Measurements of ^{222}Rn, ^{220}Rn, and CO_2 Emissions in Natural CO_2 Fields in Wyoming: MVA Techniques for Determining Gas Transport and Caprock Integrity

Project Number DE-FE0002112

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U.S. Department of Energy

National Energy Technology Laboratory

Carbon Storage R&D Project Review Meeting

Developing the Technologies and Building the Infrastructure for CO_2 Storage

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Presentation Outline

- Benefits to the Program
- Project Overview
- Technical Status
  - Results
  - Conclusions
  - Next Steps
- Summary

Benefit to the Program

- Program goal being addressed.
  - Develop technologies to demonstrate that 99 percent of injected CO_2 remains in the injection zones.
  - Monitoring, Verification, and Accounting (MVA). MVA technologies seek to monitor, verify, and account for injected CO_2. Our technology could potentially be used to distinguish between deep (stored) CO_2 and shallow (alternate) CO_2 sources.

Benefit to the Program

- Project benefits statement
  - The purpose of this project is to determine whether quantitative measurements of Rn activity and CO_2 flux, already established for natural volcanic systems, can be applied to natural CO_2 analogs to assess caprock integrity. The technology, if successful, will provide a tool to relate CO_2 emissions to source regions (i.e., deep reservoir vs. shallow soil) and mechanisms of gas transport toward the surface. This technology contributes to Program efforts of ensuring 99 percent CO_2 storage permanence in the injection zone(s).

Project Overview:
Goals and Objectives

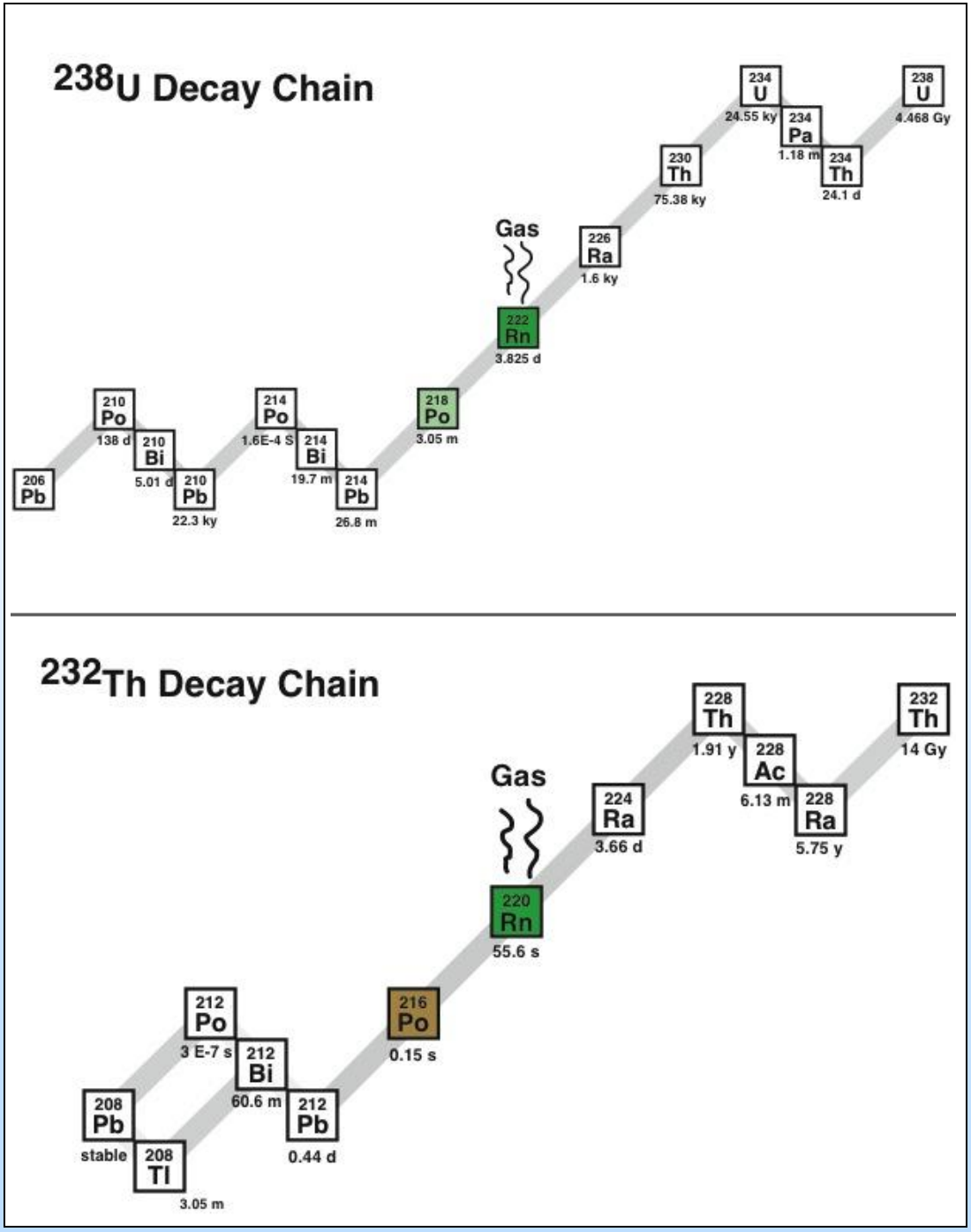
- Provide training opportunities for two graduate students and one undergraduate student, to be accomplished through fundamental geochemical research in CCS.
- Perform fundamental geochemical research to advance science in the area of Monitoring, Verification, and Accounting (MVA). To do this we quantitatively measure Rn activity and CO_2 flux in natural and laboratory systems.

Project Overview: Goals and Objectives

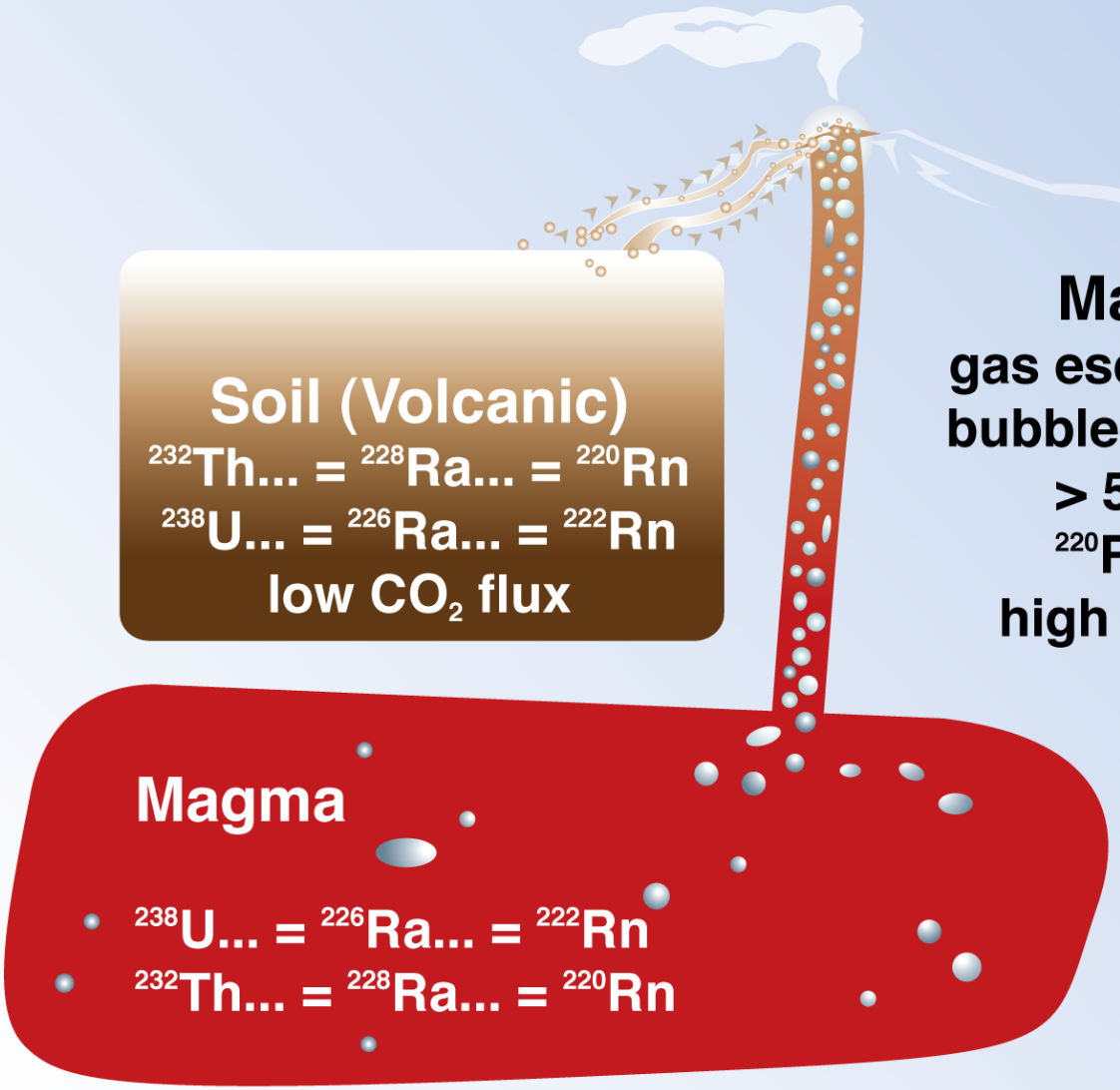
- Project goals and objectives relationship to program goals and objectives
  - Concurrent measurements of Rn and CO_2 constrain source and timescales of CO_2 degassing. Supports program goal of developing technologies to demonstrate that 99 percent of injected CO_2 remains in the injection zones.

Project Overview:
Goals and Objectives

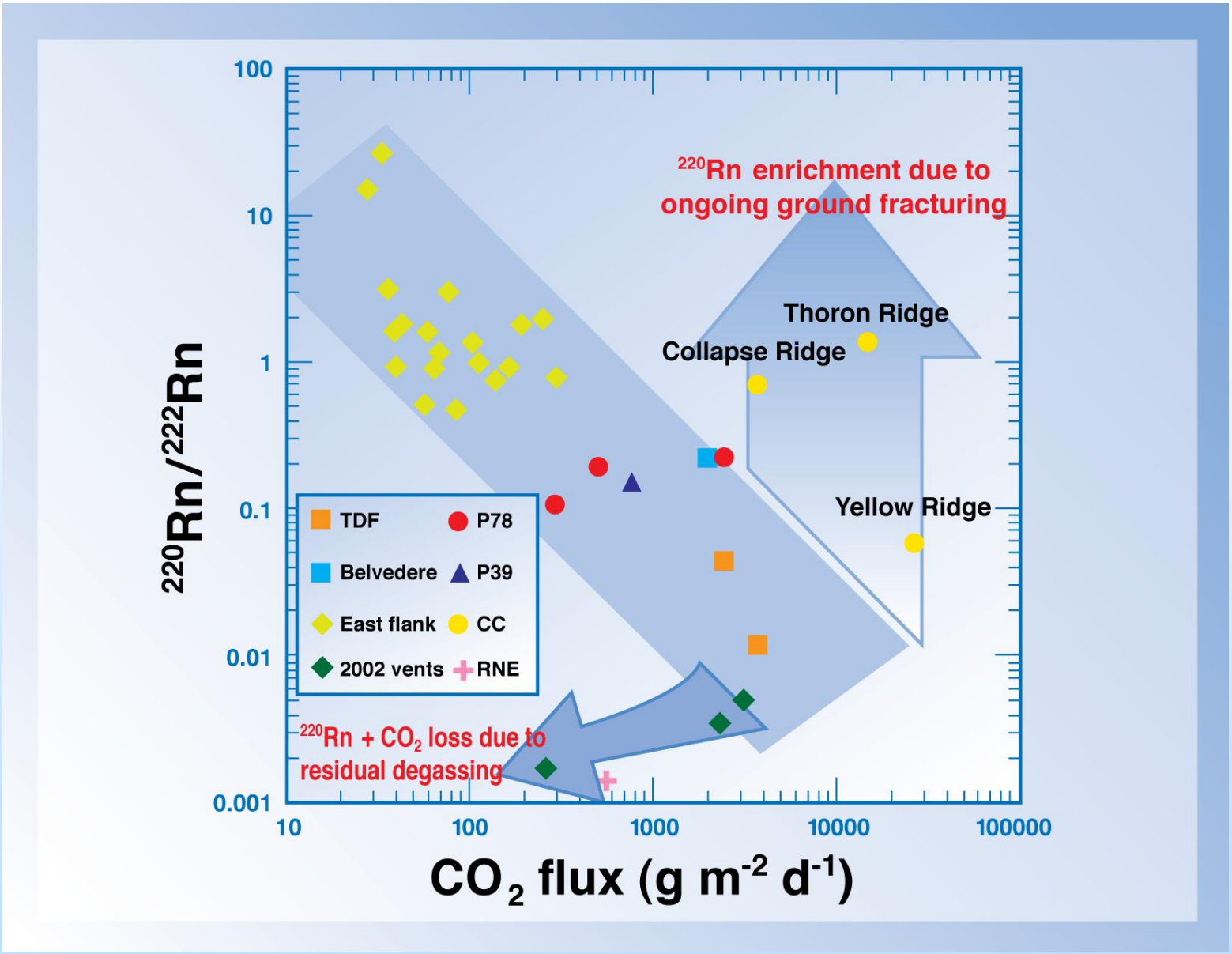
- Success criteria for student training goals
  - Two graduate students complete advanced degrees
  - One BS student perform undergraduate research
- Success criteria for MVA research
  - Perform integrated Rn and CO_2 measurements at natural analogs in Wyoming
  - Determine suitability of using measurements as MVA technique for CCS


238U Decay Chain
206 Pb
210 Po 138 d
210 Bi 5.01 d
210 Pb 22.3 ky
214 Po 1.6E-4 S
214 Bi 19.7 m
214 Pb 26.8 m
218 Po 3.05 m
Gas
222 Rn 3.825 d
226 Ra 1.6 ky
230 Th 75.38 ky
234 U 24.55 ky
234 Pa 1.18 m
234 Th 24.1 d
238 U 4.468 Gy
232Th Decay Chain
208 Pb stable
208 Tl 3.05 m
212 Po 3 E-7 s
212 Bi 60.6 m
212 Pb 0.44 d
216 Po 0.15 s
Gas
220 Rn 55.6 s
224 Ra 3.66 d
228 Th 1.91 y
228 Ac 6.13 m
228 Ra 5.75 y
232 Th 14 Gy

Two-Component Mixing



Giammanco et al., 2007

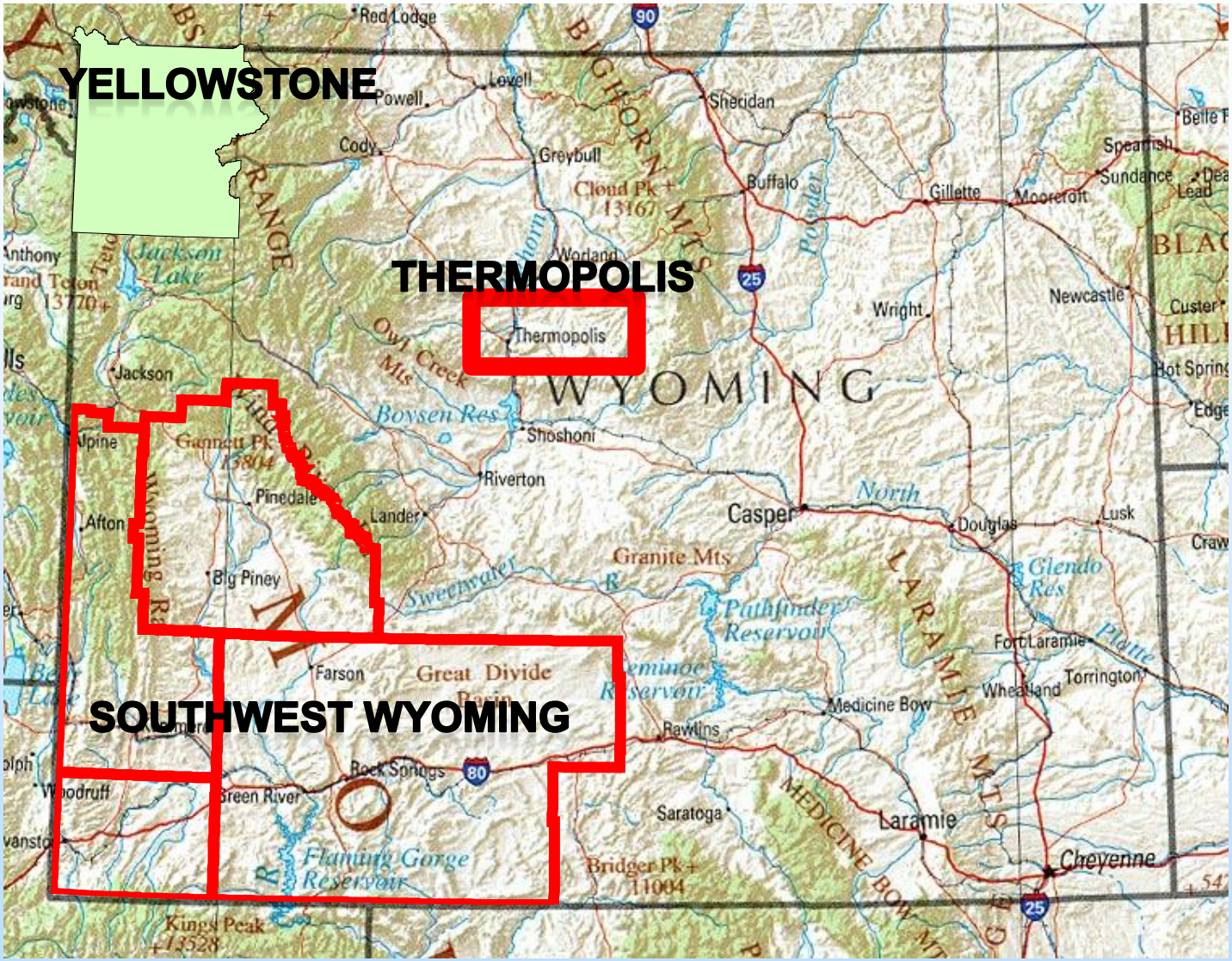


Giammanco et al., 2007

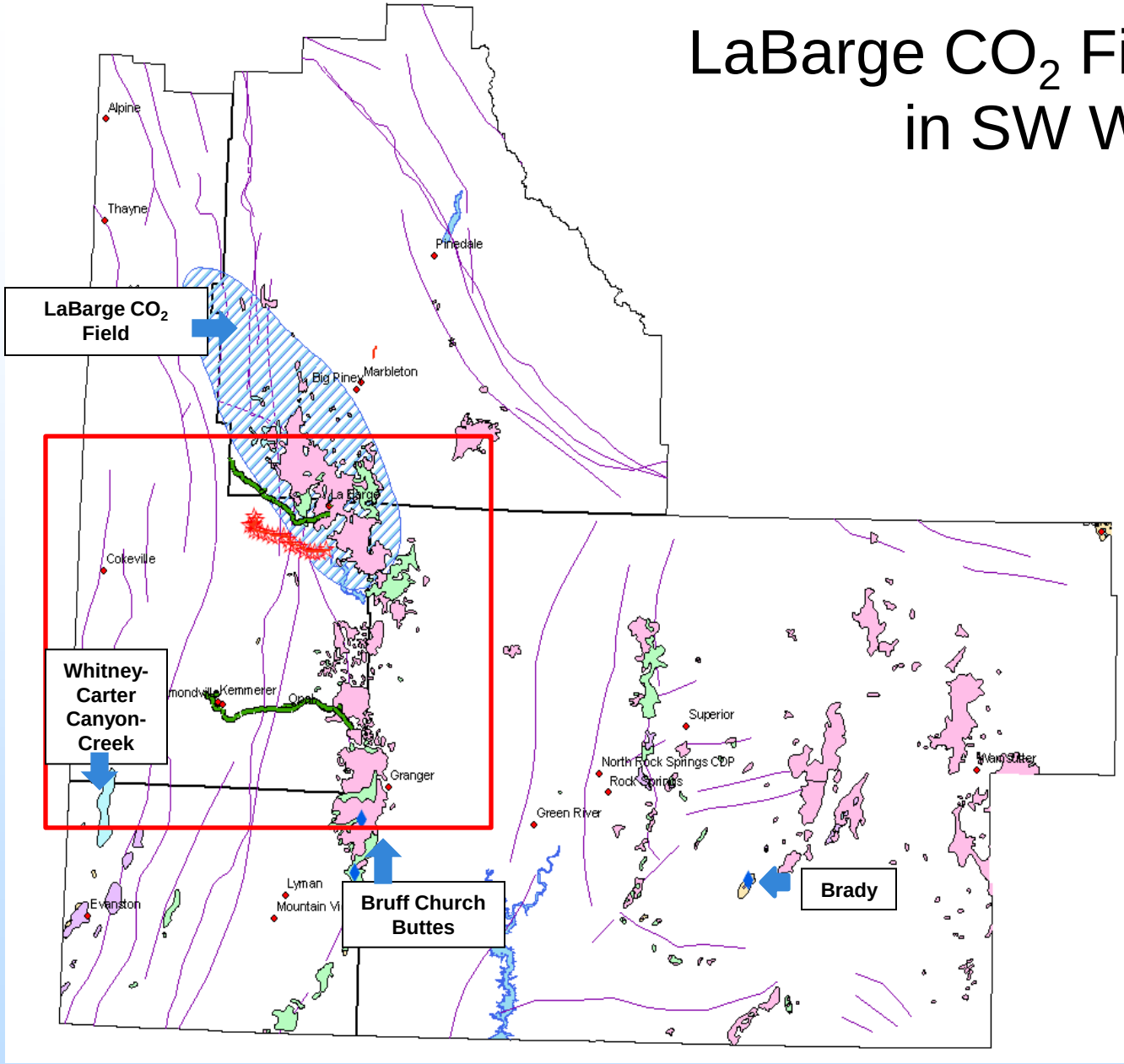
Field Components

- Yellowstone
  - Volcanic system
- Thermopolis
  - Known thermal CO_2 region
- SW Wyoming (Moxa Arch)
  - Application of methods to a natural analogue

Wyoming Field Areas



LaBarge CO_2 Field, Moxa Arch in SW Wyoming



Legend

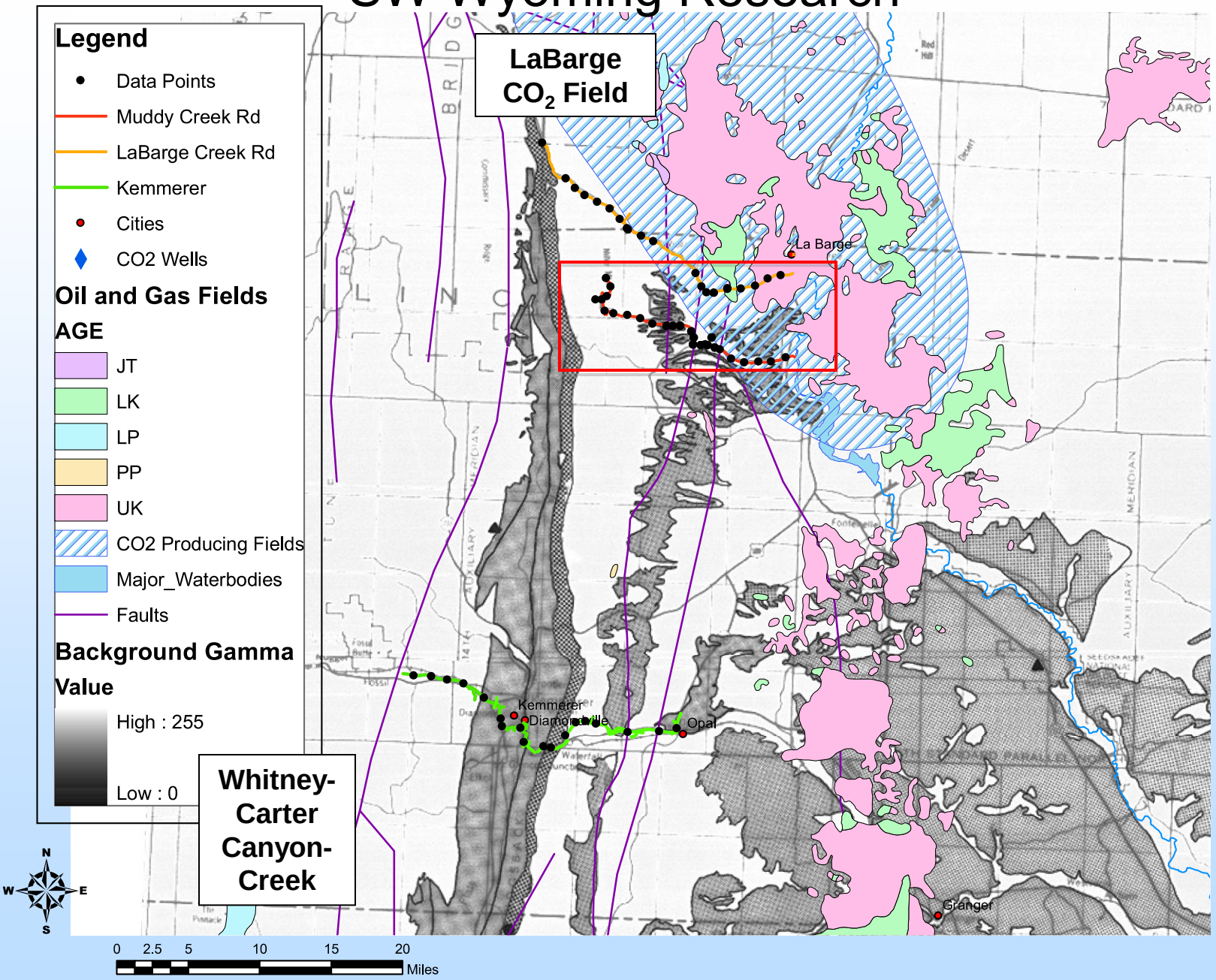
- Prospective Transects
- Muddy Creek Rd
- Data Points
- Cities
- CO2 Wells

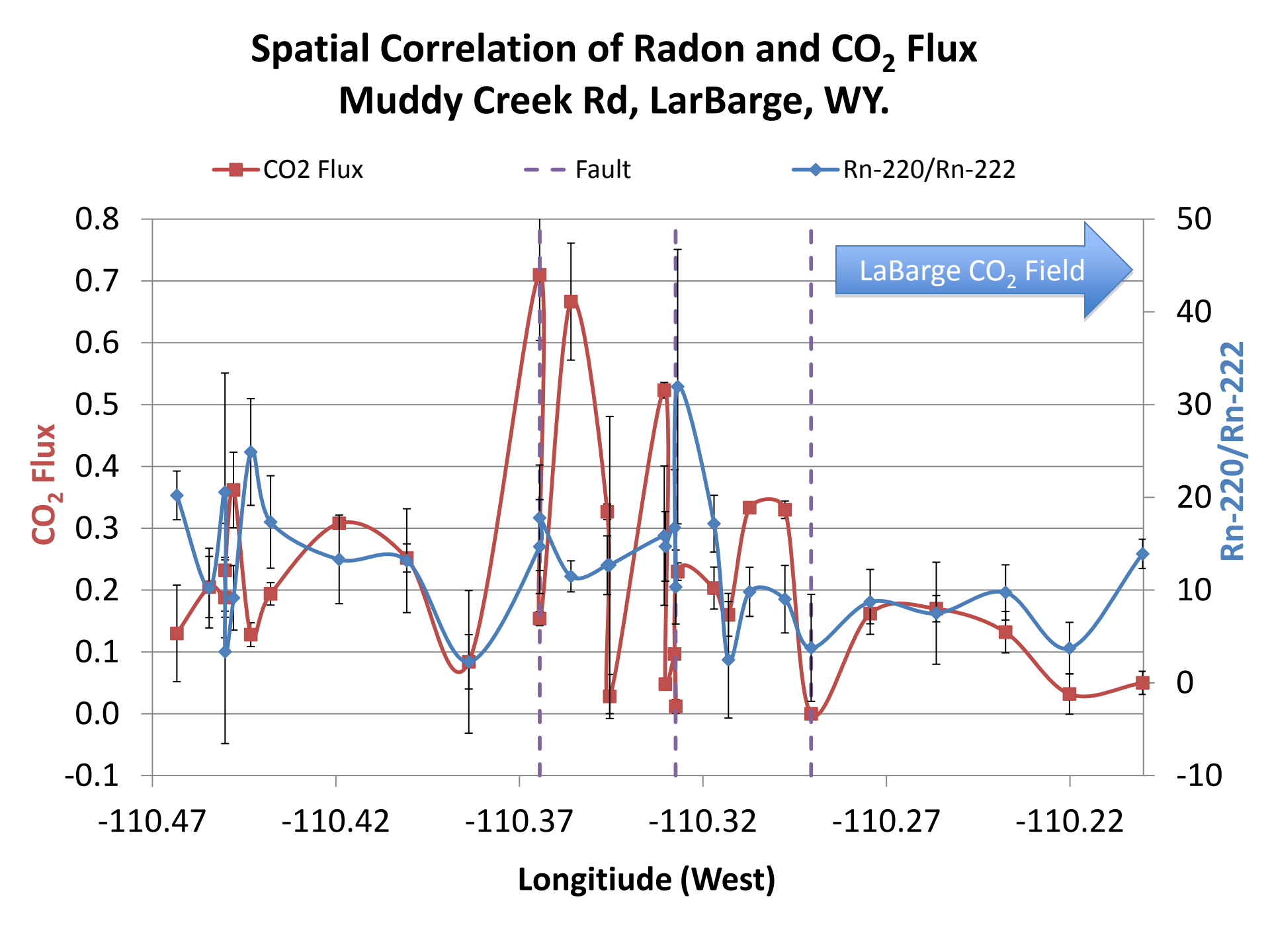
Oil and Gas Fields

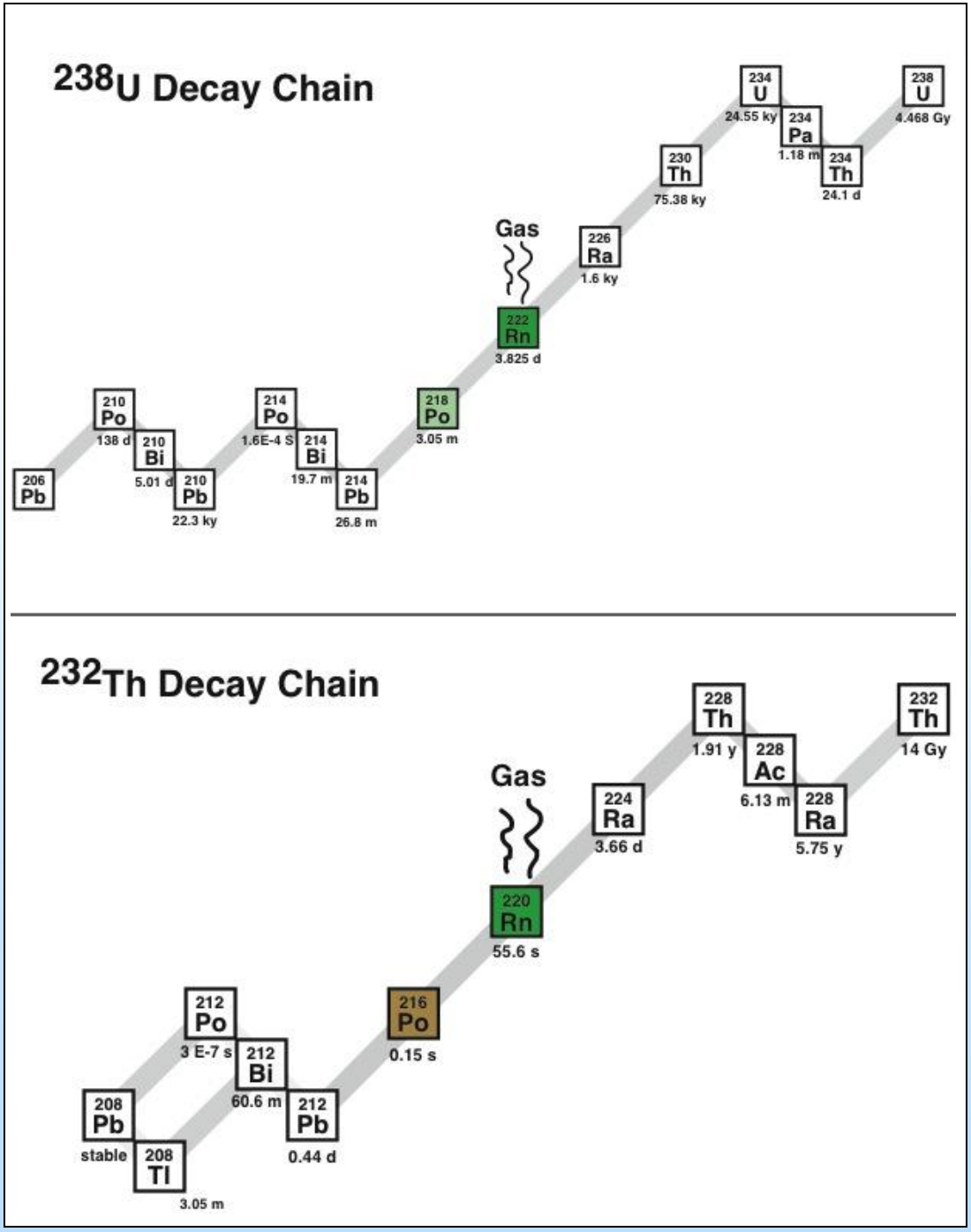
AGE

- JT
- LK
- LP
- PP
- UK
- CO2 Producing Fields
- Faults
- Counties

SW Wyoming Research




Spatial Correlation of Radon and CO_2 Flux
Muddy Creek Rd, LarBarge, WY.
CO2 Flux
Fault
Rn-220/Rn-222
LaBarge CO_2 Field
CO_2 Flux
Rn-220/Rn-222
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
50
40
30
20
10
0
-10
-110.47
-110.42
-110.37
-110.32
-110.27
-110.22
Longitiude (West)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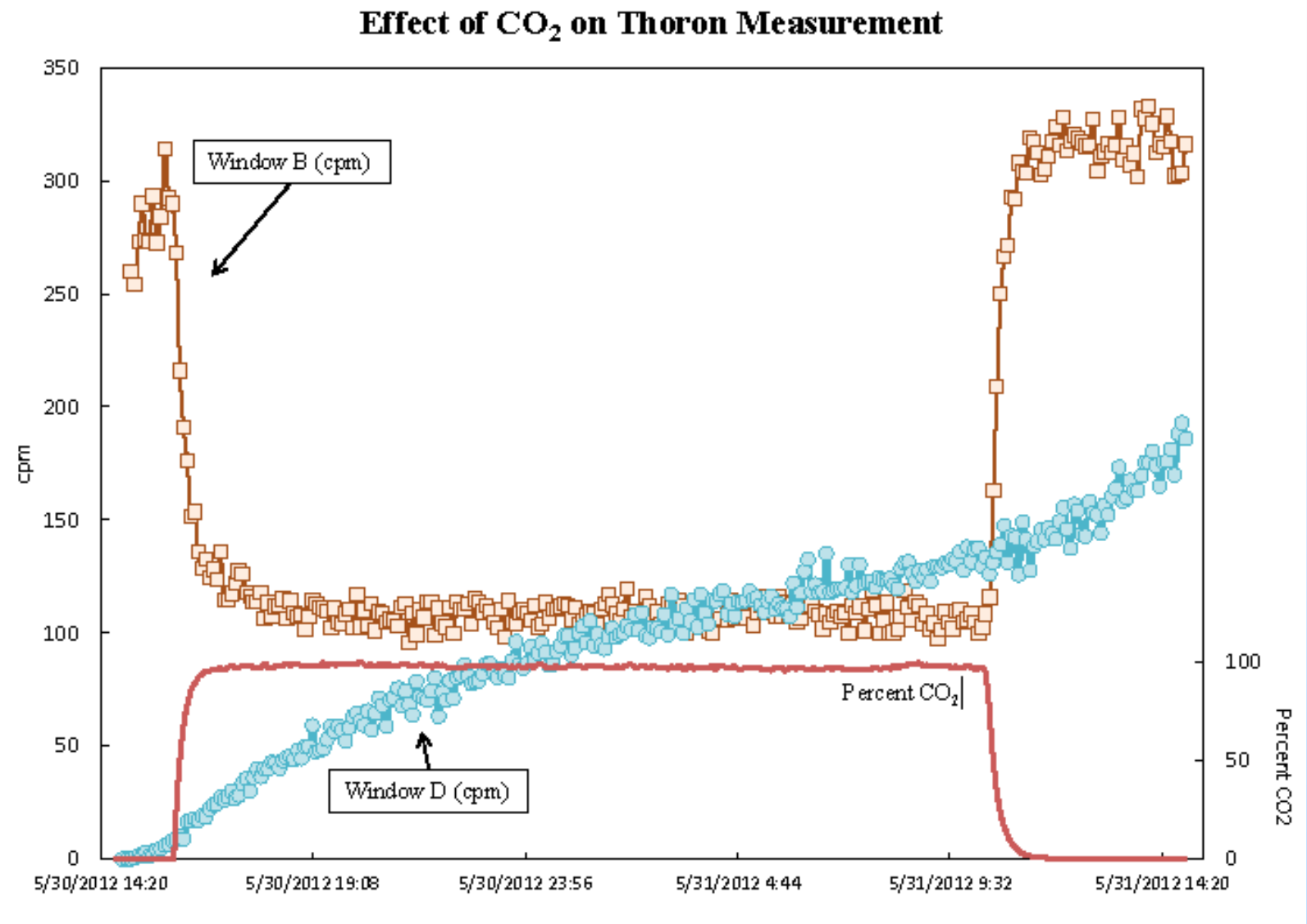
Lab Experiments



Lane-Smith and Sims, (in review)

Experimental Summary

The ratio of 220-Rn/222-Rn is an important parameter.

In the presence of CO_2 the apparent ratio is decreased.

For each percentage of CO_2

the radon reading should be multiplied by 1.003

the thoron reading should be multiplied by 1.019

so

the 220-Rn/222-Rn ratio should be multiplied by 1.016

It appears that this correction will modify but not nullify the analysis and conclusions of prior work.

Accomplishments to Date

- Two MS students performed research and successfully defended thesis
- One MS student currently working on thesis
- Four BS students have performed undergraduate research
- Site characterization of natural analog (Moxa Arch, SW Wyoming; Thermopolis thermal area; Yellowstone) is complete
- Determined that standard method for measuring Rn needs correction in high CO_2 environments
- Evaluating affect of alpha recoil in soil degassing of Rn

Summary

- Key Findings
  - Water-rock interactions and CO_2 rich environments effect Rn measurements.
- Lessons Learned
  - Simple relationship seen in Mt. Etna still holds but will be modified
  - In the presence of CO_2, both Thoron and Radon should be multiplied by a factor
- Future Plans:
  - Working on alpha recoil experiments
  - Understanding the affect of water rock interaction on Rn and Ra in Yellowstone and Thermopolis, WY.

Organization Chart

Kaszuba (co PI)

Sims (co PI)

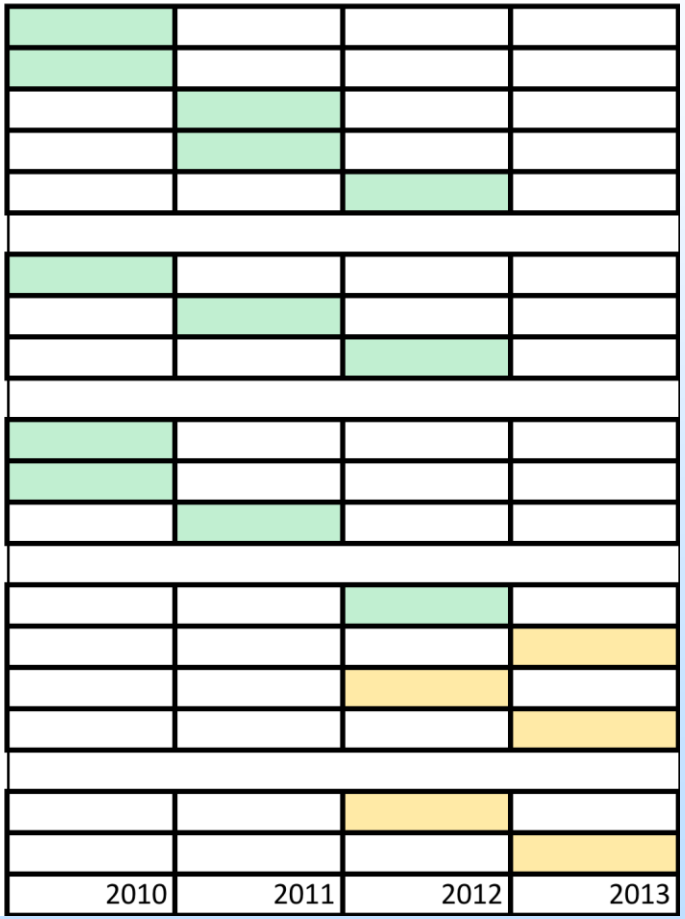
BS Students
Virginia Marcon (graduated)
Matt Carberrry (graduated)
Evan Soderberg (graduated)

MS Students
Tim Moloney (defended)
Allison Pluda (defended)
Max Mandl (midway)

External Collaborators
Dr. Salvatore Giammanco (Istituto Nazionale di Geofisica e Vulcanologia)
Dr. Matt Charette (WHOI)
Dr. Derek Lane-Smith (Durridge Company, Inc.)

Gantt Chart

Subtask	Milestone
1	HQ Milestone: Project Kick-off Meeting
1	HQ Milestone: Educational Program Instituted
1	HQ Milestone: Semi-Annual Progress Report
1	HQ Milestone: Yearly Review Meeting
1	HQ Milestone: Yearly Review Meeting
1.1	Update Project Management Plan
1.3	Annual progress report submitted
1.3	Annual progress report submitted
2.1 & 2.2	Obtain & calibrate radon and CO2 analyzers
2.3	Begin 1st set of Field Measurements
2.4	Complete 75% of Field Measurements
3.1	Begin 1st set of Laboratory Tests of Rn and Grain Size
3.2	Submit report for Laboratory Tests of Rn and Grain Size
3.3	Begin 1st set of Laboratory Tests of Effects of CO2-H2O-Rock Reaction
3.4	Submit report for Laboratory Tests of Effects of CO2-H2O-Rock Reaction
4.1	Develop initial model
4.2	Final report submitted



Bibliography

Lane-Smith, D., & Sims, K. W. W. (*In review*). The effect of CO_2 on the measurement of ^{220}Rn and ^{222}Rn, with instruments utilizing electrostatic precipitation. *Acta Geophysica*.