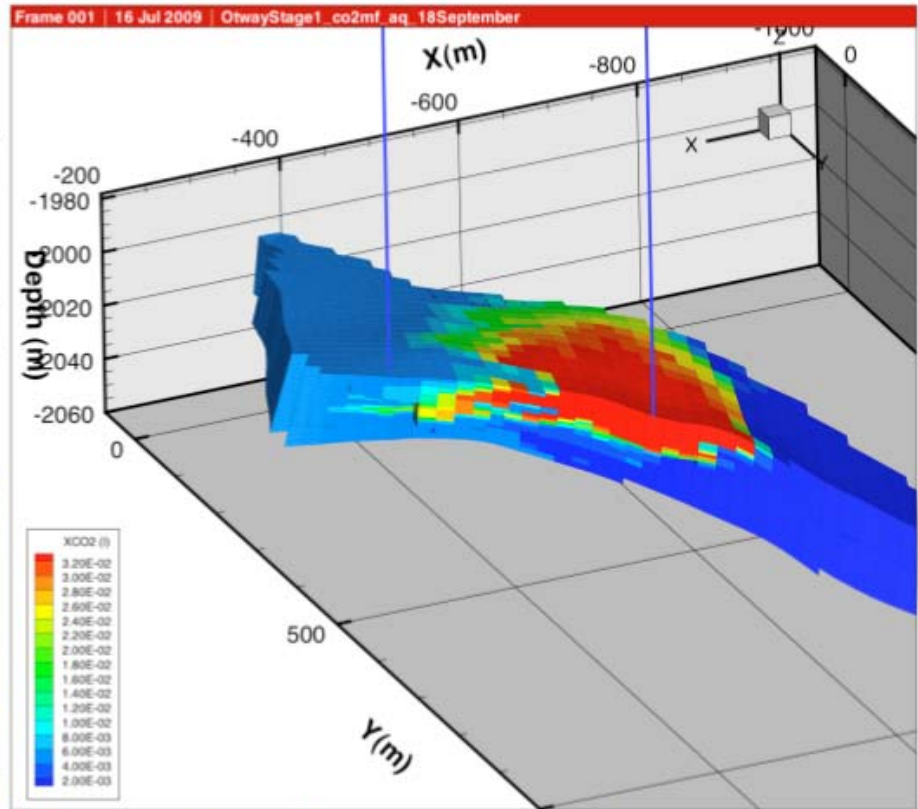
Injection well site



CO2CRC Otway project: CO₂ mass fraction

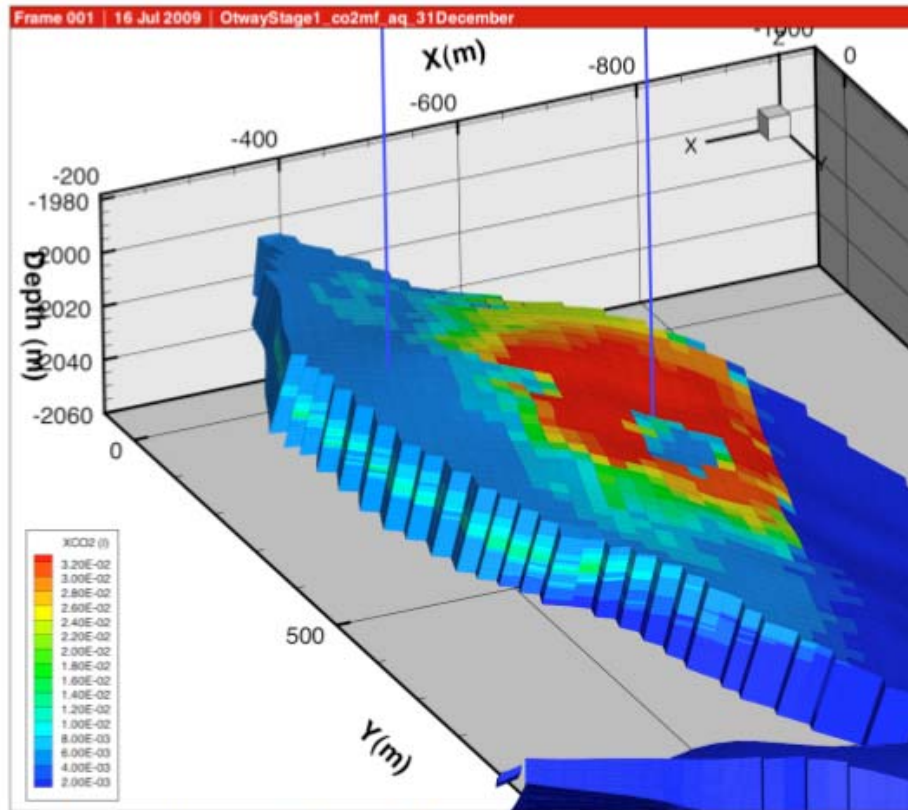


(a) Carbon dioxide mass fraction 18 Sept: no cutaway.

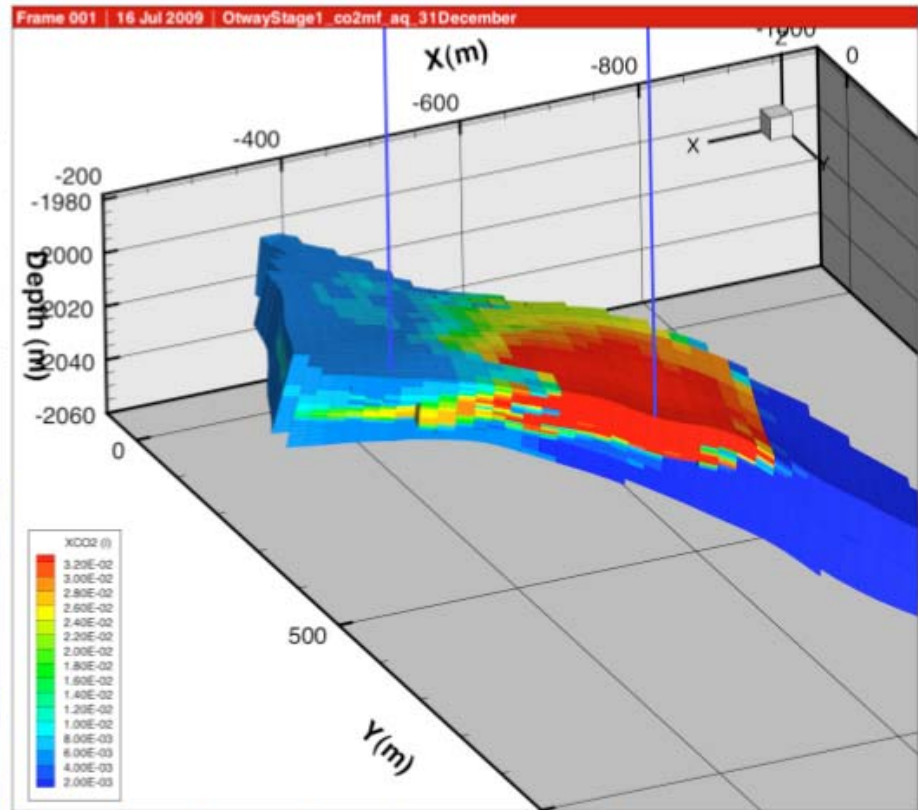


(b) Carbon dioxide mass fraction 18 Sept: cutaway.

CO2CRC Otway project: CO₂ mass fraction

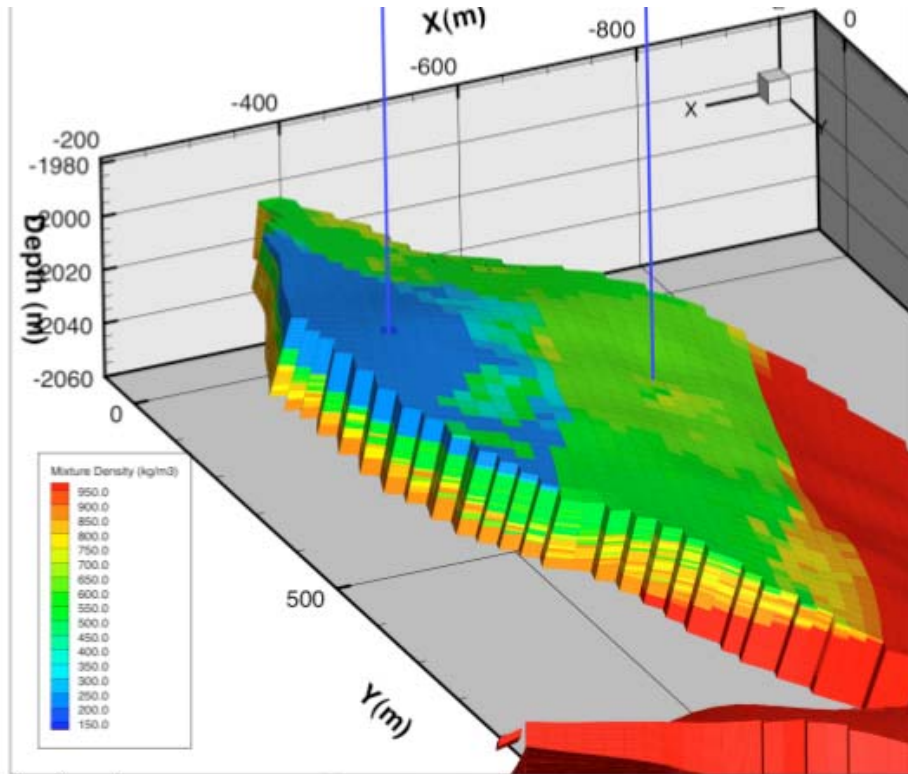


(a) Carbon dioxide mass fraction 31 Dec: no cutaway.

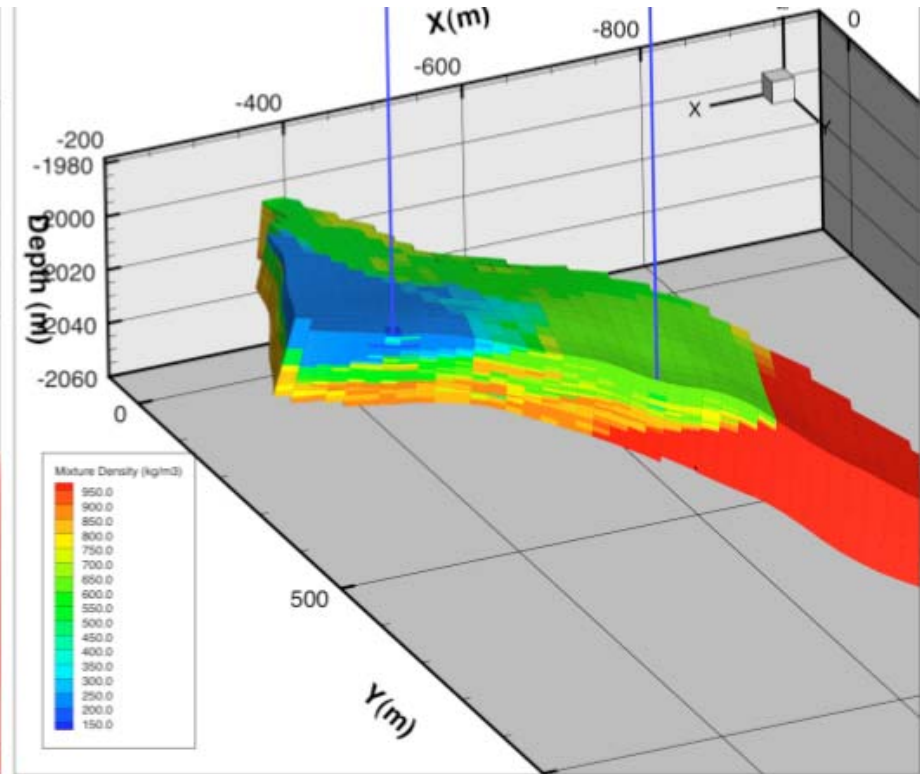


(b) Carbon dioxide mass fraction 31 Dec: cutaway.

CO2CRC Otway project: total fluid density

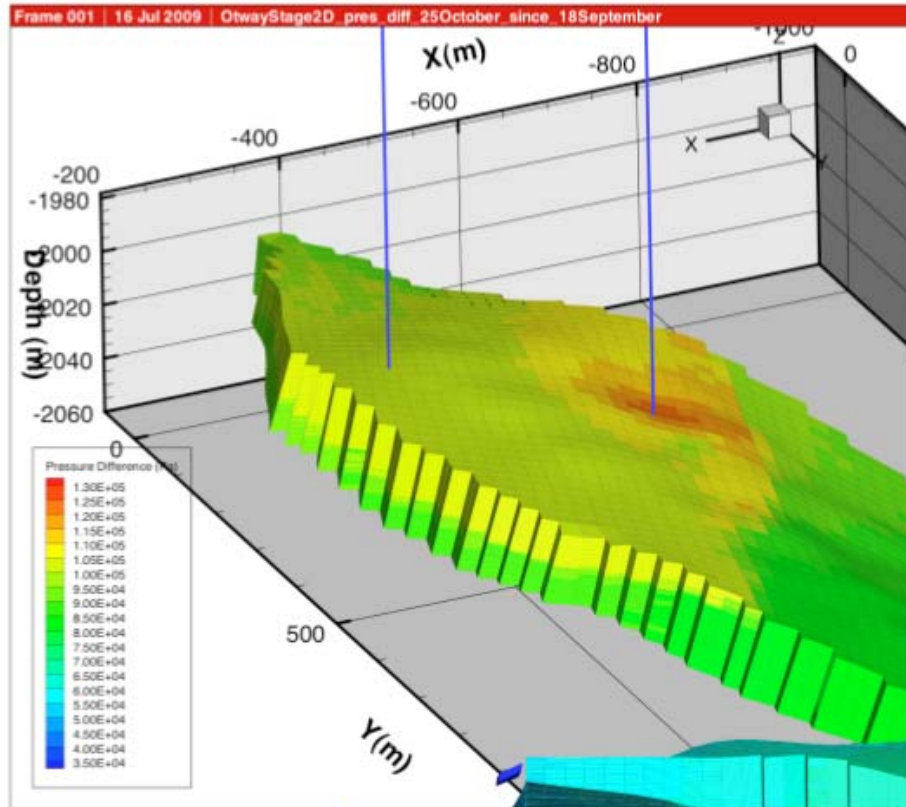


(a) Average fluid density: no cut-away.

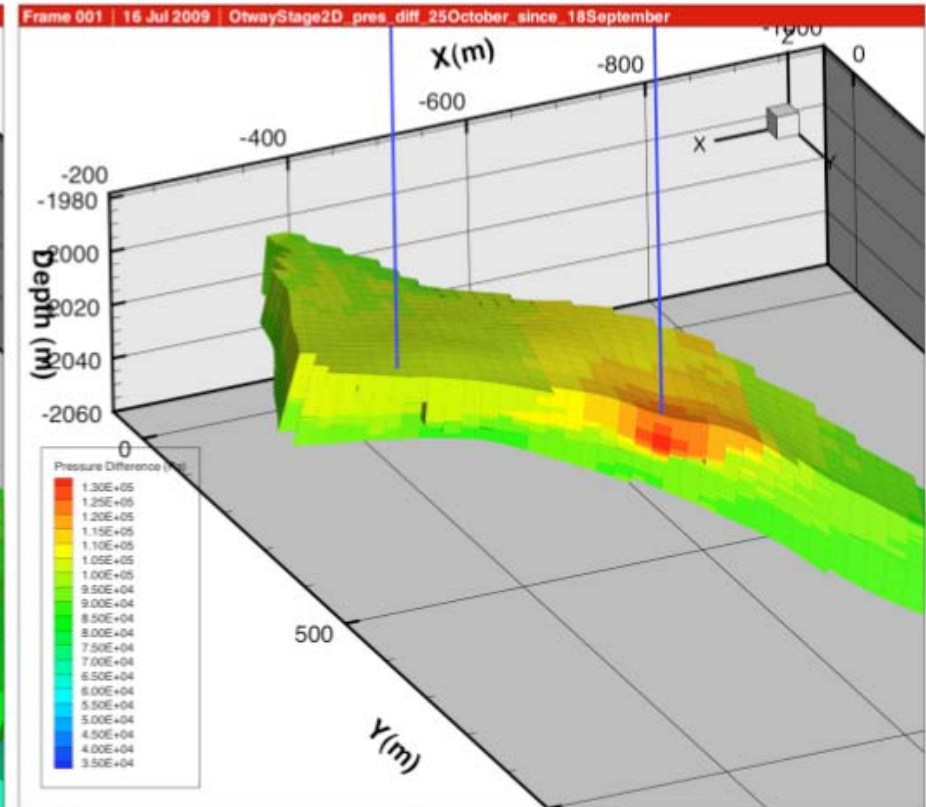


(b) Average fluid density: Cutaway.

CO2CRC Otway project: pressure difference

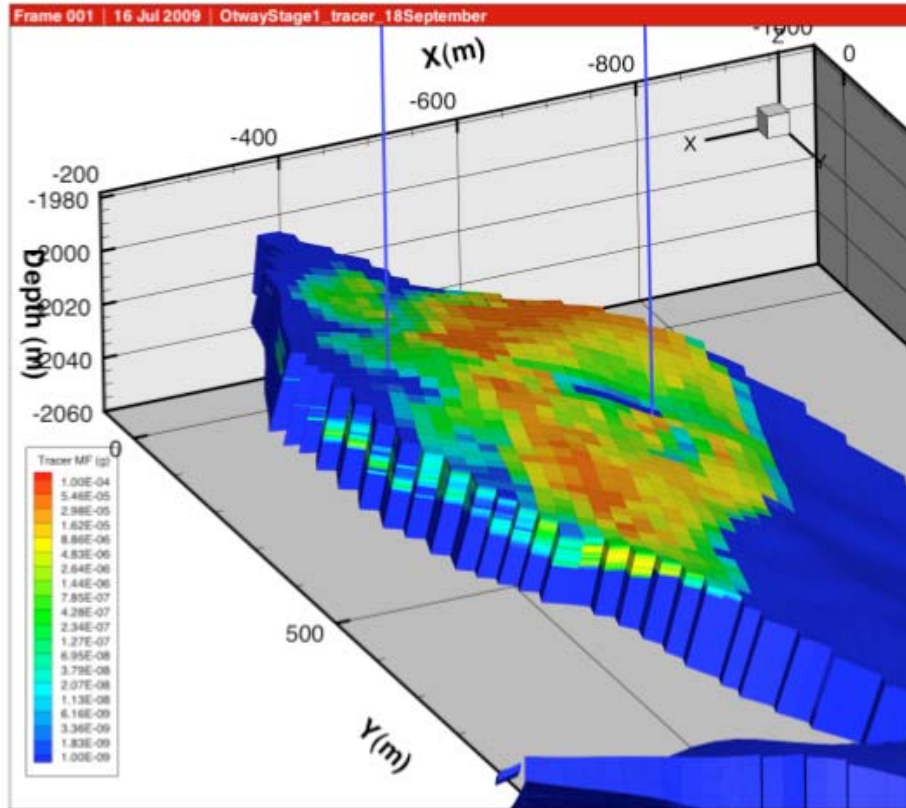


(a) Pressure difference between 18 Sept and 25 Oct: no cutaway.

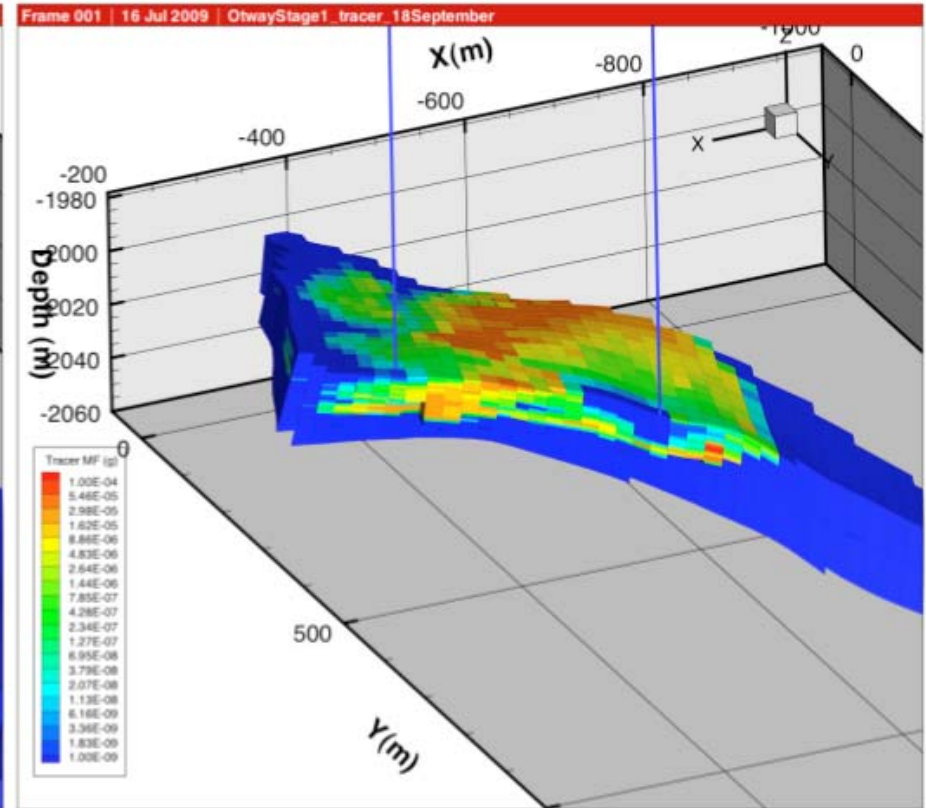


(b) Pressure difference between 18 Sept and 25 Oct: cutaway.

CO2CRC Otway project: tracers

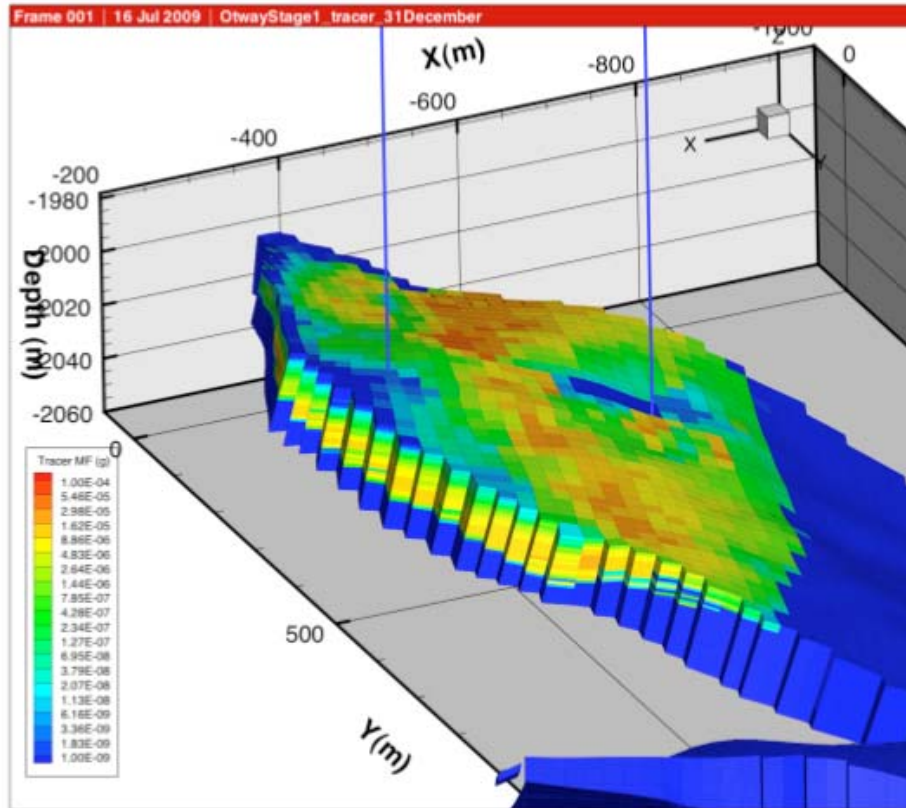


(a) Tracers 18 Sept: no cutaway.

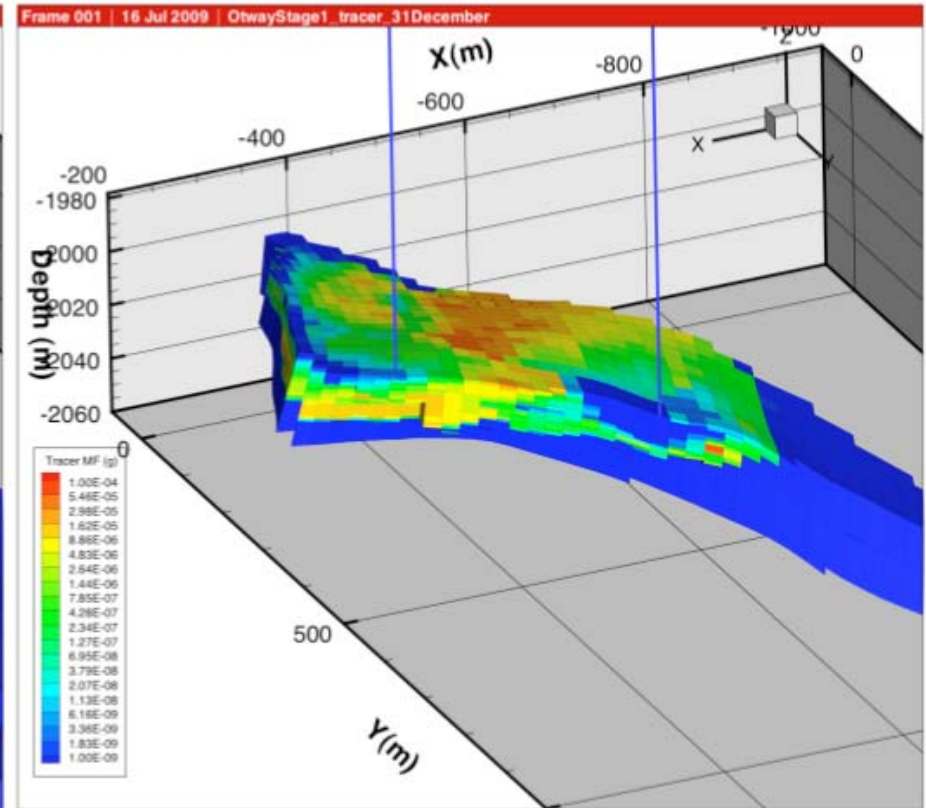


(b) Tracers 18 Sept: cutaway.

CO2CRC Otway project: tracers

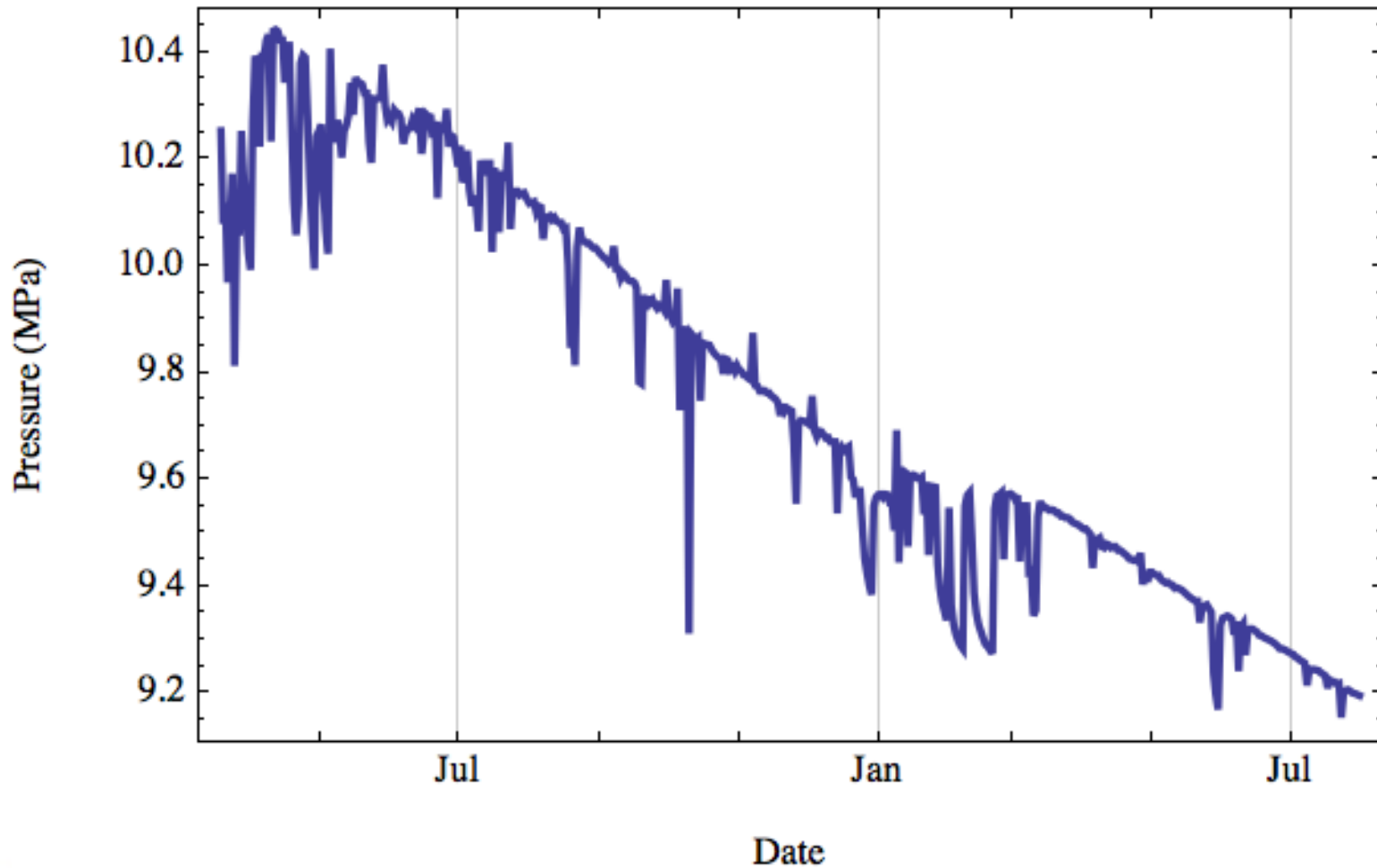


(a) Tracers 31 Dec: no cutaway.

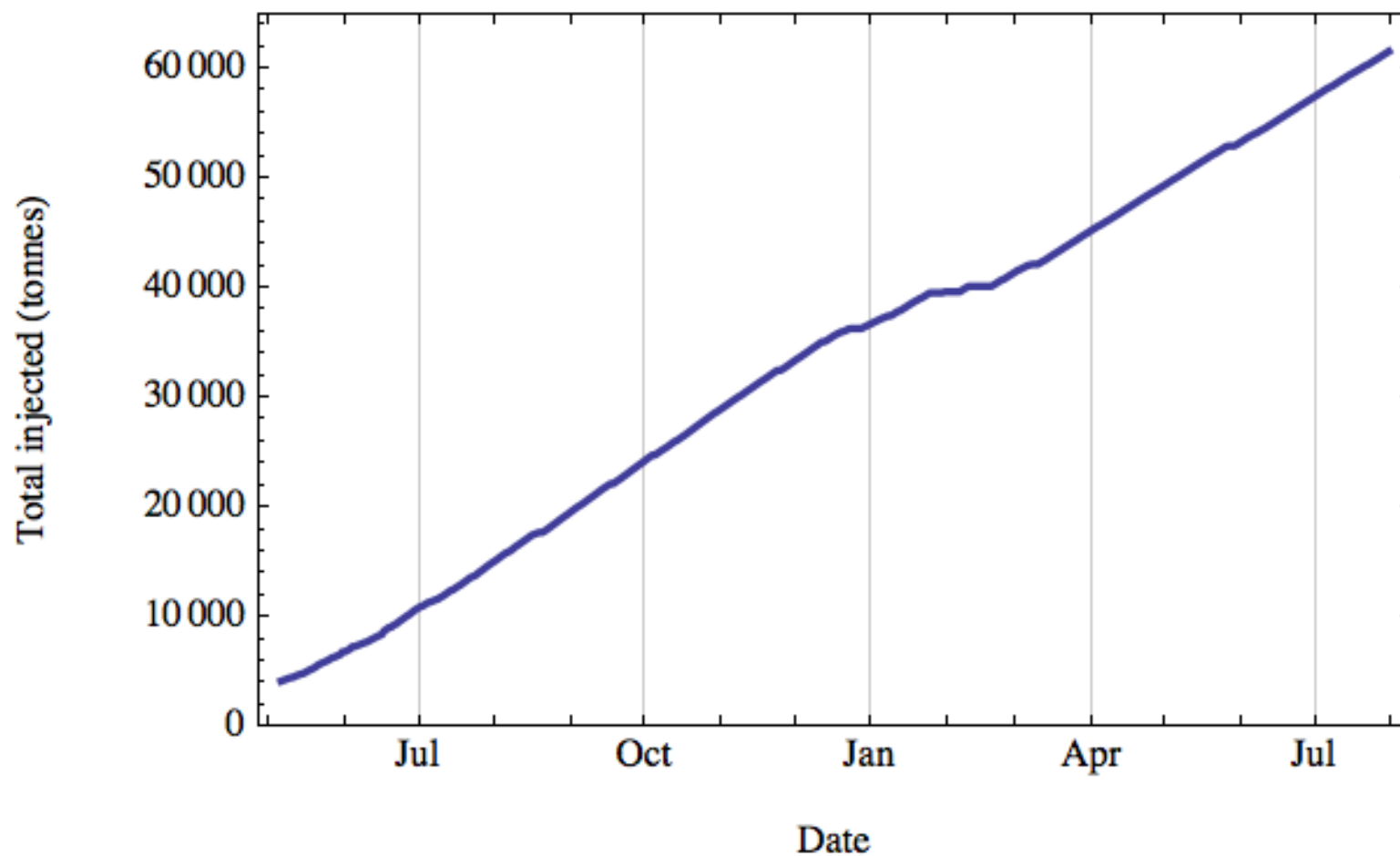


(b) Tracers 31 Dec: cutaway.

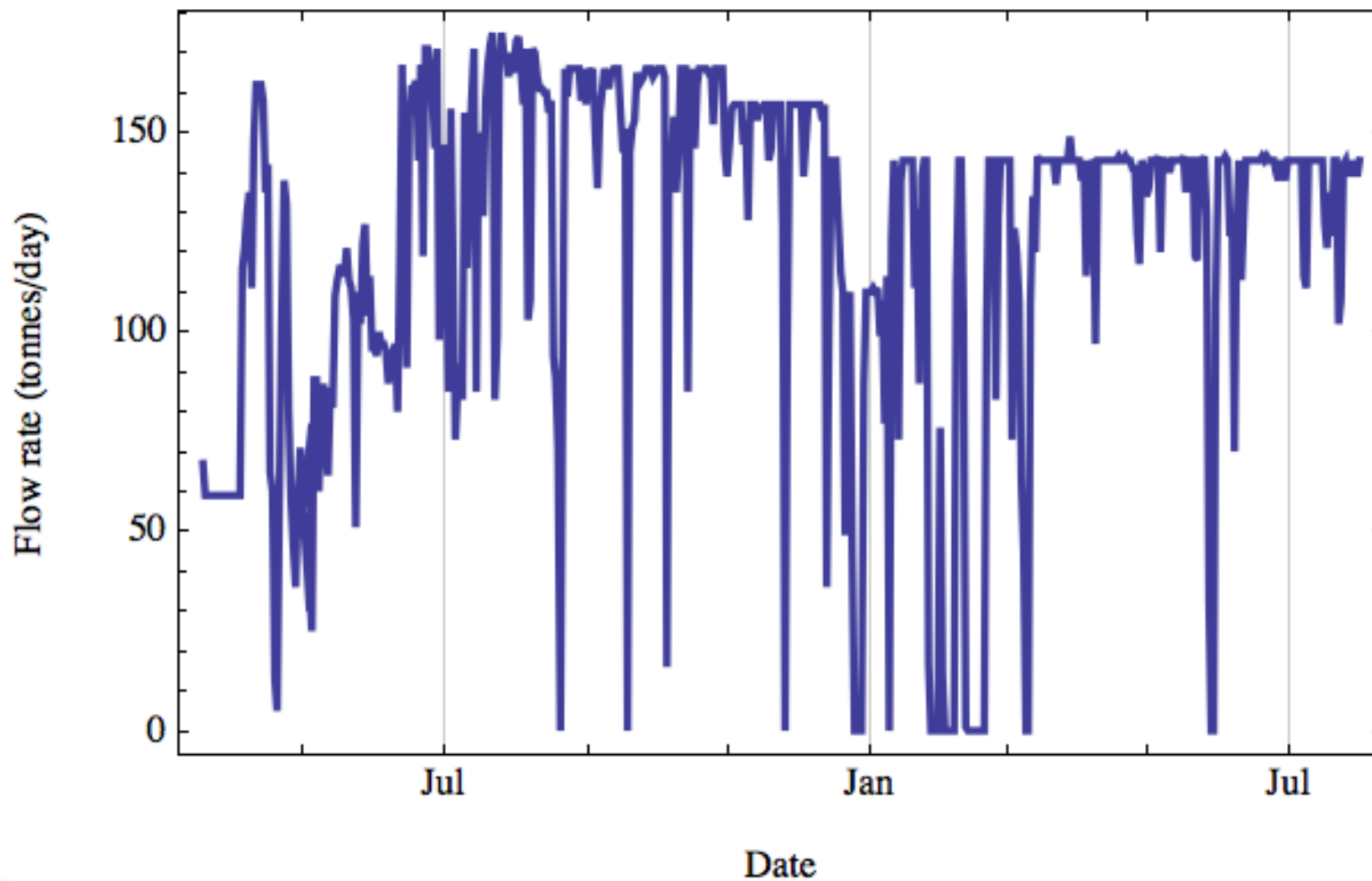
Buttress wellhead pressure



Amount injected



Injection rate



CRC-1 downhole gauges



Metrolog

PRM4-C

Pressure and temperature electronic downhole memory gauge

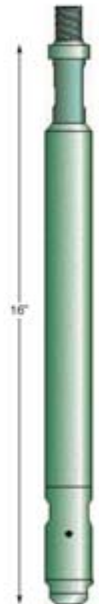
Low cost memory gauge
Large memory
unmatched metrological characteristics

- Used by any technician with no previous knowledge of electronic gauges
- Powered by Smart batteries which remember their use, can be tested for their remaining life and offer up to 12 months of continuous downhole recording
- With innovative features such as:
 - shock absorber mounted electronics
 - metal-to-metal seal for extended test in gas wells

Reservoir and well testing
Static, flowing and build-up surveys
Long duration data recording
Production testing and artificial lift control
Multi well surveys without reprogramming

Specifications

Metrolog		
Pressure (piezoresistive sensor)		
Sensor range	any	max range is 1500 psi (100 bar)
Accuracy (% of FS)	0.05	
Resolution (psi)	0.02	(0.0015 bar)
Temperature		
Range (°F)	0 to 300	-20 to 150 (°C)
Accuracy (°F)	0.6	
Resolution (°F)	0.01	
Memory capacity (points)	1 400 000	
Programming		
Modes		
Conventional	Yes	
Advanced	Yes	(up to 64 intervals)
Parameters		
Scanning rate	any	(from 1 s to 18 hrs)
Time delay	any	(from 0 s to 41 days)
Pressure start	Yes	(Threshold and trigger)
Smart battery type	P15	(for up to 12 months recording)
Mechanics		
Material	stainless steel	(for use services)
O.D. (inch)	1.25	(31.75 mm)
Length (inch)	16	(406 mm)
Weight (lbs)	3	(1.36 kg)
Thread connection	1.5" NPT	(pin up + box down)
Bottom nose connection	1.12" NPT	(female)



Metrolog

5, Avenue Marcel Dassault

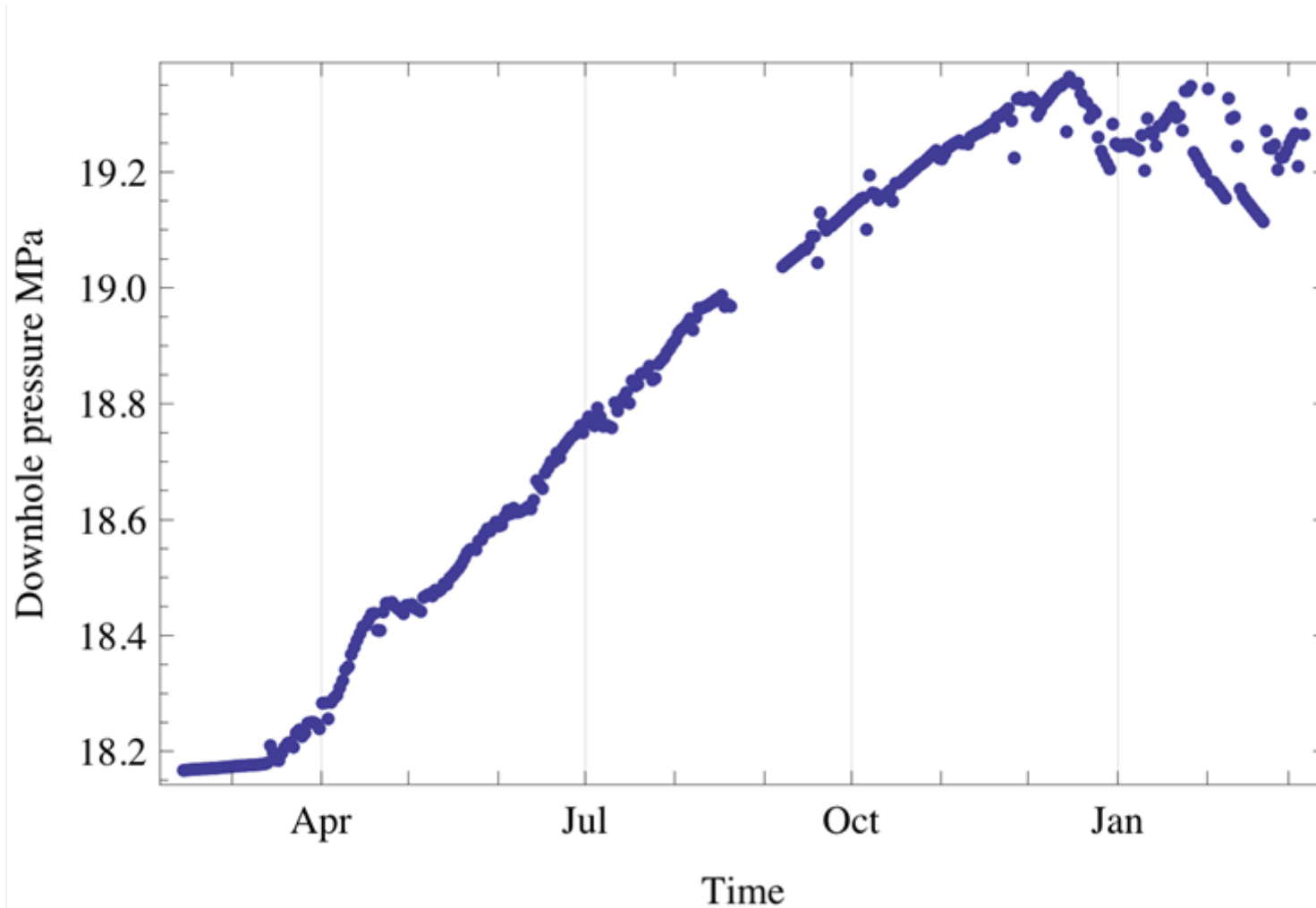
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web site: www.metrolog.com

CRC-1 downhole pressure



Models used in Class et al. 2009 comparison

Name of code/model	Applying institution	Participation in problem(s)	Discretisation	
			In space	In time
COORES	IFP	1.1, 1.2, 2.1, 2.2, 3.1	FV	Implicit
DuMux	Uni. Stuttgart	1.1	BOX	Implicit
ECLIPSE	Schlumberger, Heriot-Watt Uni.	1.1, 1.2, 2.1, 2.2, 3.1, 3.2	IFDM	Implicit
FEHM	LANL	1.1, 1.2	CVFE	Implicit
GEM	Heriot-Watt Uni.	3.1, 3.2	IFDM	Implicit
GPRS	Stanford Uni.	3.1, 3.2	FV	Implicit
IPARS-CO2	CSM Uni. Texas	1.1, 2.1, 2.2, 3.1	Mix. FEM	Impl. pressure expl. conc.
MoReS	Shell	3.1, 3.2	IFDM	Implicit
MUFTE	Uni. Stuttgart	1.1, 1.2, 2.1, 2.2, 3.1	BOX	Implicit
ROCKFLOW	BGR	1.1, 1.2	FE	Implicit
RTAFF2	BRGM	1.2	FEM	Implicit
ELSA	Uni. Bergen/Princeton	1.1		
TOUGH2	CSIRO, BRGM, RWTH Aachen	1.1, 2.1, 2.2, 3.1	IFDM	Implicit
VESA	Princeton Uni.	1.1, 3.1, 3.2	FD, vertic. averaged	Impl. pressure expl. interface

Residual capillary trapping

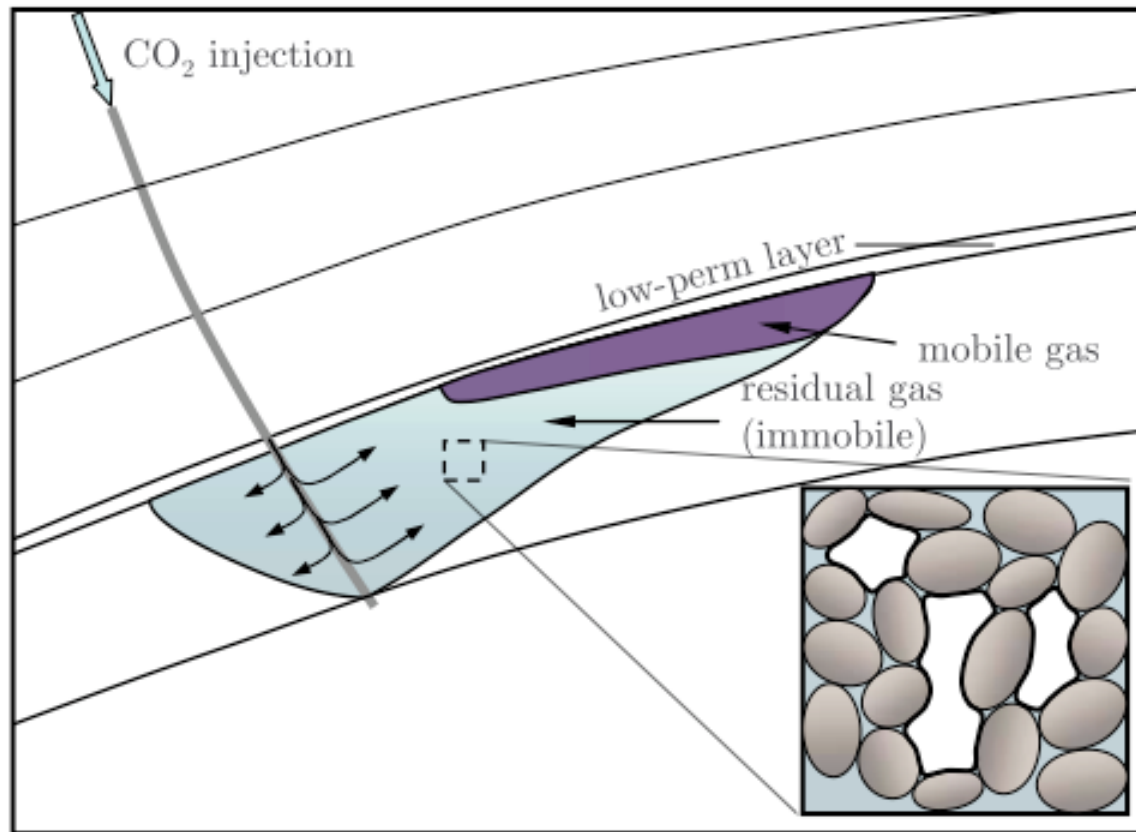


Figure 1. Schematic of the trail of residual CO₂ that is left behind because of snap-off as the plume migrates upward during the postinjection period.

Juanes et al. (2006) WRR

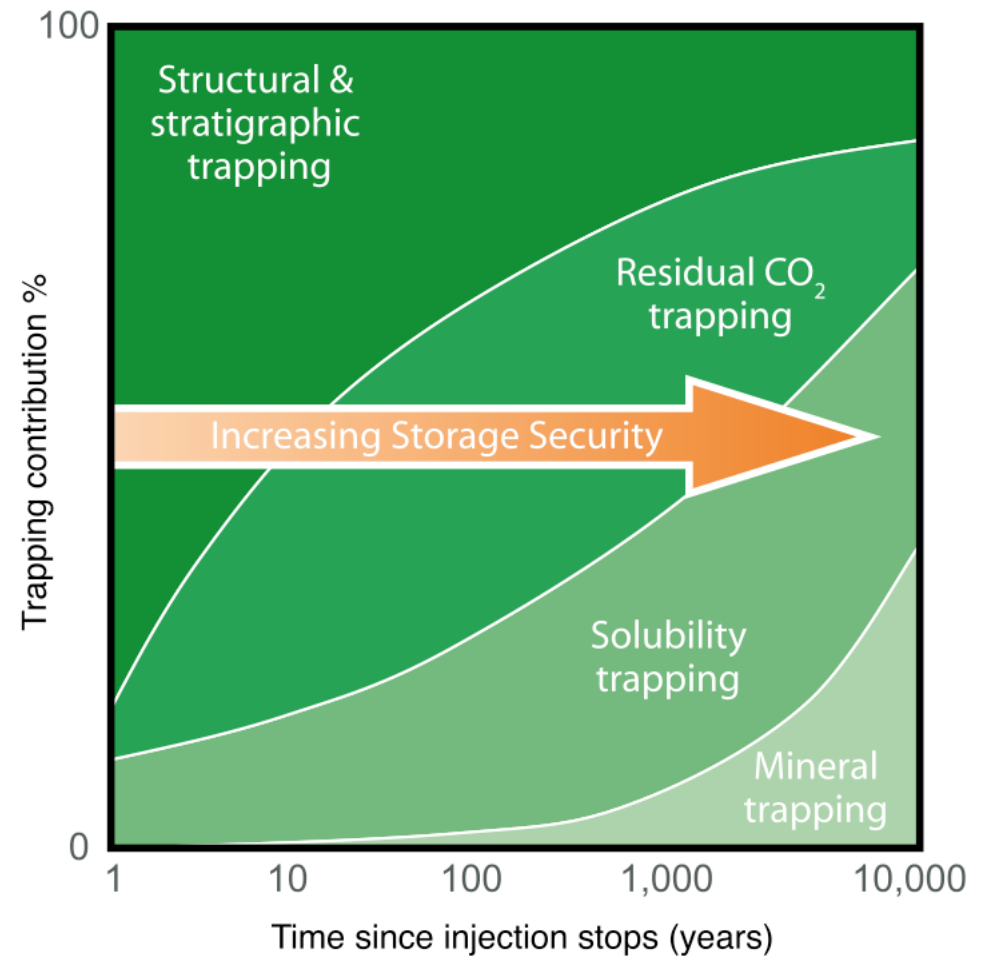
Residual oil trapping



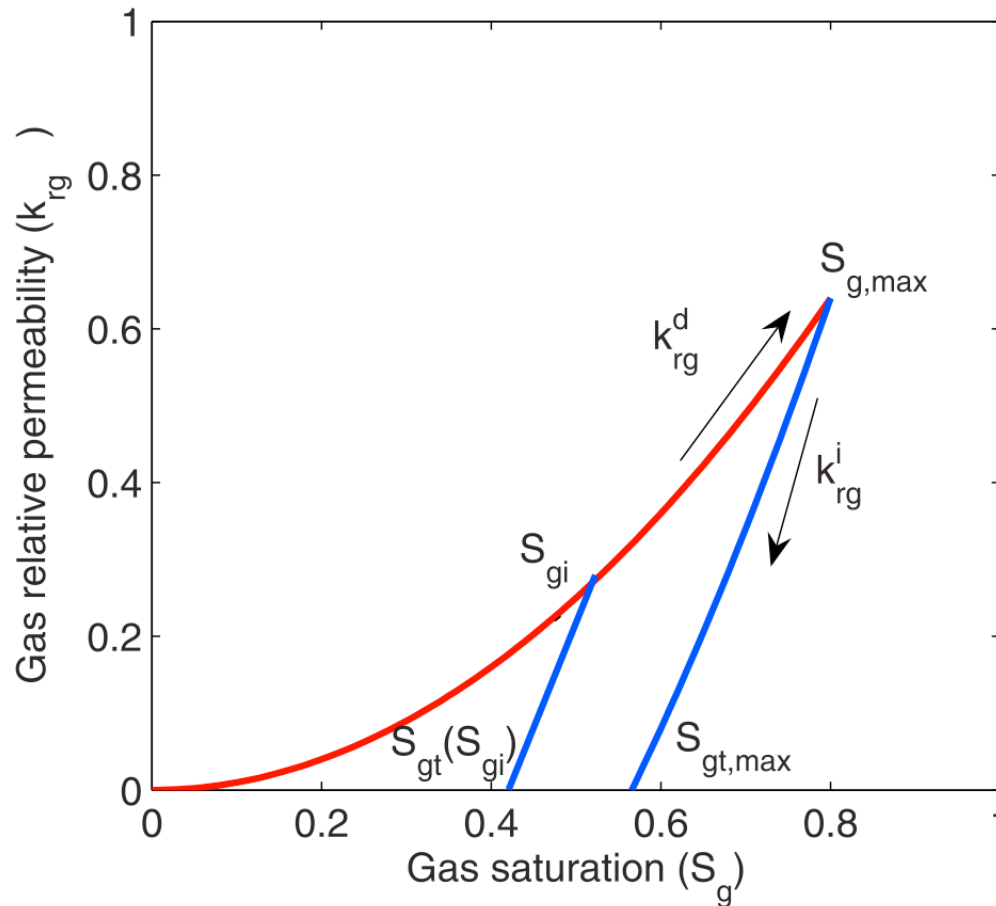
Source: X-ray microtomographic image from Mark Knackstedt, ANU

Trapping mechanisms (IPCC Special Report)

1. Structural trapping
2. Residual trapping
3. Solubility trapping
4. Mineral trapping

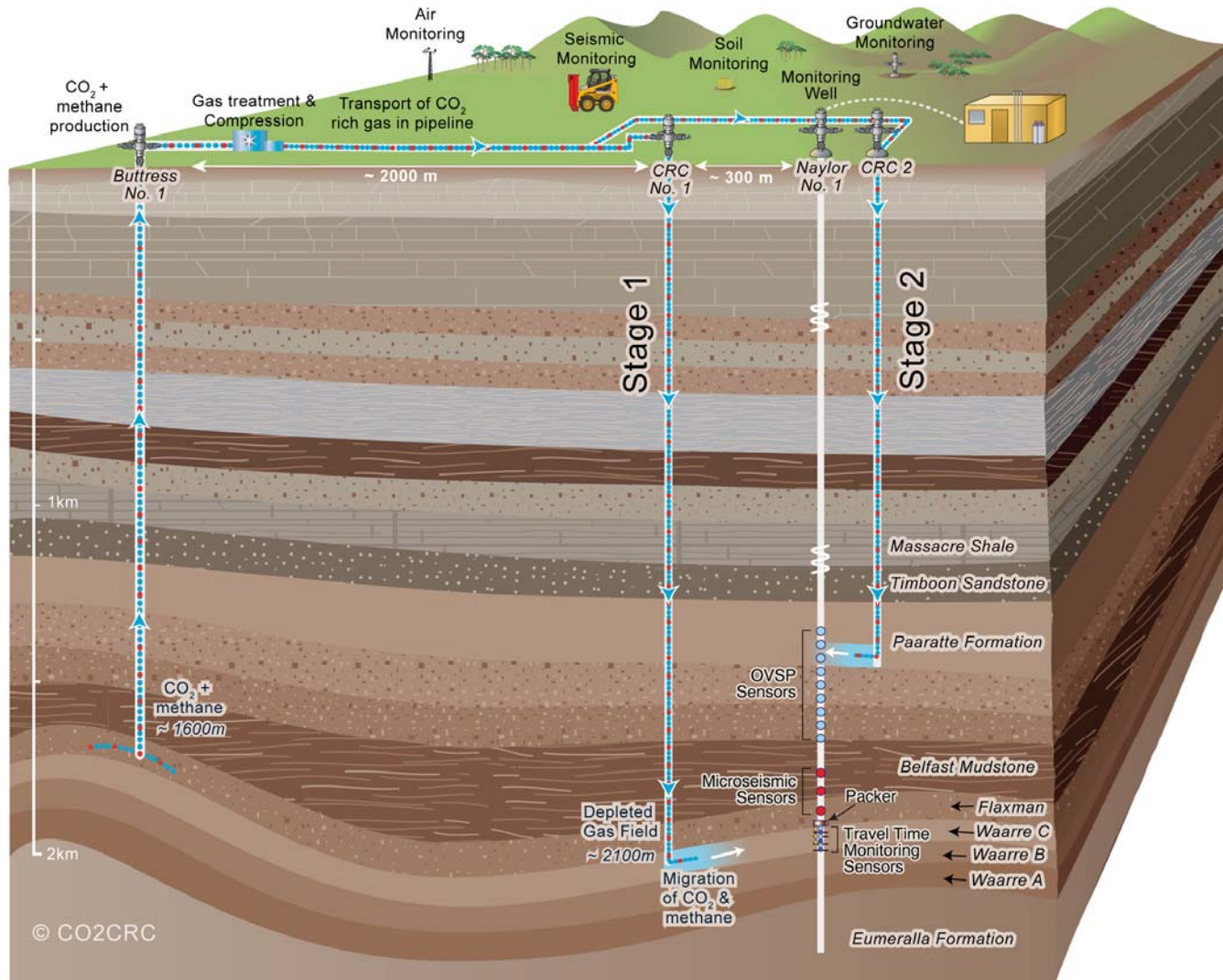


Relative permeability hysteresis



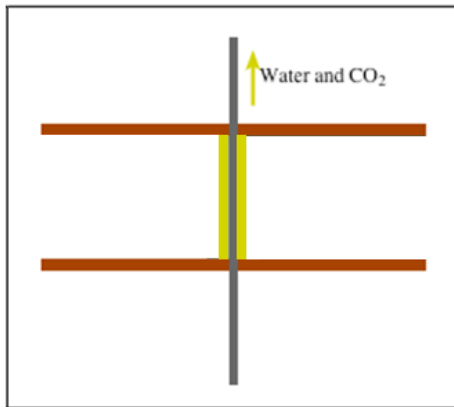
Juanes et al. (2006) WRR

CO2CRC Otway Stage 2

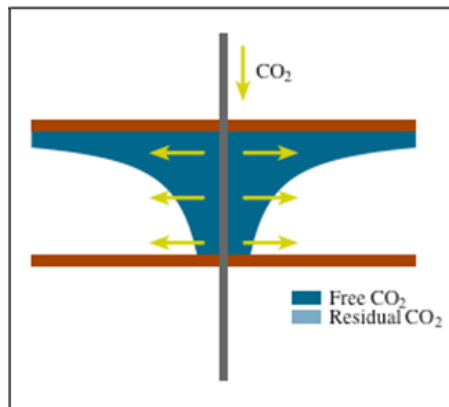


Stage 2 design concept

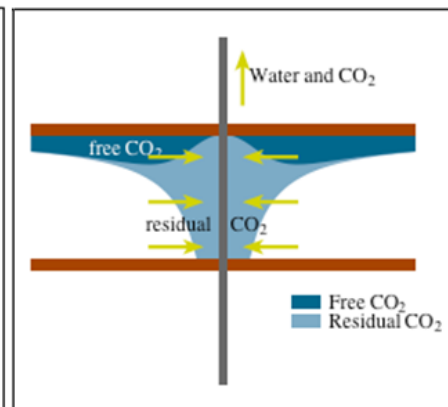
Water test for 1d



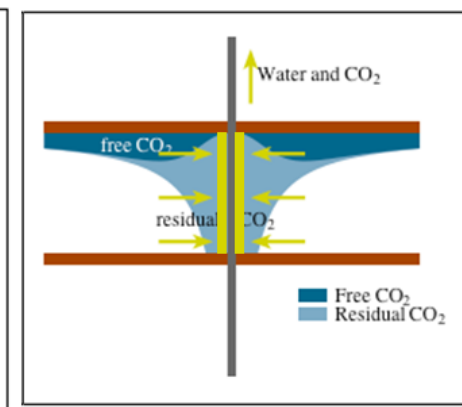
CO₂ injection for 2 days



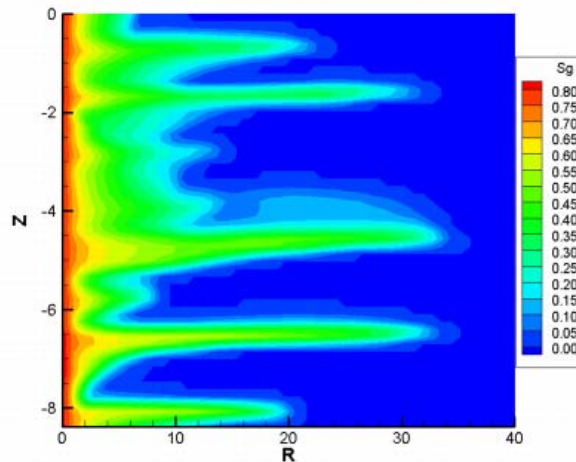
Production for 9 days



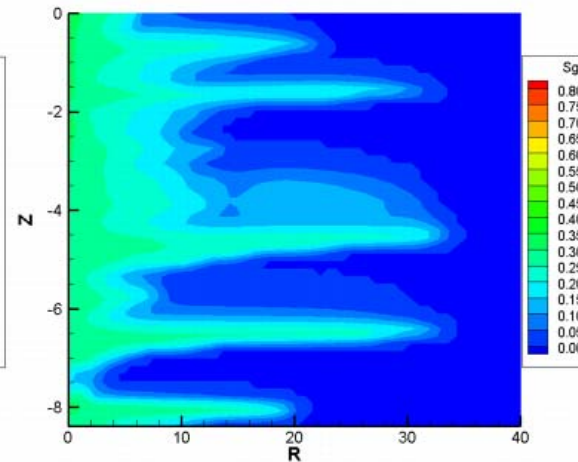
Water test for 1d



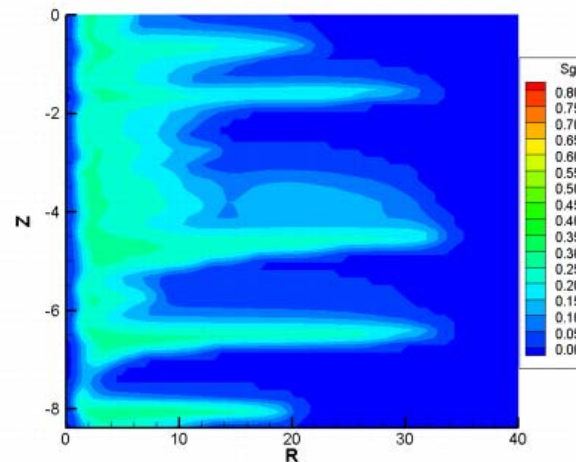
Stage 2 design simulations



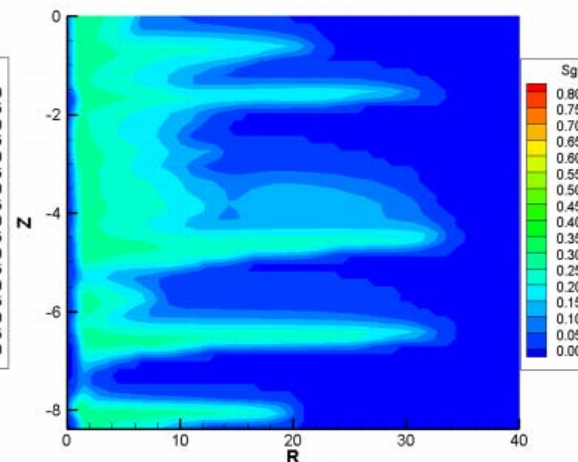
(a) 10 days, end time CO₂ - injection



(b) 19 days, end time MID PROD



(c) 20 days, end time water INJ part of test 2



(d) 27 days, end time water test 2 (end PROD)

Conclusions

- With over 60,000 tonnes injected, the CO2CRC Otway Project stage 1 has demonstrated carbon dioxide storage in Australia along with a wide spectrum of monitoring techniques.
- If successful the CO2CRC Otway Project stage 2 will be the first project worldwide to demonstrate residual trapping as the primary trapping mechanism.
- Experience for the project is applicable to proposed capture and storage demonstrations on a larger scale.

CO2CRC Participants



NSW DEPARTMENT OF
PRIMARY INDUSTRIES



한국지질자원연구원
Korea Institute of Geoscience and Mineral Resources



Mitsui & Co.
(Australia) Ltd



NZ Resource Consortium



SOLID ENERGY
Coals of New Zealand



Government of Western Australia
Department of Mines and Petroleum



woodside



Supporting participants: Department of Resources, Energy and Tourism | CANSYD | Meiji University
Process Group | University of Queensland | Newcastle University | U.S. Department of Energy | URS

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