

INTRODUCTION

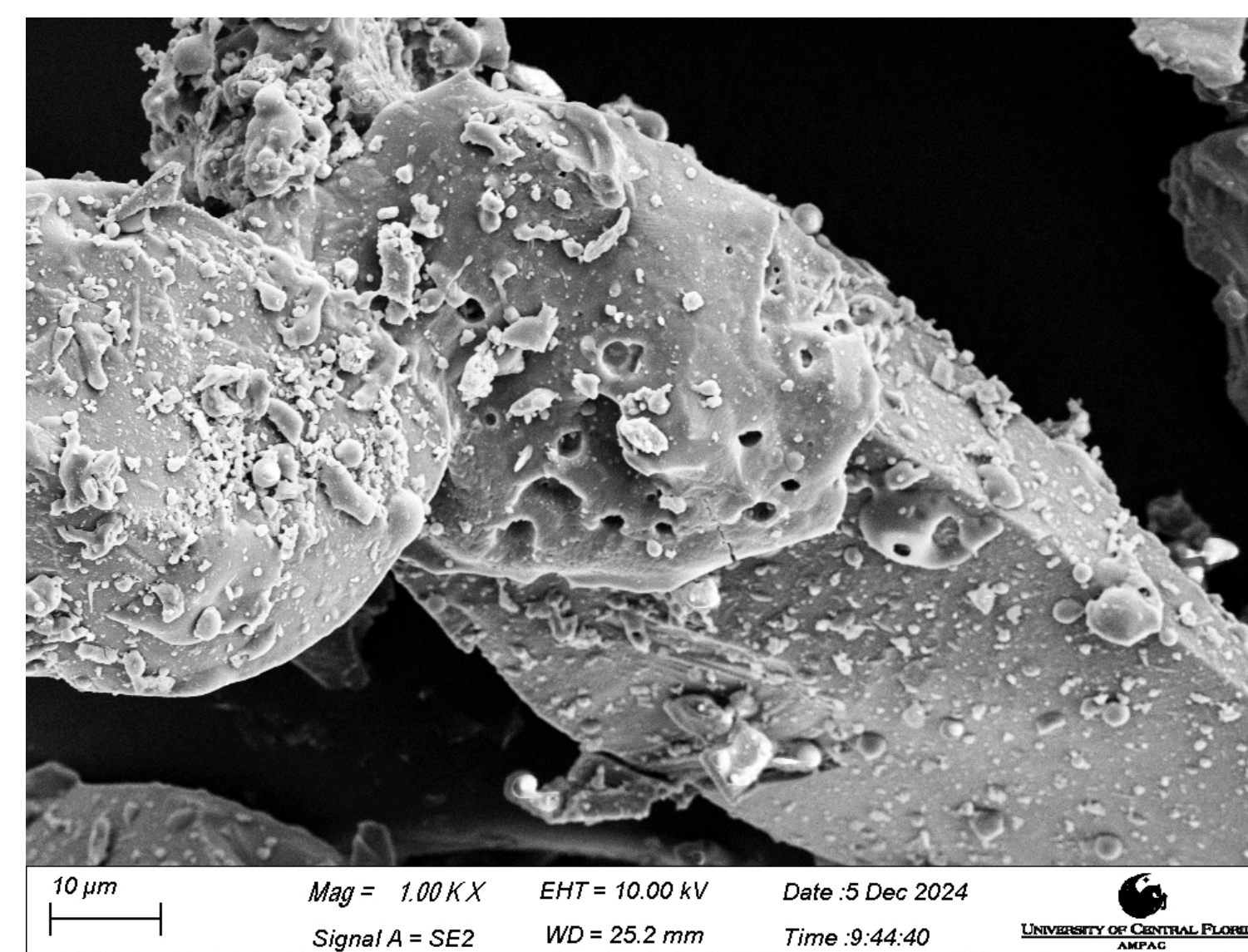
Carbon is present throughout the Solar System in many forms, but it may have played a special role in the formation and evolution of Mercury [1, 2] and carbonaceous asteroids [3, 4]. Both Mercury and C-type asteroids may contain up to 5 wt. % of carbon on their surfaces [2, 5, 6]. However, the effects of space weathering on **carbon-rich, highly reduced regoliths** remains unclear.

What space weathering products are formed when little to no Fe is present? Can the presence of carbon create nano- or microphase carbon within silicate regolith particle rims?

SIMULATED MICROMETEORITE BOMBARDMENT

WashU Laser Space Weathering Laboratory [7]

- Uniform weathering
- Formation of **agglutinates** →
- 100 ns pulse: melt
- 6-7 ns pulse: vapor
- P = 10⁻⁷ Torr



SAMPLE SUITE

- San Carlos Olivine
- Synthetic Enstatite (95 wt. %) + Carbon Black (5 wt. %)

RESULTS

VNIR spectra from 0.3-2.5 μm and TEM analyses reveal:

San Carlos Olivine

- Darkening (76% decrease @ 1.05 μm)
- Reddening (2100% increase over 1.75-2.5 μm)
- Reduction in depth of 1-μm feature (98.78% decrease)
- Vesicles, npFe-Ni, 2 μm thick melt

Synthetic Enstatite + Carbon Black

- Darkening (44% decrease at 0.56 μm)
- Reddening (198% increase over 0.4-0.55 μm)
- Change in spectral behavior: Blue to red
- Vesicles, no npOpagues, 0.03-0.24 μm thick melt
- **Carbon + silicate aggregates**

CONCLUSIONS + FUTURE WORK

- No npFe or npC required to darken and redden VNIR spectra of planetary materials
- C may generate alternative weathering products
- **Form of C may be inferred from VNIR spectra**
- Eight more mixtures to investigate!
- Graphitization state of C

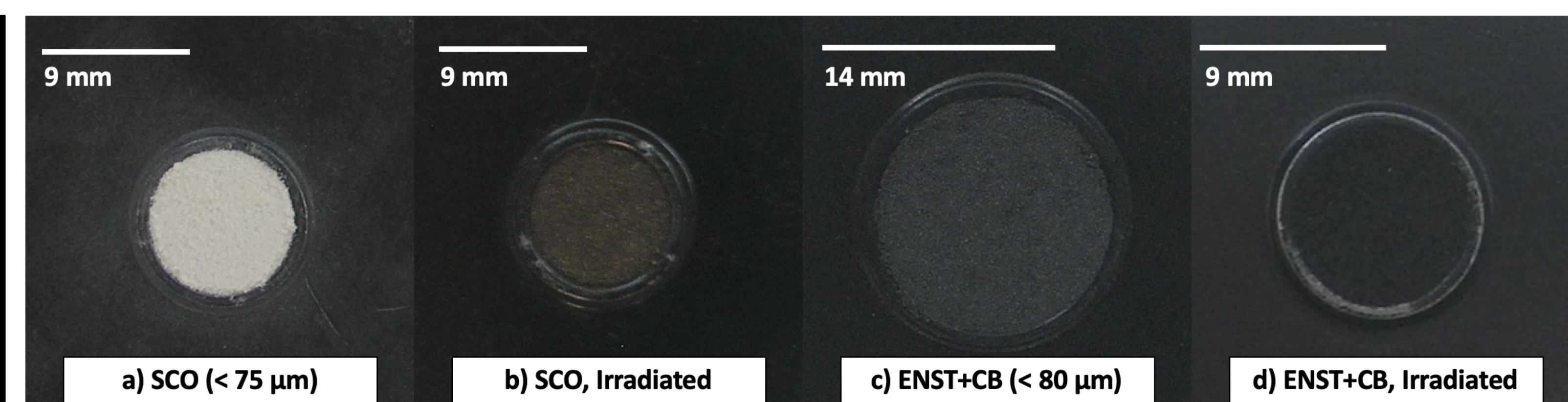


Figure 1 (above): a) San Carlos Olivine (SCO) before irradiation. b) San Carlos Olivine after 32 minutes of dual pulsed laser irradiation. c) 95 wt. % synthetic enstatite + 5 wt. % carbon black (ENST+CB) before irradiation. d) Synthetic enstatite + carbon black after 32 minutes of dual pulsed laser irradiation.

Figure 2 (right): SCO and ENST+CB spectra before and after irradiation. Note the different scales for reflectance on the y-axis for each plot.

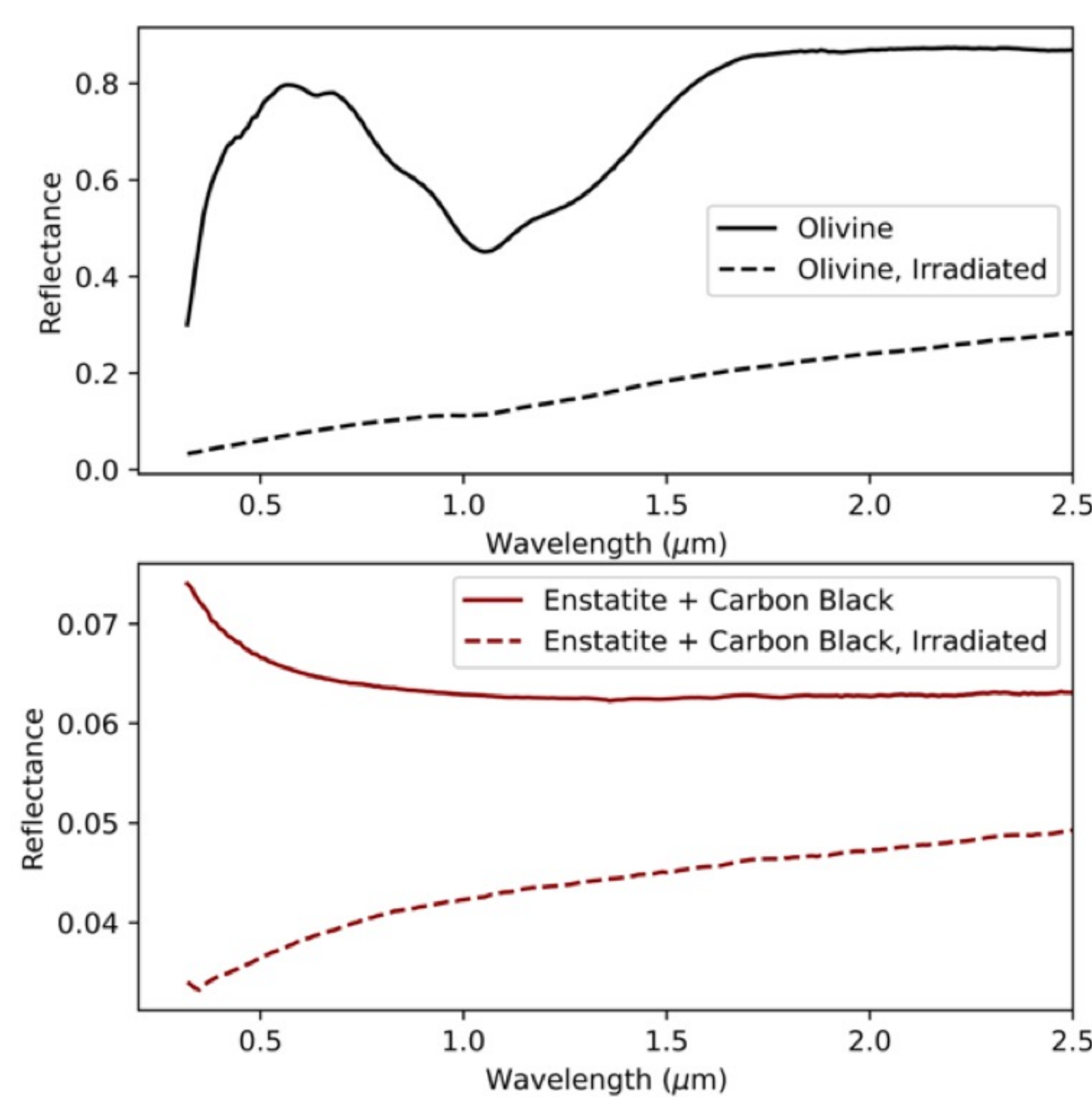


Figure 3 (below): SCO agglutinate viewed in the SEM.

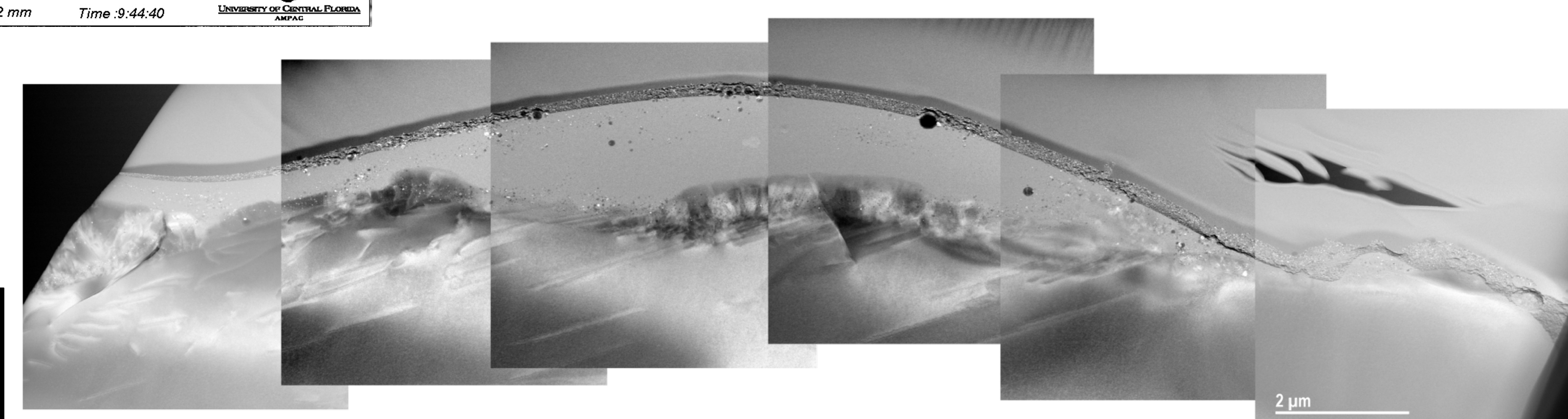


Figure 4 (above): Mosaic of SCO FIB section. Note the formation of melt, vesicles, and npFe of varying sizes (~8-230 nm).

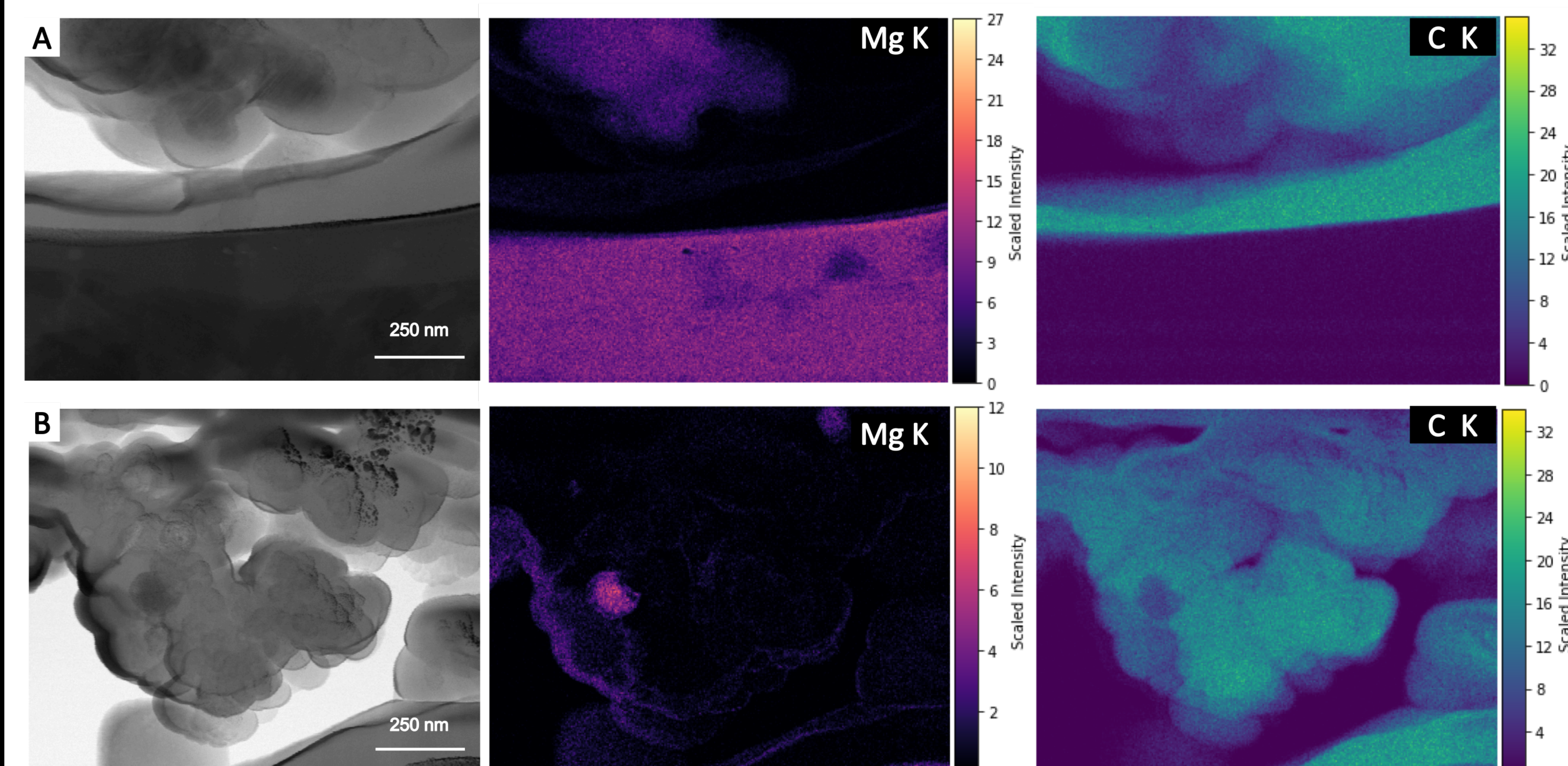


Figure 5 (above): BF STEM images of both carbon black aggregates present above the enstatite bulk with elemental maps for Mg and C obtained via EDS. Each color bar displays normalized counts for each map to obtain better image contrast. A) Aggregate displaying Mg enrichment. B) Aggregate with distinct melt spherule embedded within, evidenced by the bright Mg-rich deposit and corresponding C-depleted region.

Spectroscopy and microscopy papers coming soon to PSJ!
Shackelford et al. 2025