

# **Carbon Sequestration on Mars: Possible Insights from the Mg- Carbonate/Olivine Lithologies at NE Syrtsis or Jezero Crater**

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# Mineral Carbonation

- **Were the Mg-carbonates at NE Syrtis and/or Jezero crater formed via carbonation?**
- **How do these carbonates compare to the Comanche Spur carbonates?**
- **Was carbonation a globally significant process on Mars?**

# Mineral Carbonation

- Carbonation is the water-mediated replacement of silicate minerals by carbonate
- Occurs at low temperature and pressure, where  $\text{CO}_2$  and  $\text{H}_2\text{O}$  are available
- Exothermic reaction = self-propagating
- Common on Earth (e.g., Samail Ophiolite, Oman)



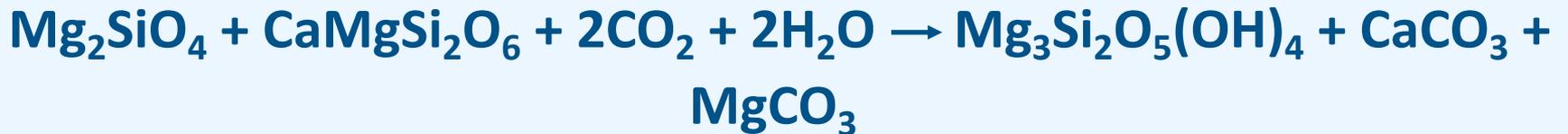
**Samail Ophiolite, Oman.**  
**Image Credit: Evelyn Mervine**

# Serpentinization



Mg-olivine + aqueous silica + water  $\rightarrow$  serpentine

# Carbonation



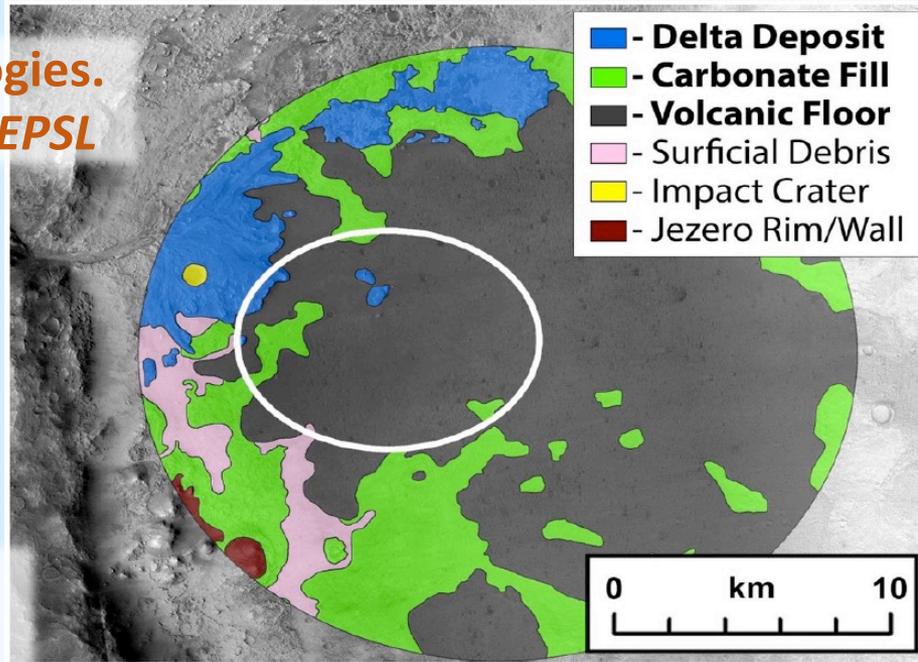
Mg-olivine + CaMg-pyroxene + carbon dioxide + water  $\rightarrow$  serpentine + calcite + magnesite



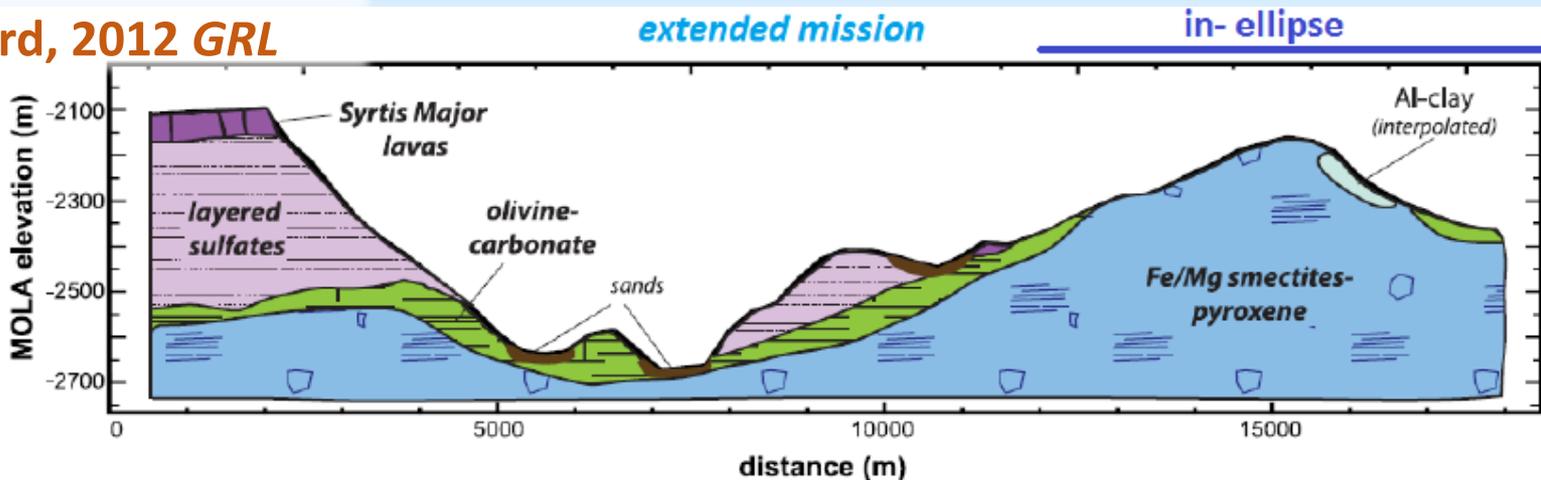
serpentine + carbon dioxide  $\rightarrow$  talc + water + magnesite

# Jezero and NE Syrtis carbonates

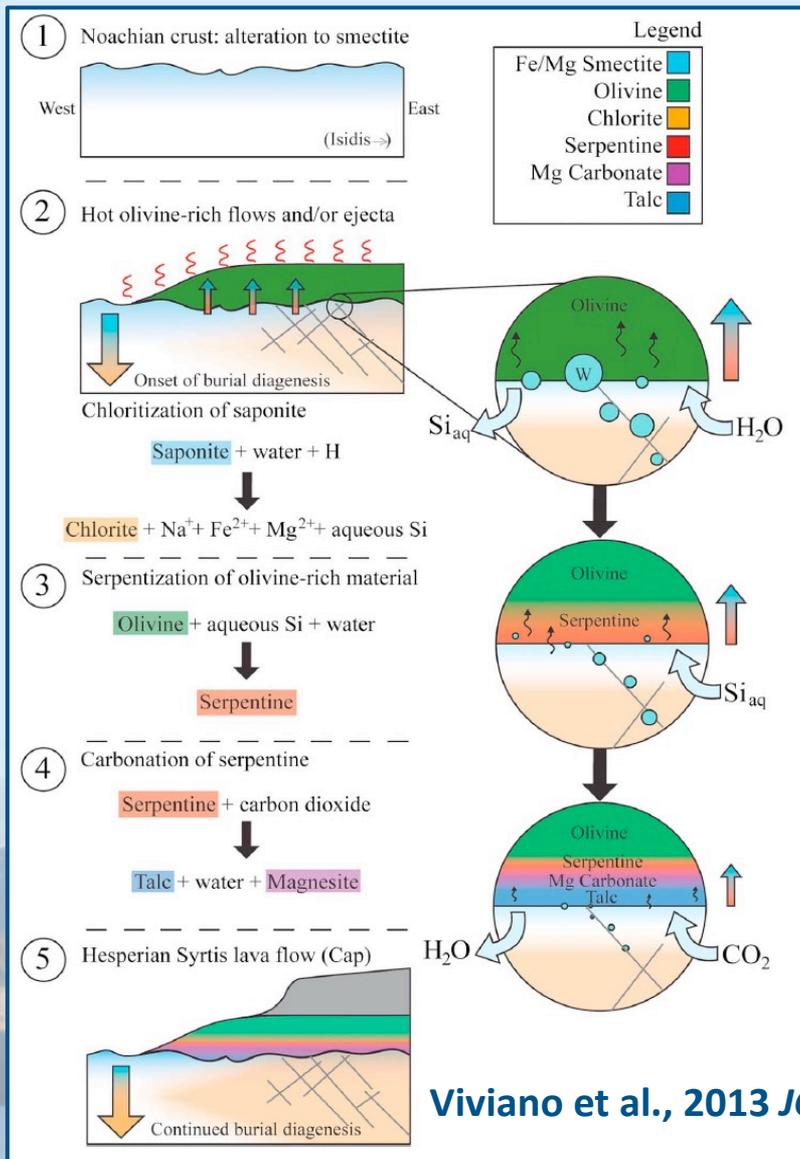
Jezero crater lithologies.  
Goudge et al. 2017 *EPSL*



NE Syrtis cross section. Ehlmann and Mustard, 2012 *GRL*



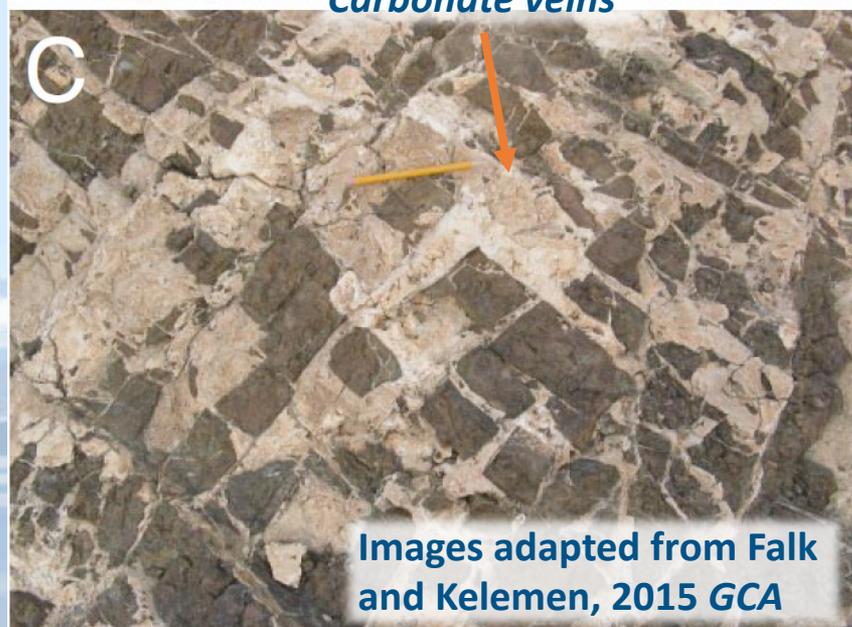
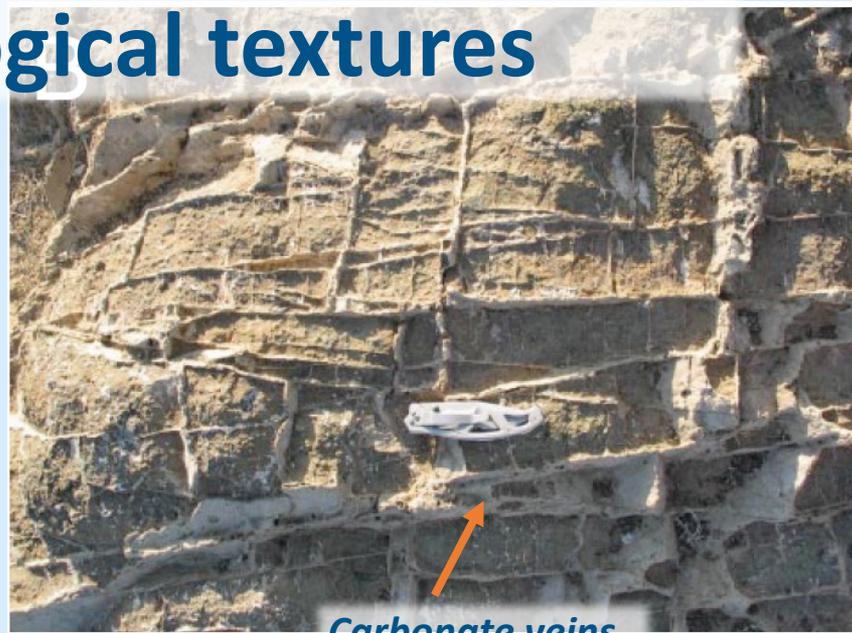
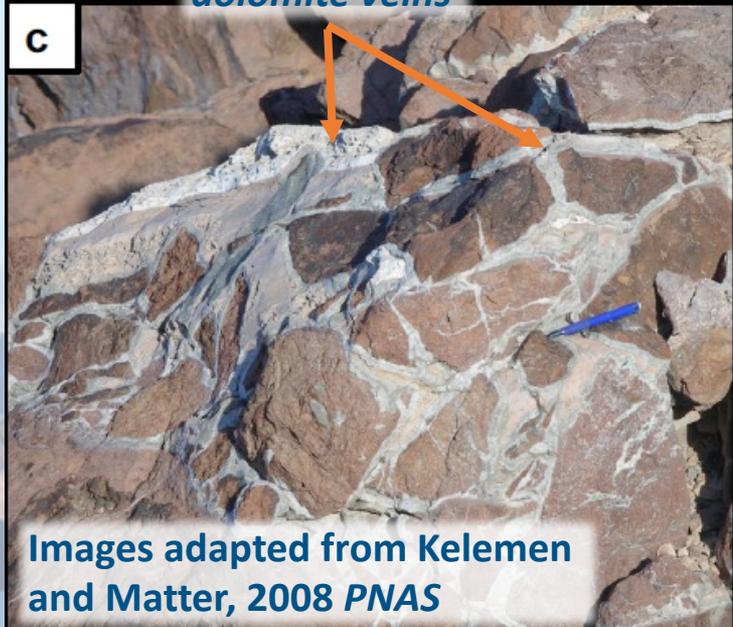
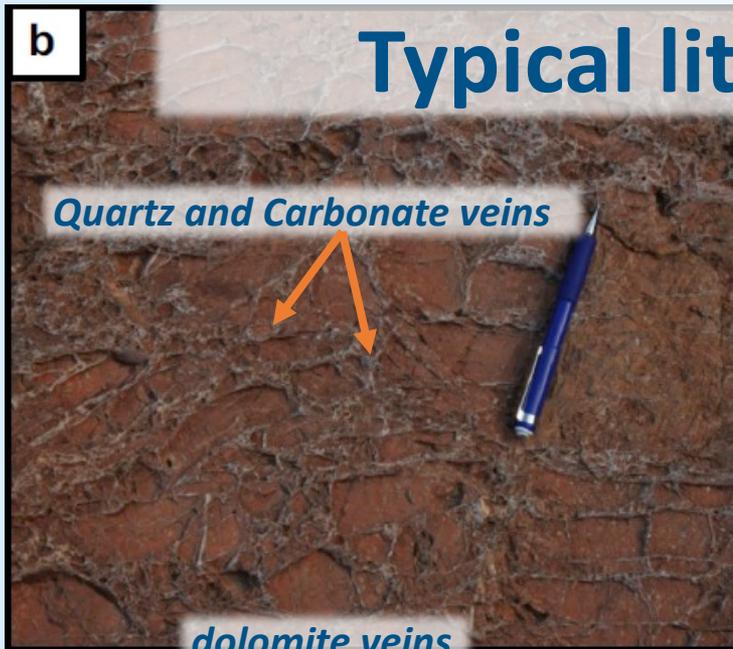
# Formation Model



Viviano et al., 2013 *JGR*

- Possible alteration sequence for E. Nilli Fossae Mg-carbonate/olivine rich region
- Initial heat source = lava/ejecta emplacement
- 2.3  $\mu\text{m}$  absorption feature represents talc and/or saponite
- Rover mineralogical and textural analyses could test this model

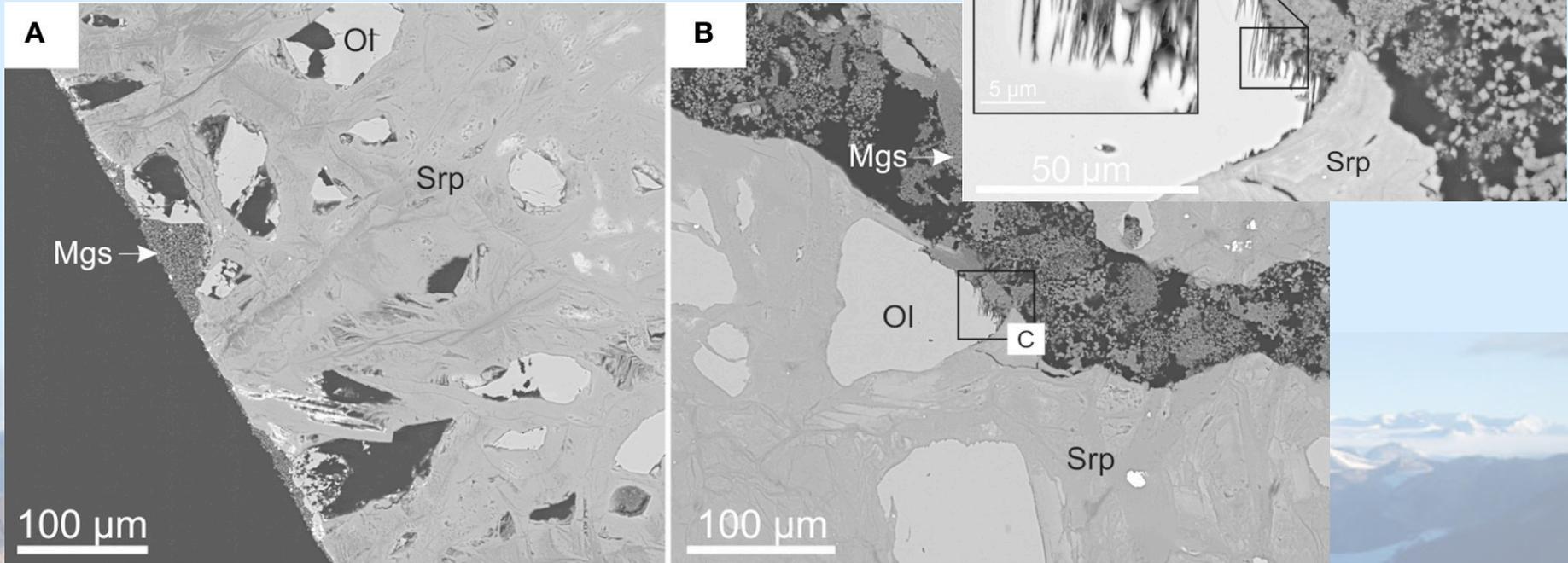
# Typical lithological textures



# Returned sample microscopic textures

Small scale features include:

- rounded/embayed olivine relics
- Increased porosity

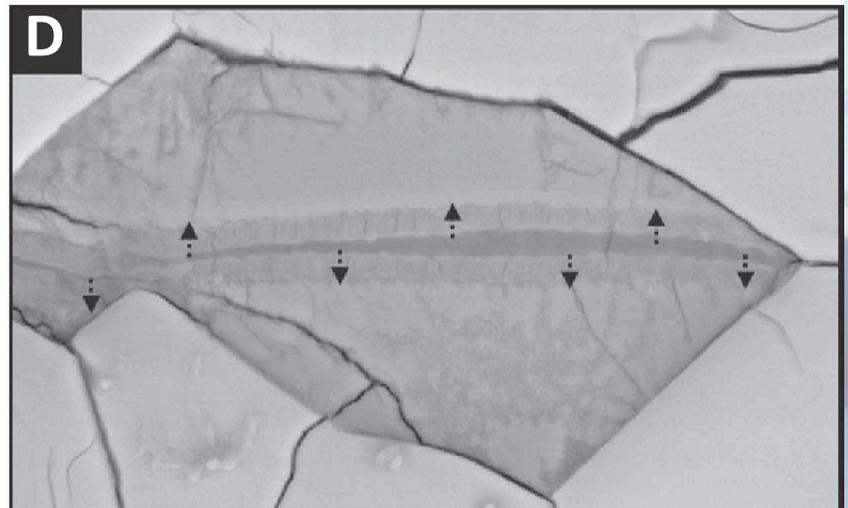
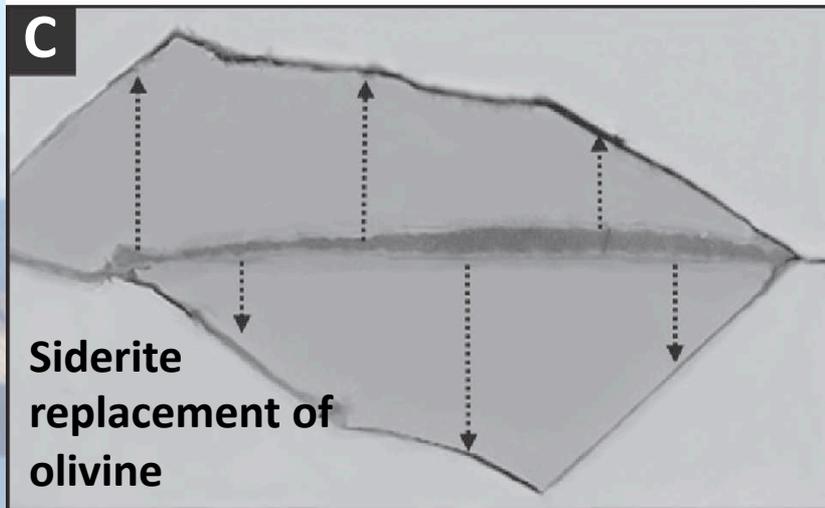
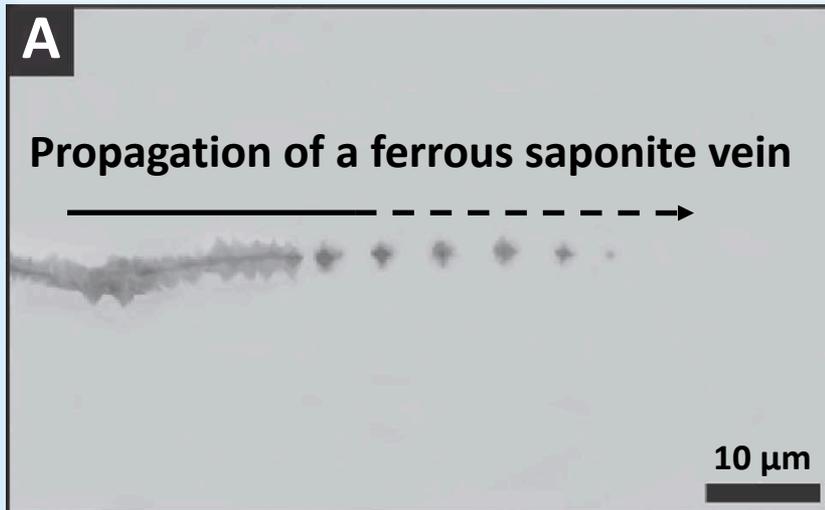


Images of altered dunite, adapted from Lacinska et al., 2017 *Frontiers in Earth Sci.*

# Evidence in Nakhrites?

A-C are cartoons showing a sequence of replacement reactions within Lafayette olivine, resulting in (D) a carbonate-rich alteration vein.

Images adapted from Tomkinson et al., 2013 *Nature. Comms.*

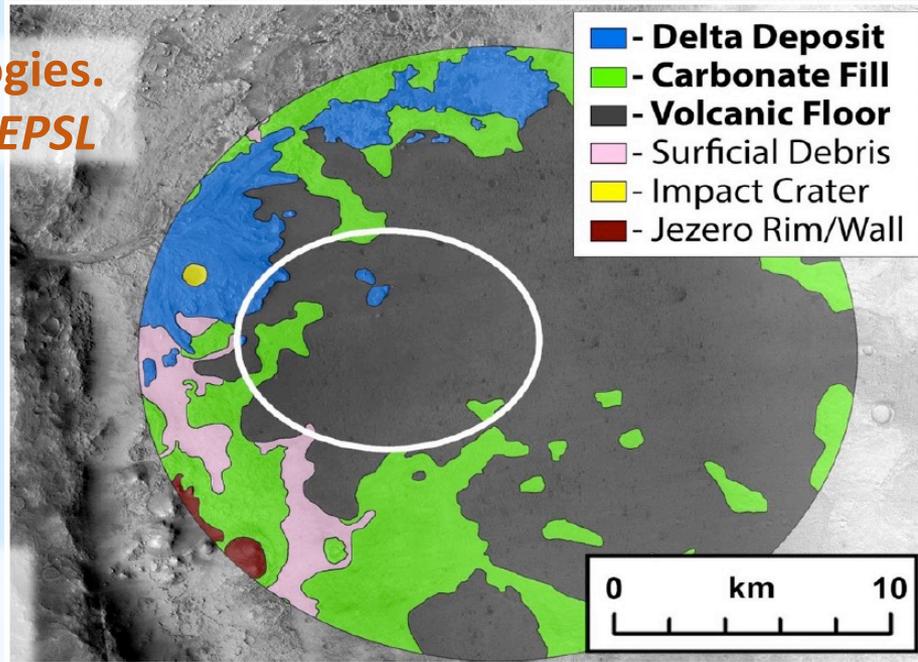


# What information could be gained from returned carbonates?

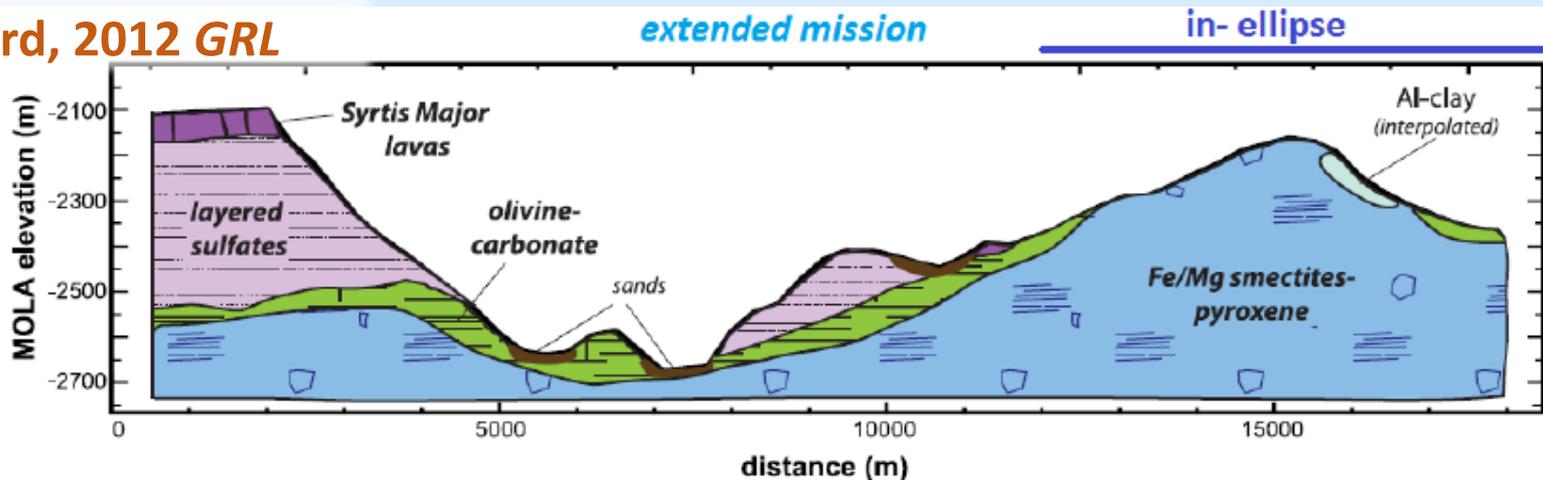
- A** • **Temperature of formation: carbonate clumped isotope paleothermometer is based on the temperature-dependent abundance of  $^{13}\text{C}$ – $^{18}\text{O}$  bonds in carbonate minerals**
- B** • **Age of formation IF formed from single fluid event**
- **Fluid composition(s) – possible presence of fluid inclusions?**
- **Quartz veins – ideal environments for the preservation of microfossils**

# Jezero and NE Syrtis carbonates

Jezero crater lithologies.  
Goudge et al. 2017 *EPSL*



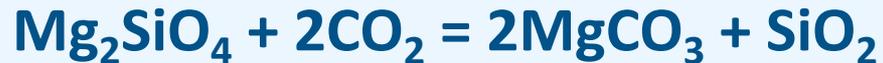
NE Syrtis cross section. Ehlmann and Mustard, 2012 *GRL*



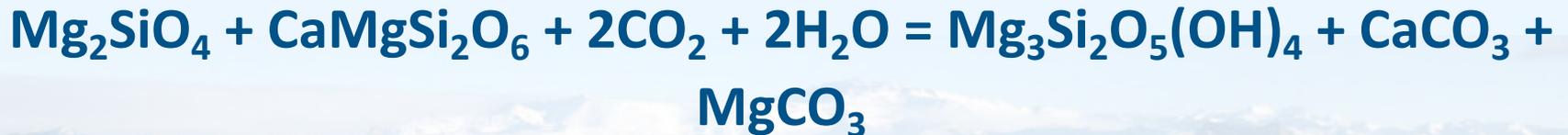
# Carbonation reactions



Mg-olivine + Mg-pyroxene + water = serpentine



Mg-olivine + carbon dioxide = magnesite + quartz



Mg-olivine + CaMg-pyroxene + carbon dioxide + water = serpentine + calcite + magnesite

# Carbonation reactions

