

Plagioclase vs Olivine: Which mineral is more reactive in driving in-situ mineralization of CO₂ in Basalt?

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INTRODUCTION & AIM

THE BACKGROUND

Basalt mineralizes CO₂ for permanent carbon storage.

- Olivine
- Plagioclase
- Pyroxene

THE AIM

Which mineral is most reactive?

Literature Splits Plagioclase or Olivine?

RESULTS & DISCUSSION

SELECTION OF FACTORS

- ✓ Low Temp
- ✓ Slow Equilibrium
- ✓ Calcite Dominant

OUTCOME

REACTIVE FRAMEWORK

- ✓ Reservoir Temp
- ✓ High Early Flux

OLIVINE

- ✓ Reservoir Temp
- ✓ High Early Flux
- Magnesite Dominant

Engineer the Reservoir: Condition-specific environment controls reactivity more than intrinsic mineralogy.

METHOD

SELECTION OF FACTORS

- ✓ Intrinsic kinetics
- ✓ Surface access
- ✓ Temp-CO₂
- ✓ Stoichiometry
- ✓ Timescale

OUTCOME

COMPARISON OF REACTIVITY

REACTIVE FRAMEWORK

Condition-dependent controls define realized reactivity

Based on 500+ studies on Surface Condition and Reservoir Conditions

Framework Comparison

| PLAGIOCLASE | OLIVINE | PYROXENE |
|--|---|---|
| | | |
| KINETICS | SURFACE REACTIVITY | INACTIVE |
| <ul style="list-style-type: none"> Slow Dissolution Higher Activation Energy | <ul style="list-style-type: none"> Fractured Texture Moderate Reactivity | <ul style="list-style-type: none"> Low Reactivity Limited Exposure |
| SURFACE | CHEMISTRY | TIMESCALE |
| <ul style="list-style-type: none"> Fractured Texture Moderate Reactivity | <ul style="list-style-type: none"> Initial Mg²⁺ & Fe²⁺ Flux Slow Ca²⁺ Dominant Release | <ul style="list-style-type: none"> Limited Mg²⁺, Ca²⁺ Release Mixed Carbonates Possible |
| CHEMISTRY (INITIAL FLUX) | CHEMISTRY (INITIAL FLUX) | TIMESCALE |
| <ul style="list-style-type: none"> Prolonged Ca²⁺ Flux Ca Dominance (Calcite Pathway) | <ul style="list-style-type: none"> Slow Ca²⁺ Dominant Release Mg Dominance (Magnesite Pathway) | <ul style="list-style-type: none"> Long Ca²⁺ Timeline Minimal Reactivity |

No single mineral governs; reactive outcomes are result of varying reactivity conditions.

FUTURE WORK AND REFERENCES

Construct a high-pressure reaction chamber to study real-world controls on mineral carbonation

- ✓ Test optimal P_{sat}, T, pCO₂ mix over time
- ✓ Measure reactive cation fluxes & initial passivation
- ✓ Track carbonate growth under realistic rates

CONCLUSION

PLAGIOCLASE

OLIVINE

DORMANT PYROXENE

- ✓ Plagioclase & Olivine effective for sustained CO₂ sequestration
- ✗ Limited reactivity makes Pyroxene unfit for rapid carbon storage

TARGETED MINERAL CARBONATION

PRECISION MATCH
MINERAL TO CONDITIONS

OPTIMIZE REACTION
PARAMETERS

MAXIMIZE CARBON
SEQUESTRATION

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