IPA

THE KERR INVESTIGATION: TECHNICAL BRIEFING

Today's Agenda

- Why
- What
- Results

IPAC CO2

MISSION

Promote the advancement and exchange of geologic storage knowledge through international understanding and co-operation

IPAC CO2 MISSION

Increase public, government and regulator confidence in the safety and permanence of geologic storage of CO_2

Contribute to creating an emerging Carbon Capture and Storage value chain

IPAC CO_2 MISSION

Participate in applied CCS research.

Participate in the practical application of commercial scale geologic storage of CO_2

IPACO_2 Mission

Not-for-profit organization focusing on the geologic storage of CO_2

Risk assessment, risk management,

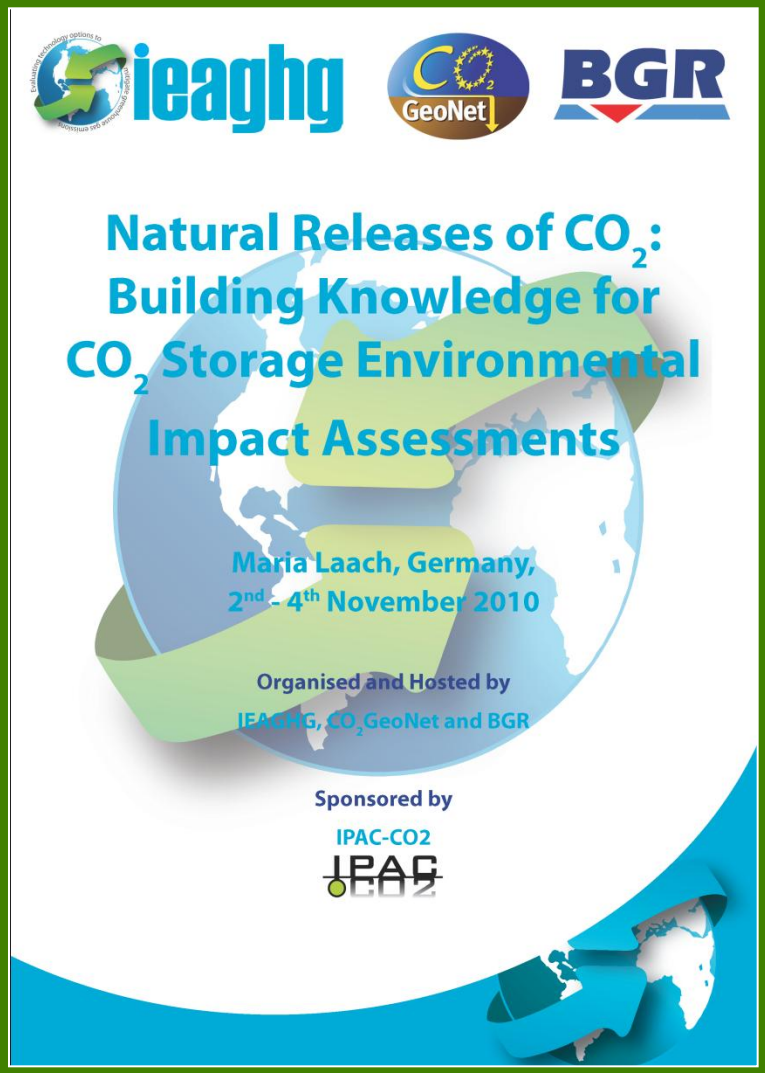
risk mitigation techniques, risk communication

IPAC CO2 Mission

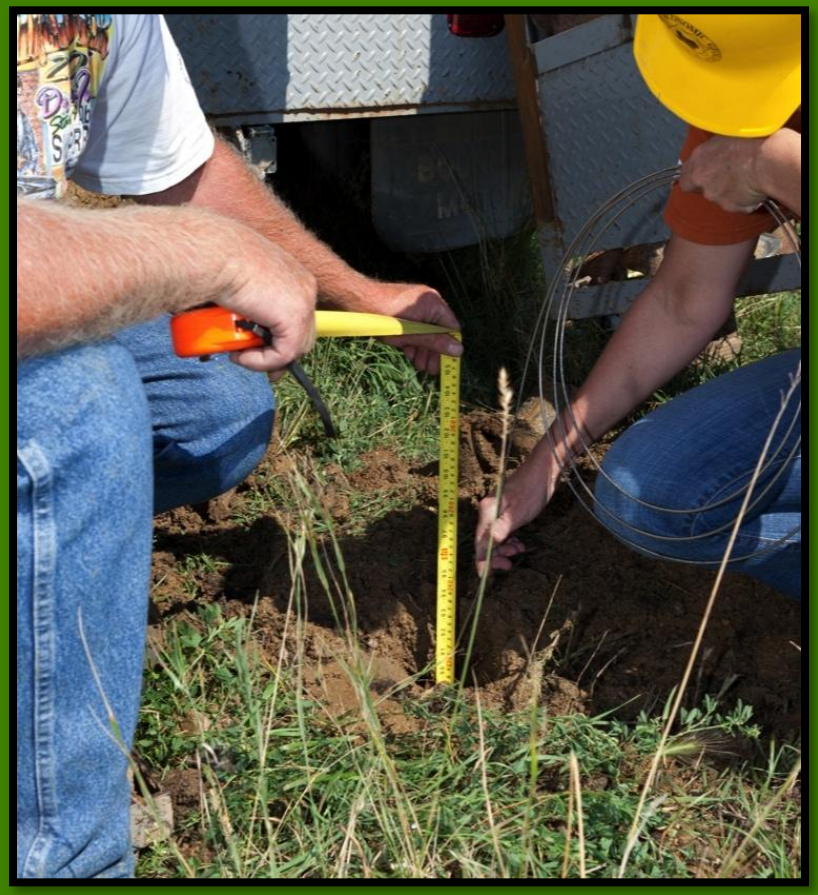
Committed to providing independent, objective information, best practices, advice and assessments

CLIENTS:

- governments
- industry
- academia
- stakeholder groups
- international organizations



The IPAC CO2 Mission



- The world's first performance standards for geologic storage of CO_2
- The Incident Response Protocol (IRP)

Incident Response Protocol

9 steps

1. Response to allegations of the unintentional release of a gas or gases associated with a specific CCS project.
2. Irrespective of the outcome of Step 1, what was the response to the allegations by:
   - The operator of the CCS project
   - Other participants in the CCS project
   - The provincial and federal governments

Incident Response Protocol

3. If there has been an unintentional release, what substances were released and what was the scope of the release?
4. If there has been an unintentional release, what were the release mechanisms?
5. If there has been an unintentional release, when was the release detected?

Incident Response Protocol

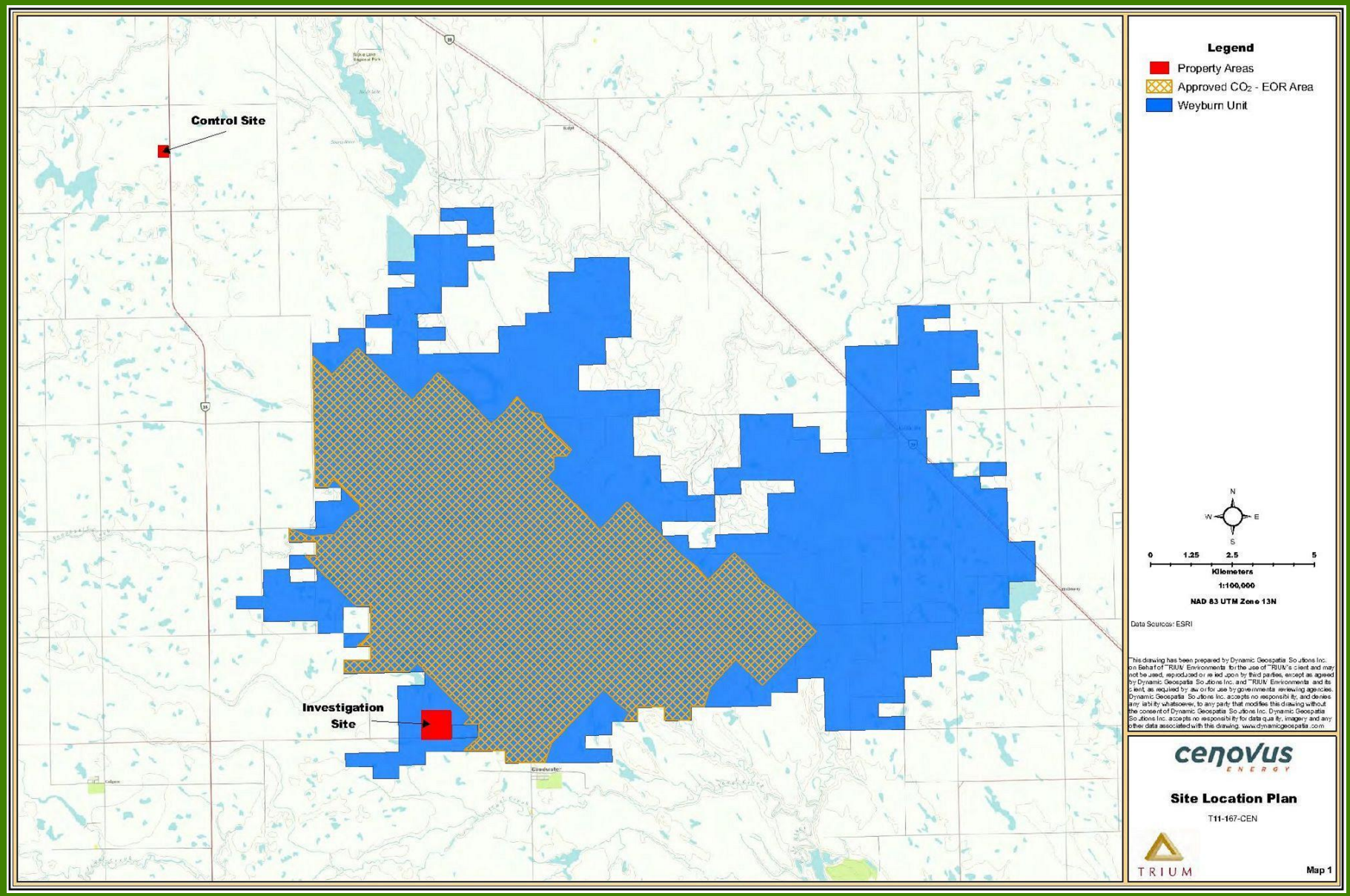
6. If there has been an unintentional release, what was the response to the release?
7. If there has been an unintentional release, what were the consequences of the release?
8. If there has been an unintentional release, was there compliance with applicable industry performance standards / best practices?
9. Conclusions and recommendations

The Kerr Investigation

To reduce the uncertainty regarding the carbon dioxide anomaly reported to exist on the property owned by Cameron and Jane Kerr

CENOVUS ENERGY

CENOVUS SITE LOCATION PLAN

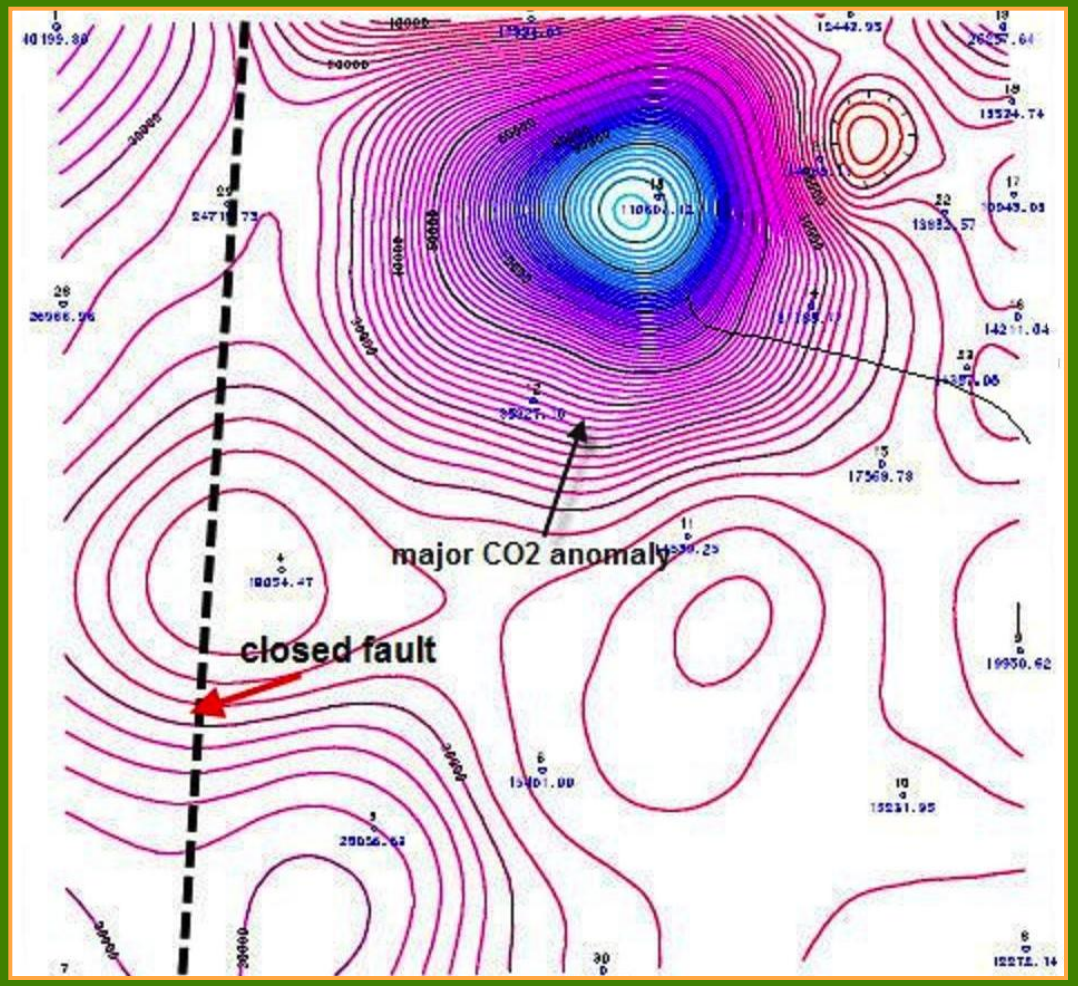


Protocol Implementation

The Kerr Property

Protocol Implementation

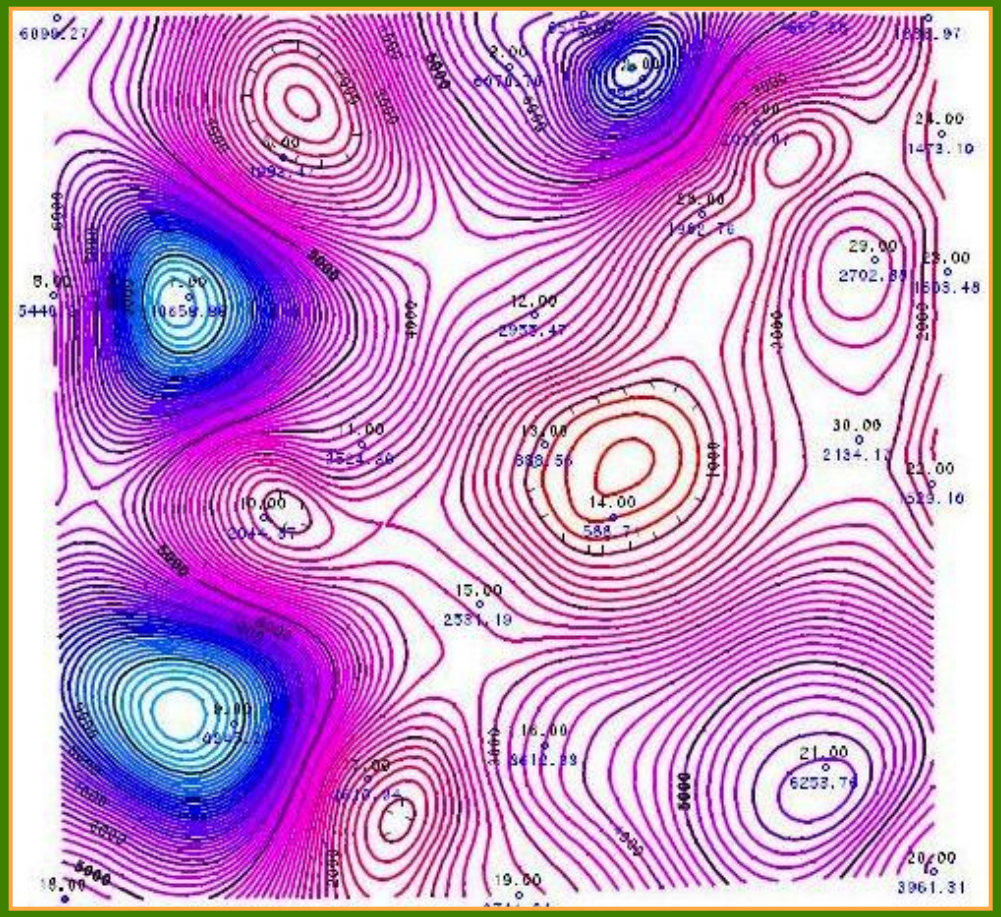
The summer CO_2 anomaly



Source: Lafleur, P. 2010. *Geochemical Soil Gas Survey: A Site Investigation of SW30-5-13-W2M Weyburn Field, Saskatchewan. Saskatoon, SK: Petro-Find Geochem Ltd.)*

Protocol Implementation

The winter CO_2 anomalies



Source: Lafleur, P. 2011. *Geochemical Soil Gas Survey: A Site Investigation of SW30-5-13-W2M, Weyburn Field, Saskatchewan, Monitoring Project Number 2. Saskatoon, SK: Petro-Find Geochem Ltd.*

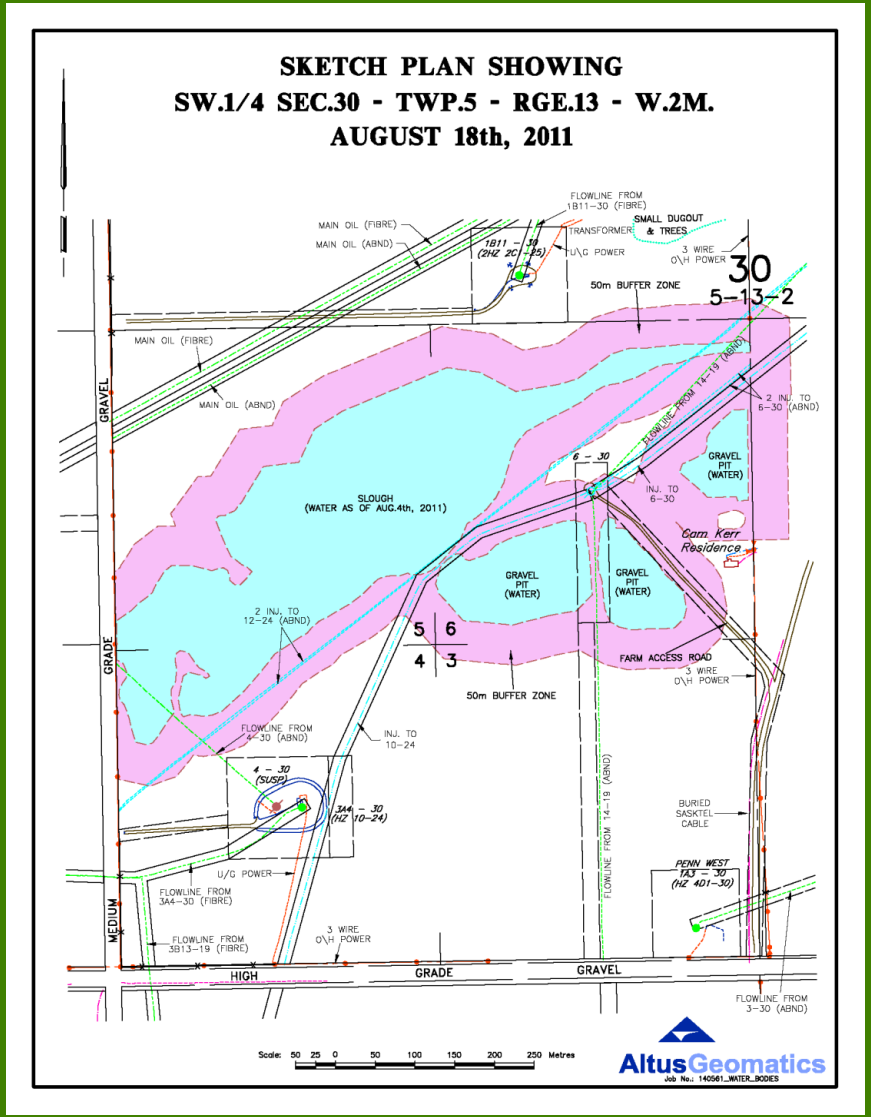
Protocol Implementation: Quality Assurance

Mr. Eric S. Ringler
Consultant, Research Triangle, North Carolina, U.S.A

Protocol Implementation: Constraints

Northern Leopard Frog (*Lithobates pipiens)*

National Energy Board pipeline setback requirements



Protocol Implementation

- Vicinity inspection:
  - Overview
  - Wells (active and abandoned)
  - Pipelines (active and abandoned)
  - Injection sites
  - Monitoring sites
  - Study sites

Protocol Implementation

- Vicinity history:
  - Chronology of events
  - Injection history (substances, depth, formations)
  - Land use history
  - Incidents in vicinity (*e.g.*, hydrocarbon spills)
  - Release history (if any)

The Kerr Investigation Team

- Dr. Janis Dale, Department of Geology, University of Regina, Canada
- Dr. Stuart M.V. Gilfillan, Scottish Carbon Capture and Storage, School of Geosciences, University of Edinburgh, Scotland
- Mr. Eric S. Ringler, Consultant, Research Triangle, North Carolina, U.S.A.

The Kerr Investigation Team

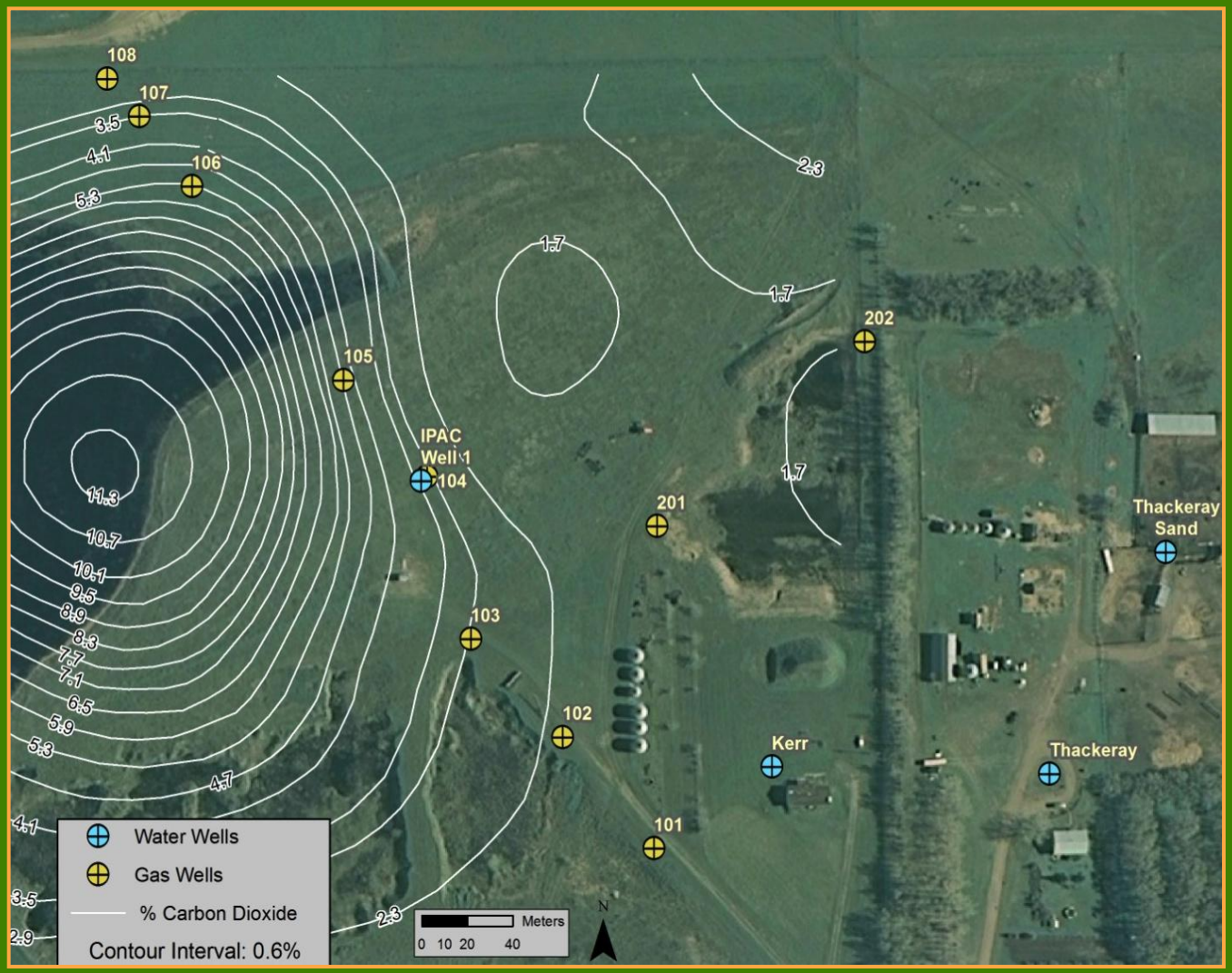
- Dr. Katherine D. Romanak, Principle Investigator, Gulf Coast Carbon Center, Bureau of Economic Geology, University of Texas at Austin, U.S.A.
- Dr. Brad D. Wolaver, Gulf Coast Carbon Center, Bureau of Economic Geology, University of Texas at Austin, U.S.A.
- Dr. Changbing Yang, Gulf Coast Carbon Center, Bureau of Economic Geology, University of Texas at Austin, U.S.A.

Soil Gas Analysis

Dr. Katherine D. Romanak

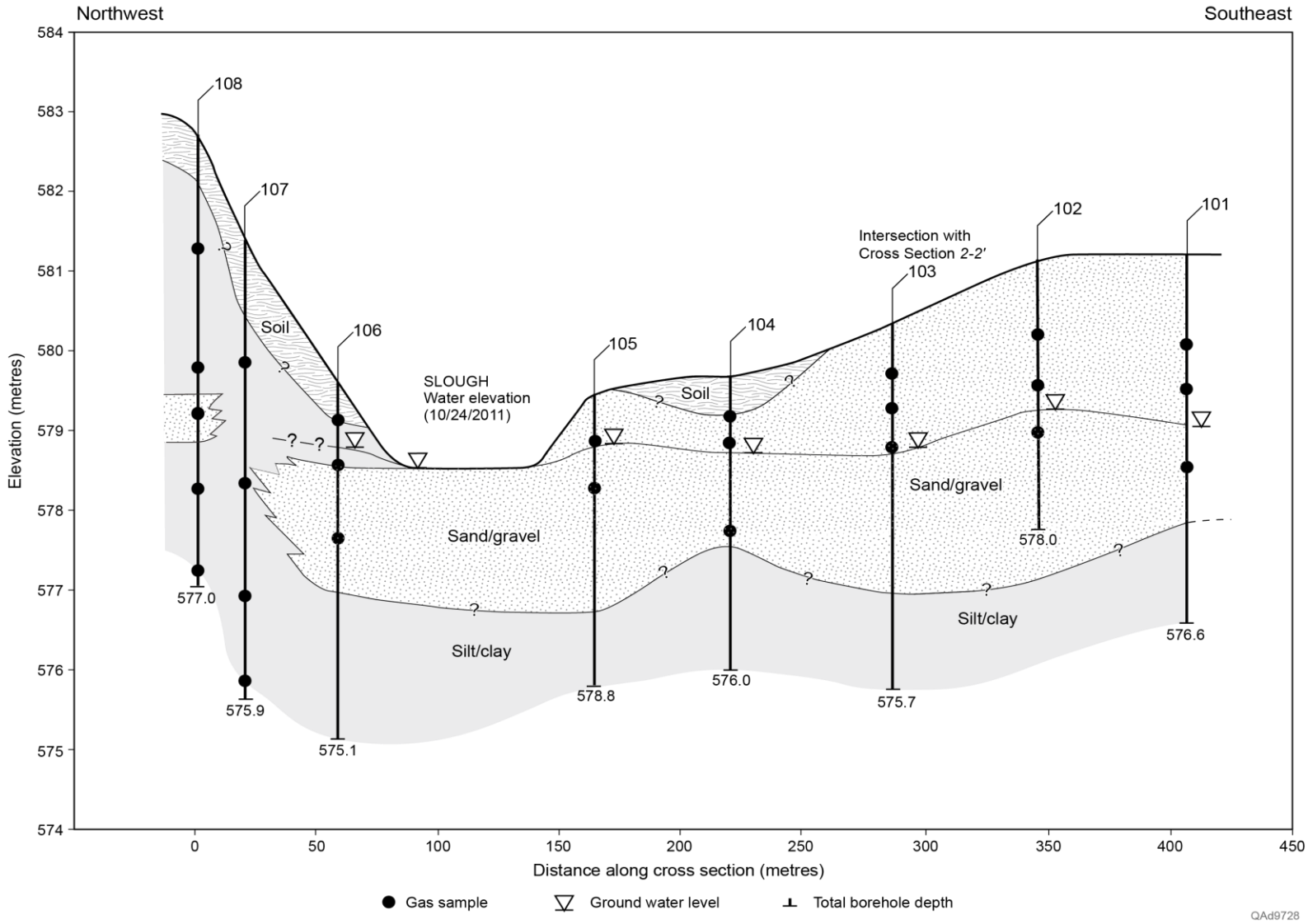
Principle Investigator,
Gulf Coast Carbon Center,
Bureau of Economic
Geology, at the University
of Texas in Austin

The Kerr Property

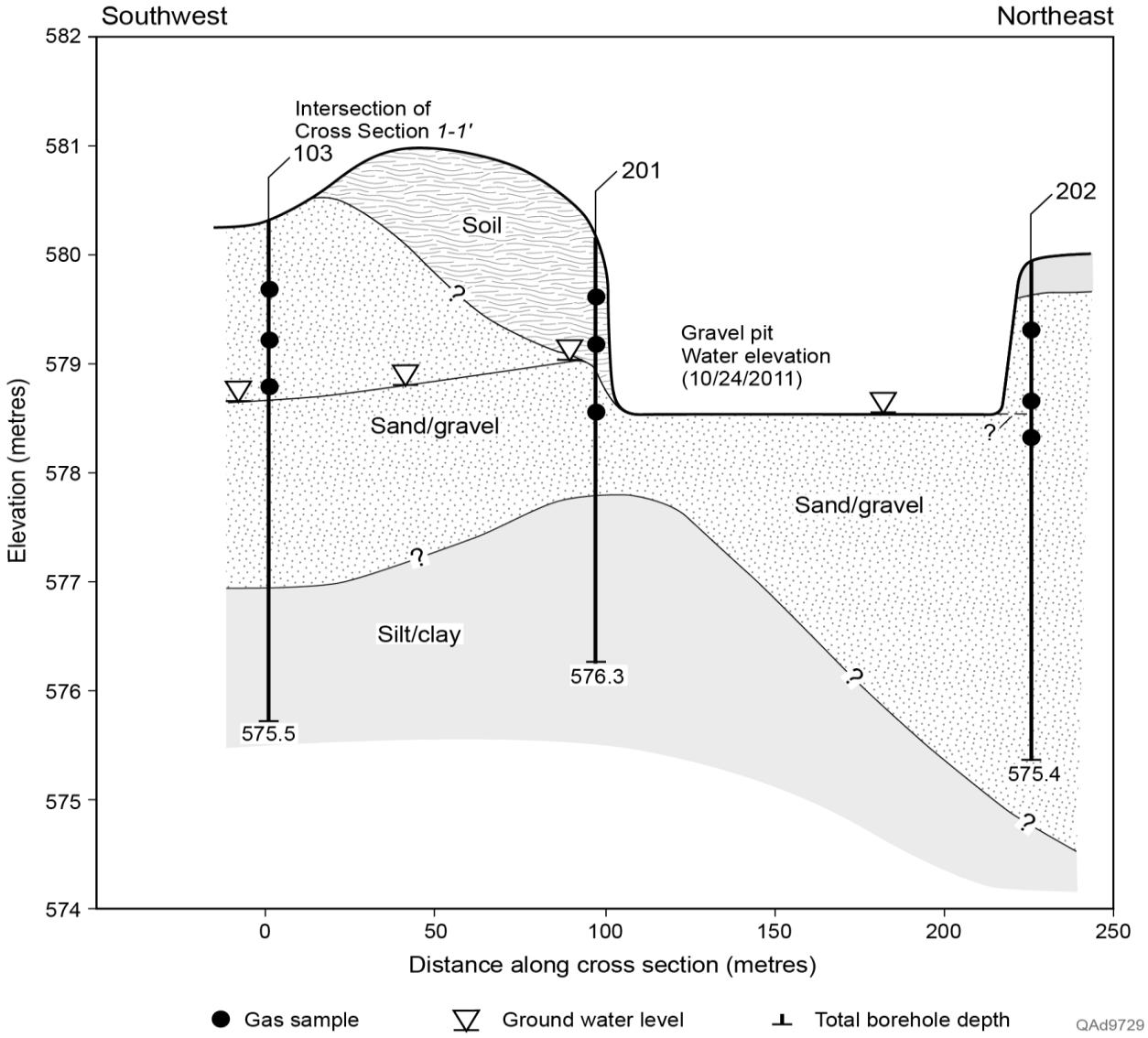


The Kerr Property

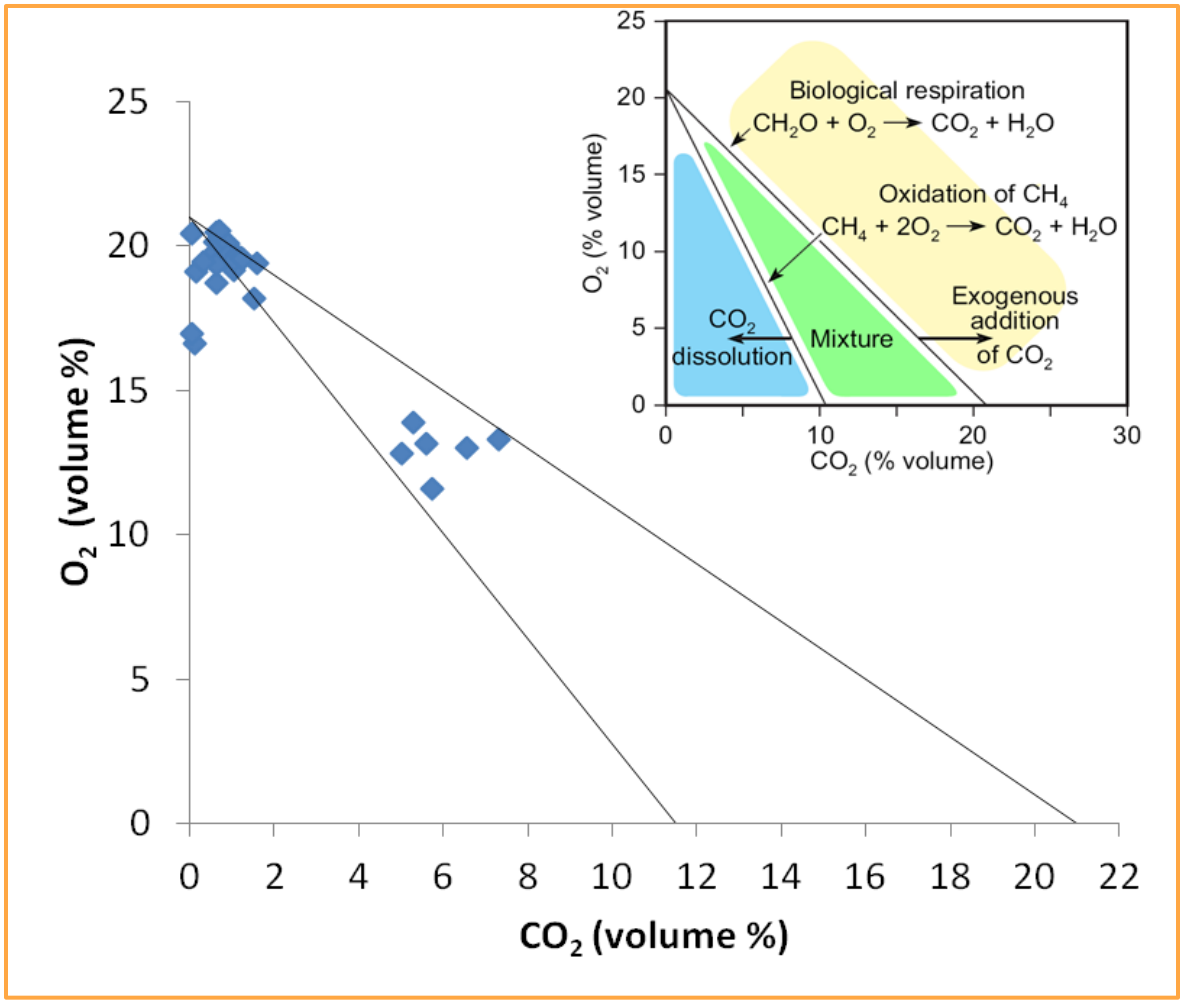
SOIL-GAS SAMPLING STATIONS: NW-SE TRANSECT



Soil-gas Sampling Stations: sw-ne Transect

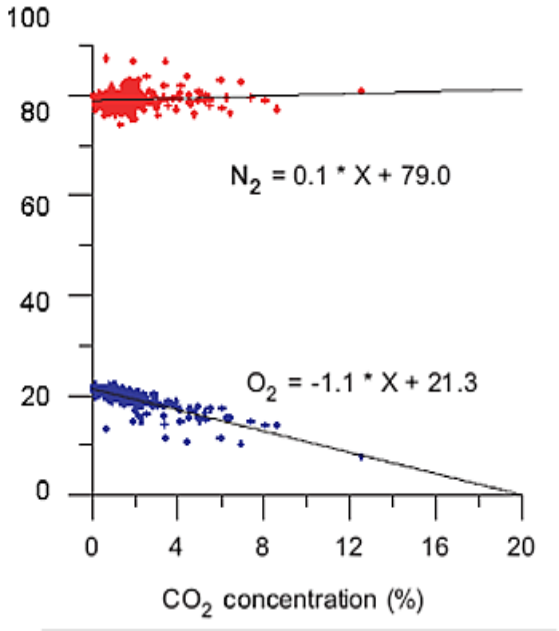


O_2:CO_2 Relationships



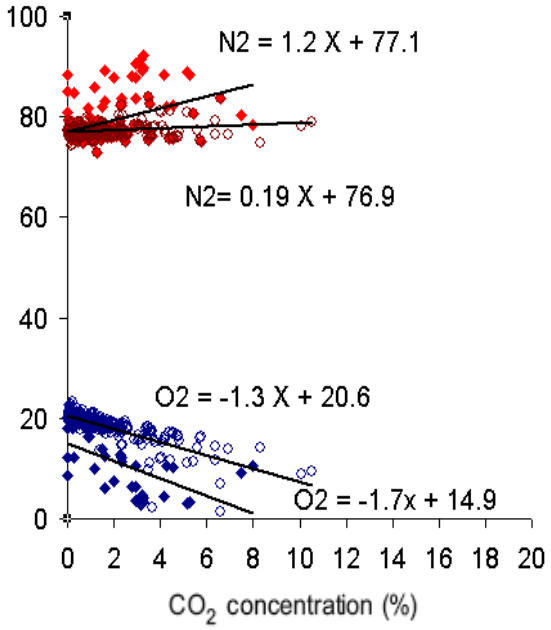
GAS CONCENTRATION RELATIONSHIPS

Weyburn Background
Microbial near-surface
No impact on N_2
Slope N_2:CO_2 = 0



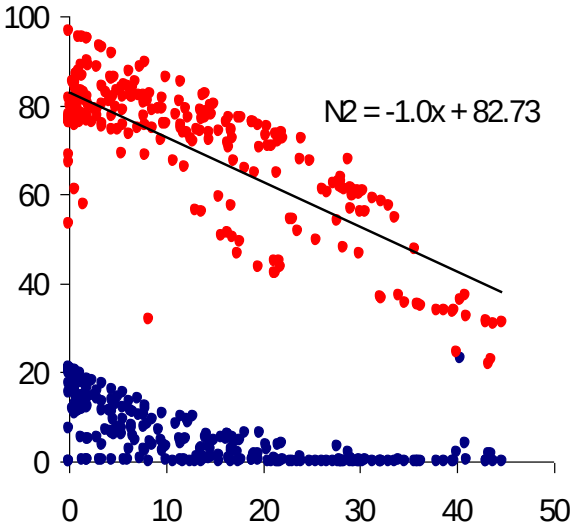
Riding and Rochelle, 2005

Natural Wetland Soils
CO_2 dissolution
Slope N_2:CO_2 is positive



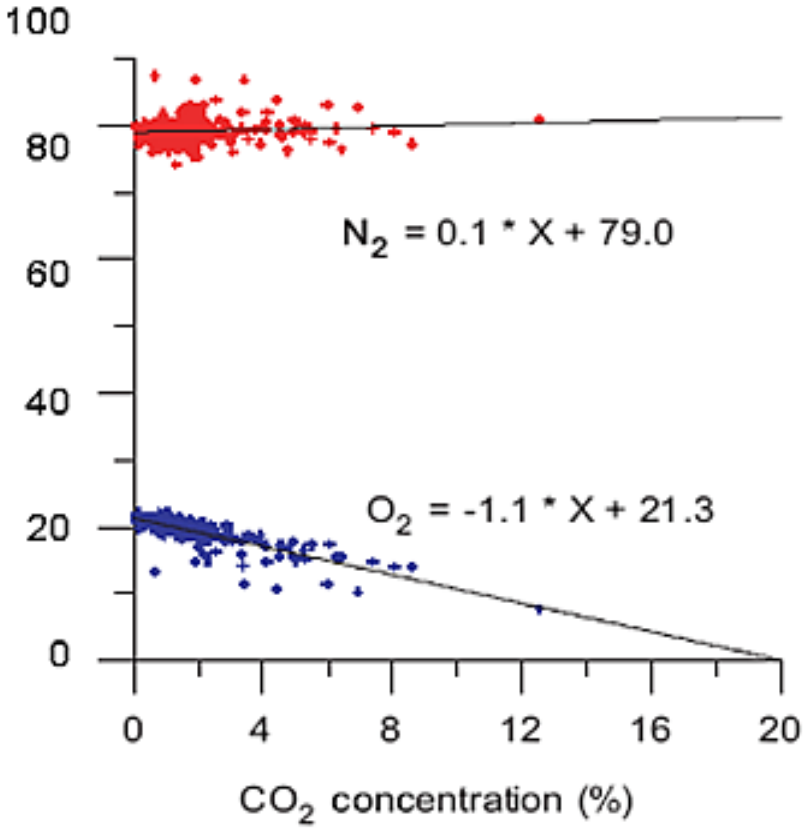
Romanak, 1997
Romanak and Bennett, 2009

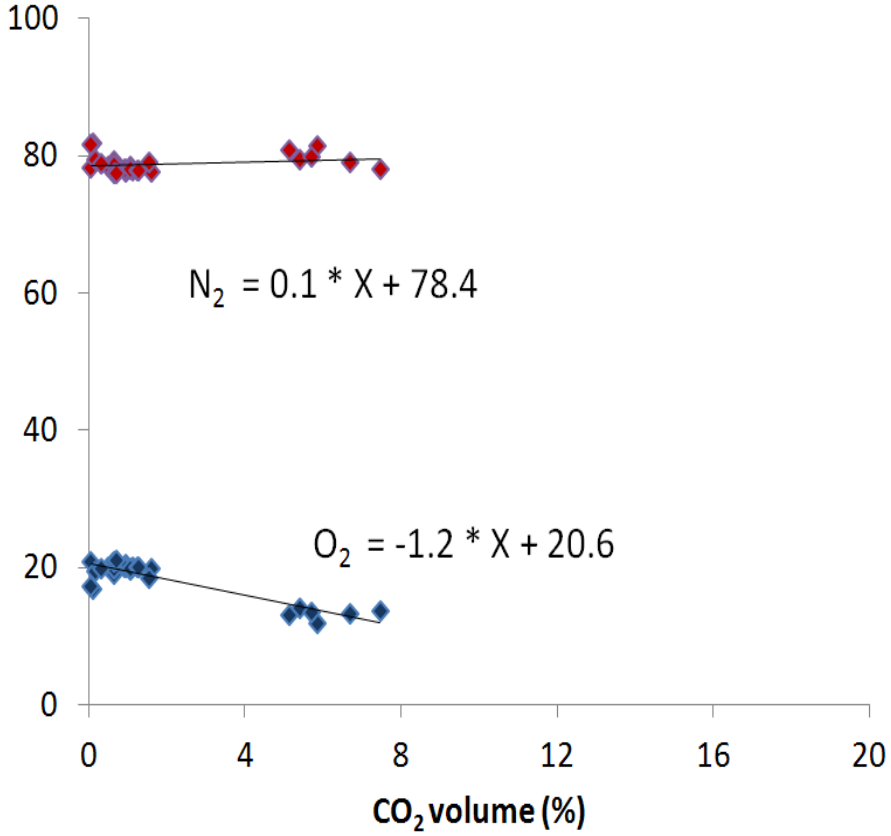
Industrial Site
Input of deep gas
Dilution of N_2
Slope N_2:CO_2 is negative



Romanak et. al., 2010

GAS CONCENTRATION RELATIONSHIPS





Weyburn Background

Kerr Investigation

Carbon Isotopic Signatures Of Various Potential CO_2 Sources

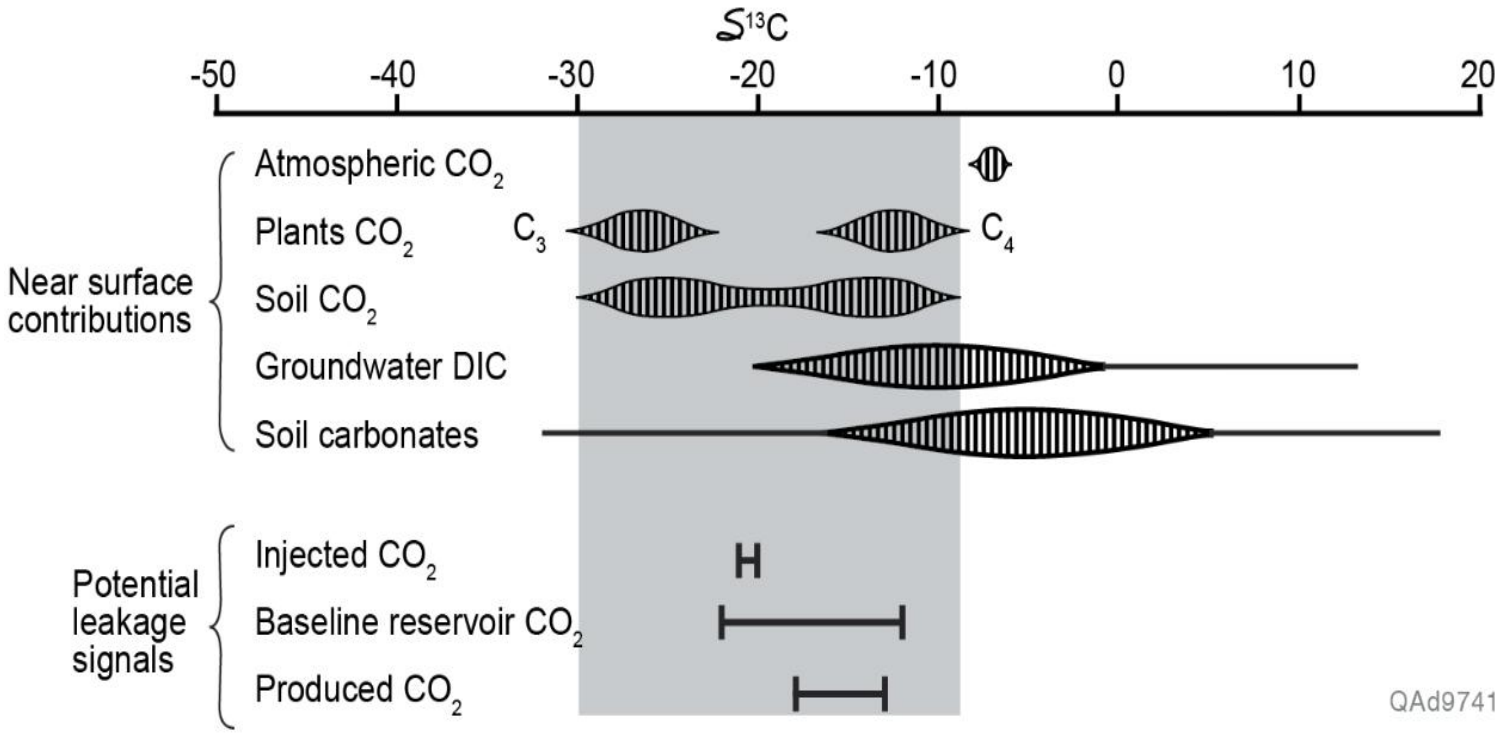


Figure is modified from Clark and Fritz, 1997, with data for potential leakage signals from Emberley et al., 2005.

Conclusions

CO_2 is biological in origin, not the result of leaks associated with the CO_2 storage reservoir

No evidence suggests that gases originating in the deep subsurface migrated to the near surface

Analysis of noble gas, carbon stable isotope and hydrogen carbonate HCO_3

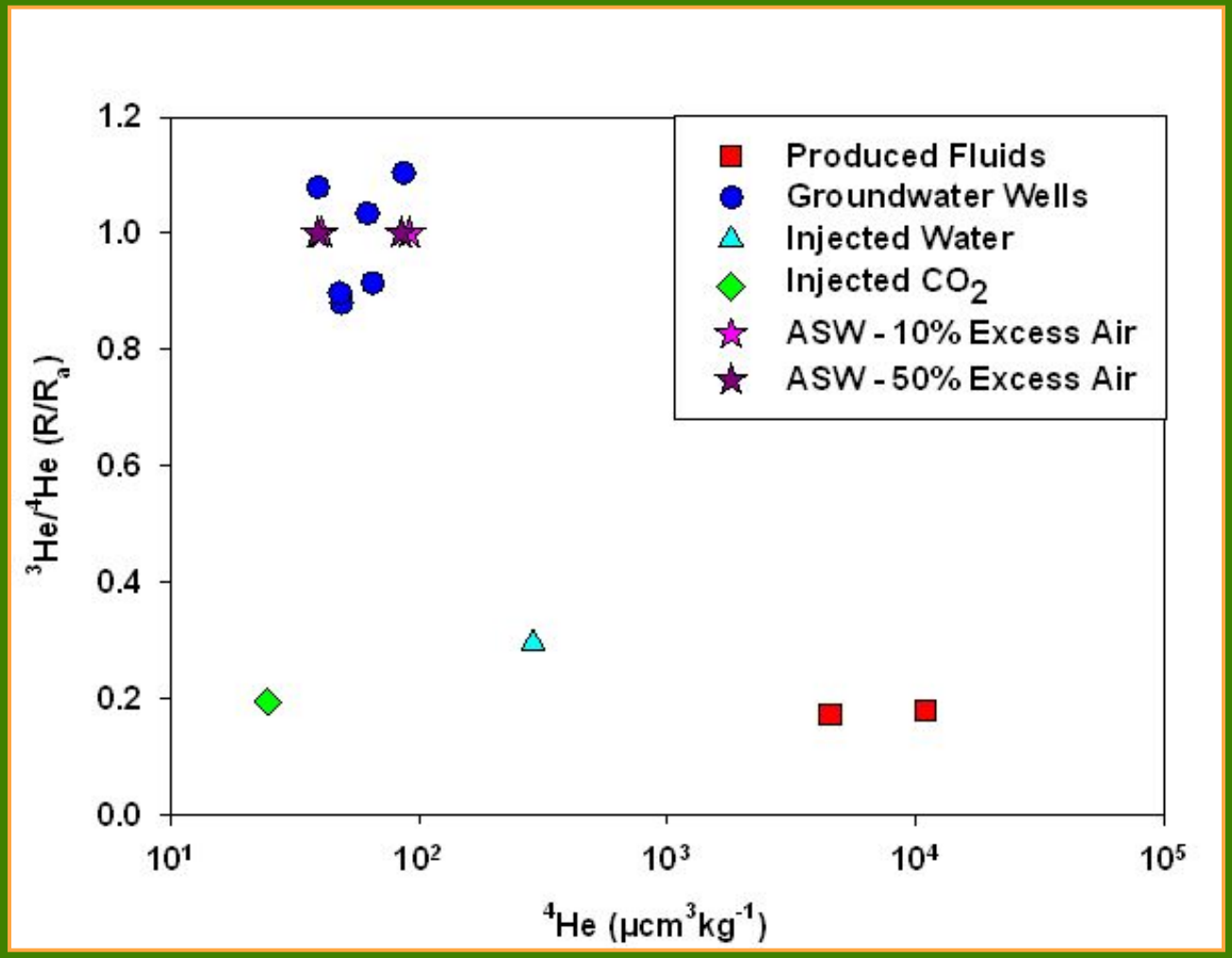
Dr. Stuart Gilfillan

Scottish Carbon Capture and Storage, School of Geosciences, University of Edinburgh, Scotland

Noble Gas Analysis: Samples Obtained

- Water injected into the oil field
- CO_2 injected into the oil field
- Fluids produced from the oil field
- Ground water wells on the Kerr and adjacent Thackeray farms

Noble Gas Analysis: $^3He/^4He$ plotted against ^4He concentrations in the produced reservoir fluids, groundwater wells and water injected into the reservoir surrounding the Kerr quarter



Conclusions

"We find no evidence in any of the noble gas data derived within the ground waters surrounding the Kerr quarter that there is a detectible presence of noble gases derived from the deep injected water or CO_2 or the fluids produced from the Weyburn field."

Hydrogeological Analysis

Dr. Brad D. Wolaver and
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Dr. Janis Dale
Department of Geology,
University of Regina

Hydrogeological Analysis: Methods

Hydrogeological Analysis: Process

Hydrogeological Analysis: Water Chemistry Analysis - 1

Sample	Well	Sampling date	EC	TDS	Alkalinity	pH	Total Hardness	HCO3+ CO3	HCO3	Sodium	Potassium	Calcium	Magnesium	Chloride	Sulfate	NO3+NO2
			mS/cm	mg/L	mg Caco3/L		mg $CaCO_3$/L	(mg/L)	mg/L	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg N/L)
Saskatchewan's Drinking Water Quality Standards and Objectives		MAC														10
		IMAC														
		AO		1500	500	6.50-9.00	800			300			200	250	500	
1	IPAC-1	9/1/2011	N/A	N/A	N/A	N/A	N/A	N/A	N/A	109	14.4	116	94.4	30.8	300	0.74
2	Kerr House	9/1/2011	N/A	N/A	N/A	N/A	N/A	N/A	N/A	34.4	7	111	46.8	5.5	180	3.3
3	Thackeray House	9/1/2011	N/A	N/A	N/A	N/A	N/A	N/A	N/A	41.4	10.9	111	71.8	43.5	120	18.4
4	Thackeray Farm	9/1/2011	N/A	N/A	N/A	N/A	N/A	N/A	N/A	56.6	242	205	87.4	150	167	64
5	Kerr House	6/30/2011	0.74	546	288	7.80	292	351	351	25	9	69	29	8	54	0.54
6	Thackeray House	6/30/2011	1.66	1187	405	8.00	645	495	495	103	20	118	85	86	250	29.9
7	Thackeray Farm	6/30/2011	2.25	1369	471	7.50	707	575	575	67	133	148	82	136	180	48.1

HYDROGEOLOGICAL ANALYSIS: WATER CHEMISTRY ANALYSIS - 2

Sample	Well	Aluminum (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Selenium (mg/L)	Uranium (mg/L)	Zinc (mg/L)	$\delta^{13}C_{DIC}$ [4] (‰)
Saskatchewan's Drinking Water Quality Standards and Objectives	MAC		0.006[*]		1		0.005	0.05			0.01		0.001	0.01	0.02		
	IMAC			0.025													
	AO	0.1/0.2[*]				5.0			1.0	0.3		0.05				5.0	
1	IPAC-1	<0.02	<0.001	0.00089	0.097	<0.1	<0.0004	<0.004	0.0025	<0.03	<0.001	0.0176	<0.0002	<0.002	0.014	0.09	-14.71
2	Kerr House	<0.02	<0.001	0.00151	0.199	<0.1	<0.0004	<0.004	0.0214	0.059	<0.001	0.0663	<0.0002	0.0045	0.00426	3.77	-14.51
3	Thackeray House	<0.02	<0.001	0.00098	0.097	0.12	<0.0004	<0.004	0.0051	<0.03	<0.001	0.0198	<0.0002	0.003	0.00422	0.666	-13.51
4	Thackeray Farm	<0.05	<0.0025	0.00125	0.273	0.14	<0.001	<0.01	0.0176	0.5	<0.0025	1.59	<0.0002	<0.005	0.0064	0.103	-17.07
5	Kerr House	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6	Thackeray House	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7	Thackeray Farm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Summary

Regardless of whether CO_2 was measured in the soil gases or in groundwater, it was produced by natural processes

IPAC CO2

THE KERR INVESTIGATION: FINAL REPORT