

Compositions of Diverse Noachian Lithologies at Marathon Valley, Endeavour Crater Rim, Mars

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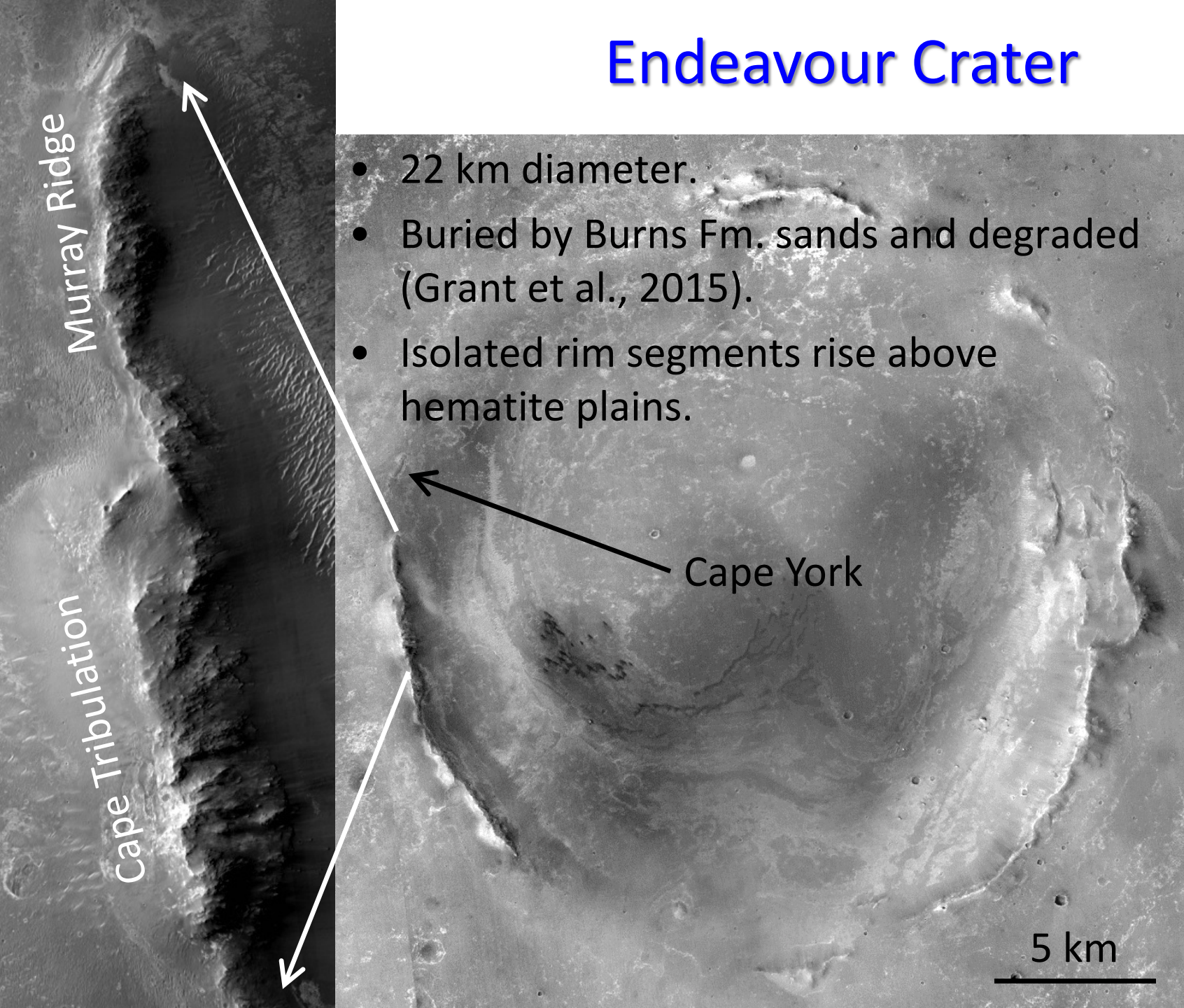
synopsis

- Opportunity is working on Sol (day) 4187 activities, having completed 4552% of her primary mission*.
- Describe the rocks from Marathon Valley region.
- Present the compositional data for different locations.
- Give preliminary interpretation/discuss open issues.

*It would be like me being out in the field with my rock hammer at 3536 years of age!

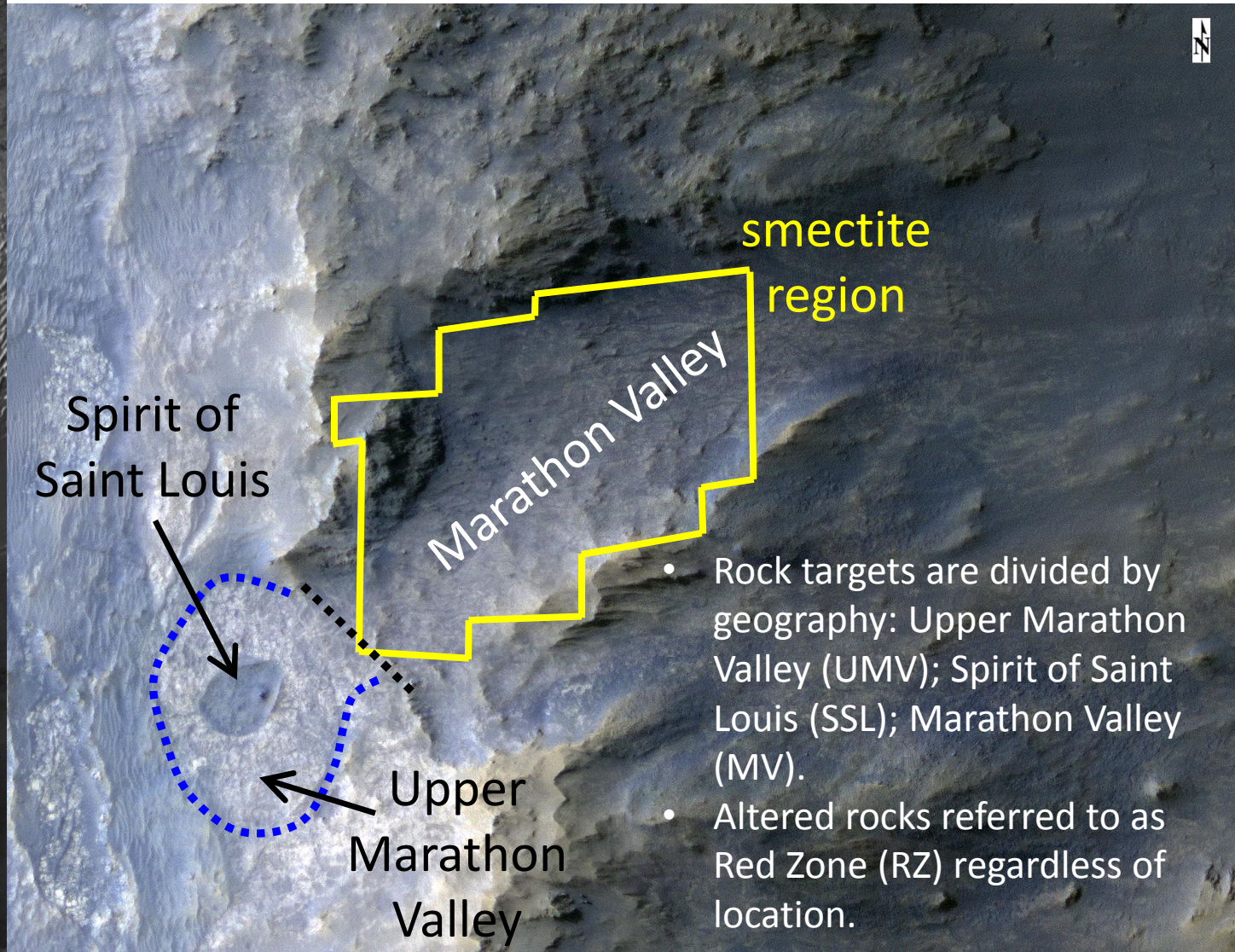
Endeavour Crater

- 22 km diameter.
- Buried by Burns Fm. sands and degraded (Grant et al., 2015).
- Isolated rim segments rise above hematite plains.



Marathon Valley

- Fe-Mg smectites identified in floor of Marathon Valley from CRISM data (Fox et al., 2014).

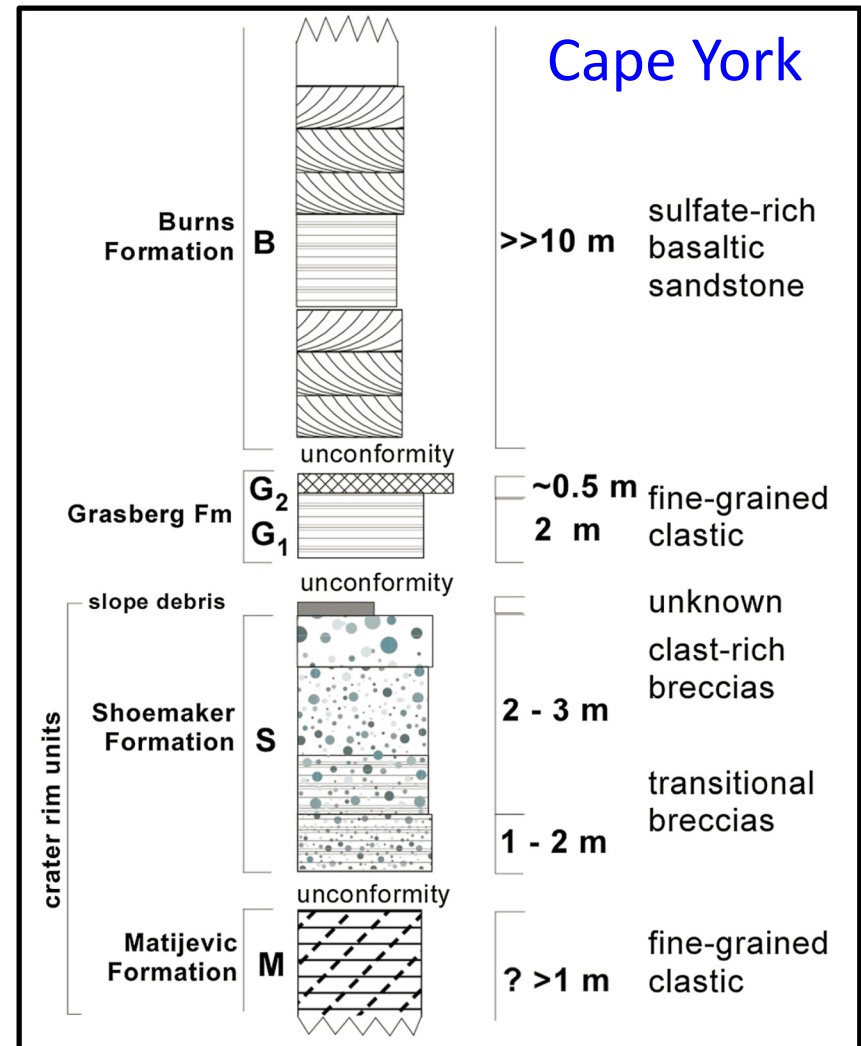


- Rock targets are divided by geography: Upper Marathon Valley (UMV); Spirit of Saint Louis (SSL); Marathon Valley (MV).
- Altered rocks referred to as Red Zone (RZ) regardless of location.

Geological Background

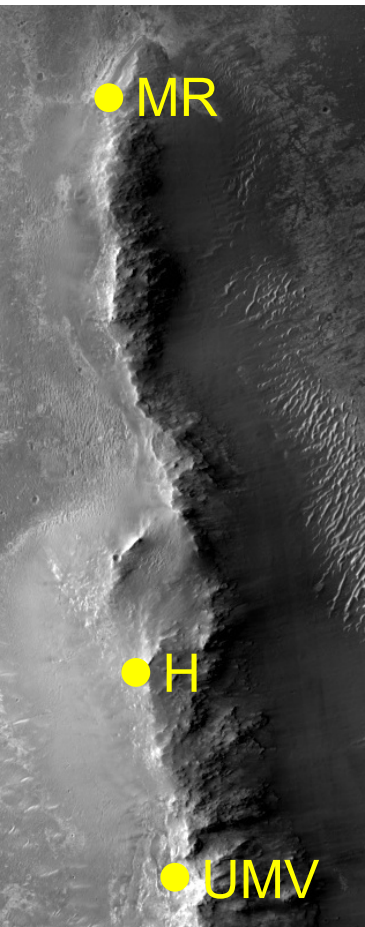
- **Matijevic Formation:** Pre-impact lithology; observed only on inboard side of Cape York segment.
- **Shoemaker Formation:** Polymict impact breccias formed by the Endeavour impact.
- **Grasberg Formation:** Post-impact unit draping lower portions of Endeavour rim segments; forms annuli around rim segments.
- **Burns Formation:** Widespread plains unit; sulfate-rich sandstones; partially infills Endeavour crater.

Crumpler et al. (2015)

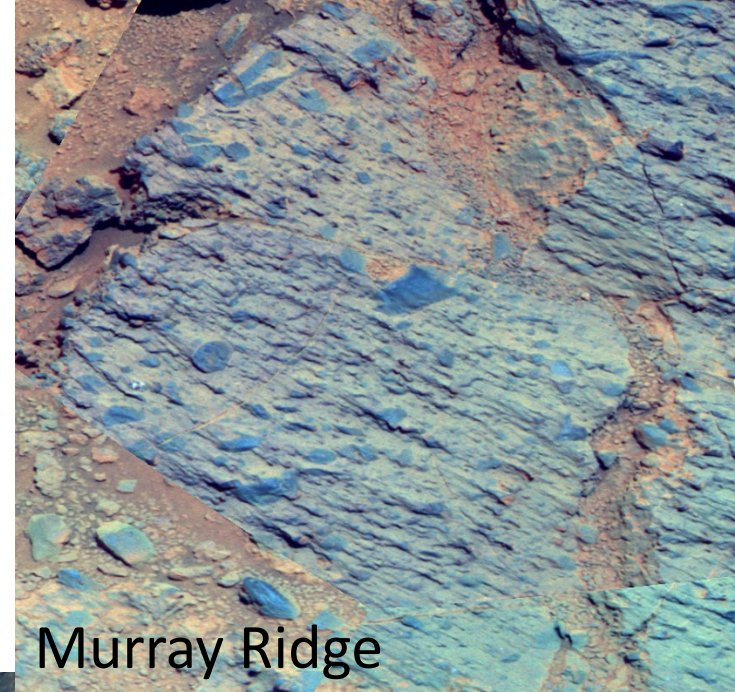


Macroscopic Textures

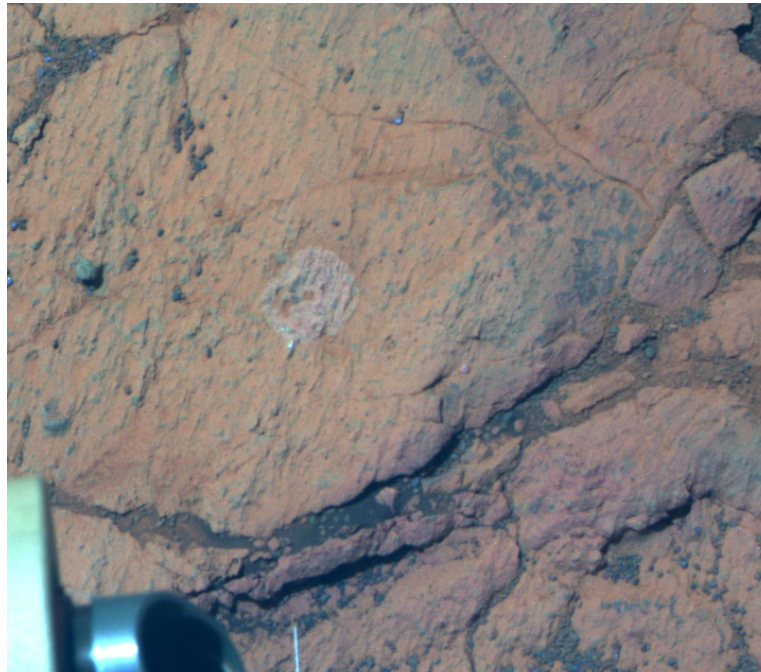
- Endeavour rim breccias (Shoemaker Fm.) typically coarse, clast-rich polymict breccias (Murray Ridge).
- Some finer grained and clast-poor (Hueytown).
- Upper Marathon Valley rocks more like the latter.



Pancam false-color images



Murray Ridge



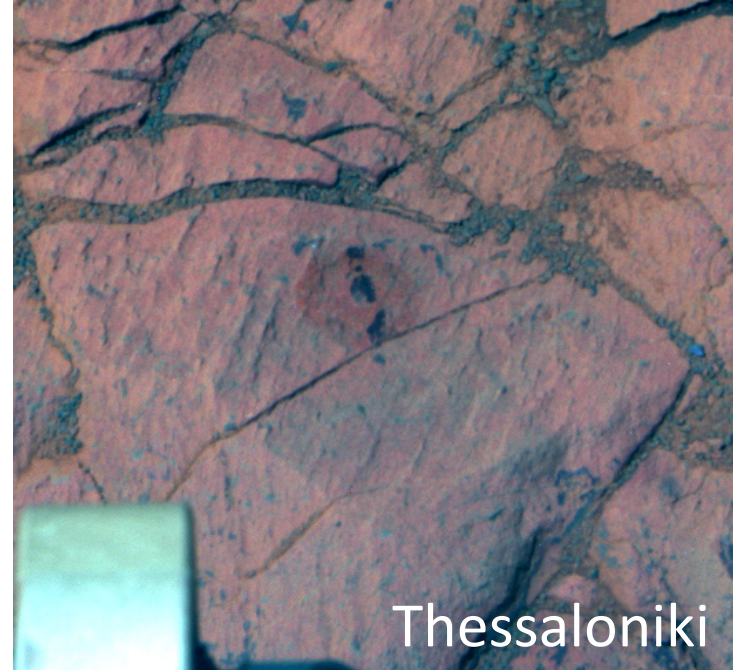
Upper Marathon Valley



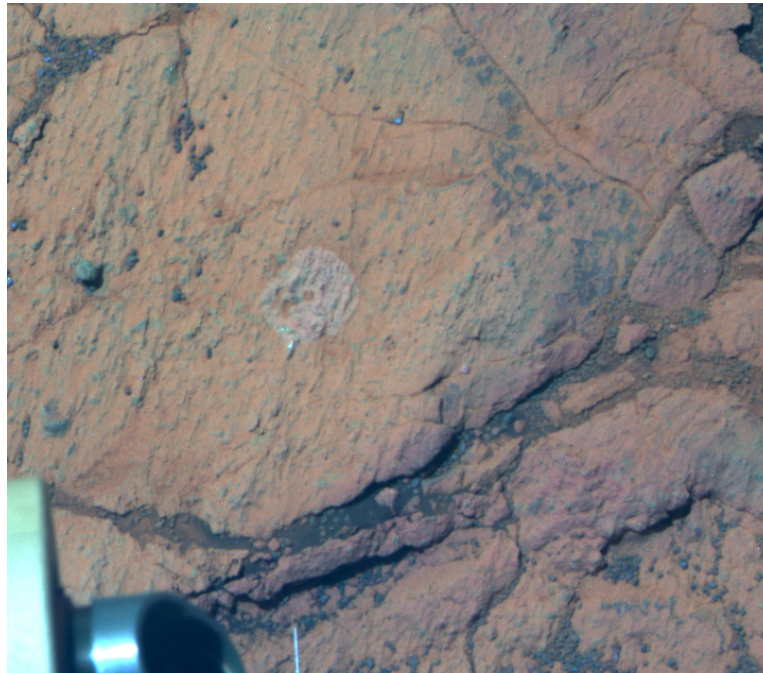
Hueytown

Macroscopic Textures

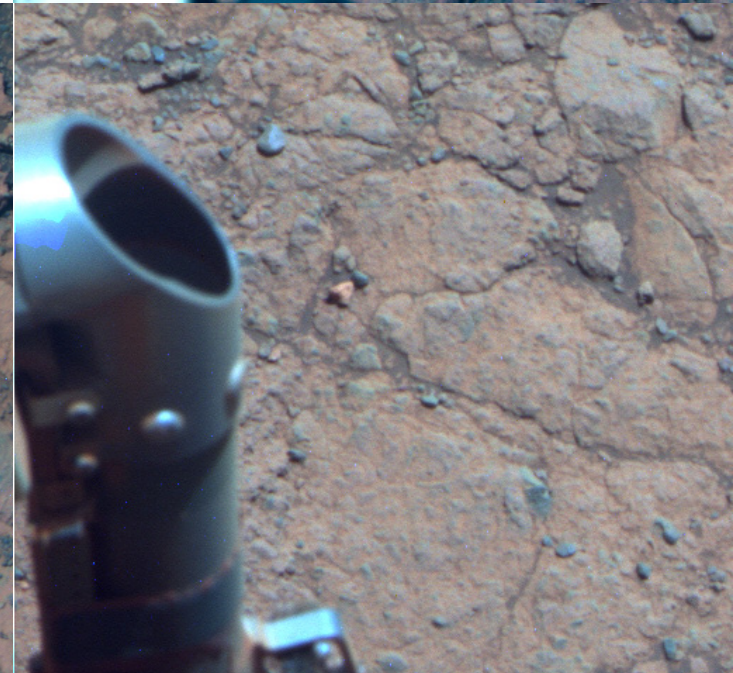
- Marathon Valley rocks generally similar to Upper Marathon Valley rocks; finer-grained and clast-poor compared to Shoemaker Fm. breccias.
- Some Upper Marathon Valley rocks very fine-grained (Thessaloniki).



Thessaloniki



Upper Marathon Valley

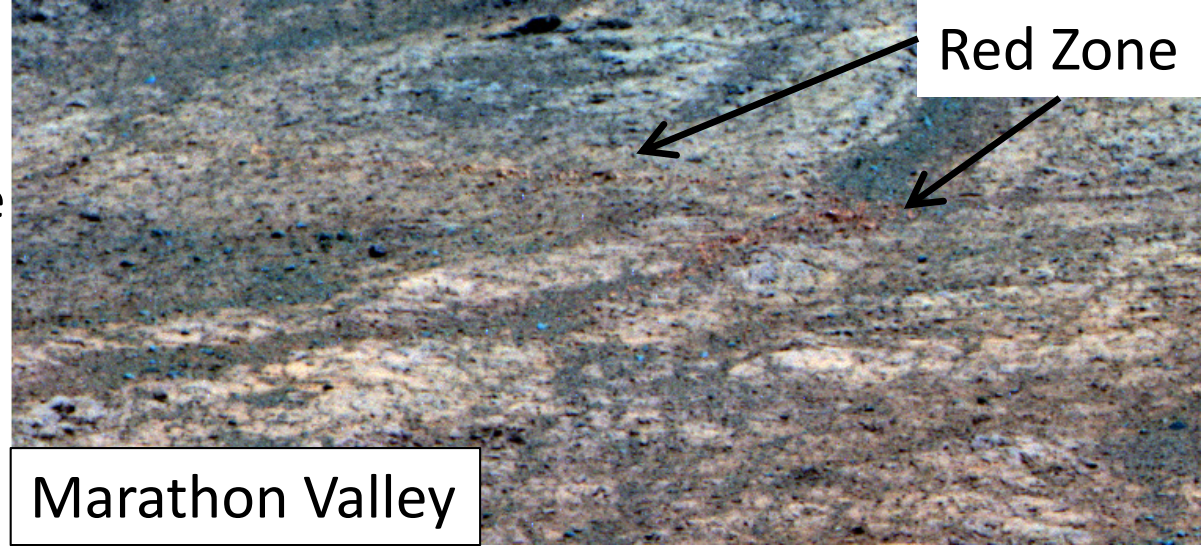


Marathon Valley

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Alteration

- Curvilinear zones of more reddish rock (Red Zones) occur throughout the region.
- Red Zone locally borders Spirit of Saint Louis.
- Red Zones not observed in Shoemaker Fm. outcrops.



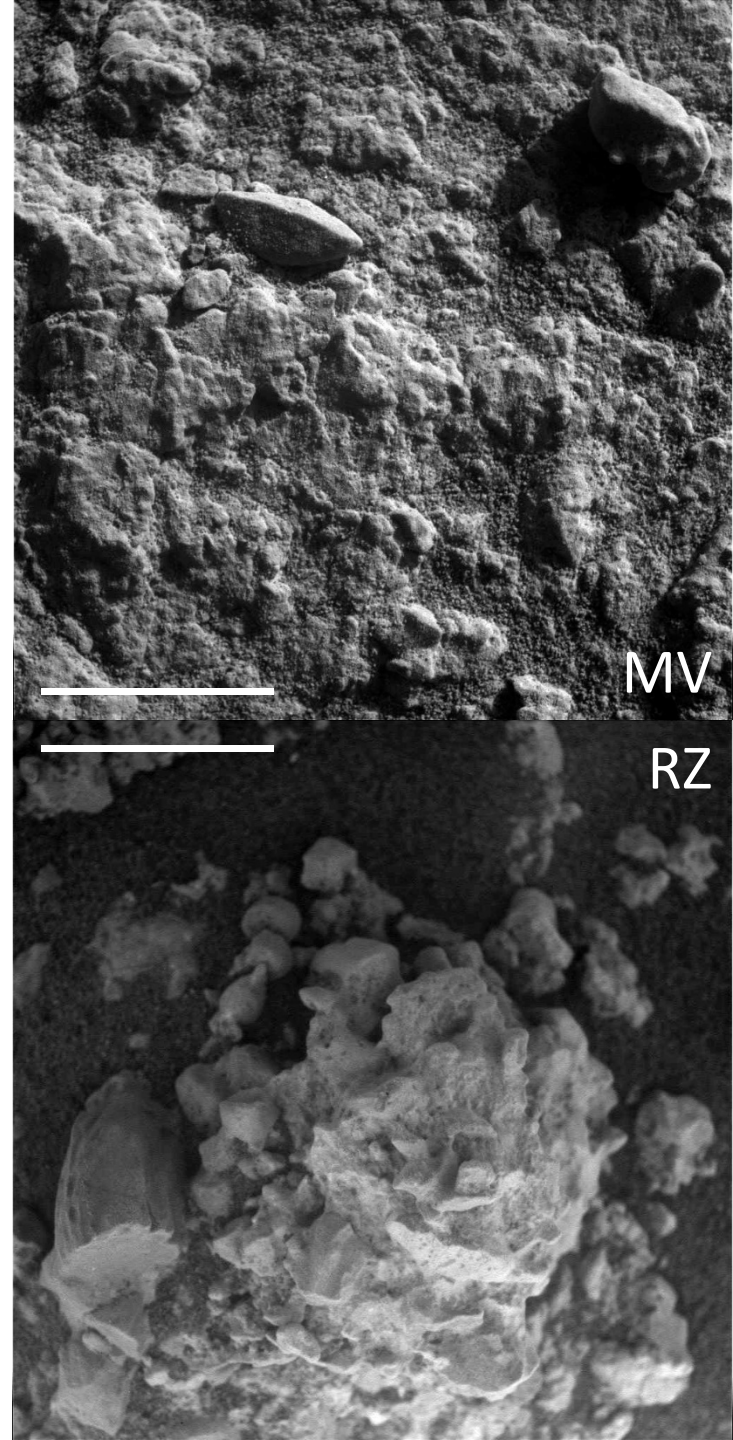
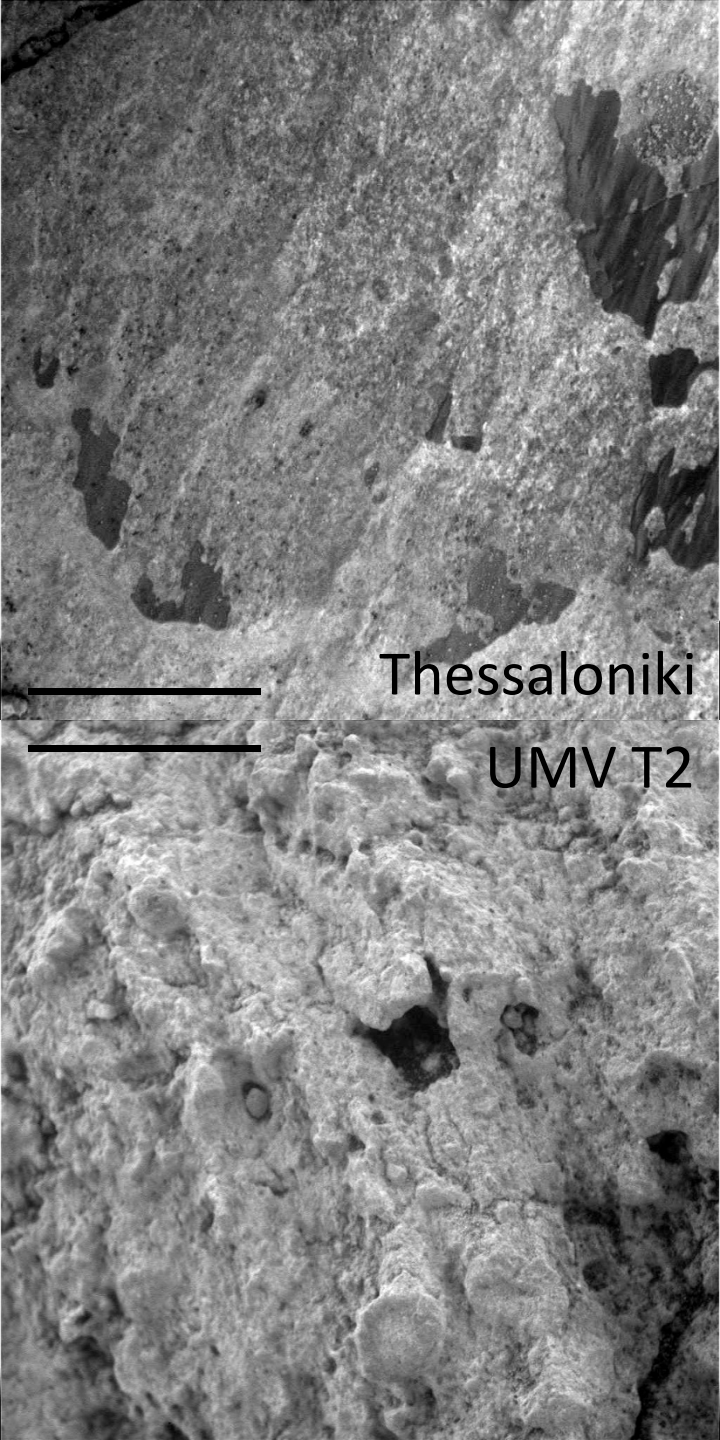
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Textures

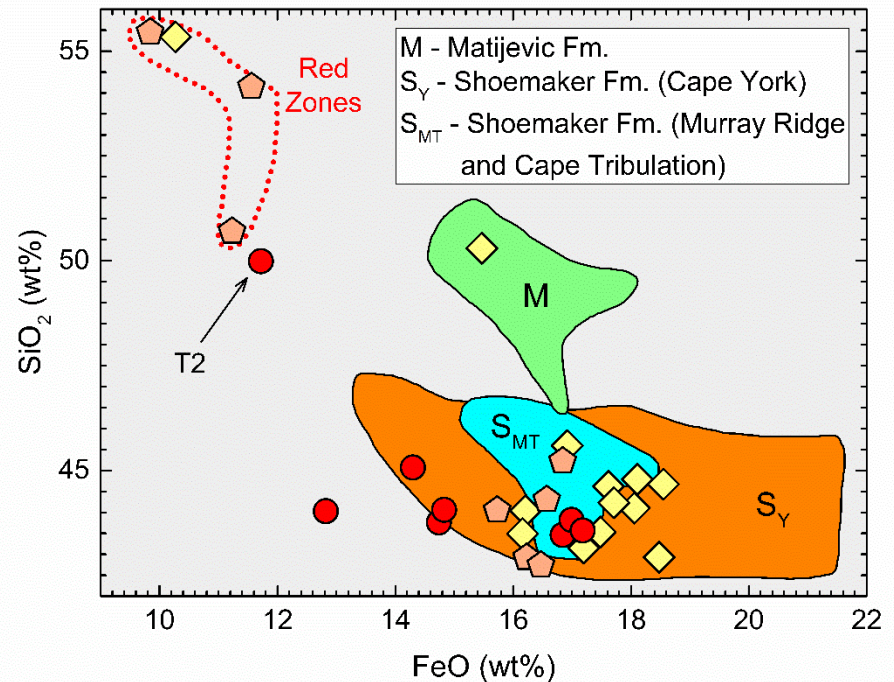
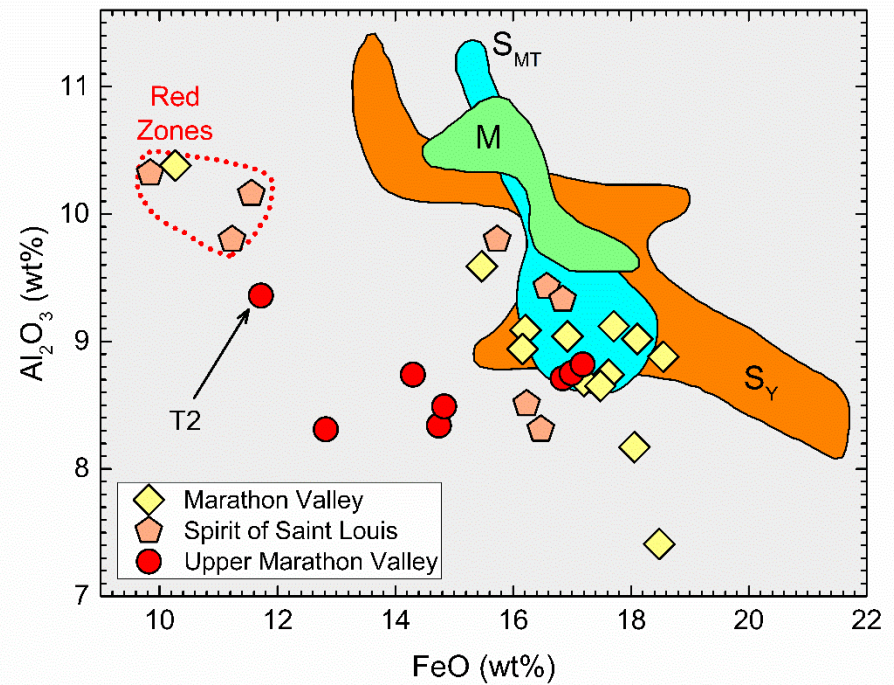
- Some Upper Marathon Valley rocks fine-grained with small clasts (Thessaloniki).
- Others are coarser-grained with larger clasts (UMV T2); similar to Marathon Valley (MV) rocks.
- Red Zone (RZ) rocks have hackly surfaces; appear cemented.

MI images
Scale bars = 1 cm



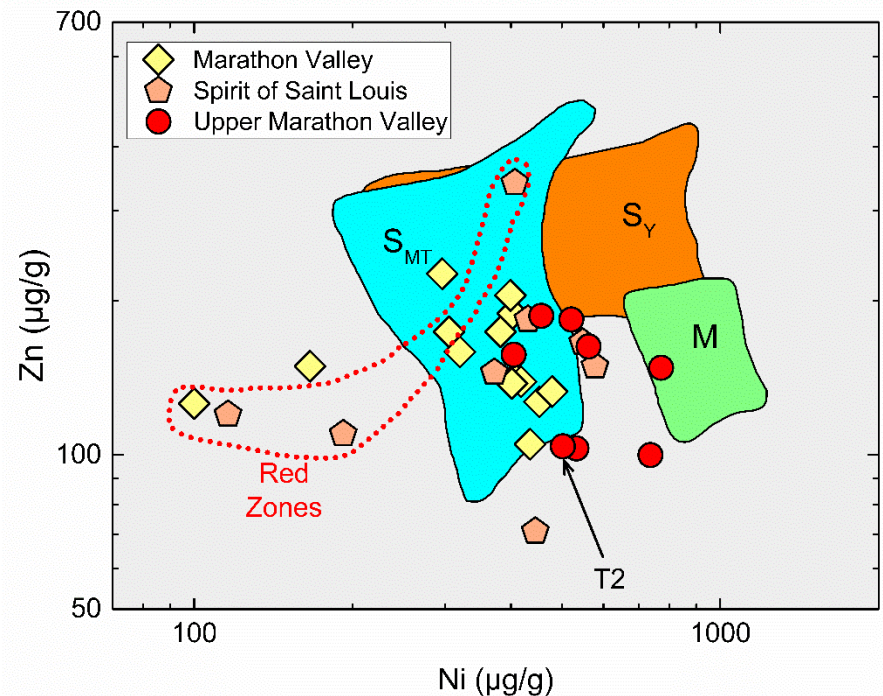
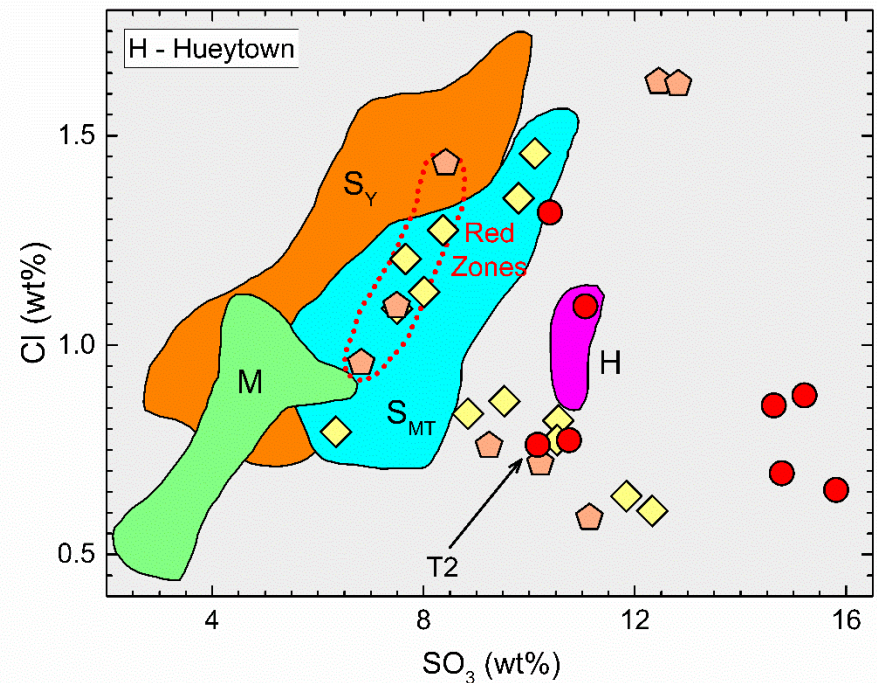
Compositions

- Rocks from Marathon Valley region generally distinct in composition from Matijevic Fm.
- They are compositionally similar to Shoemaker Fm. impact breccias.
- Rocks from Red Zones are compositionally distinct.
- Thermopylae2 (T2) has compositional signature of Red Zones; textural similarity too.



Compositions

- Marathon Valley and region rocks generally have higher SO_3 than Shoemaker Fm. impact breccias.
- Volatile/mobile elements generally similar inside and outside Red Zones, but:
 - SO_3 and Ni tend to be lower in the Red Zones.



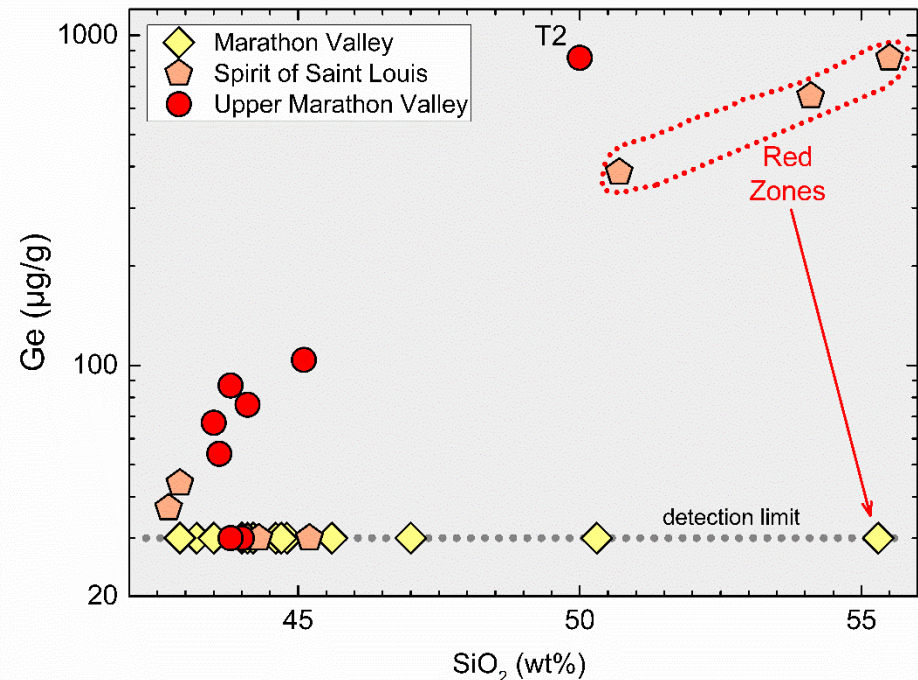
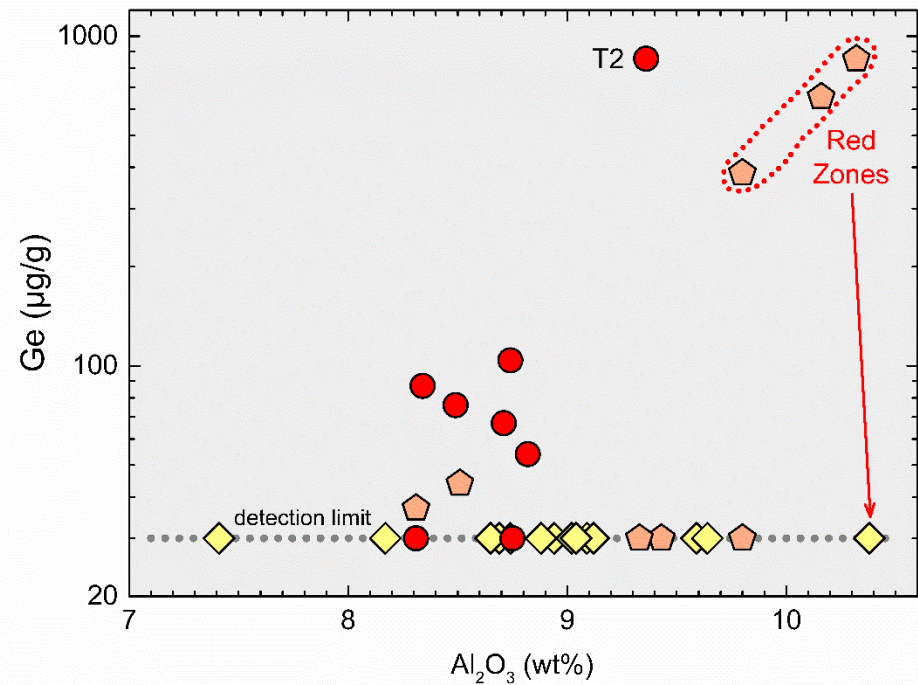
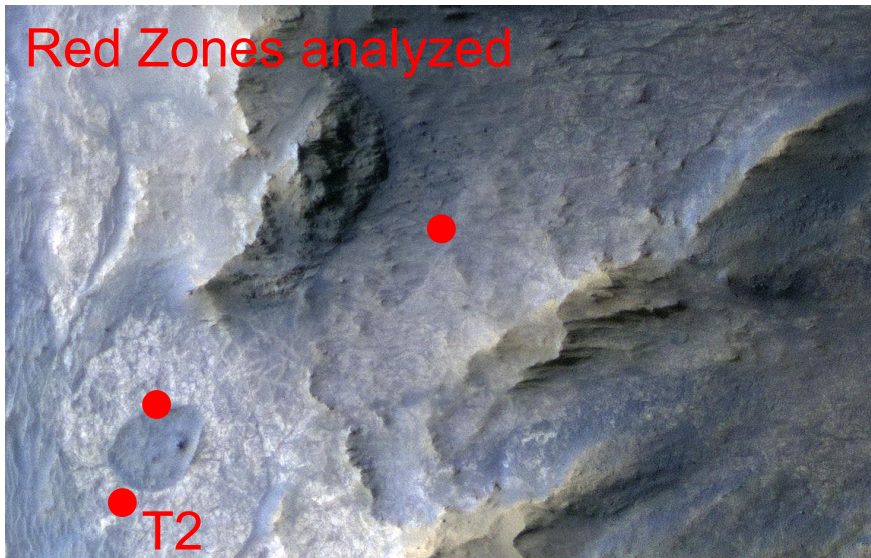
Summary 1

- Marathon Valley region rocks are breccias, but texturally distinct from most Shoemaker Fm. breccias.
- They show some textural similarity to breccias from nearby Hueytown.
- They are broadly similar in composition to Shoemaker Fm.
- They are distinct from the pre-impact Matijevic Fm.
- Are Marathon Valley region rocks Endeavour crater breccias?
 - Need to work out geology at the contact.



Compositions

- Ge enrichment observed in many, but not all, Upper Marathon Valley and Spirit of Saint Louis rocks.
- Ge enrichment correlates with Al_2O_3 and SiO_2 .
- Highest Ge yet measured on Mars in Red Zones.
- No Ge enrichment in Marathon Valley rocks, not even in Red Zones.*

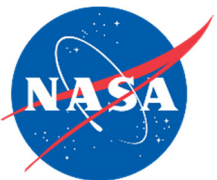


Ge Mobilization

- Ge is mobilized in hydrothermal fluids.
- High Ge in some Red Zones, but not, all suggests differences in fluid compositions and/or properties.
- Fluid temperature can affect Ge/Si ratio (Pokrovski & Schotte, 1998) but is not likely to explain observations.
- Earlier mineral precipitation could raise Ge/Si of fluids (Escoube et al., 2015; Mortlock et al., 1993)
 - Does not explain high- and low-Ge Red Zones with similar major element contents.
- In hydrothermal deposits, Ge substitutes in Fe-oxyhydroxides, sulfides or sulfosalts (Bernstein, 1985).
 - No Ge-S or Ge-Fe correlations.

Summary 2

- Red Zones show strong enrichments in SiO_2 and lesser enrichments in Al_2O_3 .
- Upper Marathon Valley/Spirit of Saint Louis rocks have enrichments in Ge correlated with Al_2O_3 and SiO_2 .
- Coupled Ge-Si (and Al) mobilization suggests alteration by aqueous fluids, but compositional signature does not yet constrain the process.
- **Marathon Valley has broad-scale mineralogical evidence for alteration, yet has no Ge enrichment.**
- Go figure.



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