IEAGHG Activities in CO_2 Geological Storage

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IEAGHG

US RCSP Meeting,

Pittsburgh, PA, August 2012

BG GROUP

bp

CEZ GROUP

Chevron

eni

TOTAL

BR PETROBRAS

ALSTOM

CIAB

DOOSAN Doosan Babcock

EnBW

e·on

VATTENFALL

Evaluating technology options to mitigate greenhouse gas emissions

ieaghg

EPRI

ExxonMobil

Schlumberger

SCOTTISHPOWER

REPSOL YPF

INSTITUTO DE INVESTIGACIONES ELECTRICAS

B&W power generation group

Enel L'ENERGIA CHE TI ASCOLTA.

GLOBAL CCS INSTITUTE

JGC

RWE The energy to lead

Statoil

Partner Organisations:

JCOAL Japan Coal Energy Center

ptrc Petroleum Technology Research Centre

CO_2 GeoNet

carbon sequestration leadership forum

IEAGHG Storage Portfolio

- Storage Research Networks
  - Risk Assessment
  - Monitoring
  - Modelling
  - Wellbore Integrity
  - Environmental Research
  - **Joint Network Meeting, June 2012**
- Study Programme
  - Reports produced 1996 – 2012
  - Study ideas – knowledge gaps identified through research networks/ ExCo Members

Joint Storage Network Meeting Santa Fe,

- Aims before the meeting:
  - to ensure the Networks are working in the most efficient way without duplication or gaps
  - to identify cross-cutting issues and their consequences; requiring input from more than one Network
  - to set the framework for the future direction of the Networks
- Recommendations from the meeting:
  - More Network to Network collaboration
  - Virtual meetings on hot topics
  - Topic-based workshops e.g. Remediation
  - Reassessment of steering committees each year
  - Activity in between meetings
  - Interaction with Social Research Network (due to relevance to all storage networks)

Environmental Research CO_2 Storage Network– July ’12, Bozeman, Montana

- Session 1: Welcome and Aims of the Meeting
- Session 2: Environmental Impact Assessments and Regulations
- **Session 3: Controlled release experiments – project updates**
- Session 4: Monitoring
  - Part I: Overview
  - Part II: Baseline Monitoring and Sensitivity
  - Part III: Quantification and diffuse leakage
- Session 5: Overburden/ Mechanisms of migration from deep to shallow subsurface
- Session 6 : Leakage Scenarios
- Session 7: Communication of leakage
- Session 8: Conclusions and decision on aims and objectives

Main Conclusions/Outcomes

- EIA regulations are not seen as a barrier to projects
- Increase in controlled release projects, which show a variation in focus over a wide range of settings (based on knowledge gaps)
- Indicator species being identified, especially benthic and terrestrial plants
- Monitoring – potential for large area of coverage for lower cost, i.e. EM remote sensing (on shore) AUVs (offshore)
- New techniques for potential diffuse leakage and brine migration
- Using a process-based methodology – potentially less baseline monitoring needed. Though baselines still needed for leak detection and impacts
- Seasonality and timing can effect potential leakage impact
- Gaps identified in the past are being addressed

Recent and Current Studies

- Global Storage Resources Gap Analysis for Policy Makers, Geogreen – Published 2011
- Feasibility of Monitoring Substances Mobilised by CO_2, CO2CRC – Published 2011
- Quantification of CO_2 Leakage, CO_2GeoNet – Published 2012
- Extraction of Formation Water from CO_2 Storage, EERC – Final Report Received
- Induced Seismicity and its Implications for CO_2 Storage Risk, CO2CRC – Draft Received/ Expert Review Stage
- Subsurface Resource Interaction, CO2CRC – Draft Received
- Potential Implications of Gas Production from Shales and Coal for CO_2 Geological Storage, ARI – In Progress
- Mitigation of Unwanted CO_2 in the Subsurface, CO_2GeoNet – in progress
- The Process of Developing a CO_2 Test Injection Experience to Date and Best Practice – In Progress

Quantification Techniques for CO_2 Leakage (CO_2GeoNet)

- Primary focus of monitoring techniques has been to monitor plume behaviour and detect leakage to the biosphere;

- EU ETS and for national GHG inventory purposes, need to quantify leaked emissions should leakage occur.

- Identify & review potential methods for quantifying CO_2 leakages from a geological storage site, from the ground or seabed surface.

Monitoring Methods

- Marine Monitoring
  - E.g. Sonar methods
- Atmospheric Monitoring
  - E.g. Eddy Covariance
- Shallow subsurface
  - E.g. gas flux or soil gas samples
- Ecosystem & Remote Sensing Monitoring

Monitoring the shallow subsurface

Colour	Applicability
	Good
	Moderate
	Poor (at present)

Task	Method	Pre-injection	Operation	Post-injection	Comments
Leakage detection	Hydrochemical monitoring				Parameters such as pH may indicate leakage; particularly useful where monitoring wells already exist
	Visible surface effects				e.g. bubbling streams; rust deposits
	Gravimetry				Detects changes in density; baseline /natural variations required; verification of cause by sampling
	Electrical/EM				Conductivity/resisitvity; baseline /natural variations required; verification of cause by sampling
	Airborne EM				Conductivity/resisitvity; baseline /natural variations required; verification of cause by sampling
	4D seismic survey				Can be done at same time as reservoir/overburden with shorter offset; may lack sensitivity
	4D multicomp. seismic				Can be done at same time as reservoir/overburden with shorter offset; may lack sensitivity
Leakage quantification	Hydrochemical + flux				Carbon content analysis with flux measurements (from stream flow or groundwater volume)
	4D seismic survey				With Gassmann modelling/post-stack inversion, structural analysis methods; high uncertainty
	4D multicomp. seismic				With above methods, also pre-stack inversion which may be more accurate
	Gravimetry				Analysis of density changes; research on natural analogues required; natural variation
	Electrical/EM				Analysis of conductivity/resistivity changes; research on natural analogues required; natural variation
	Airborne EM				Analysis of conductivity/resistivity changes; research on natural analogues required; natural variation
Reducing uncertainty	Tracers				Addition of e.g. perfluorocarbons tracers to injected CO_2
	Isotopic analysis				Elicidates source of gas
	Gravimetry				Can help constrain density when used in conjunction with seismic quantification methods
	Electrical/EM & Airborne EM				Can help constrain saturation when used in conjunction with seismic quantification methods

Quantification Conclusions

- Portfolio of methods that may provide better leakage quantification with reduced uncertainty
  - In monitoring the **shallow subsurface**, hydrochemical monitoring combined with flux measurements and the use of tracers/isotopic analysis
  - In monitoring the **marine environment**, plume profiles obtained with sonar methods combined with chemical analysis and the use of current meters
  - In monitoring the **surface/atmospheric** environment, soil gas analysis combined with flux measurements, the use of tracers/isotopic analysis and meteorological monitoring

Extraction of Formation Water from CO_2 Storage (EERC)

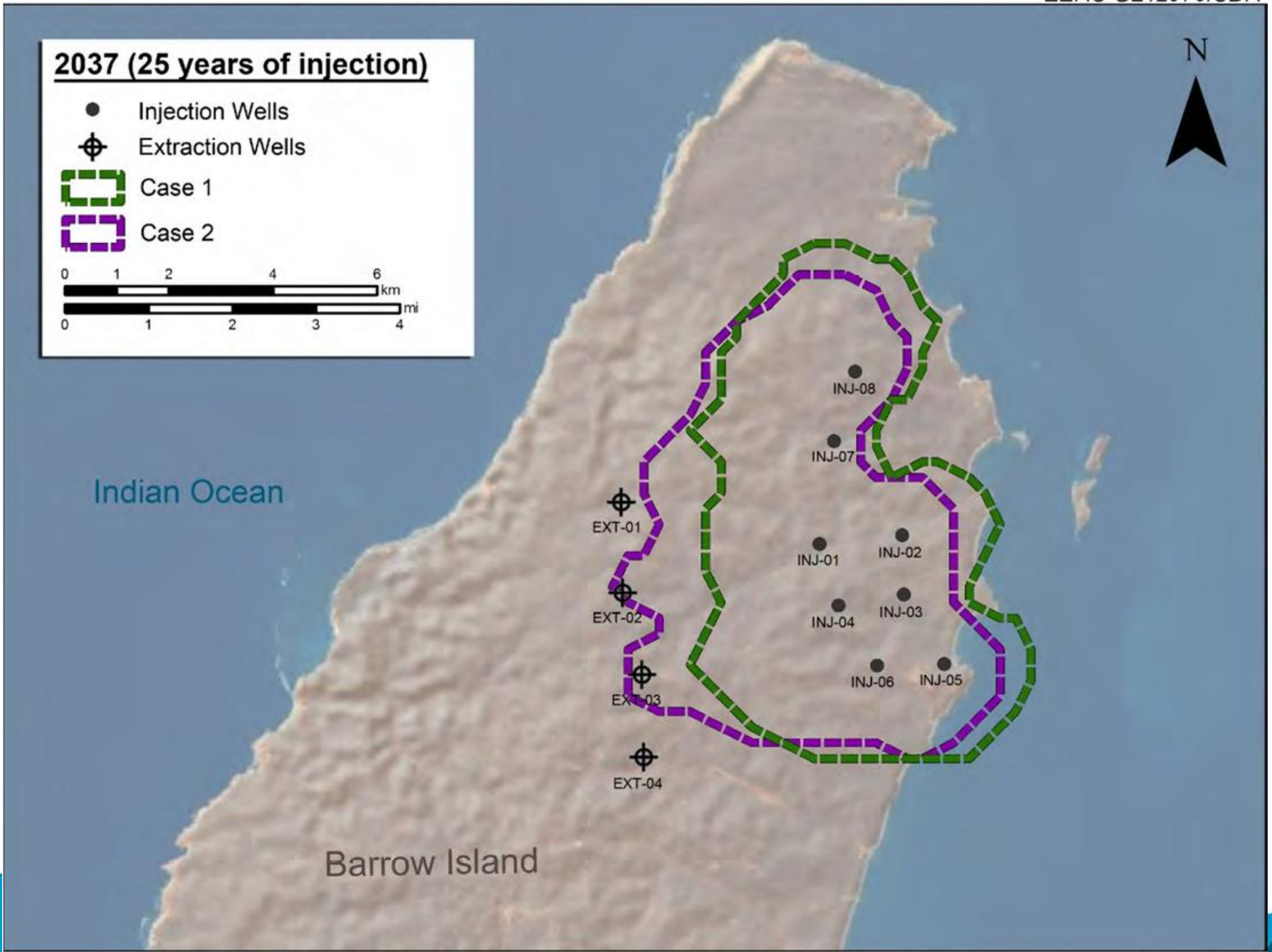
- Study considers injection/ extraction scenarios
  - Capacity
  - Plume/ Pressure Management
- Surface Dissolution
- Water Use
- Case Studies – Ketzin, Gorgon, Teapot Dome, Zama

Capacity and Pressure and Plume Management

- Capacity increased for all case studies
  - Most effective in closed system – Zama
  - For Ketzin and Teapot dome, most increased capacity by extra injection well
  - Least effective at Gorgon – reservoir capacity vastly exceed injection/ extraction capacity
- Pressure and Plume management
  - achieved at Ketzin, Gorgon and Teapot Dome
  - Zama – pressure maintained below acceptable limits, until reservoir nearly filled
  - Reasonable method of pressure and plume management

Plume Management at Gorgon

EERC GL42976.CDR



Case 1:
8 injectors
97.3 Mt
in 25 years

Case 2:
8 injectors
4 extractors
97.5 Mt
In 25 years

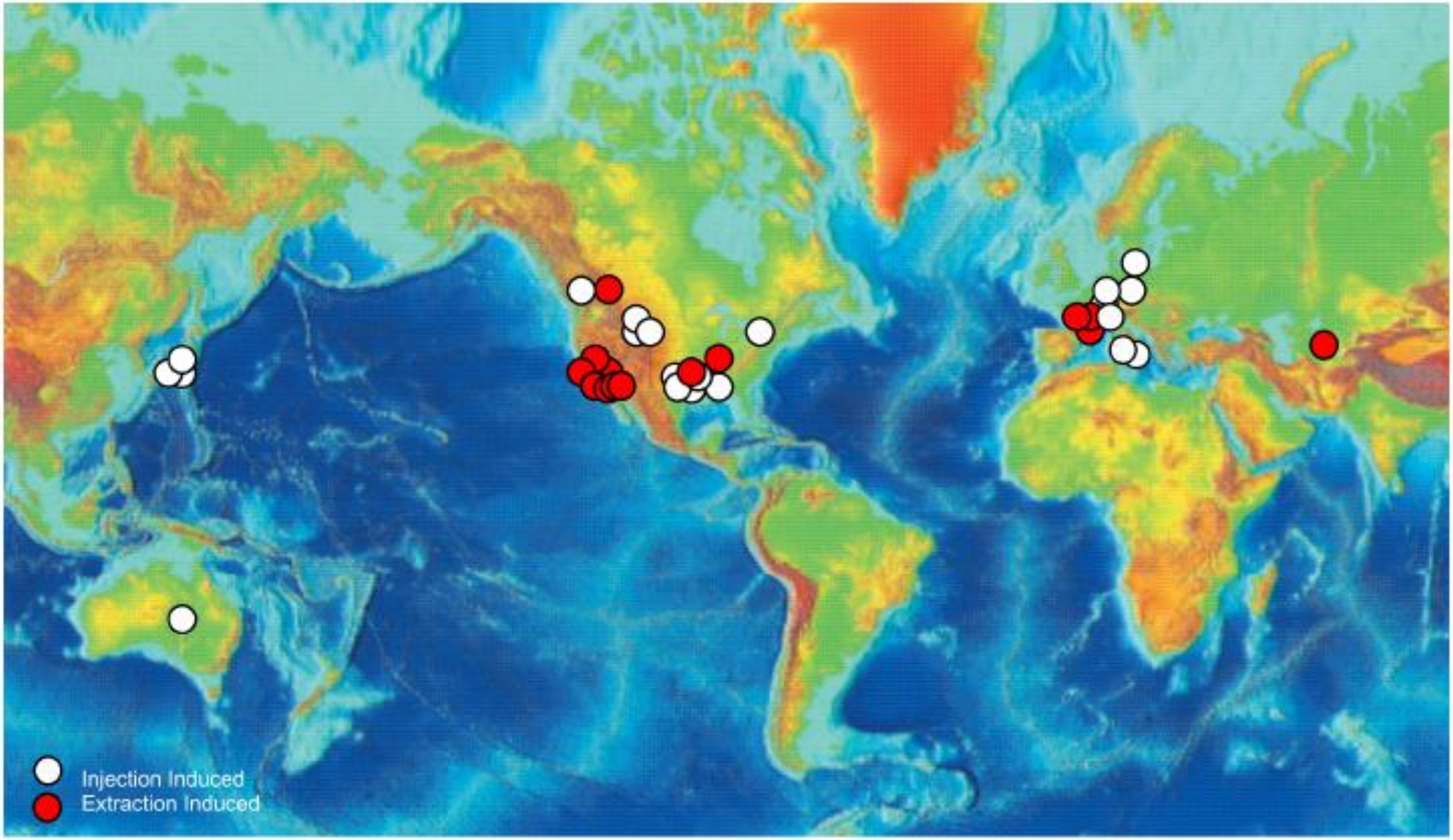
Brine Extraction Conclusions

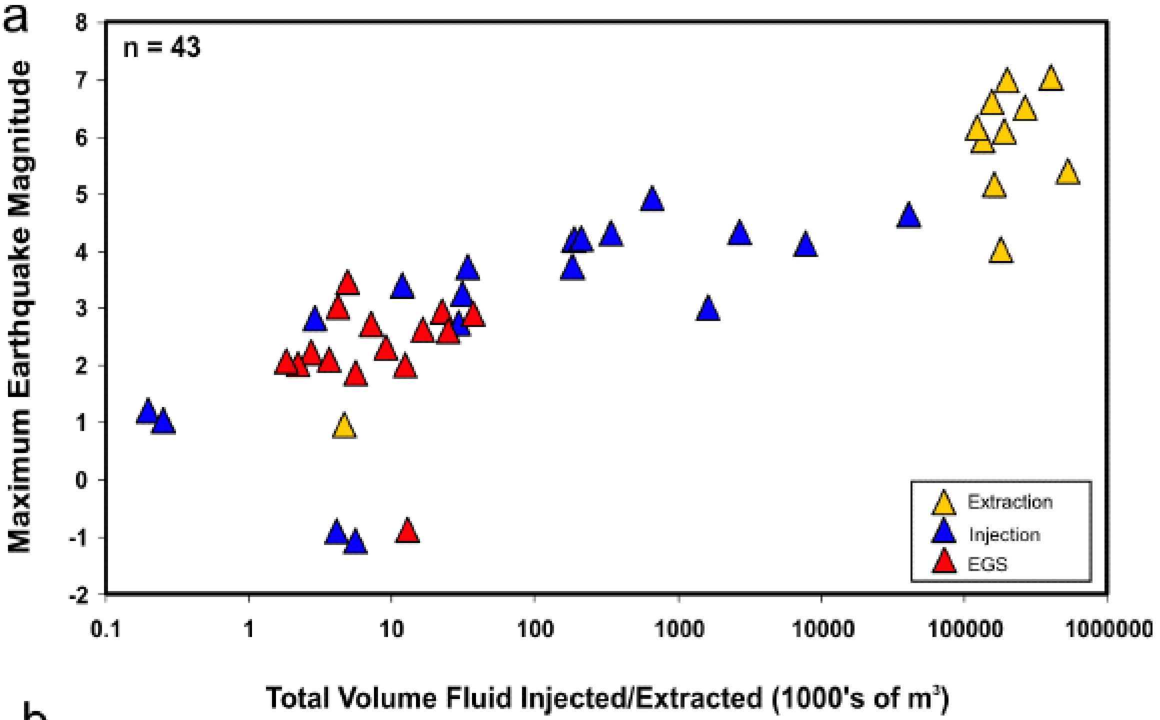
- **Site specific** – variable effects depending on geological and operational factors
- Capacity increase **most effective for closed systems**
- Optimising for pressure maintenance generally decrease storage capacity and increase extracted water volume
- Extracted water unlikely to be beneficial offshore/ coastal as seawater desalination more cost effective
- High TDS – unlikely to be cost effective to treat water
- Feasible if moderate water quality, available inexpensive energy and local demand
- **Surface dissolution unlikely to be a viable option** in most situations as the capacity of produced fluids to dissolve and carry CO_2 is too low

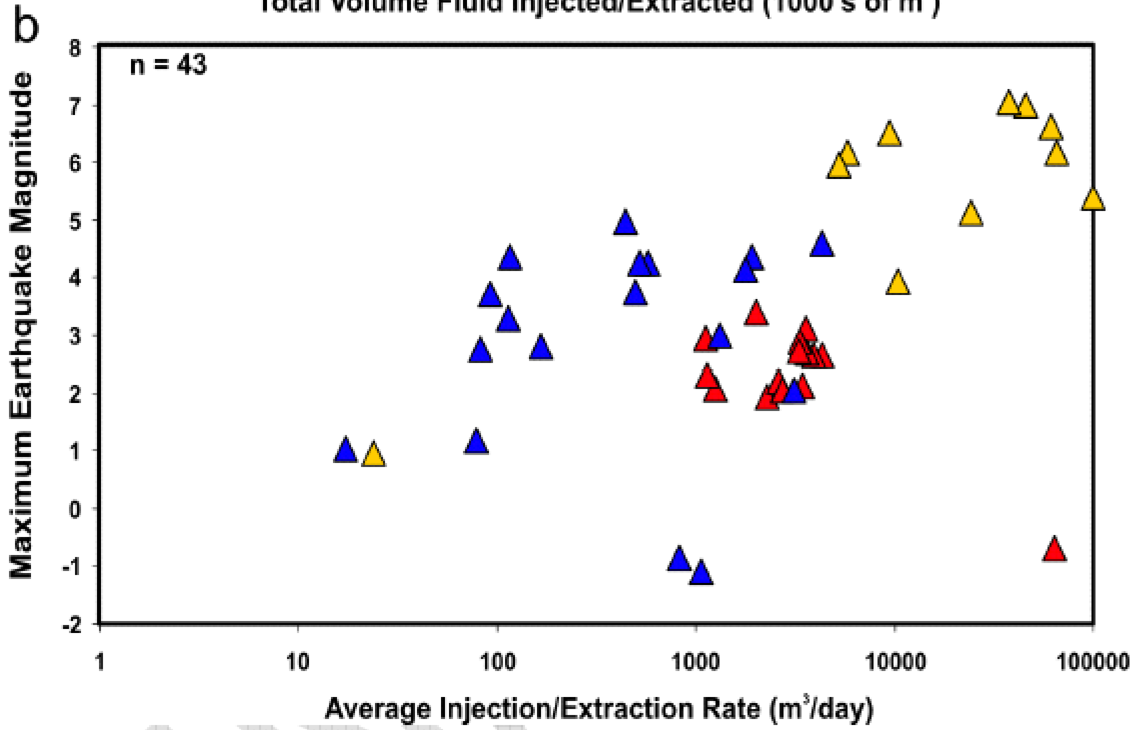
Induced Seismicity (CO2CRC)

- Aim of study: review of the mechanisms that cause induced seismicity and their application to geological storage of CO_2.
- Not much data related to CO_2 Storage sites, also used data from analogues from geothermal, hydrocarbon production, waste disposal
- From this data a range of relationships can be noted for when there is induced seismicity, for example:
  - Positive correlation between max induced earthquake and
    - Total volume of fluid injected/ extracted
    - Average injection/ extraction rate
  - Increase in permeability with decreasing b-value
  - Spatial clustering around inj/ext wells

Injection and Extraction Sites considered







- Relationship of max earthquake to total fluid
- Relationship of max earthquake to average injection/ extraction

Induced Seismicity Conclusions

- To date - few earthquakes at CO_2 injection sites – but low volume and some sites lack seismographs
- From collective analysis, induced earthquakes generally small magnitude, occasional large ($M \geq 4$) in some cases
- Relationships seen from accumulated data
- Models used to predict reviewed – statistical and physical
  - Used to ID cases where risk of induced seismicity can be minimised by changing injection strategy
- Risks can be reduced and mitigated using a systematic and structured risk management programme

Knowledge gaps/ further research identified are:

- Produce across industry seismicity catalogue database,
- Improve understanding of fundamental relationships,
- Improve physical modelling – e.g. poroelastic effects,
- Study scaling effects from pilot projects to production,
- Develop standard risk management procedures and guidelines,
- Fill in some knowledge gaps by collaborating with other industries

Thank you
See you at GHGT-11
www.ghgt.info

For reference:

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