King City Asbestos Corporation (KCAC) Mine Carbon Mineralization Field Test

FWP-FEW0278

U.S. Department of Energy
National Energy Technology Laboratory
Carbon Management Project Review Meeting
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LLNL-PRES-868282
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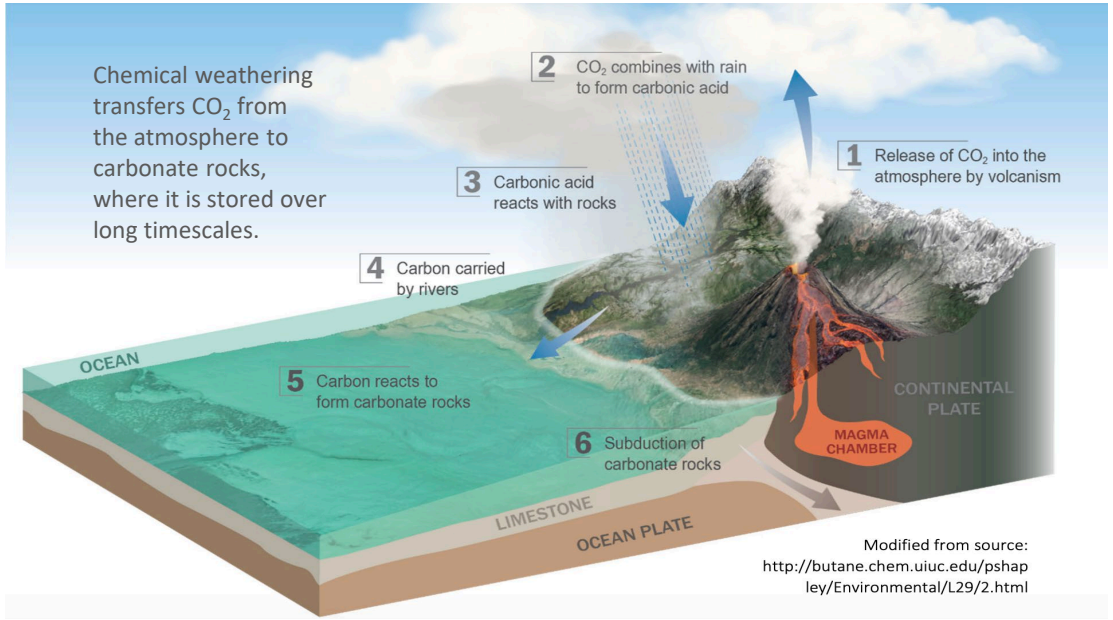
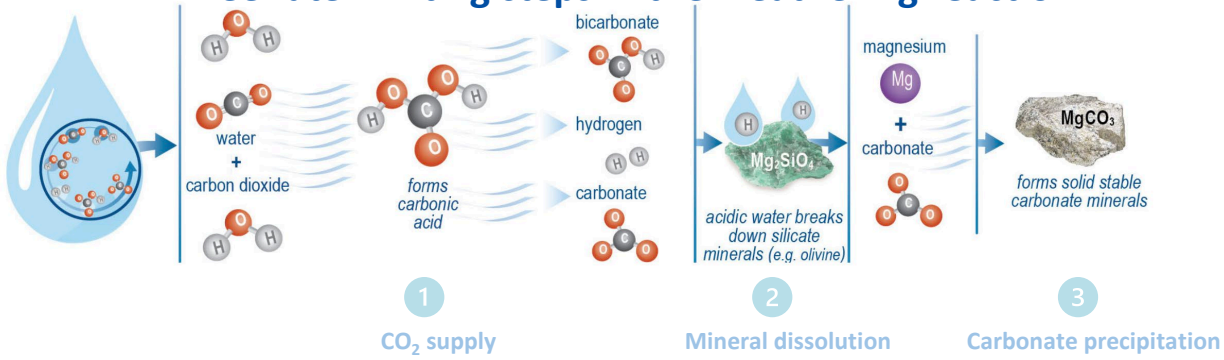
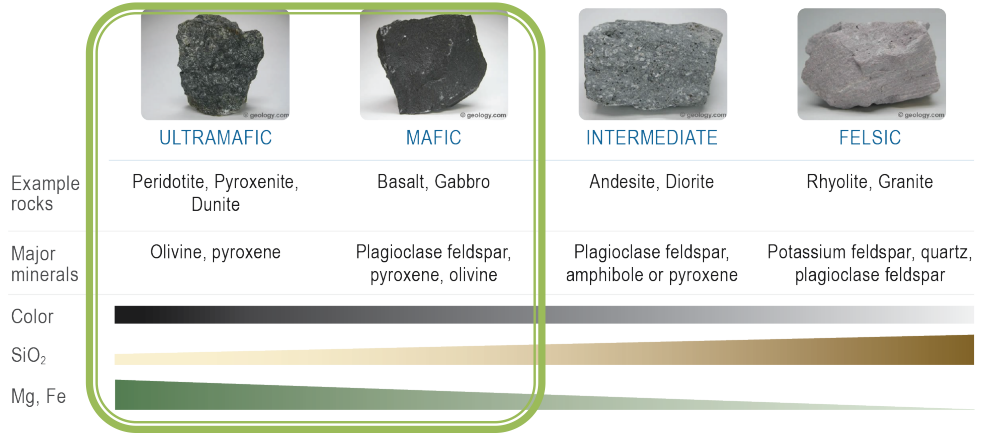
Challenge: Speeding up the natural process from geologic timescales to gigatons of CO_2 per year

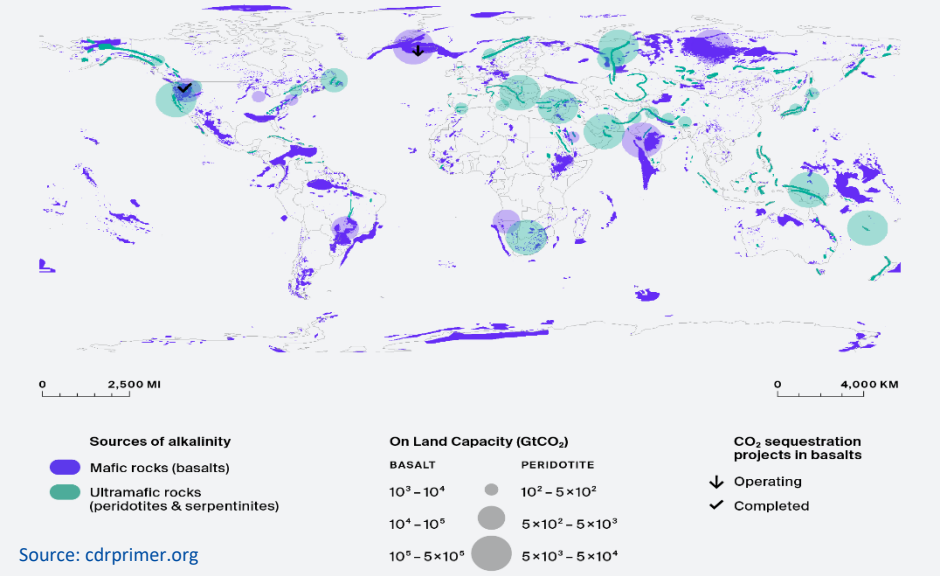
B.E. Schmidt, K. Finstad, H.M. Goldstein, K.K., Mayfield, C.A. Myers, and M.M., Smith (LLNL); G.M. Dipple, A.M. Doucet, F. Jones, B. Ladd (UBC)



Three rate-limiting steps in the weathering reaction







- Carbon mineralization is a promising method to remove CO_2 directly from the atmosphere. Most work to date is at the bench or small field trial scale; larger-scale field trials are crucial to advancing the field.

- California has an ideal site for such field trials – a serpentinite rock-hosted former asbestos mine in San Benito County, the King City Asbestos Corporation (KCAC) Joe Pit Mine.

80% short fiber, high surface area chrysotile $(Mg,Fe)_3Si_2O_5(OH)_4$

Why KCAC?

coalingite $Mg_{10}Fe^{3+}{}_2(OH)_{24}[CO_3] \cdot 2H_2O$

hydromagnesite $Mg_5(CO_3)4(OH)_2 \cdot 4H_2O$

brucite $Mg(OH)_2$
Avg 7-8 wt%
Up to 10-25 wt%

OBJECTIVE: test multiple approaches to accelerate CO_2 mineralization of serpentinite rocks and asbestos tailings while providing a tightly controlled monitoring and safety environment.

Scope of Work

Phase 1: Site Characterization, Baseline Measurements, Design

- Collect samples from si
  perform geoche
  analysis.
- Characterize base
  conditions an
  variability at the
  temperature, wa
  CO_2 flux)
- Finalize design and costs of the test phase (Phase 2)

Complete Sept 2022

NEPA

Phase 2: Field Testing and Closeout

- of carbon
  ation methods at the
  te
- iciency, safety, and
  using serpentinite to
- e oversight of monitoring,
  procedures, data, and
  porting
- eport and publish results
- Remediate the site.

Starts Late August 2024

CO_2 flux: EC and DCC Data

Anne-Martine Doucet, Frances Jones, Melissa Cook, Bethany Ladd, Greg Dipple
University of British Columbia, Department of Earth, Ocean and Atmospheric Sciences,

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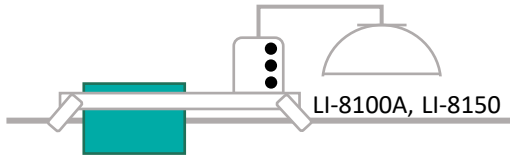
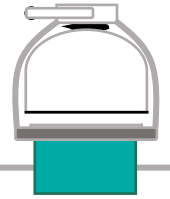
Measuring CO_2 Flux

Soil Flux Chambers (DCC)



LI-8100A, LI-8150

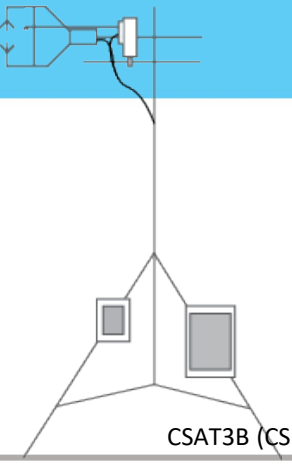


LI-8100A

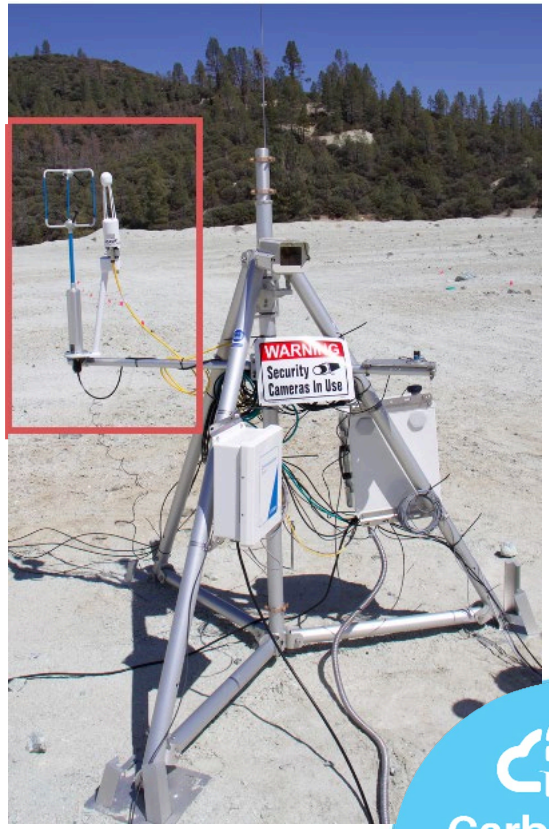
Long-term chamber

Survey chamber

Eddy Covariance (EC)



CSAT3B (CSI) and LI-7500DS



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Site Map and Monitoring Layout

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Site Map and Monitoring Layout

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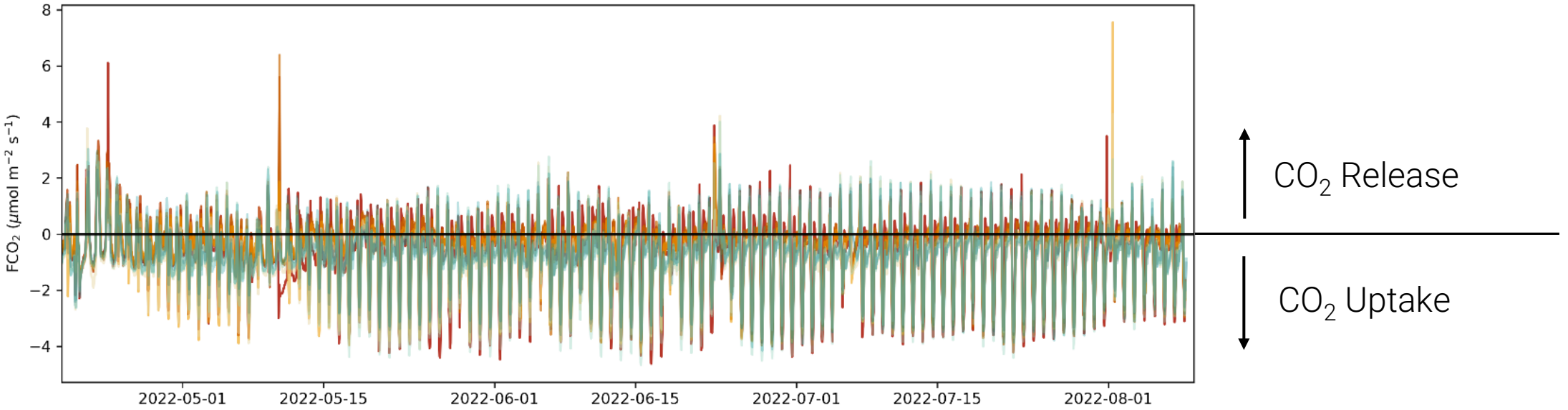
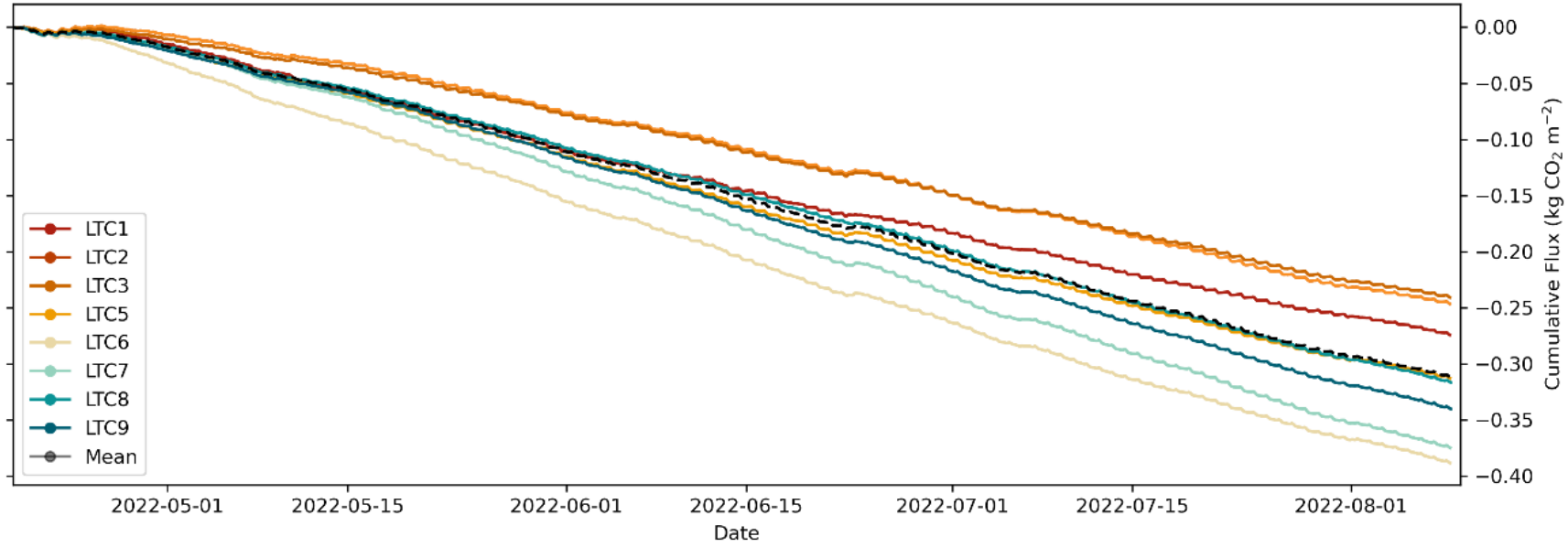
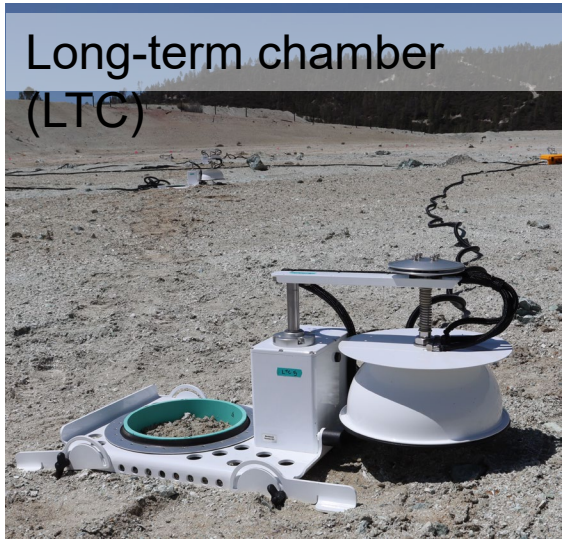
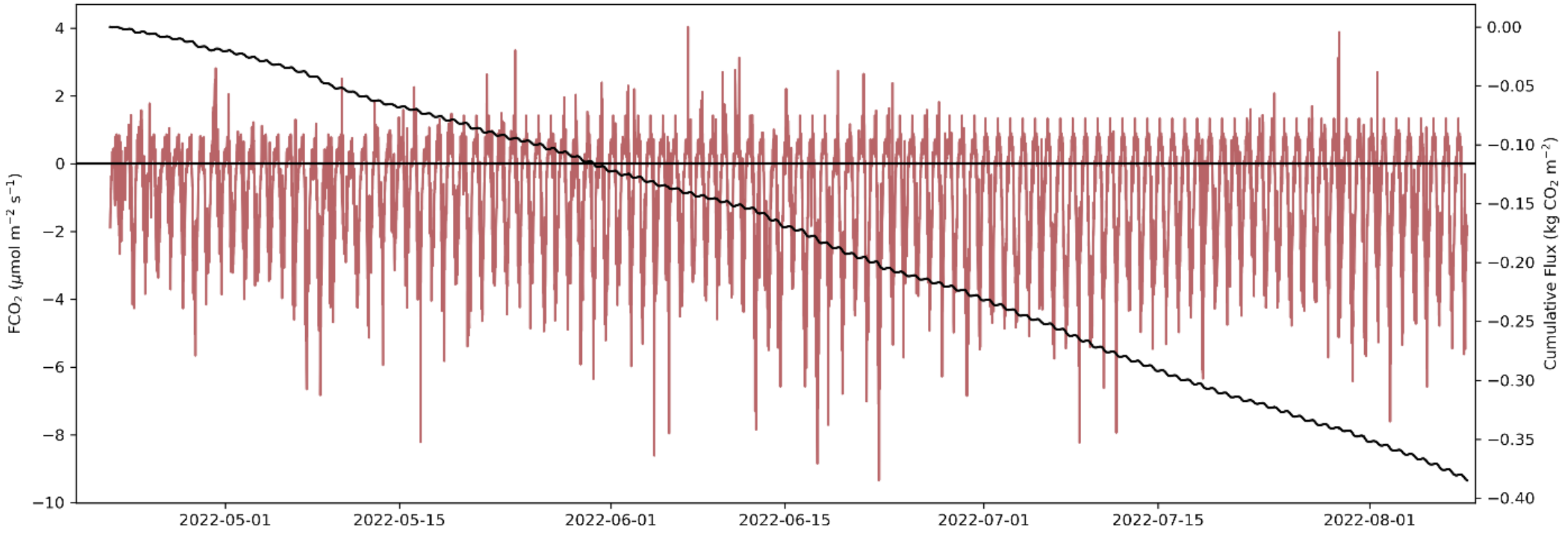
CO_2 flux time series - LTC







CO_2 flux time series - EC



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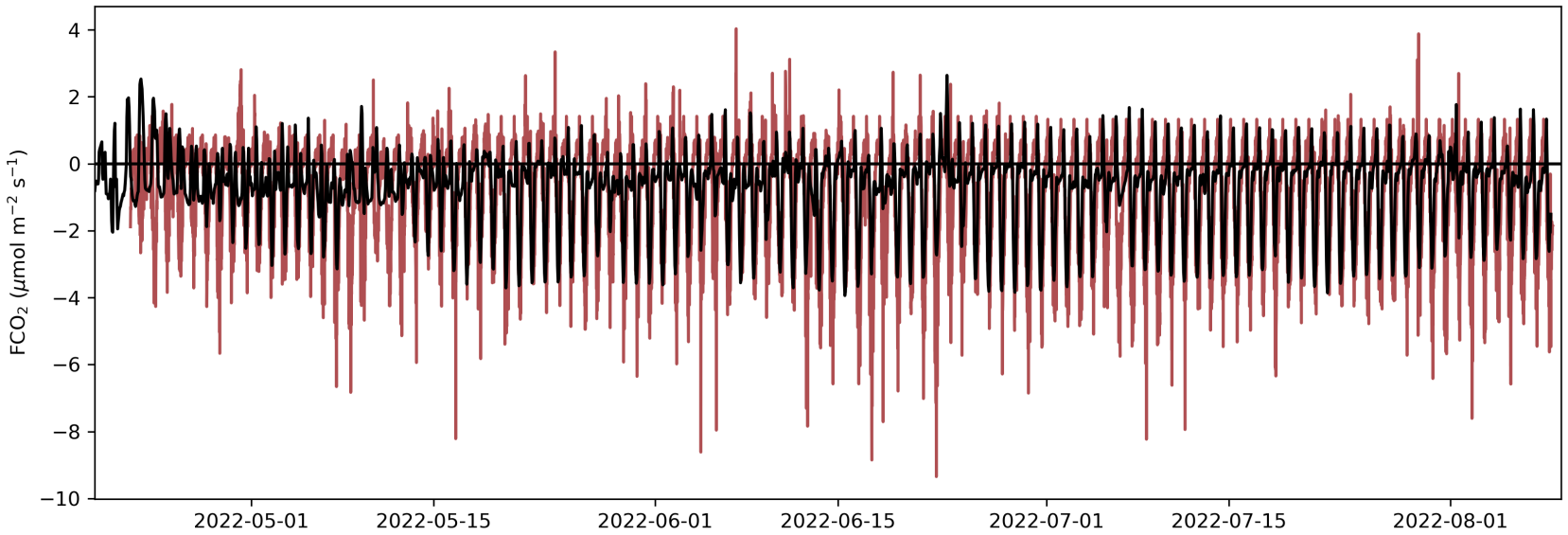
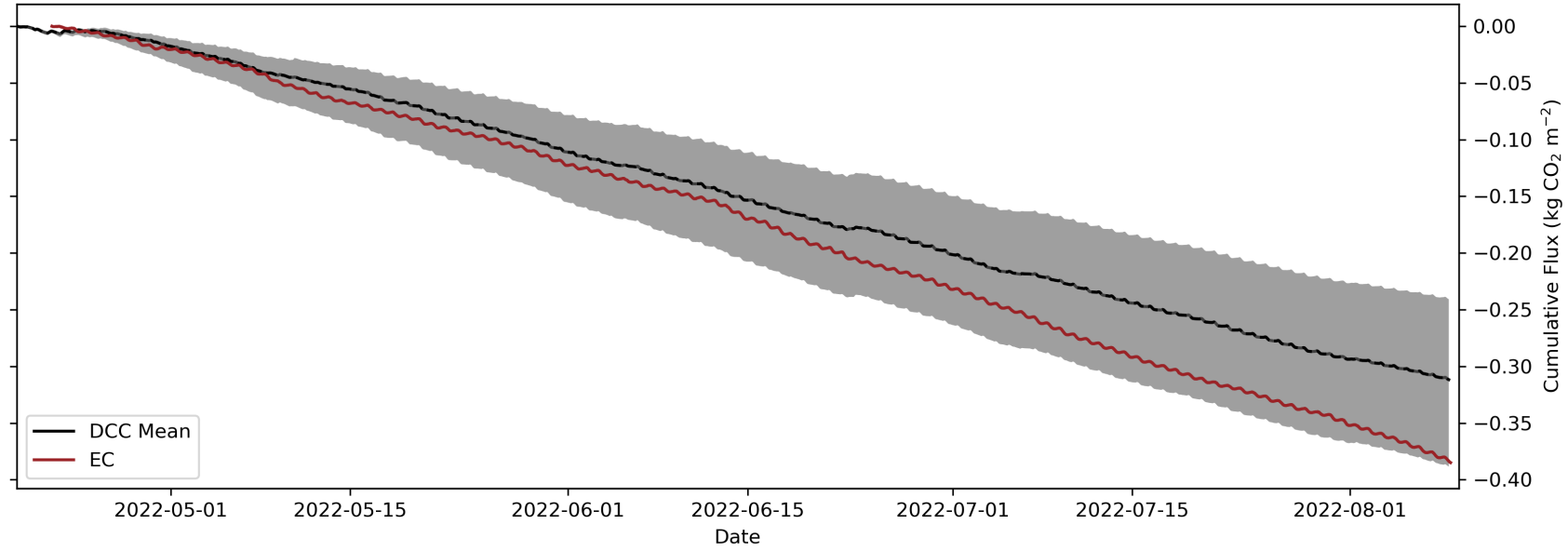
CO_2 flux comparison – EC + DCC





Key Point

- Both systems indicate that CO_2 is being absorbed by the waste material

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Base Flux Rates

Net uptake measured over the summer (April-August) :

- EC : **1.26 kg CO_2 m^{-2} yr^{-1}**
- DCC : **1.03 kg CO_2 m^{-2} yr^{-1}**

- For comparison Mount Keith mine passively takes up **2.3 kg CO_2 m^{-2} yr^{-1} (Wilson, et al 2014)** and Woodsreef 0.4 kg CO_2 m^{-2} yr^{-1} (max brucite 2%)

- Surface area (mine waste and benches): ~140 000 m^2

- Tons per year: 145 (DCC) – 177 (EC) tons yr^{-1}

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Sample Analysis: TGA and XRD

Anne-Martine Doucet, Frances Jones, Melissa Cook, Bethany Ladd, Greg Dipple
University of British Columbia, Department of Earth, Ocean and Atmospheric Sciences,

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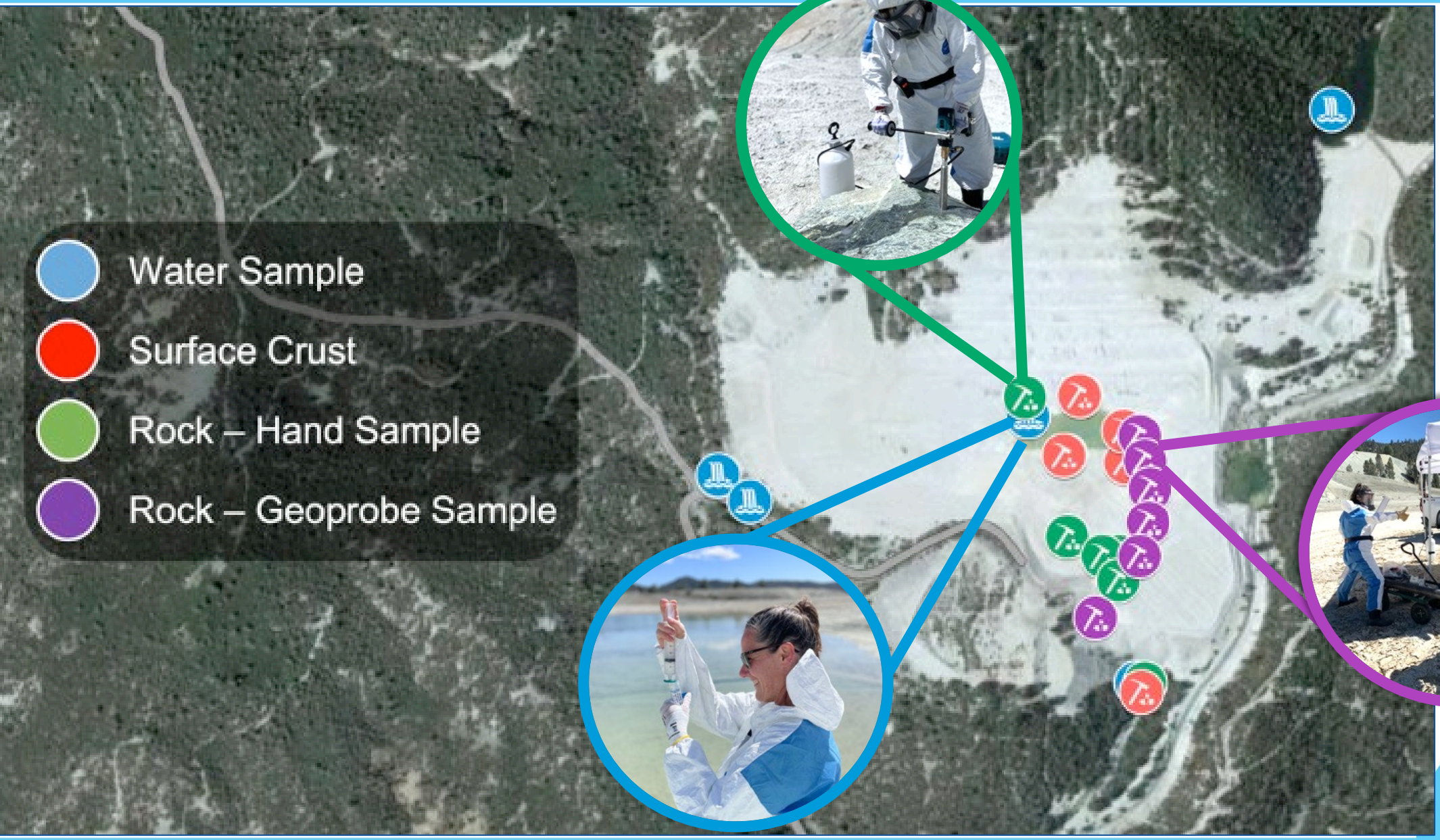
Mineralogy - Sampling



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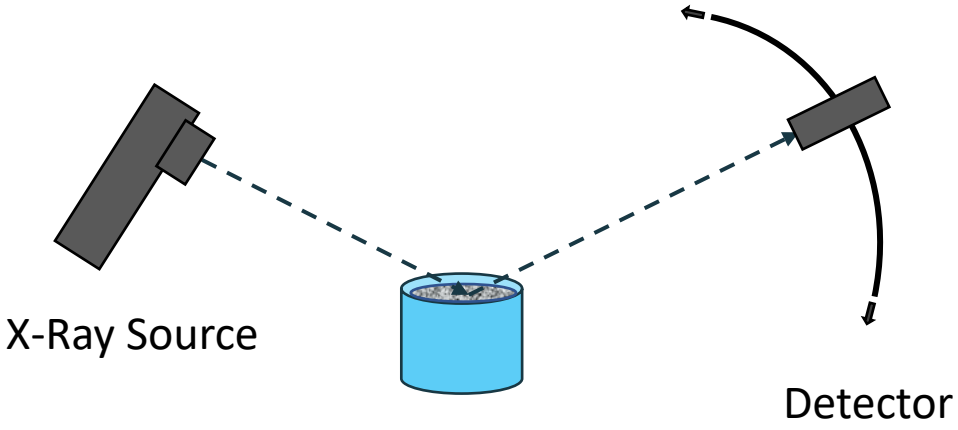
Mineralogy - Methods

X-Ray Diffraction (XRD)



Pros: reliable mineralogical characterization and identification
Cons: low-abundance = high-relative error for minerals phases in serpentine-rich samples

Thermogravimetric Analysis (TGA)

Pros: high accuracy for mineral quantification
Cons: isolation of similar minerals for quantification complex
e.g. Hmg → hydrotalcite → brucite

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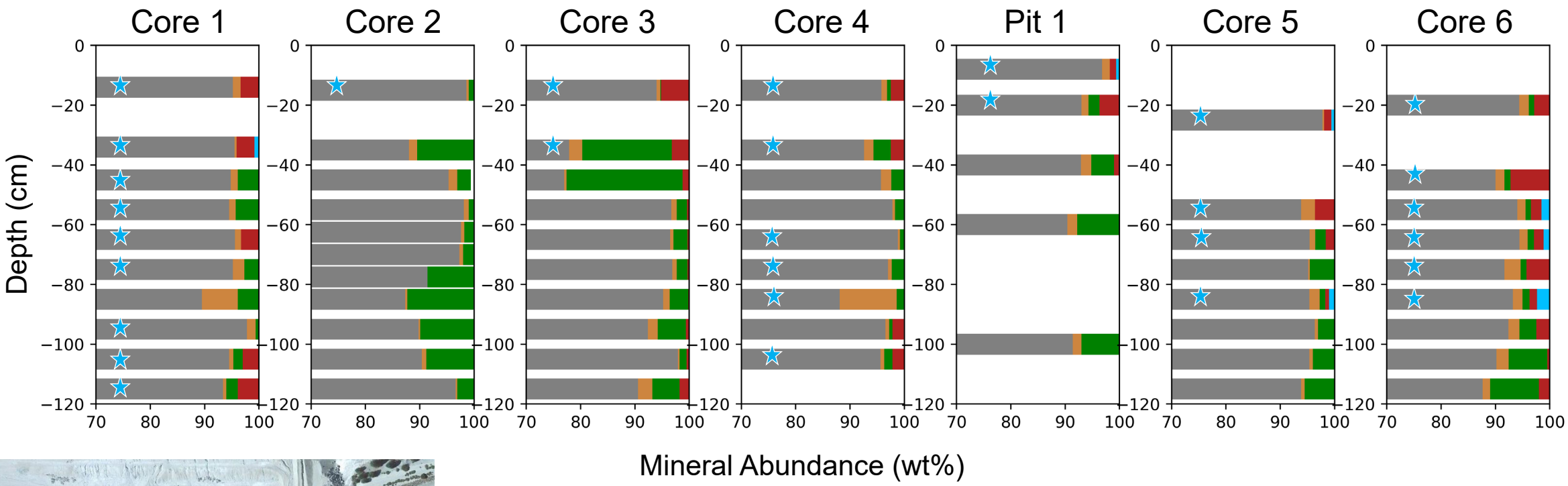
Mineralogy – QXRD (bars) + TGA (stars)



- Serpentine group minerals + Magnetite + Quartz
- Calcite + Dolomite
- Brucite
- Hydrotalcite group minerals
- Hydromagnesite + Nesquihonite

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Radiocarbon

Kari Finstad, LLNL

LLNL-PRES-868282

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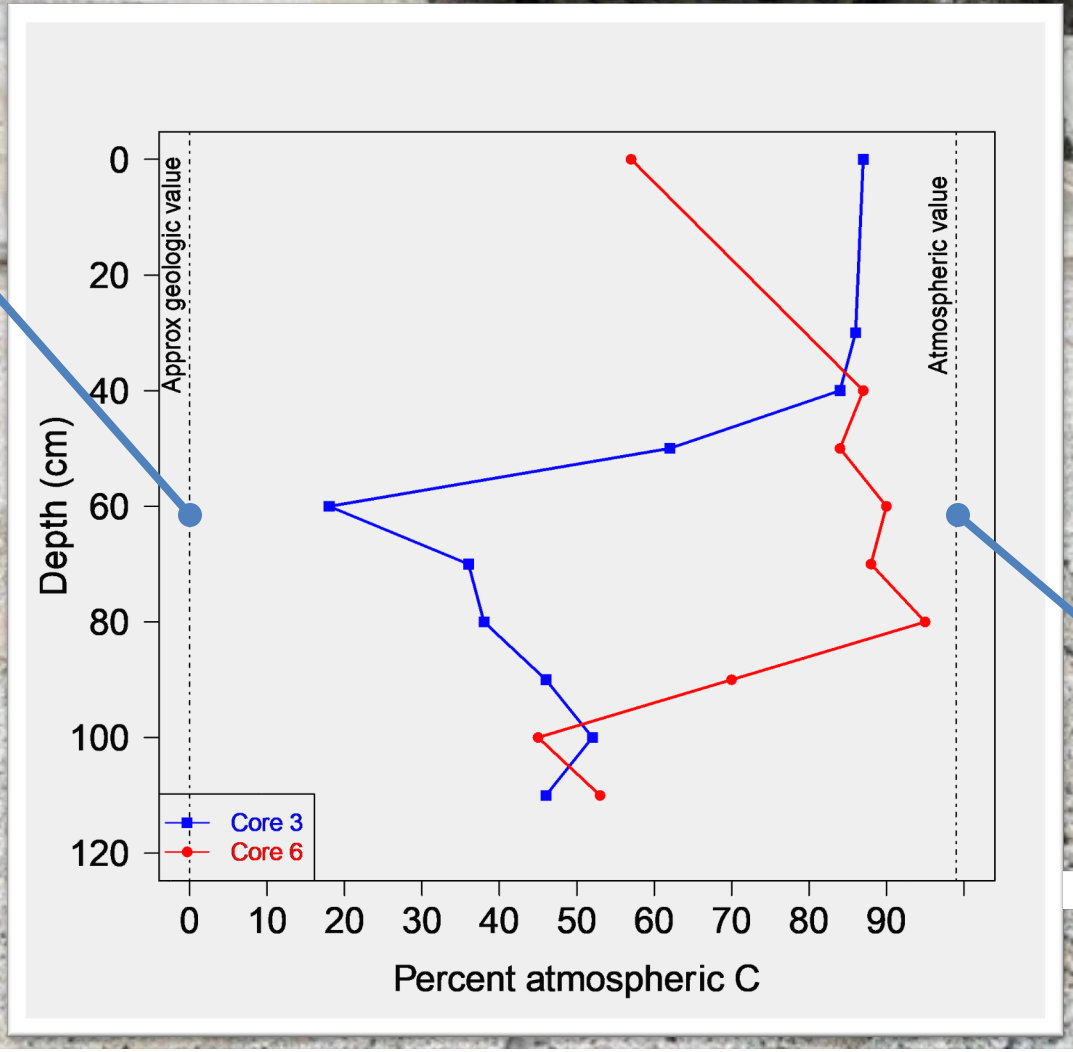
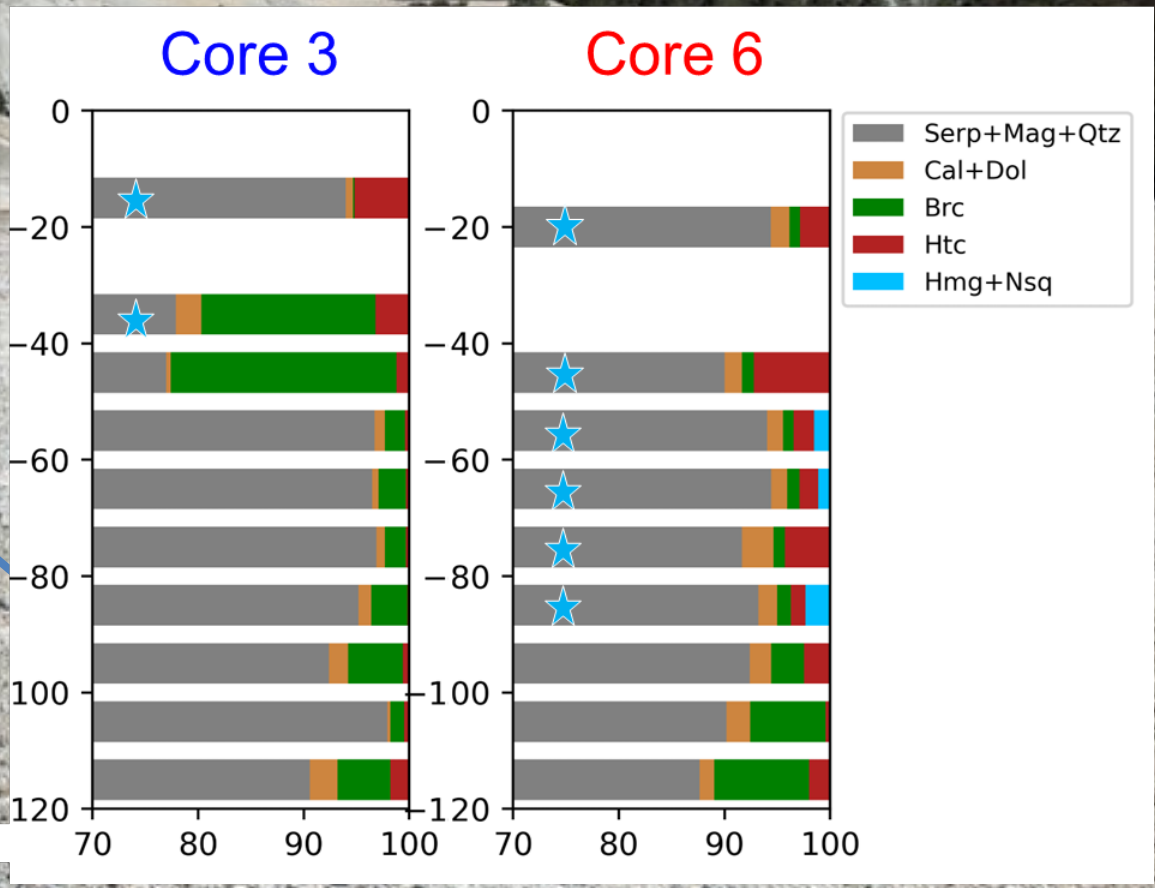
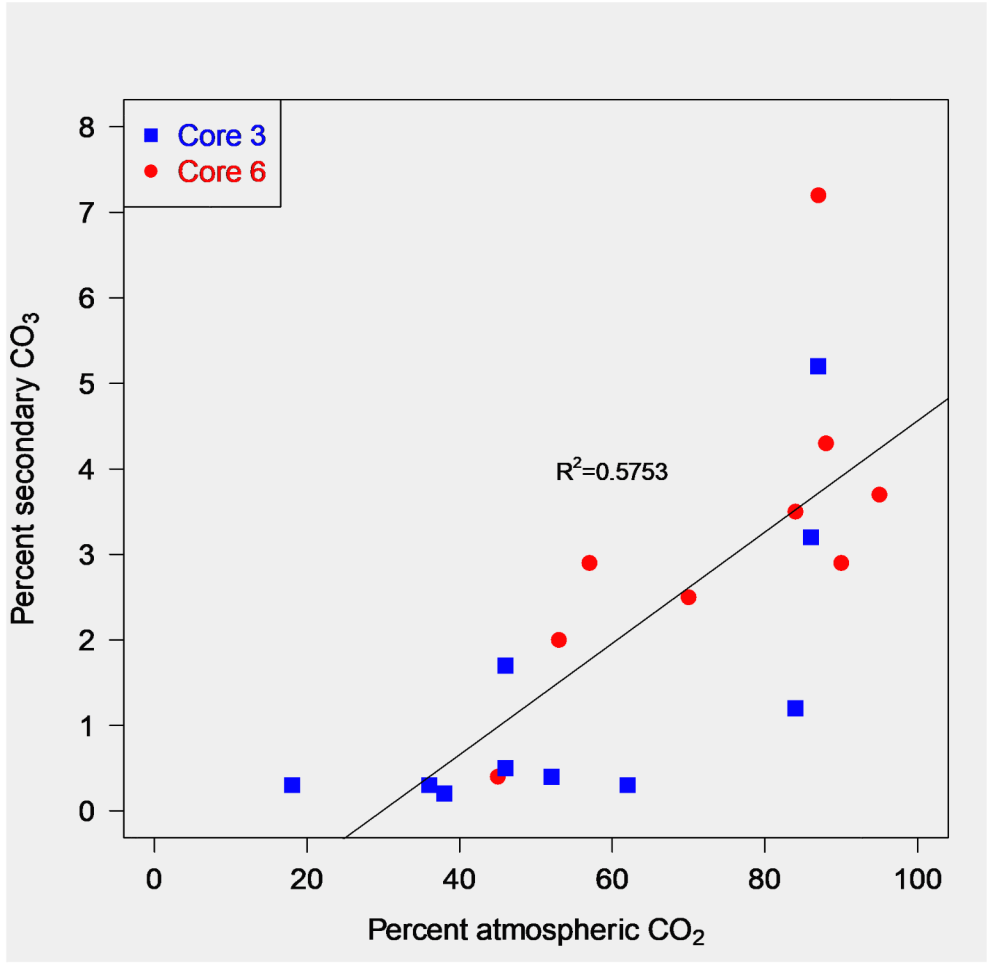
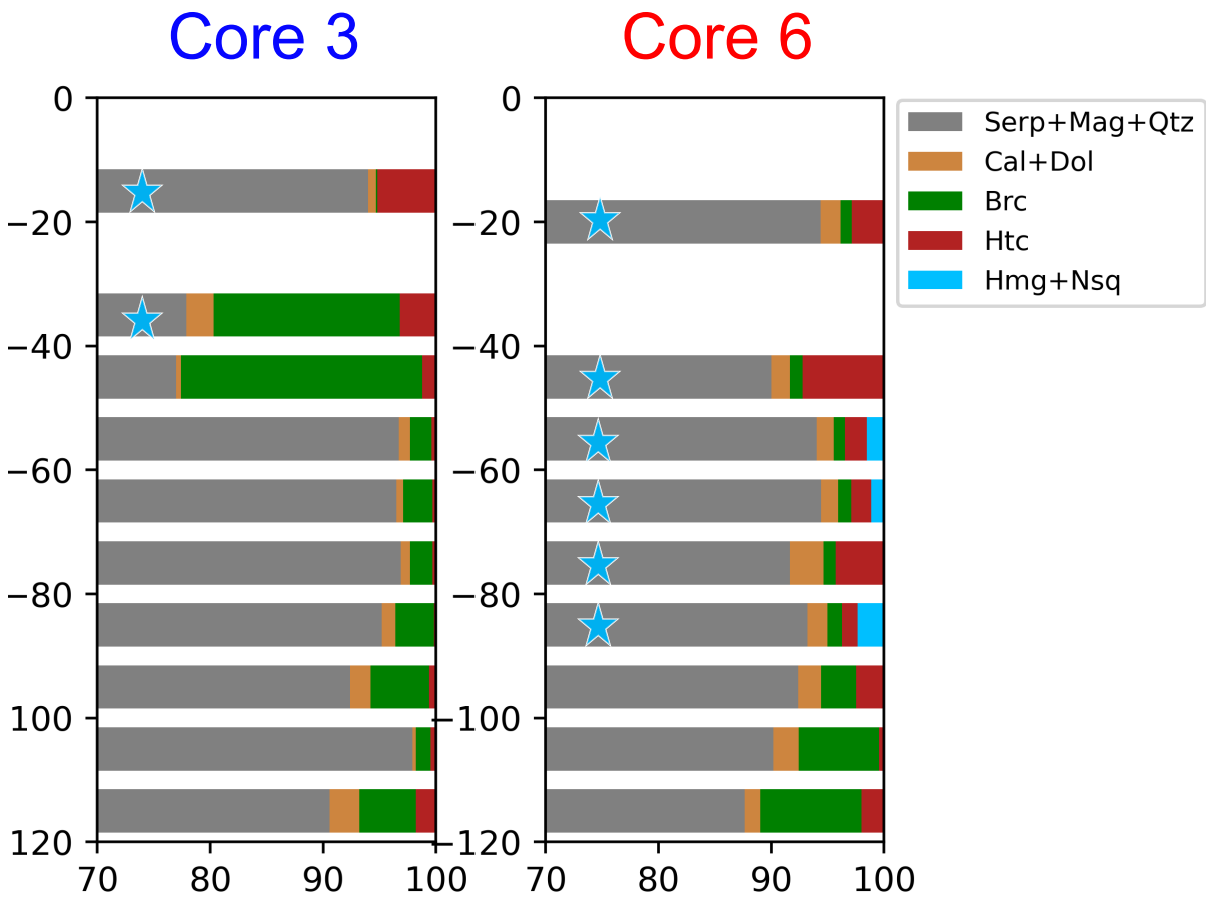
Radiocarbon vs. depth





^{14}C vs. Rx Products (Mg Carbonates + Hydrotalcites)





Notification of Air Monitoring Results

SUBJECT:	[KCAC Mines] [Personal Air] [Asbestos] [Ground-disturbance] (HCP 103678) [4-11-22 to 4-17-22]
SAMPLING DATES:	4-11-22 to 4-17-22
EXCEEDED LIMIT?	No
CONCLUSION:	Worker exposure to Asbestos during ground-disturbing activities at a closed asbestos mine did not exceed the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) of 0.1 fibers/cc.
REQUIRED ACTIONS:	1. Continue to use controls stated in the above referenced work control document. 2. Notify the IH or H&S Technician if the work changes (i.e., frequency, duration, materials, methods, controls, etc.). 3. Share these results with all employees under your supervision who perform this type of work.

Table 1: Air Monitoring Results (Batches 20222234, 20222275, 20222273, 20222242, 20222274, 20222272)

Sample Date	Sample Number	Monitored Agent	Sample Duration[1] (minutes)	Analytical Result[2,4] (f/cc)	8-hour TWA [2,3,4] (f/cc)	Exposure Limit[4] (f/cc)	Percentage of Exposure Limit
4-11-22	3121772	Asbestos	14	NA	NA	0.1	NA
4-11-22	3121773	Asbestos	63	<0.019	<0.0025	0.1	<2.5
4-13-22	3121776	Asbestos	30	<0.036	<0.0023	0.1	<2.3
4-13-22	3121777	Asbestos	194	<0.0060	<0.0024	0.1	<2.4
4-13-22	3121778	Asbestos	193	0.010	0.0040	0.1	4.0
4-13-22	3121779	Asbestos	193	<0.0060	<0.0024	0.1	<2.4
4-14-22	3121774	Asbestos	137	<0.0090	<0.0026	0.1	<2.6
4-15-22	4647498	Asbestos	297	0.011	0.0068	0.1	6.8
4-16-22	3121775	Asbestos	159	<0.0080	<0.0027	0.1	<2.7
4-17-22	4647499	Asbestos	45	<0.025	<0.0023	0.1	<2.3

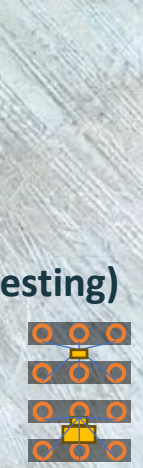
Key Findings – Phase I

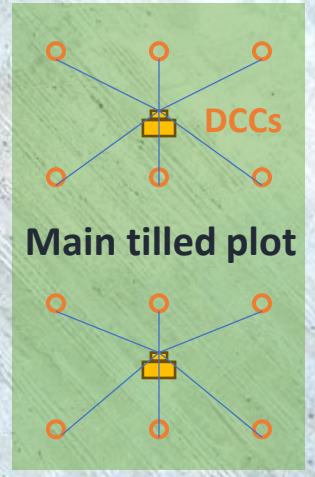
- **Near-surface mine waste contains magnesium carbonates and hydrotalcites, indicating past carbon mineralization.**
- **Brucite is consistently present and abundant at depths below ~40cm, indicating significant unreacted material at relatively shallow depths.**
- **Background CO_2 uptake of ~1kg $CO_2/m^2/yr$ indicates presence of reactive material**
- **Based on results to date, two methods selected to accelerate the rate of CO_2 mineralization: Tilling Method and the Greenhouse Method.**
- **We hypothesize these methods can increase the natural background rate of CO_2 mineralization rate by 5 times.**
- **Monitoring of personnel indicated asbestos exposure is well below regulated limits for all activities to date**

Phase II Experimental Design: Tilling Method (CarbMinLab)

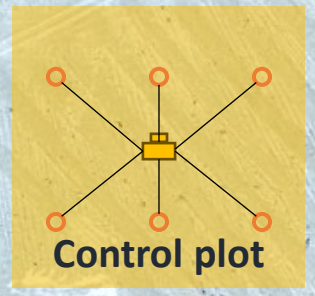
Test Cells (sensitivity testing)

- T0: Control plot
- T1: Wet plot
- T2: Scraped plot
- T3: Modified depth plot





EC



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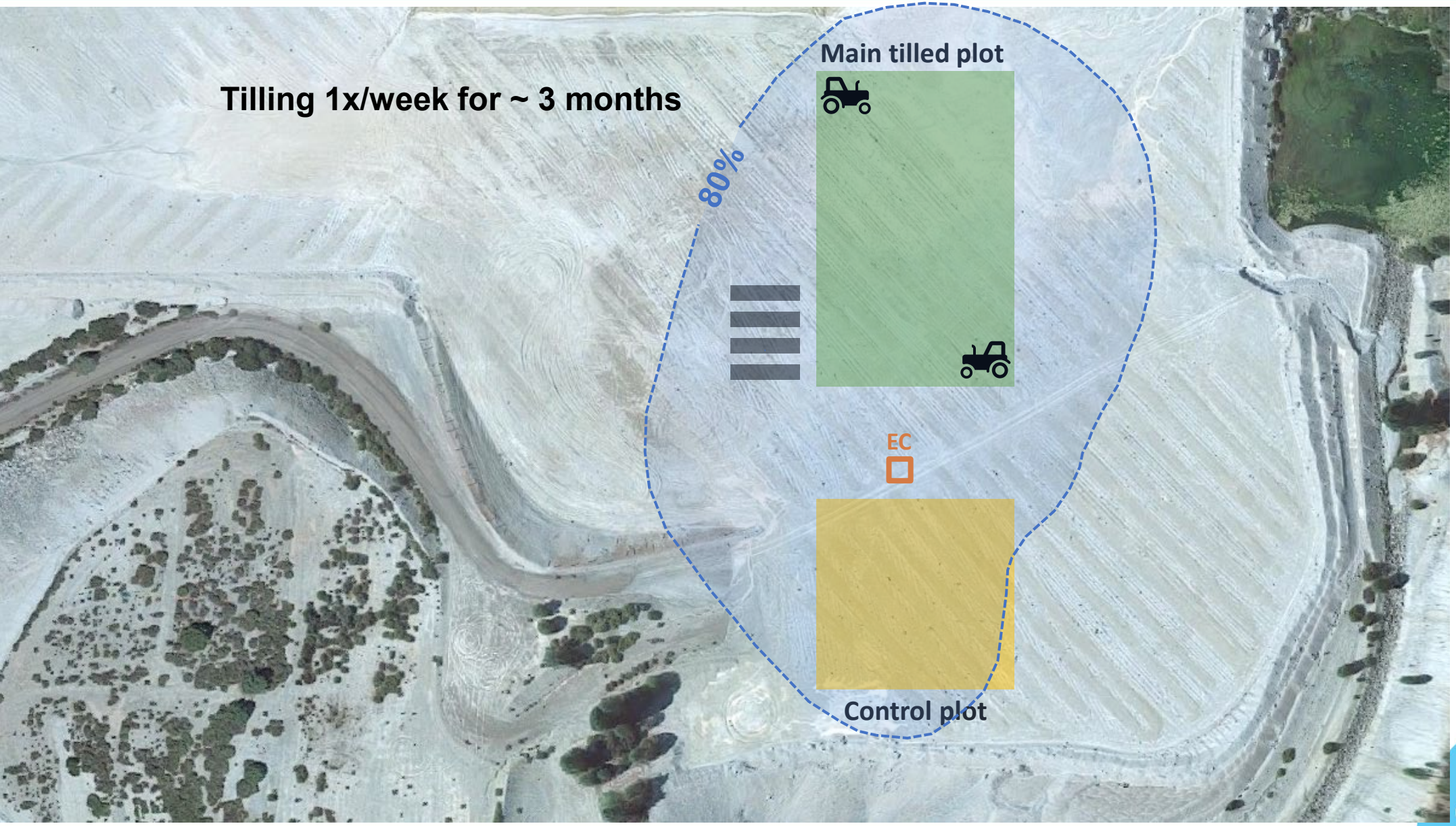
Phase II Experimental Design: Tilling Method (CarbMinLab)



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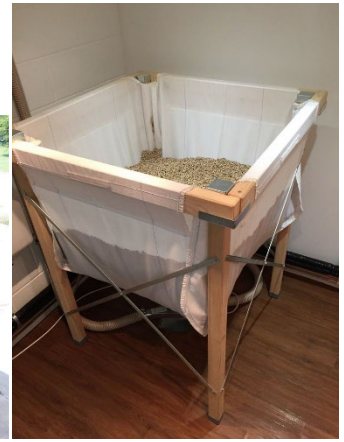
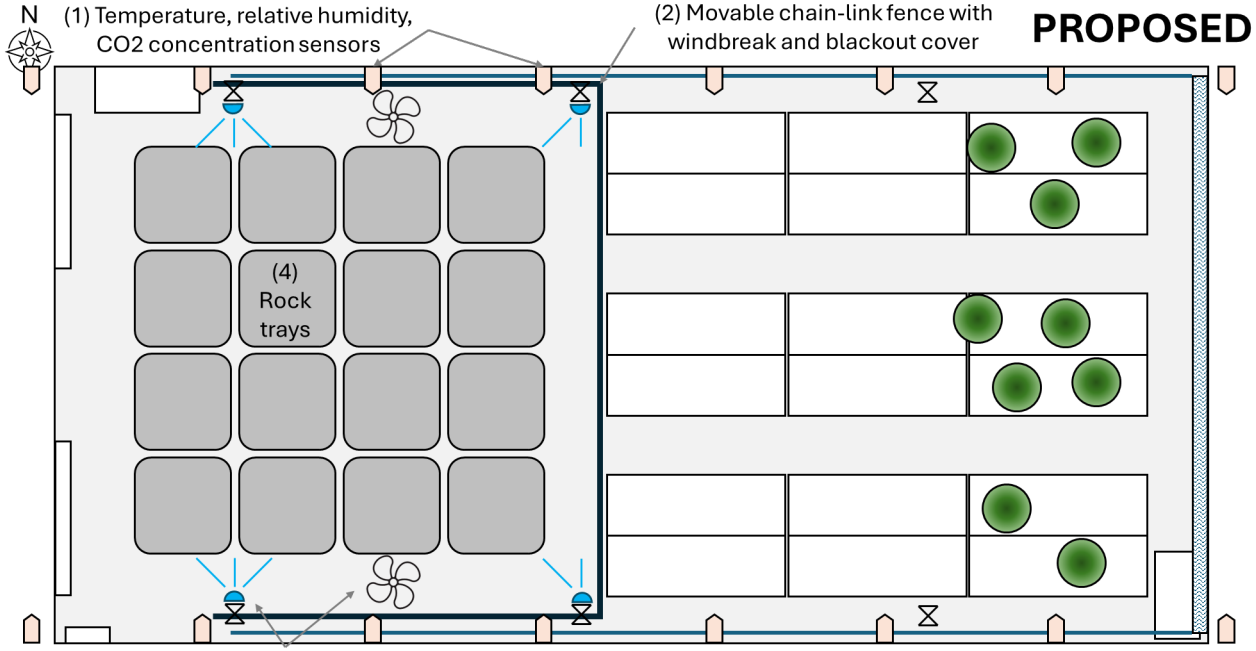
Phase II Experimental Design: Greenhouse Method (Corey Myers, LLNL)





Partners

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U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT


Thank you!
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https://www.netl.doe.gov/project-information?p=FWP-FEW0278