CO2 Mineralization for *in situ* Storage and *ex situ* Enhanced Metals Recovery Workshop Day 2

Thursday July 15, 2021

Chemical Approaches (Breakout 1)

- Moderator: Jenifer Shafer, Program Director, ARPA-E Notes: Kalena Stovall, Tech SETA

1. For any mineralization - *ex situ*/surficial/*in situ* – base metrics should include reaction rates, conversion/yield efficiency, product distributions, extent of reaction per unit time, and analytical method.
   - What values can be assigned to these and how can they be measured?
   - Does the mineralization impact critical minerals for energy liberation?

2. Are there additional metrics which need to be included for *ex situ*/surficial/*in situ* approaches?

3. What needs to be in the LCA for this approach, process and reaction?

4. What is the estimated expense of each approach with/without carbon credits/pricing?

5. How quickly could we expect to be ready for deployment?

Chemical Approaches (Breakout 2)

- Moderator: Scott Litzelman, Program Director, ARPA-E Notes: Carlos Noyes, Tech SETA

1. For any mineralization - *ex situ*/surficial/*in situ* – base metrics should include reaction rates, conversion/yield efficiency, product distributions, extent of reaction per unit time, and analytical method.
    - What values can be assigned to these and how can they be measured?
    - Will mineralization improve recovery of energy relevant minerals?

2. For in situ, what key process constraints need be included and controlled/monitored/measured; *e.g.* rate of fluid injection, *in situ* pressure, water-CO_2 ratio, catalyst concentration, *etc*.?

3. How large can these processes be scaled to: megatonnes, gigatonnes, unknown . . .?

4. Are major technical improvements needed to make these processes viable and more cost effective?

Chemical Approaches (Breakout 3)

- Moderator: Bob Ledoux, Program Director, ARPA-E Notes: Kate Pitman, Tech SETA

1. For any mineralization - *ex situ*/surficial/*in situ* – base metrics should include reaction rates, conversion/yield efficiency, product distributions, extent of reaction per unit time, and analytical method.
    - What values can be assigned to these and how can they be measured?
    - Will mineralization improve recovery of energy relevant minerals?

2. For in situ, what key process constraints need be included and controlled/monitored/measured; *e.g.* rate of fluid injection, *in situ* pressure, water-CO_2 ratio, catalyst concentration, *etc*.?

3. How large can these processes be scaled to: megatonnes, gigatonnes, unknown . . .?

4. Are major technical improvements needed to make these processes viable and more cost effective?

Microbiological Approaches (Breakout 1)

- Moderator: David Babson, Program Director, ARPA-E Notes: Grace Ryan, Tech SETA

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   - What values can be assigned to these and how can they be measured?
   - Does the mineralization impact critical minerals for energy liberation?

2. Are there additional metrics which need to be included for *ex situ*/surficial/*in situ* approaches?

3. What needs to be in the LCA for this approach, process and reaction?

4. What is the estimated expense of each approach with/without carbon credits/pricing?

5. How quickly could we expect to be ready for deployment?

Microbiological Approaches (Breakout 2)

- Moderator: Marc von Keitz, Program Director, ARPA-E Notes: Laura Demetrion, Tech SETA

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    - What values can be assigned to these and how can they be measured?
    - Will mineralization improve recovery of energy relevant minerals?

2. For in situ, what key process constraints need be included and controlled/monitored/measured; *e.g.* rate of fluid injection, *in situ* pressure, water-CO_2 ratio, catalyst concentration, *etc*.?

3. How large can these processes be scaled to: megatonnes, gigatonnes, unknown . . .?

4. Are major technical improvements needed to make these processes viable and more cost effective?

Electrochemical Approaches (Breakout 1)

- Moderator: Halle Cheeseman, Program Director, ARPA-E Notes: Matt Mattozzi, Tech SETA

1. For any mineralization - *ex situ*/surficial/*in situ* – base metrics should include reaction rates, conversion/yield efficiency, product distributions, extent of reaction per unit time, and analytical method.
   - What values can be assigned to these and how can they be measured?
   - Does the mineralization impact critical minerals for energy liberation?

2. Are there additional metrics which need to be included for *ex situ*/surficial/*in situ* approaches?

3. What needs to be in the LCA for this approach, process and reaction?

4. What is the estimated expense of each approach with/without carbon credits/pricing?

5. How quickly could we expect to be ready for deployment?

Phytomining Approaches (Breakout 1)

- Moderator: Phil Kim, Program Director, ARPA-E Notes: David Lee, Tech SETA

1. For any mineralization – base metrics should include reaction rates, conversion/yield efficiency, product distributions, extent of reaction per unit time, and analytical method.
    - What values can be assigned to these and how can they be measured?
    - Will phytomining improve recovery of energy relevant minerals in the U.S.?
    - Can any ancillary benefits of phytomining be assessed?

2. Are there additional metrics which need to be included for phytomining, especially any that would not apply to *ex situ*/surficial/*in situ* approaches?

3. What components should be incorporated into the LCA for phytomining? Can phytomining be carbon-negative?

4. Can phytomining be profitable with/without carbon credits/pricing?

5. How quickly could we expect to be ready for deployment?