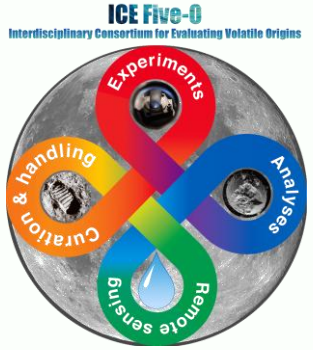

Laboratory Simulations of Aqueous Reactions in Lunar Polar Regions

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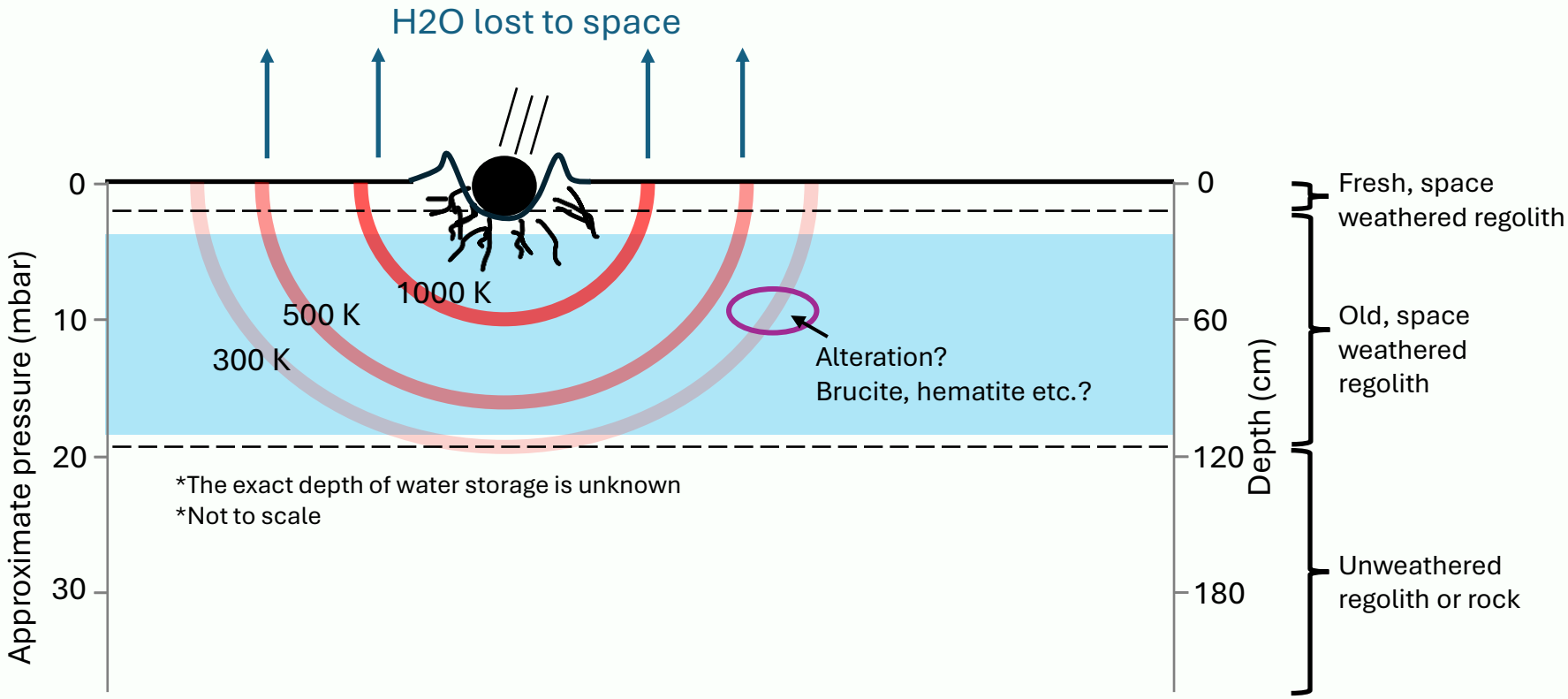
McDonnel Center for the Space Sciences

Background

- We might expect aqueous alteration on the Moon in the polar regions
- Heat + ice + pressure + long duration = alteration
- Experimental methods to simulate alterations



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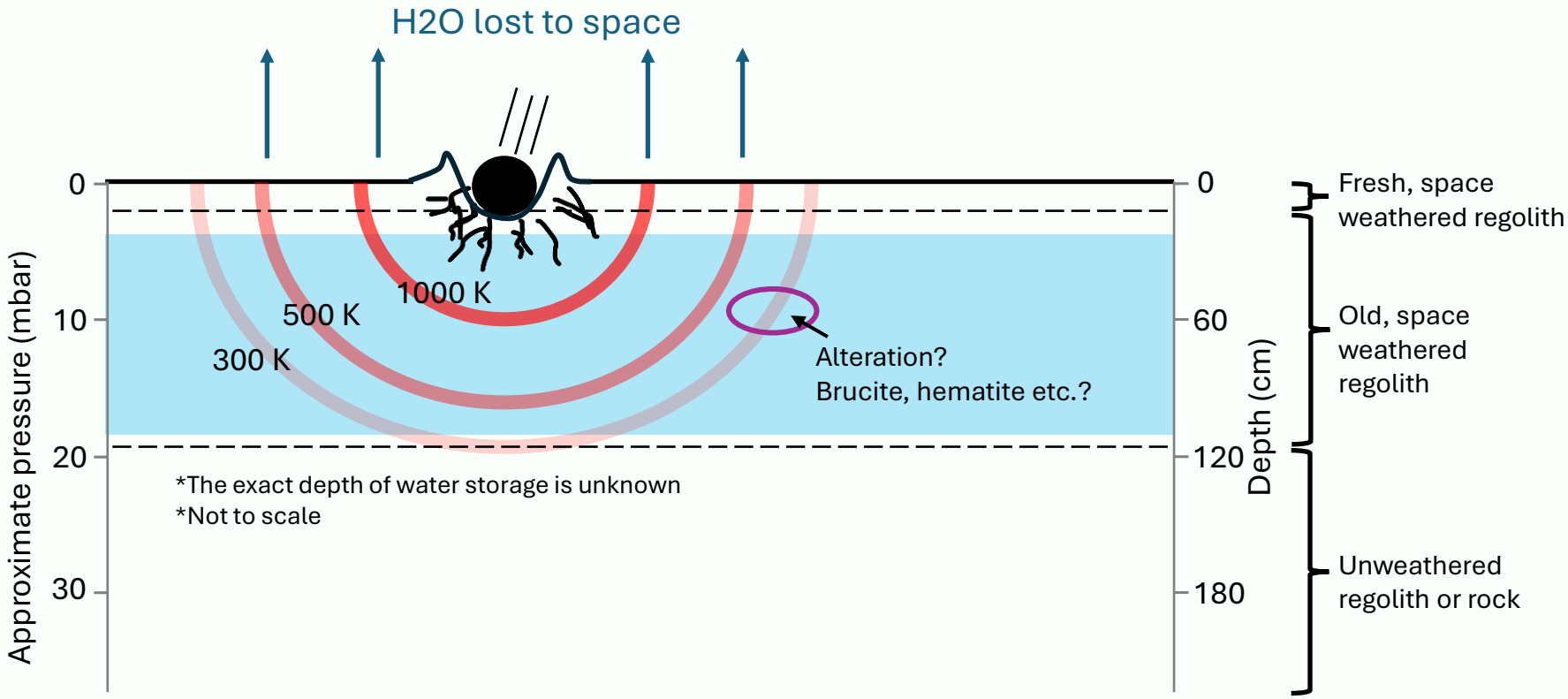
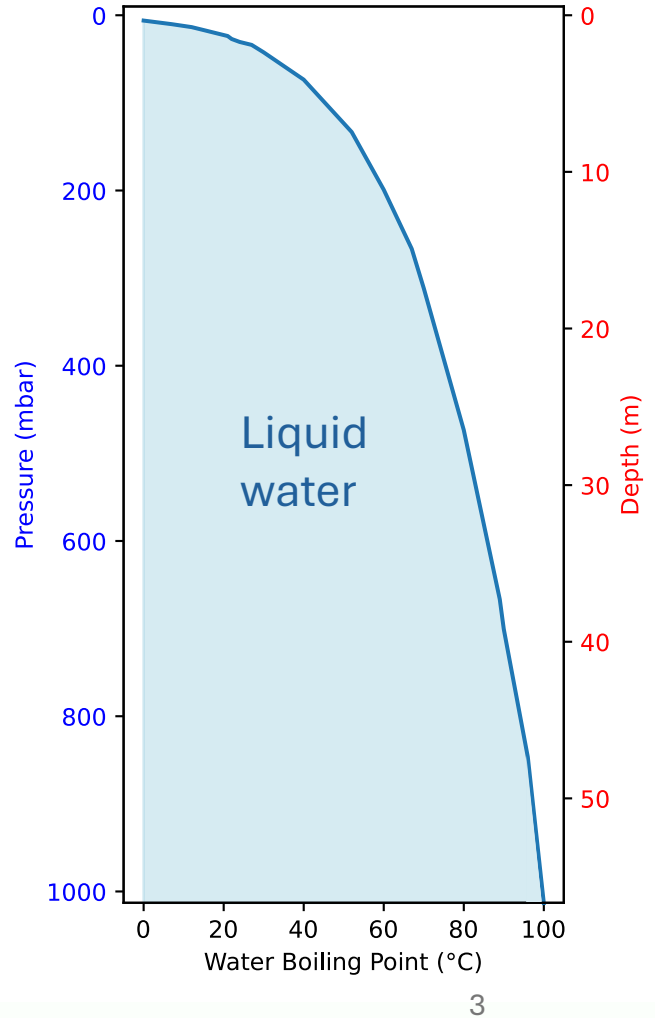
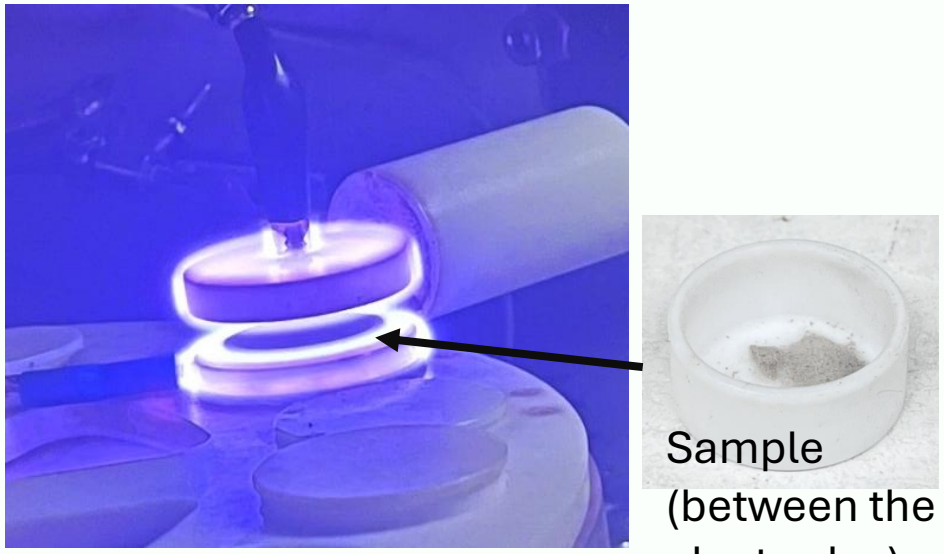


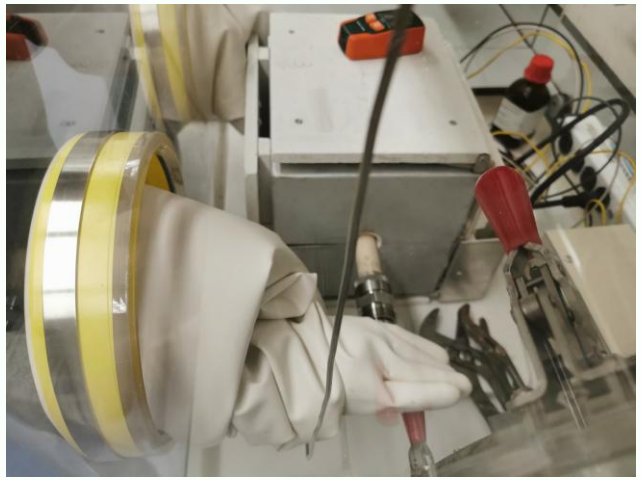


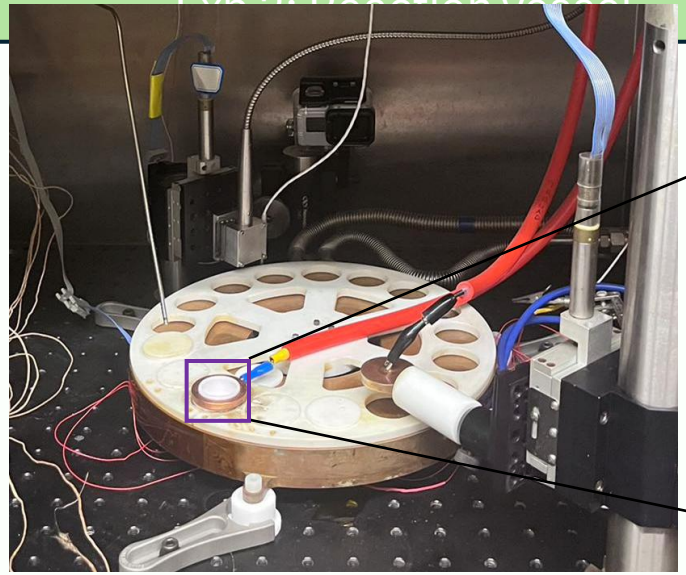
Experiment 1: Vacuum chamber + Energetic electron impact (EEI)

Key functions:

- Using EEI to activate the sample surface
- React water with olivine and basaltic glass
- Use D_2O (to distinguish from atmospheric H_2O)
- Controlled P-T condition ~16m under the surface







Sample (olivine)

Glove box (N_2 gas)

Bake samples at 500 °C in vacuum

Immerse samples in D_2O

Transfer samples

Vacuum chamber (Ar gas)

Multiple **Argon** flushes → Set P = 3 mbar → Set P = 300 mbar

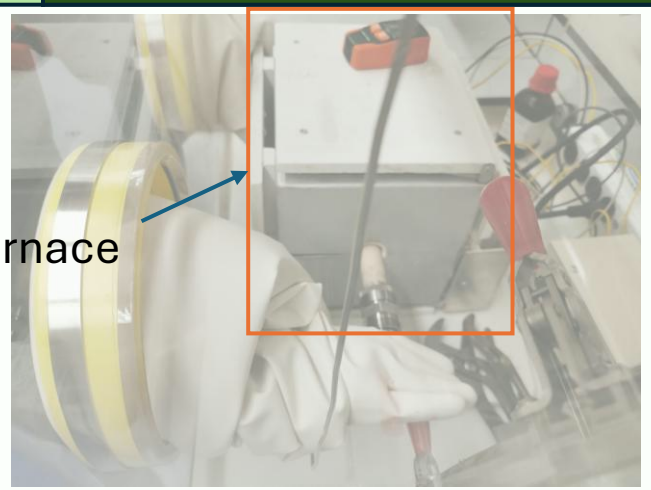
Baked samples → EEI → Samples after EEI

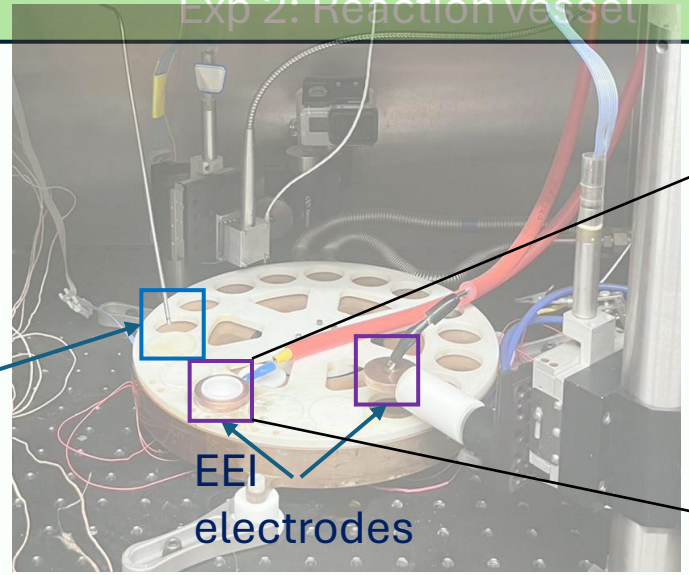
Inject D_2O

Set T = 65 °C

Characterization

Raman spectroscopy





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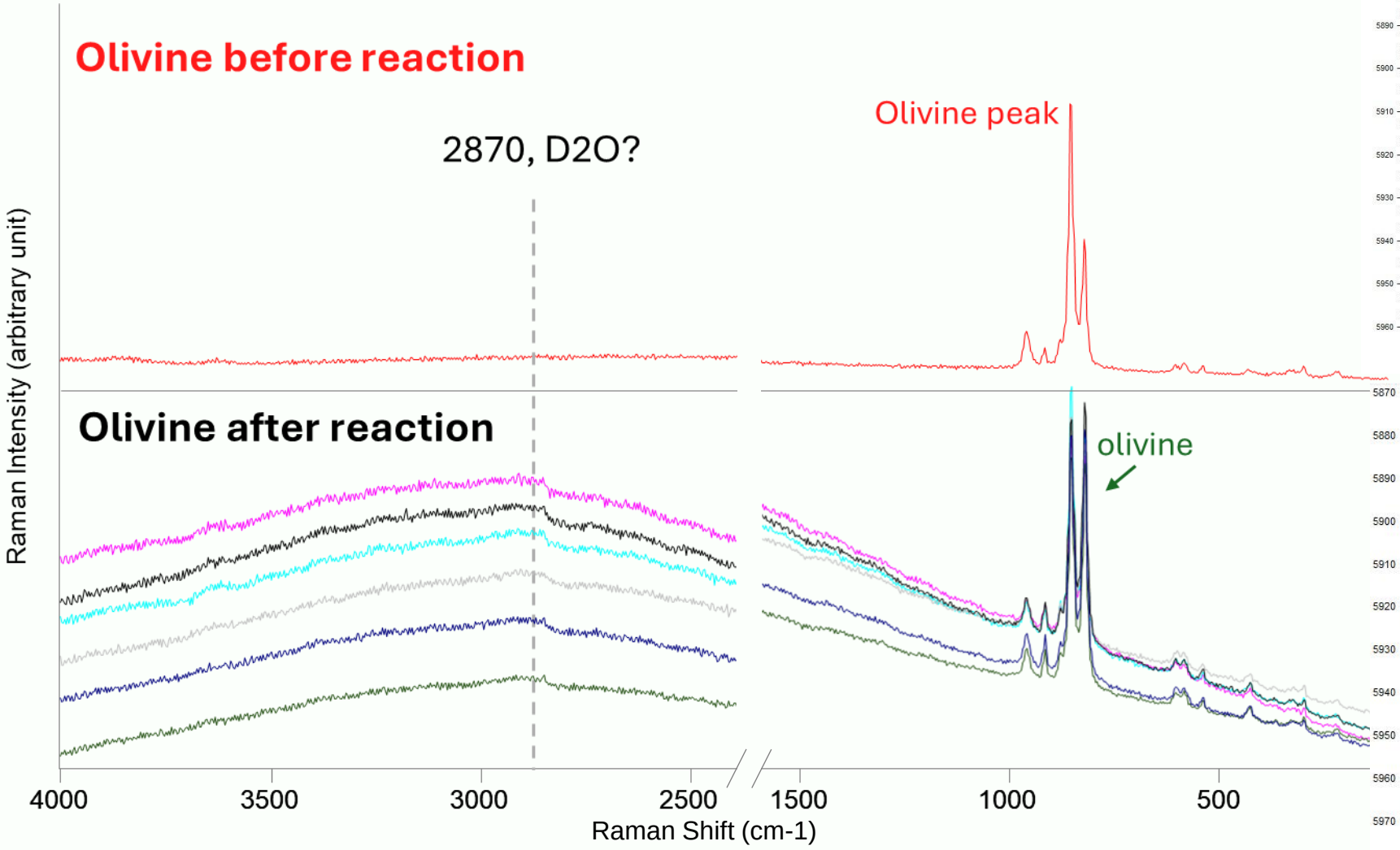

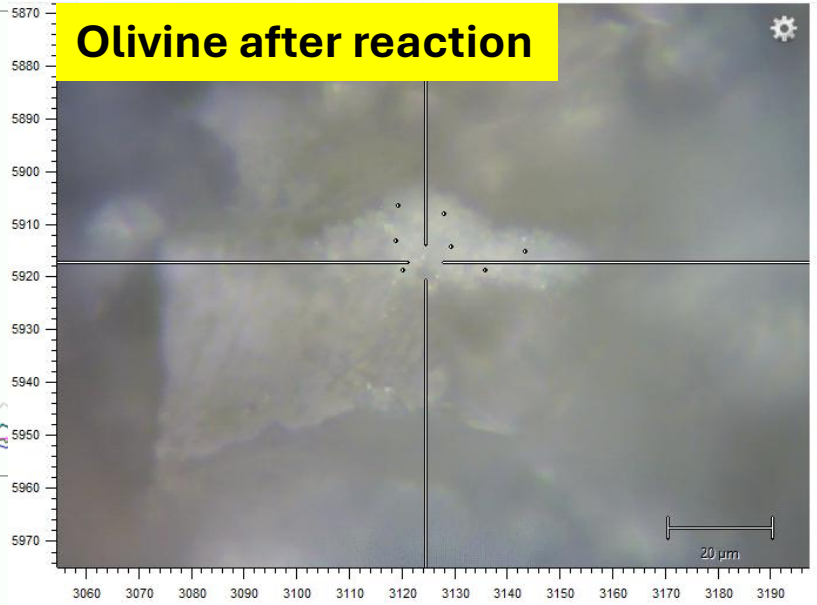

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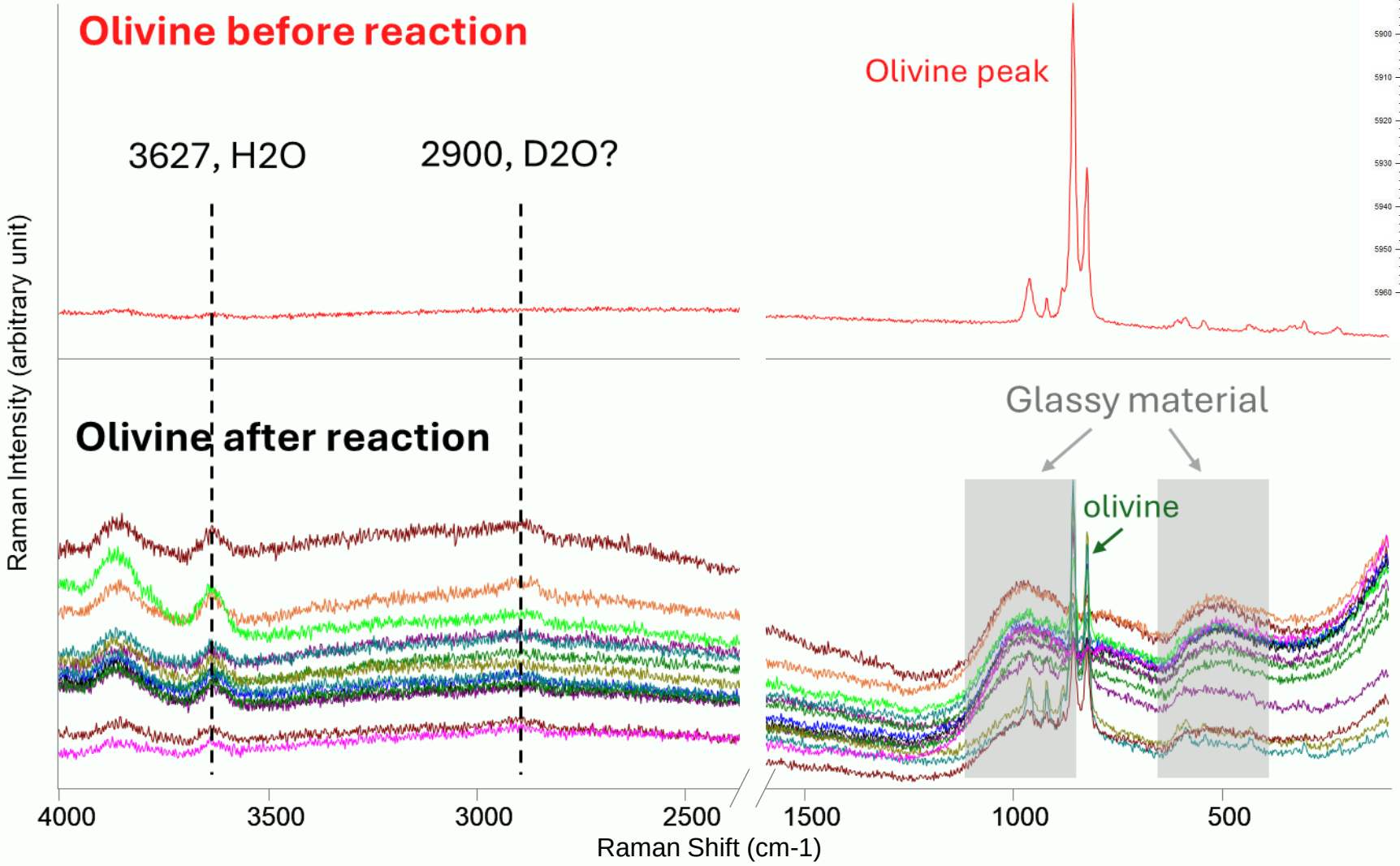
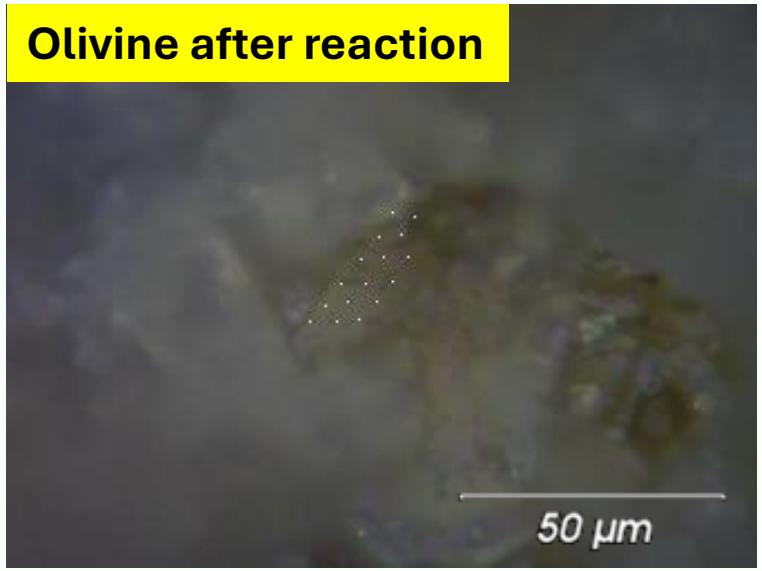
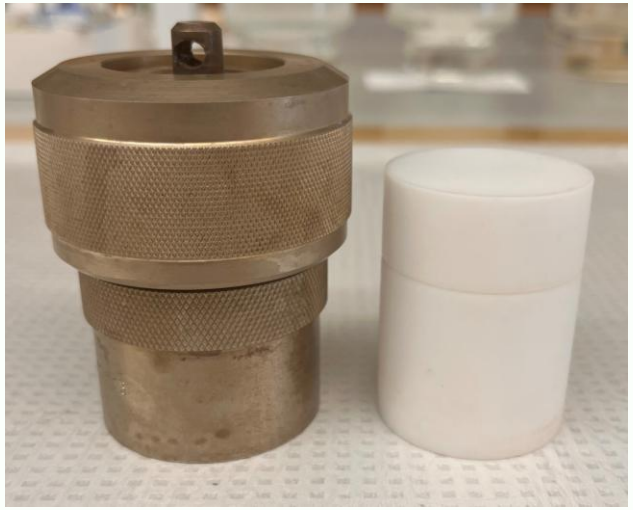




Experiment 2: Pressurized reaction vessel



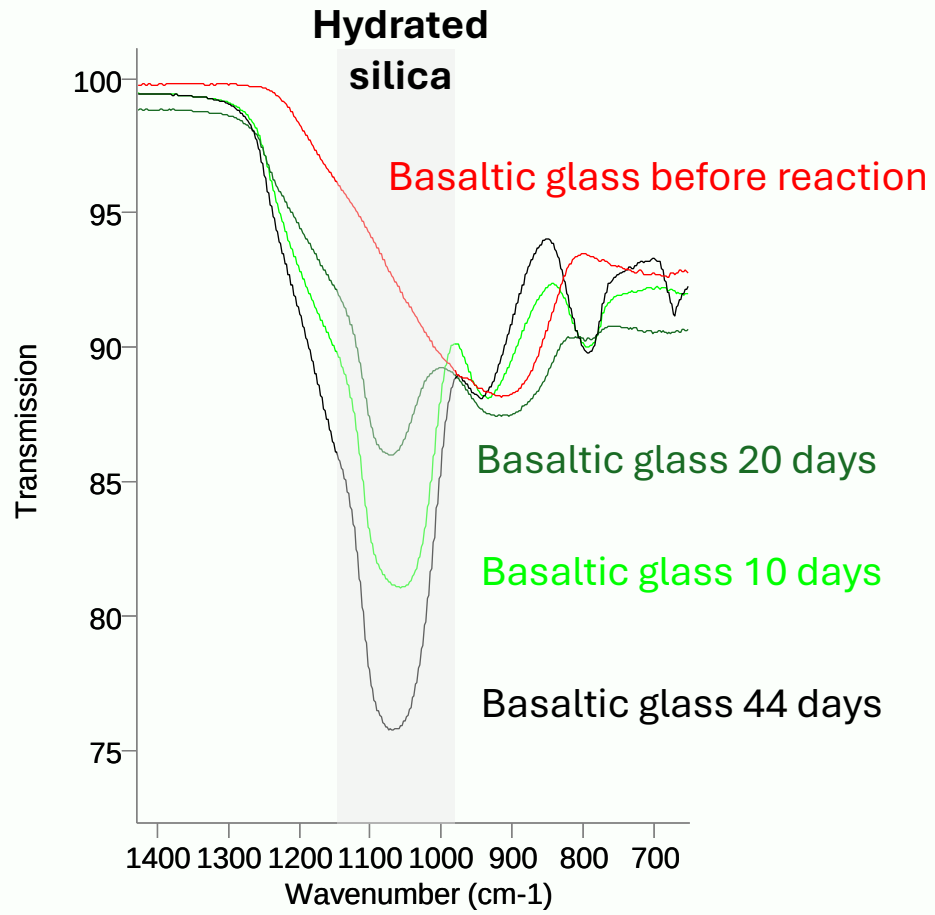
- Teflon-lined
- Solid: olivine or basaltic glass 50 mg
- Solution: 0.5 ml D_2O +0.5 ml dilute H_2SO_4 (16%)
- Temperature: 90 °C
- Duration: 10 days, 20 days, 44 days
- Characterization: FT-IR and Raman

Bulk composition change

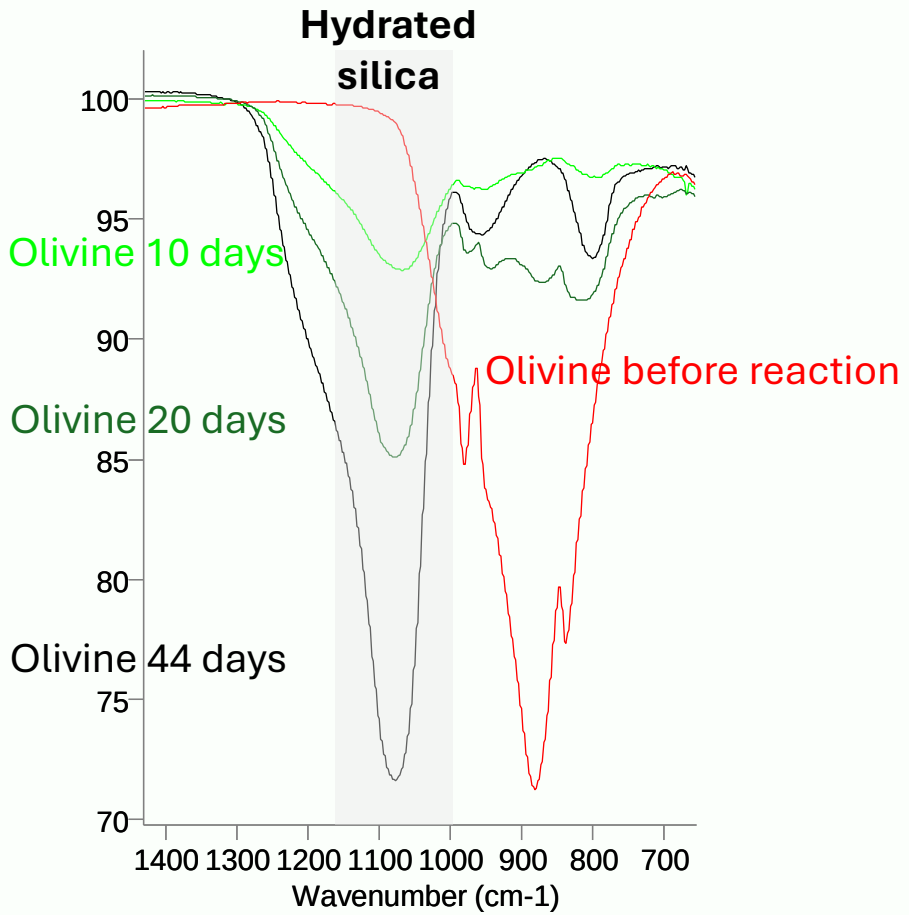
Micro-analysis on single points

Exp 2: FT-IR spectra – the main reaction product is hydrated silica

Basaltic glass IR spectra



Olivine IR spectra



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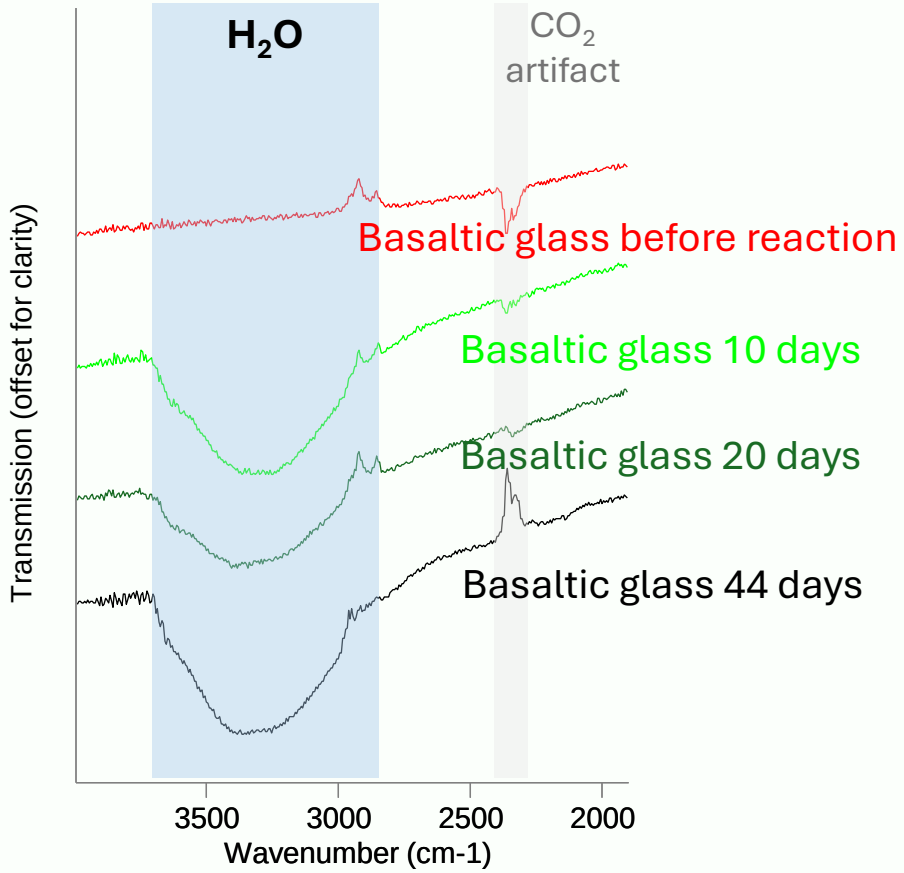

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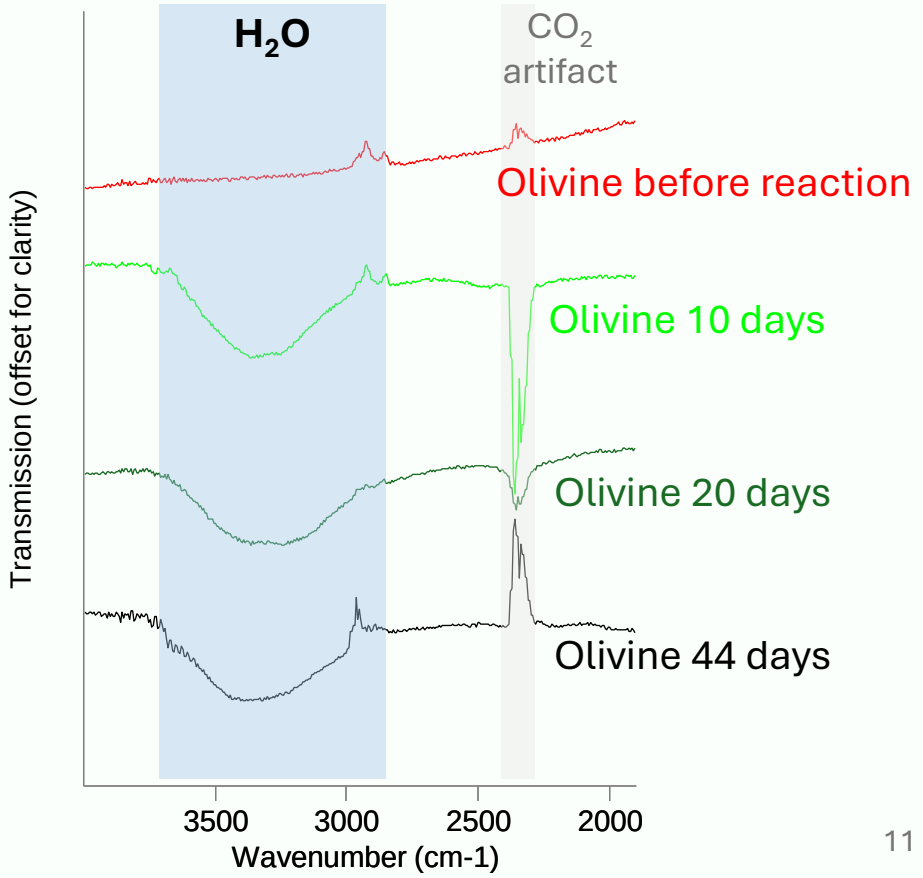

Experiment 2: Pressurized reaction vessel

Summary of Raman features found after different reactions

Duration	Olivine	Basaltic glass
10 days	Sulfate feature	No apparent change
20 days	Hematite feature	No apparent change
44 days	Completely dissolved	Sulfate+D_2O+H_2O

- Olivine: different reaction products depending on reaction time.
- Basaltic glass: dissolves slower than olivine

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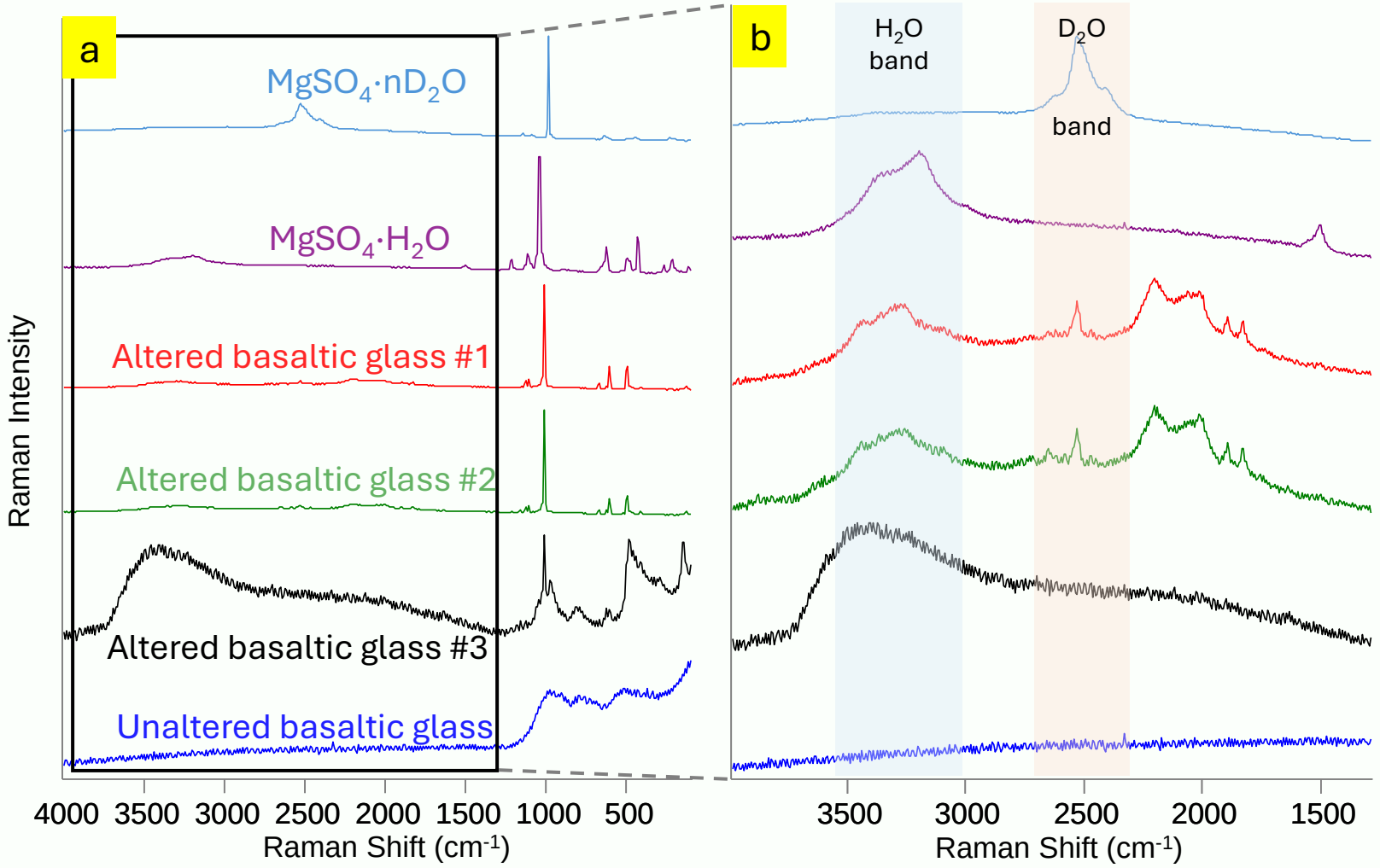
Exp 2: H_2O, D_2O, sulfate Raman features after 44 days of reaction with basaltic glass



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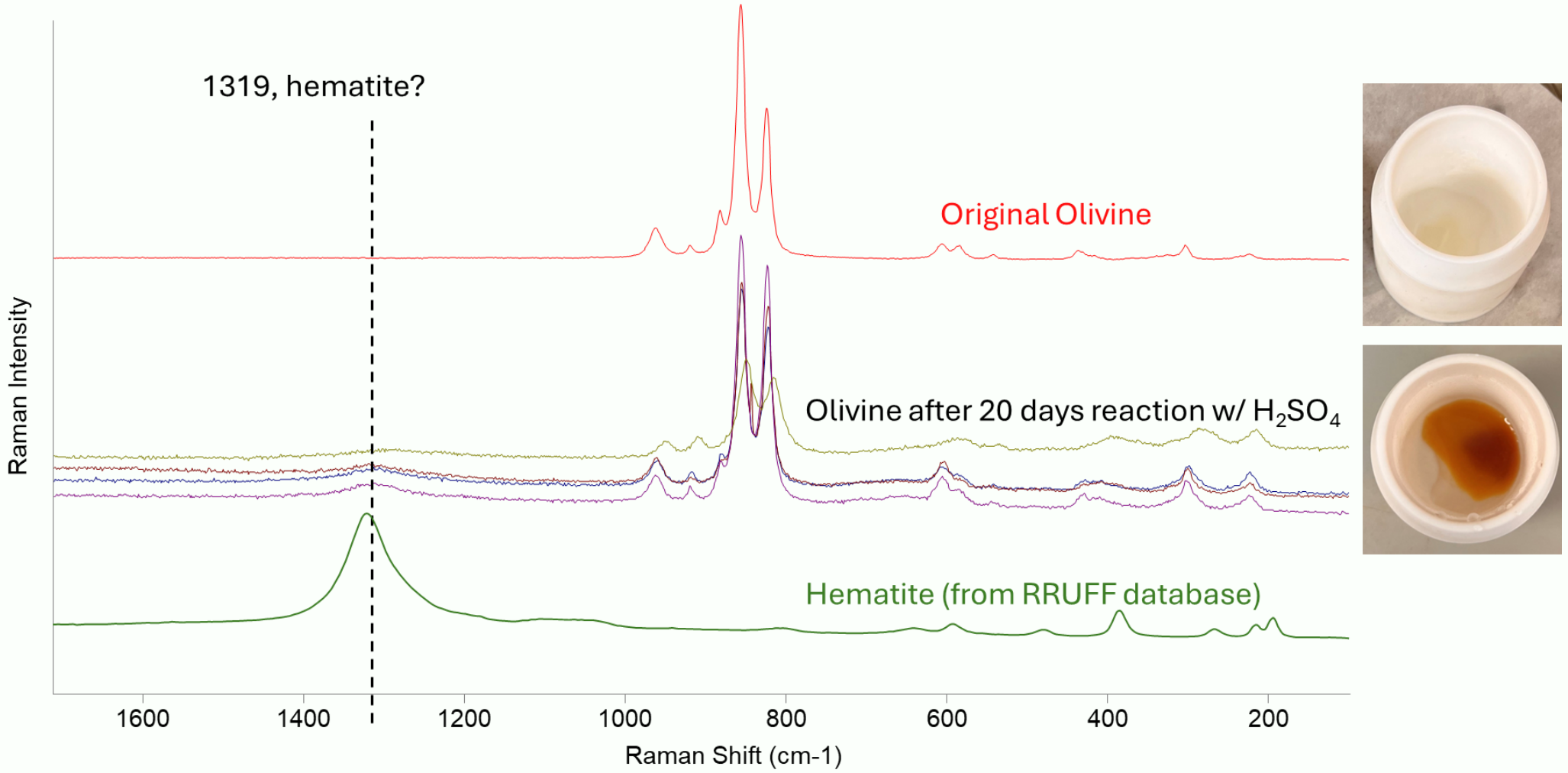
44 days	Completely dissolved	Sulfate+D_2O+H_2O

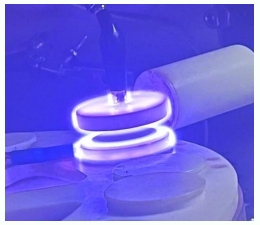
- Olivine: different reaction products depending on reaction time.
- Basaltic glass: dissolves slower than olivine

Exp 2: Hematite Raman feature after 20 days of reaction in olivine



Conclusions

Exp 1 (EEI + D_2O + heating)



- D_2O feature identified by Raman spectroscopy → EEI effectively activates grain surfaces as we might expect occurs on the lunar surface by space weathering

Exp 2 (Acid + D_2O + longer term heating)

- Multiple alteration products (silica, ferric oxide, sulfate, D_2O enters mineral structure) →
  - Dissolution of olivine/basaltic glass
  - Evaporation of "brine" produces secondary deposits of salts

Thank you!

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