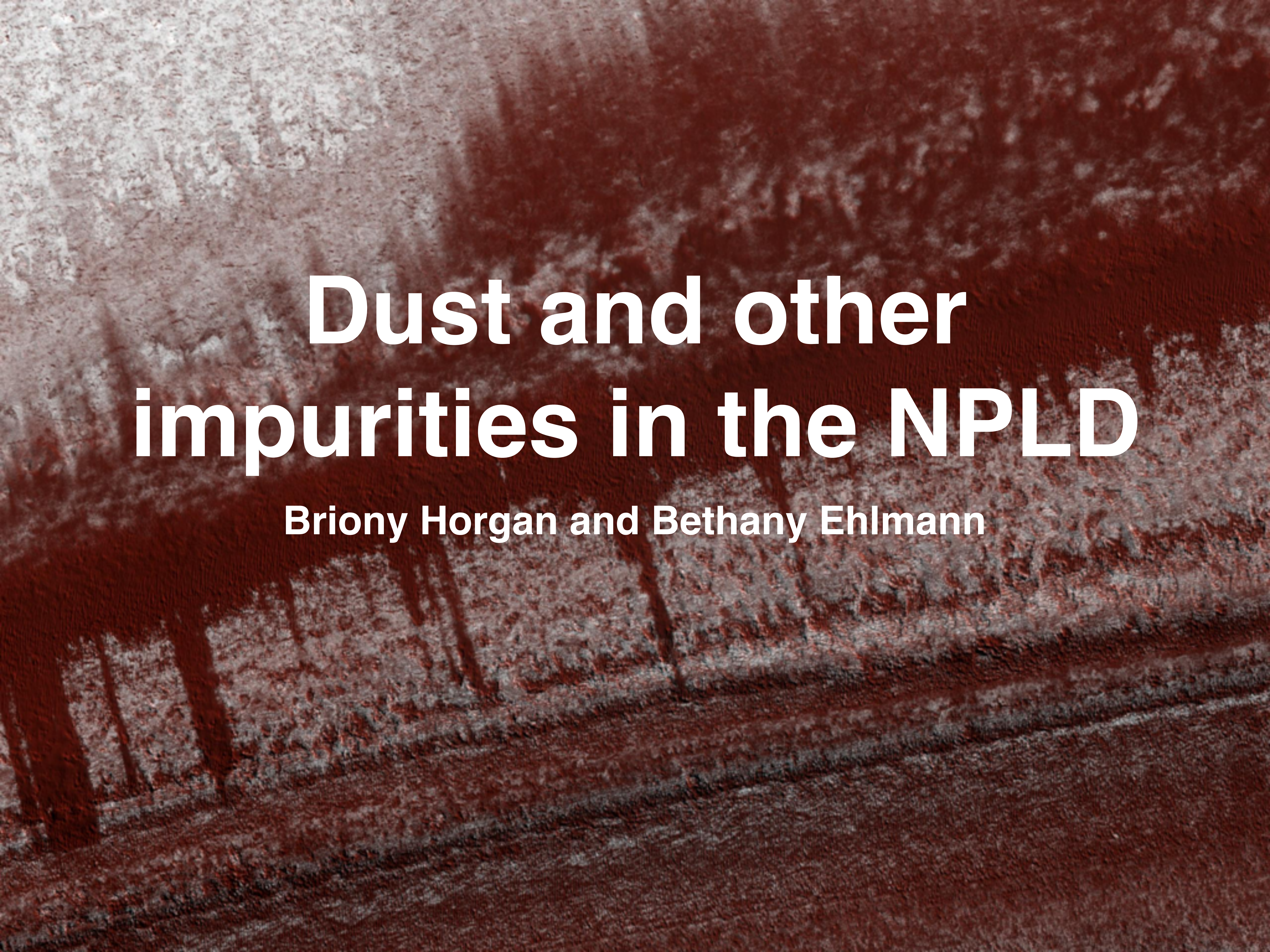


Dust and other impurities in the NPLD

Briony Horgan and Bethany Ehlmann

Three types of "impurities/dust/lithics" have been detected via orbital visible/near-infrared spectroscopy in the NPLD:

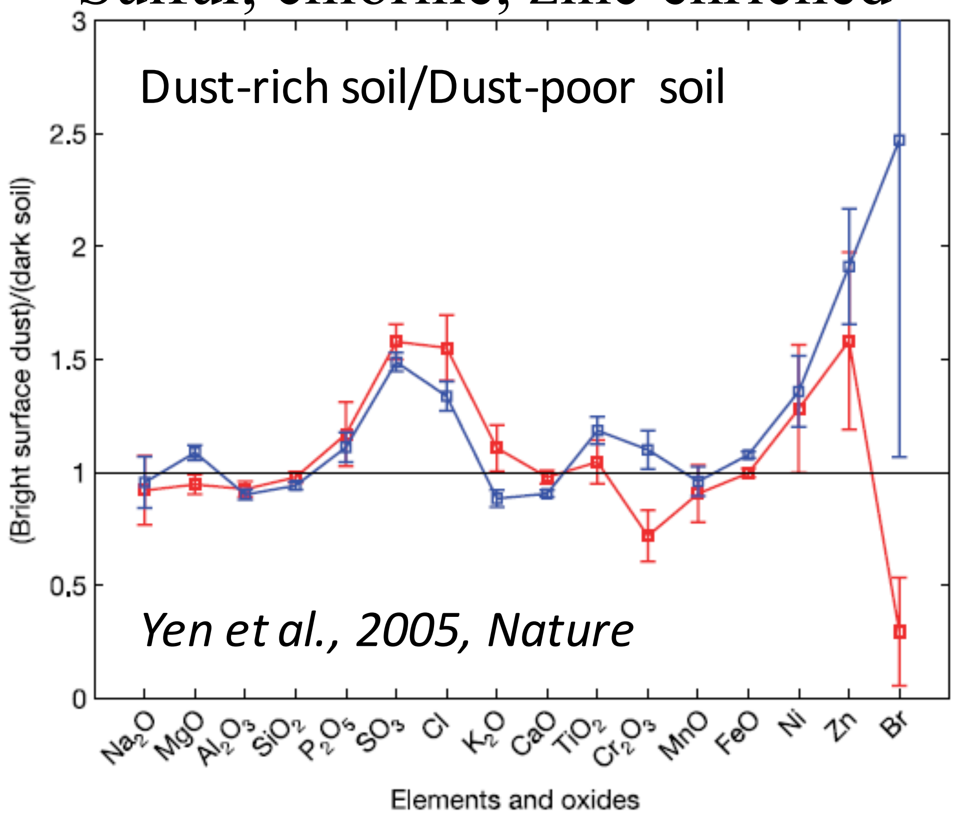
(1) **Dust** - on Mars, a globally distributed material with an apparently homogeneous and thus specific composition. Exhibits strong *ferric* iron spectral signatures. Lofted into suspension by saltating sand and dust devils to form an important component of the climate system.

(2) **Mafic sediments** - sand and other unknown grain sizes with strong *ferrous* iron spectral signatures. Present in the basal unit and PB2 unit, provide a sand source for the north polar sand sea. Often exhibit evidence for aqueous alteration.

(3) **Salts** - sulfate and perchlorate spectral signatures are found within the NPLD and the surrounding dunes at variable concentrations. Origin could be related to atmospheric deposition and/or weathering within/on the ice cap.

What we know about Mars dust

Sulfur, chlorine, zinc enriched

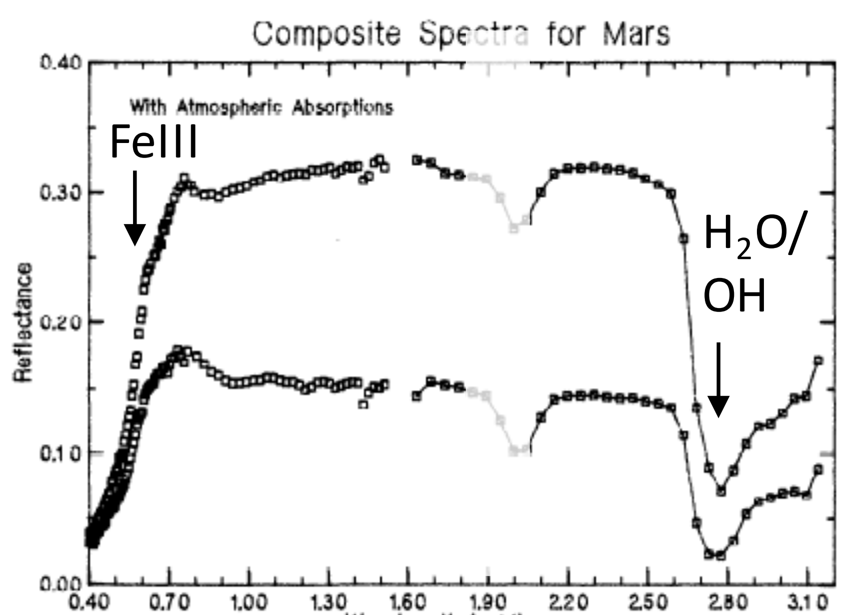


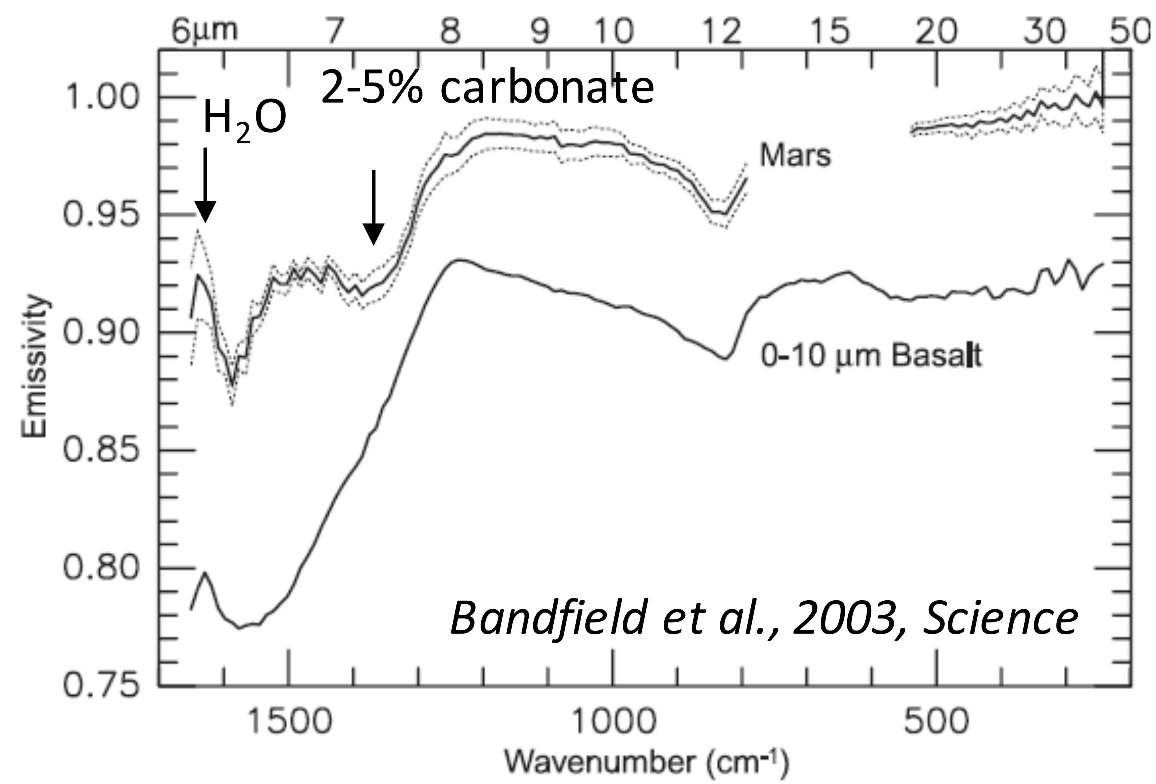
45% Fe(III)/FeT, mainly as ferric nanocrystalline oxides

55% FeII/FeT, incl. olivine, pyroxene, titanomagnetite

Goetz et al., 2005, Nature

A strong FeIII absorption but lack the absorptions of well-crystalline oxides (Morris et al. 2000). Dominantly plagioclase and framework hydrated silicates, lesser amounts of olivine, pyroxenes, and sulfates (Hamilton et al. 2005).





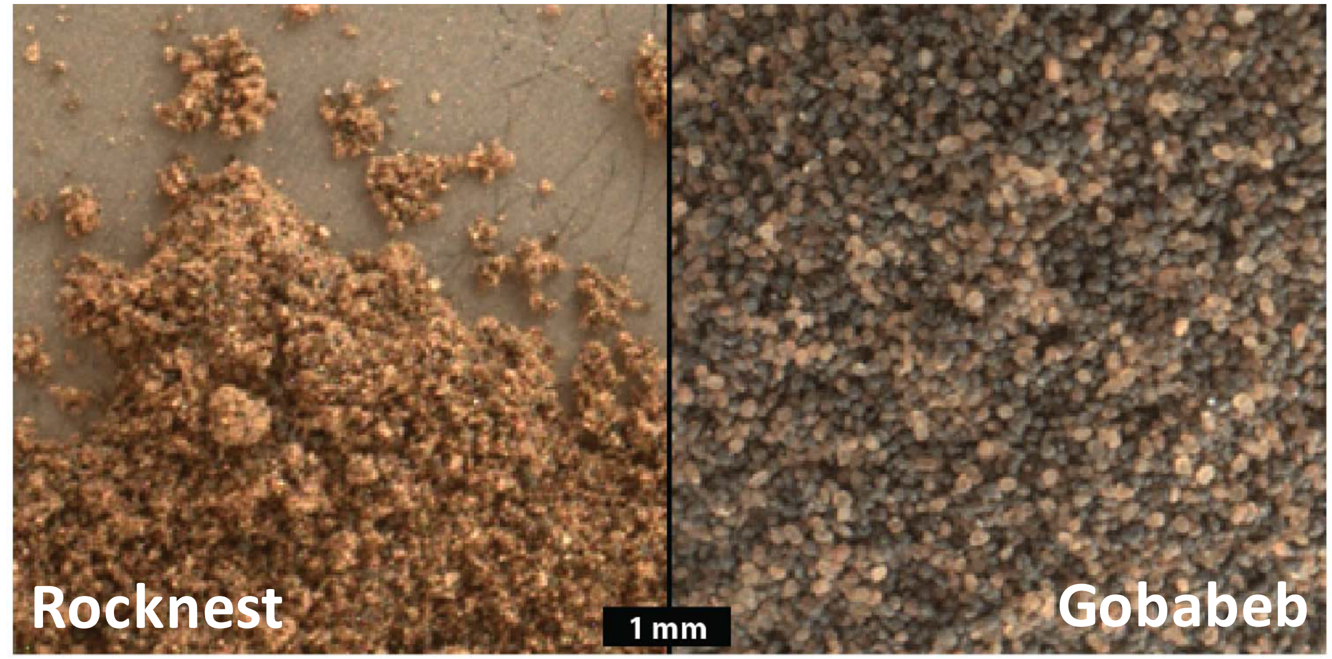
New Mars Science Laboratory Result:
Two Distinct Amorphous Phases Identified in Mars Soils

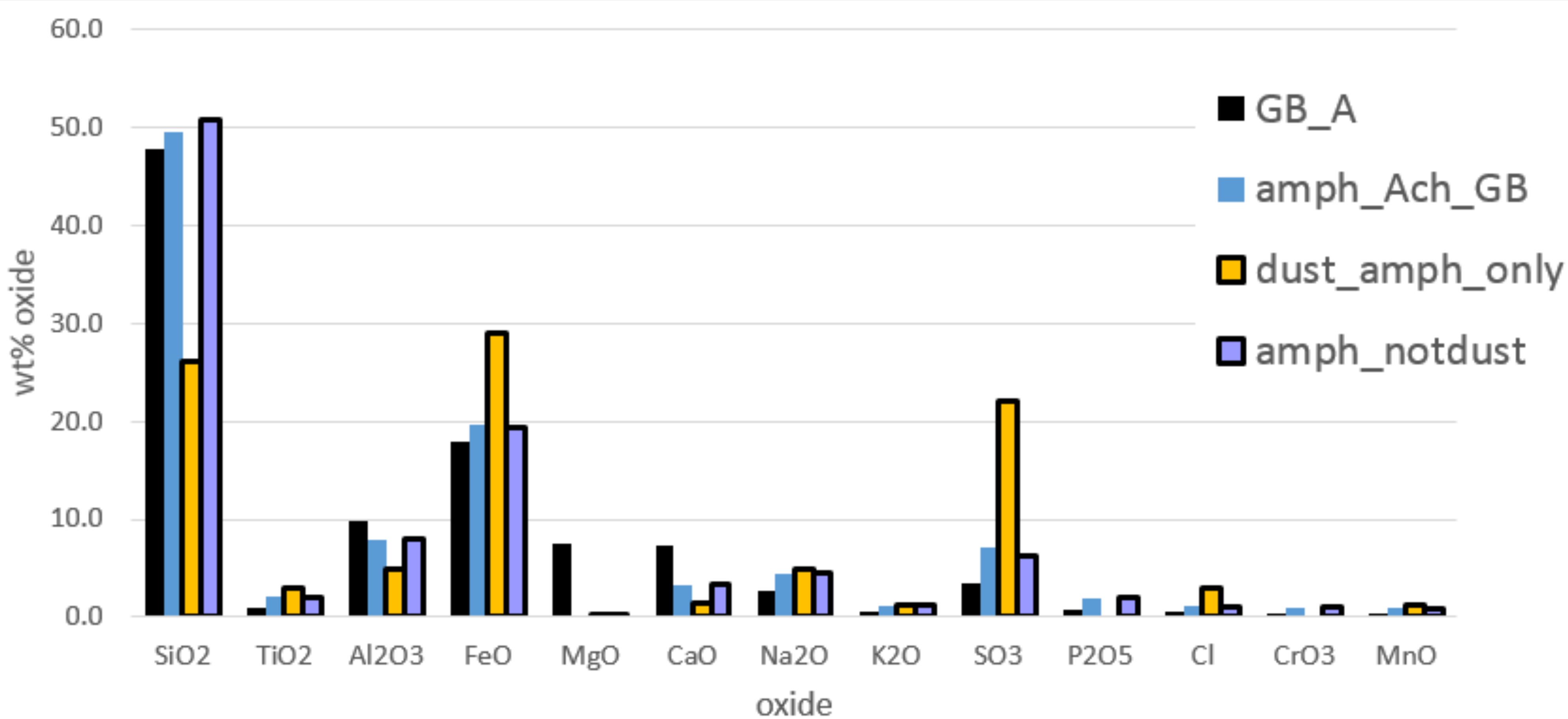
Our team's detailed investigation of Rocknest soil and well-sorted Gobabeb sands enables isolation of **two discrete reservoirs of volatiles in the <u>amorphous phase(s)</u>**

1. **Dust & Silt Fraction: Fe-rich, Si-poor, S-rich, Cl-rich and w/ adsorbed H_2O** (low T SAM release) [Fe oxides, sulfates, Cl-bearing]

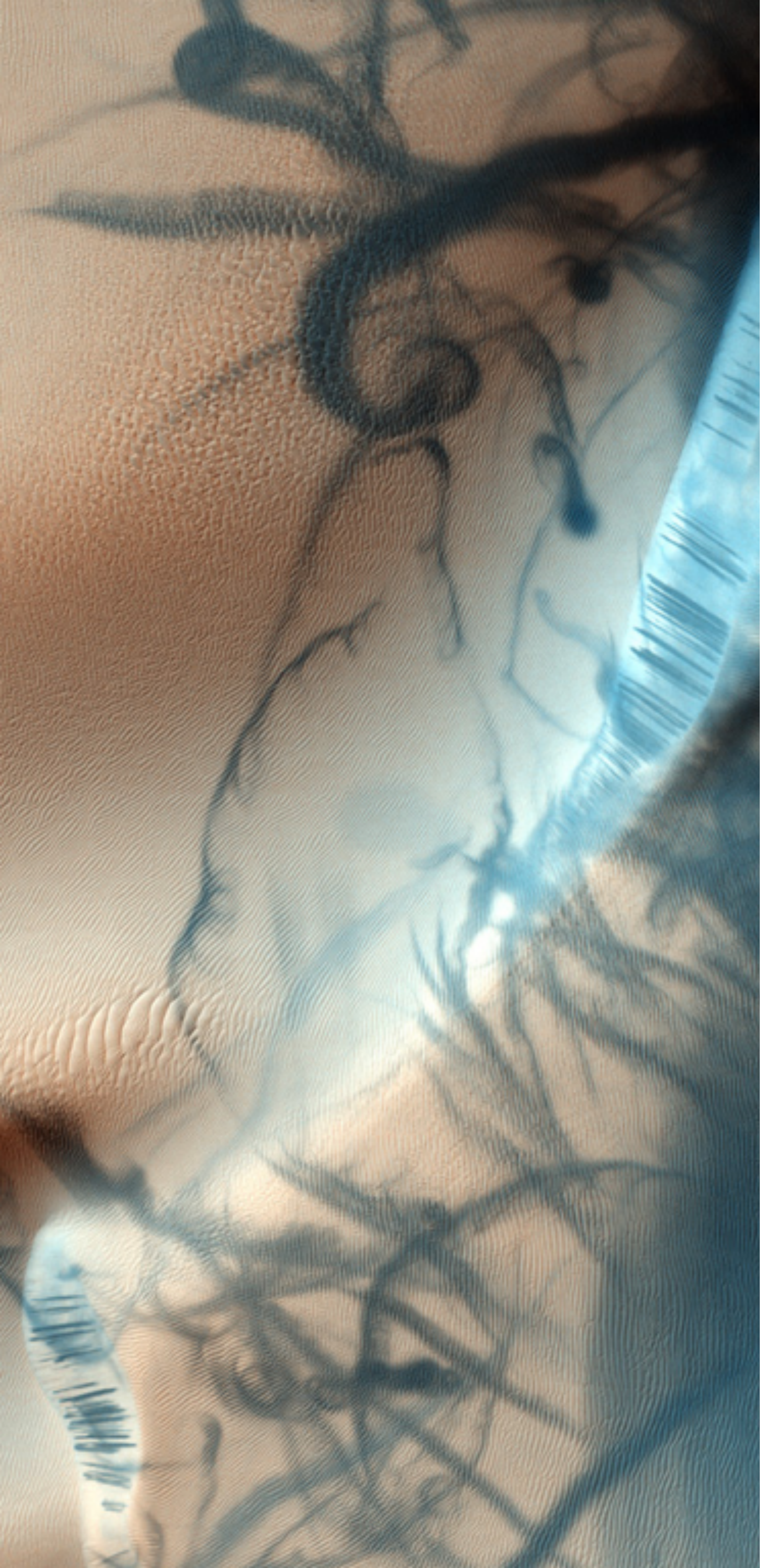
2. **Sand Fraction: Si-rich, Al-/Fe- phase(s), w/ mineral-bound H_2O or hydroxylation** (higher T SAM release) [hydrated silicates]

Both fractions have nitrates and carbonates





Ehlmann et al., JGR, submitted



Martian global dust contains:

- crystalline silicates
- nanophase ferric oxides
- crystalline sulfates and amorphous S-phases
- carbonates, nitrates, (perchlorates?)
- other amorphous phases (Cl, Si, etc.)
- **Not just an oxidized martian sand!**

How did the dust form?

- Previous theory showed that mechanical abrasion can form crystalline oxides (Merrison et al., 2010), but doesn't explain nanophase oxides + other alteration phases
- Probably requires water in some form, but the alteration mechanism, water:rock ratios, etc. are poorly constrained.

Big unknowns: *<u>When</u>* did Mars become dusty? Is dust still being generated today?

Key questions about the non-ice fraction of the PLD

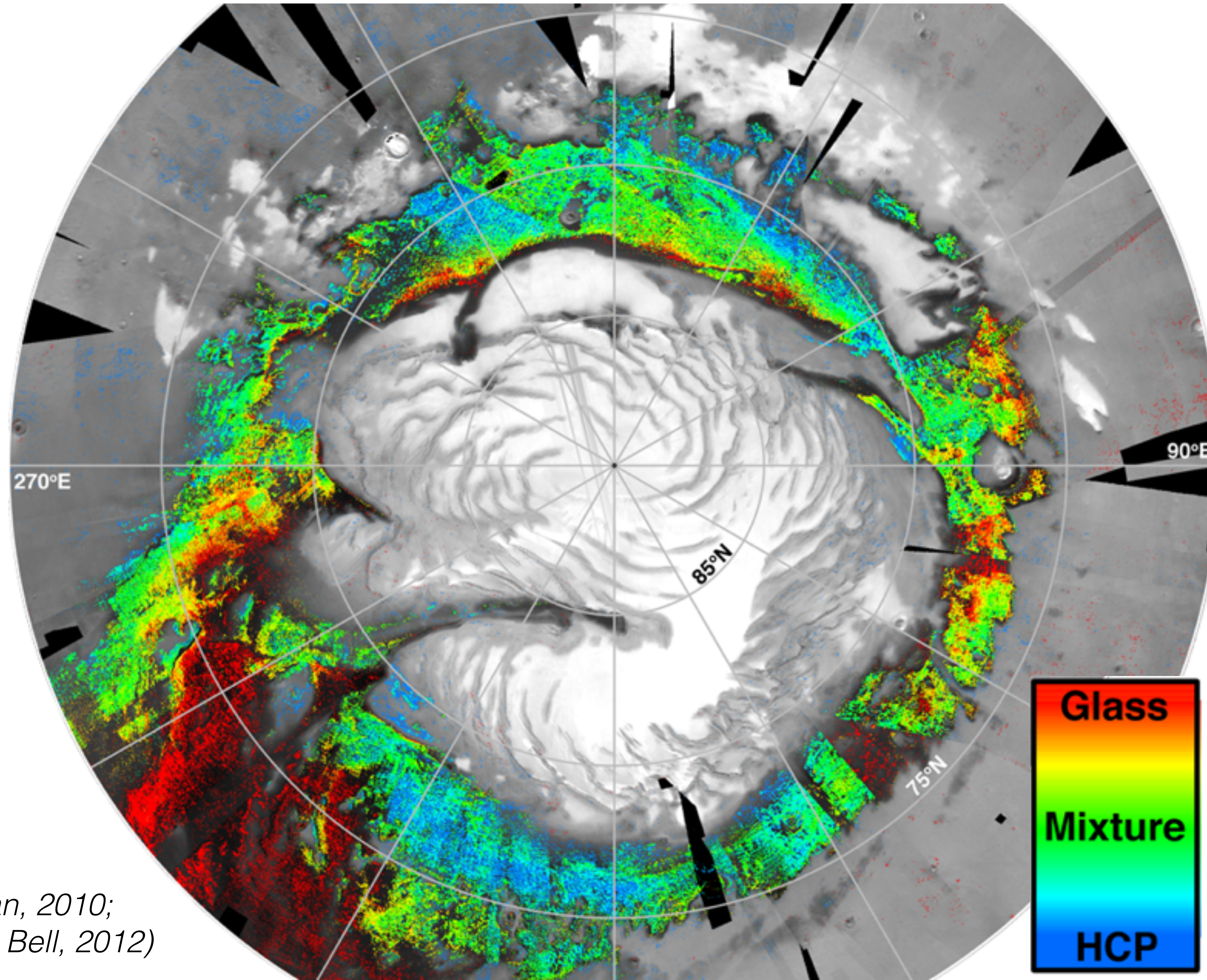
What is the grain size of the non-ice fraction? What is the concentration? Does it change and if so why?

- Wind-borne suspension (dust-sized, expected to be <~2 μm) vs. reworked/inherited saltation products or ashes (could include silt- or sand-sized)

What is the composition of the non-ice fraction and does it change?

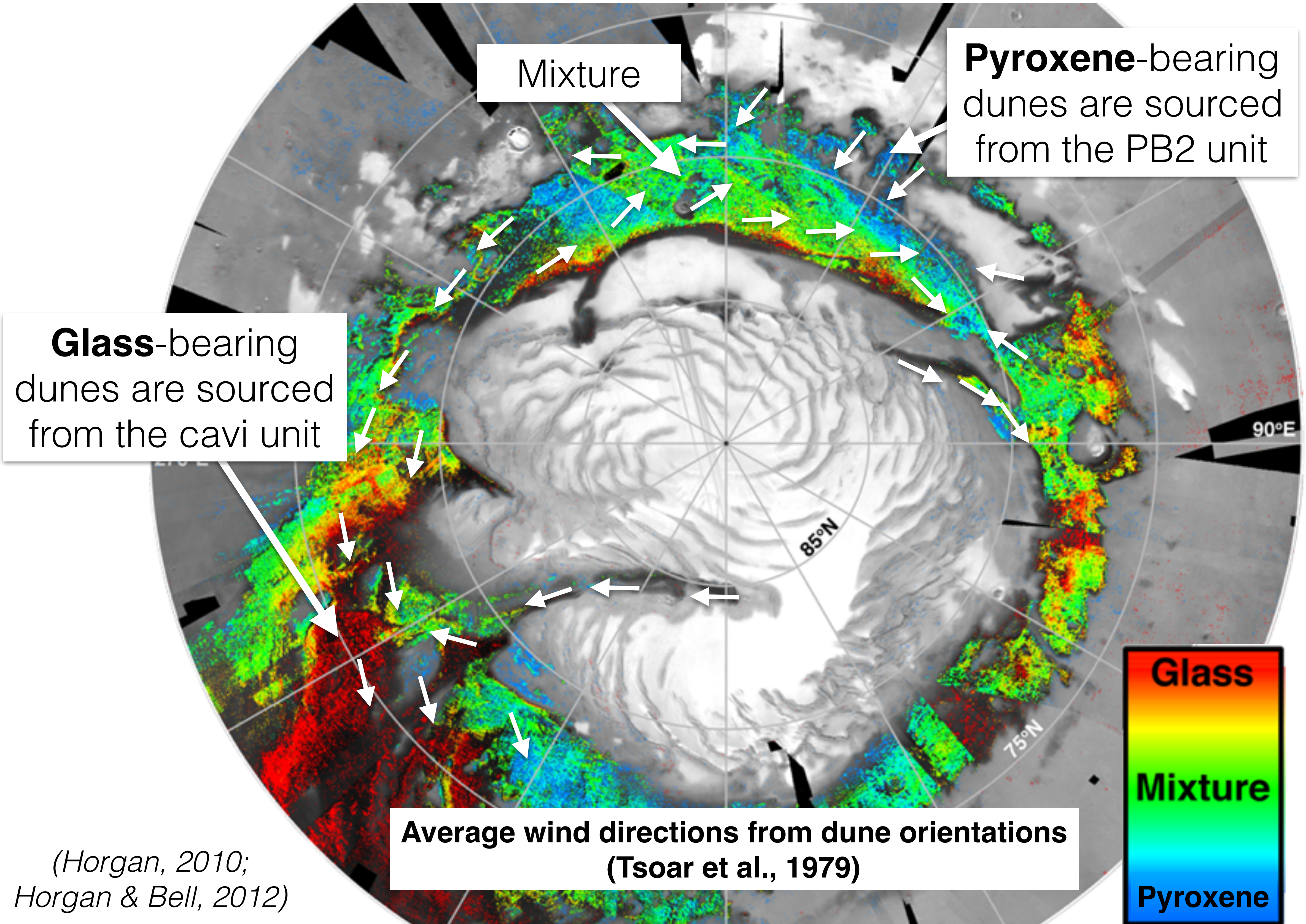
- Is it “global dust” and homogeneous (temporally and spatially)?
- Are there discrete ash layers?
- Are there salts/volatiles that signify contributions from volcanic gas release to the atmosphere or aqueous, salt-forming processes?

Two mafic compositions are detected in the circumpolar sand sea, which can be traced back to sources in the NPLD



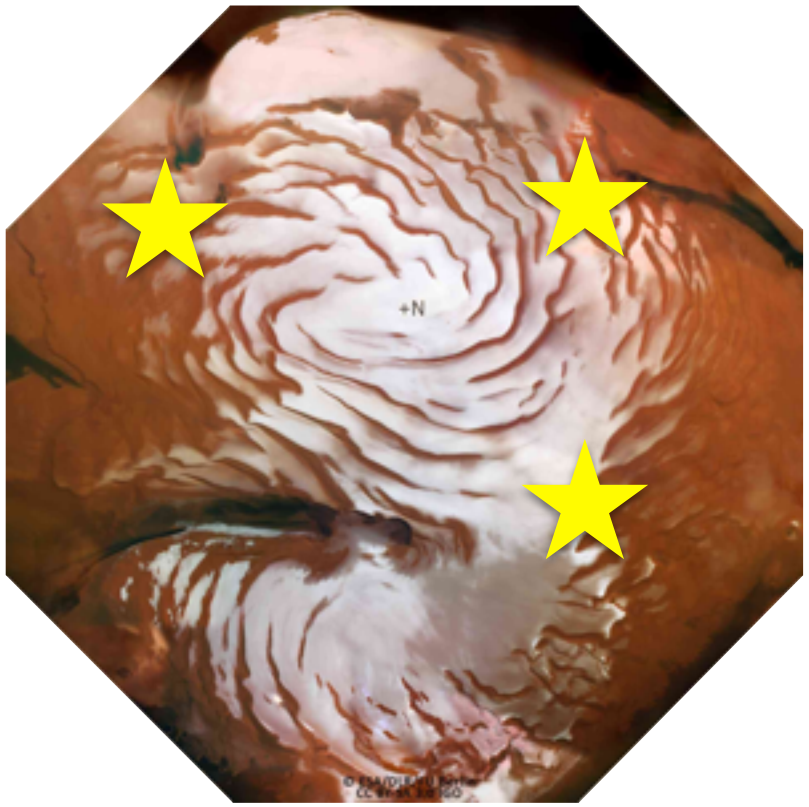
(Horgan, 2010; Horgan & Bell, 2012)

Two mafic compositions are detected in the circumpolar dunes, which can be traced back to sources in the NPLD



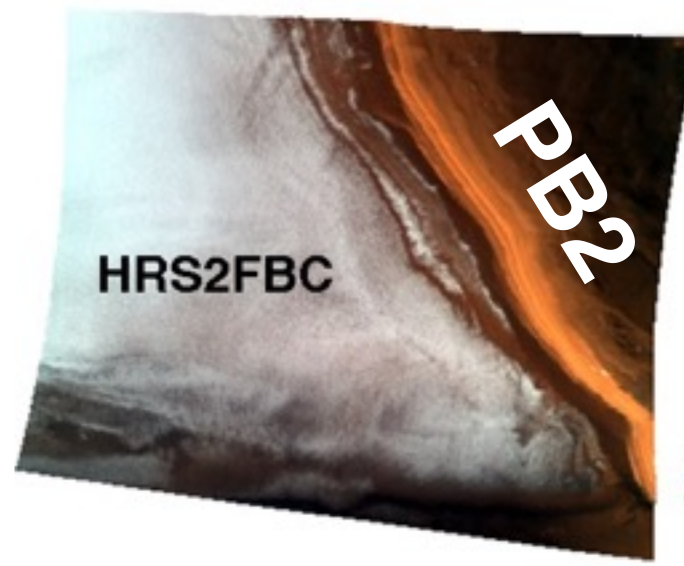
(Horgan, 2010; Horgan & Bell, 2012)

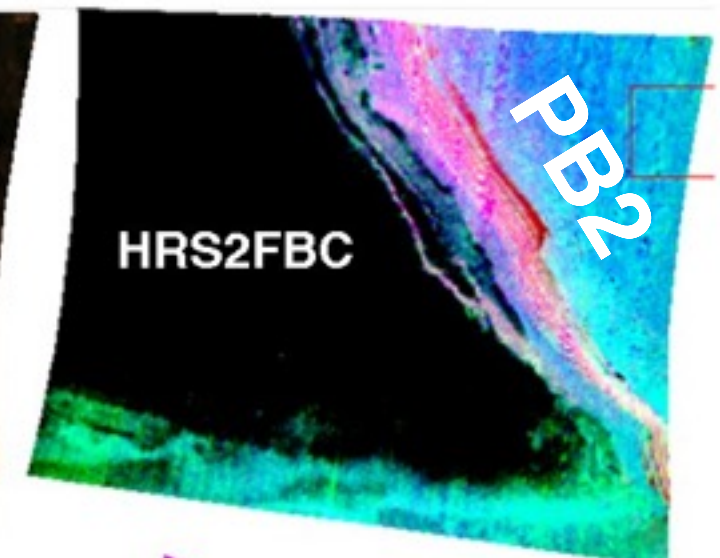
Many PLD surface sediments also contain pyroxene, and are often (but not always) colocated with the PB2 unit

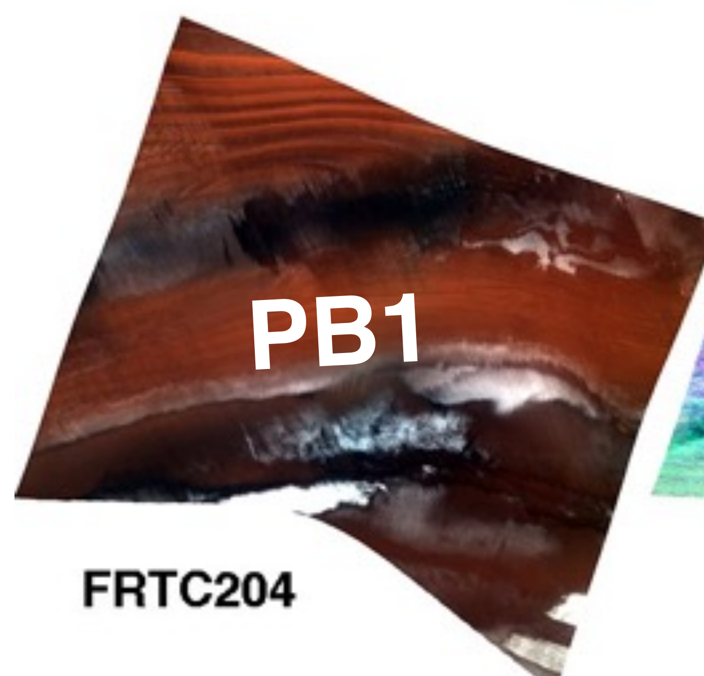


Red = Ferric iron in dust (BD530)
Green/Blue = Ferrous iron in pyroxene

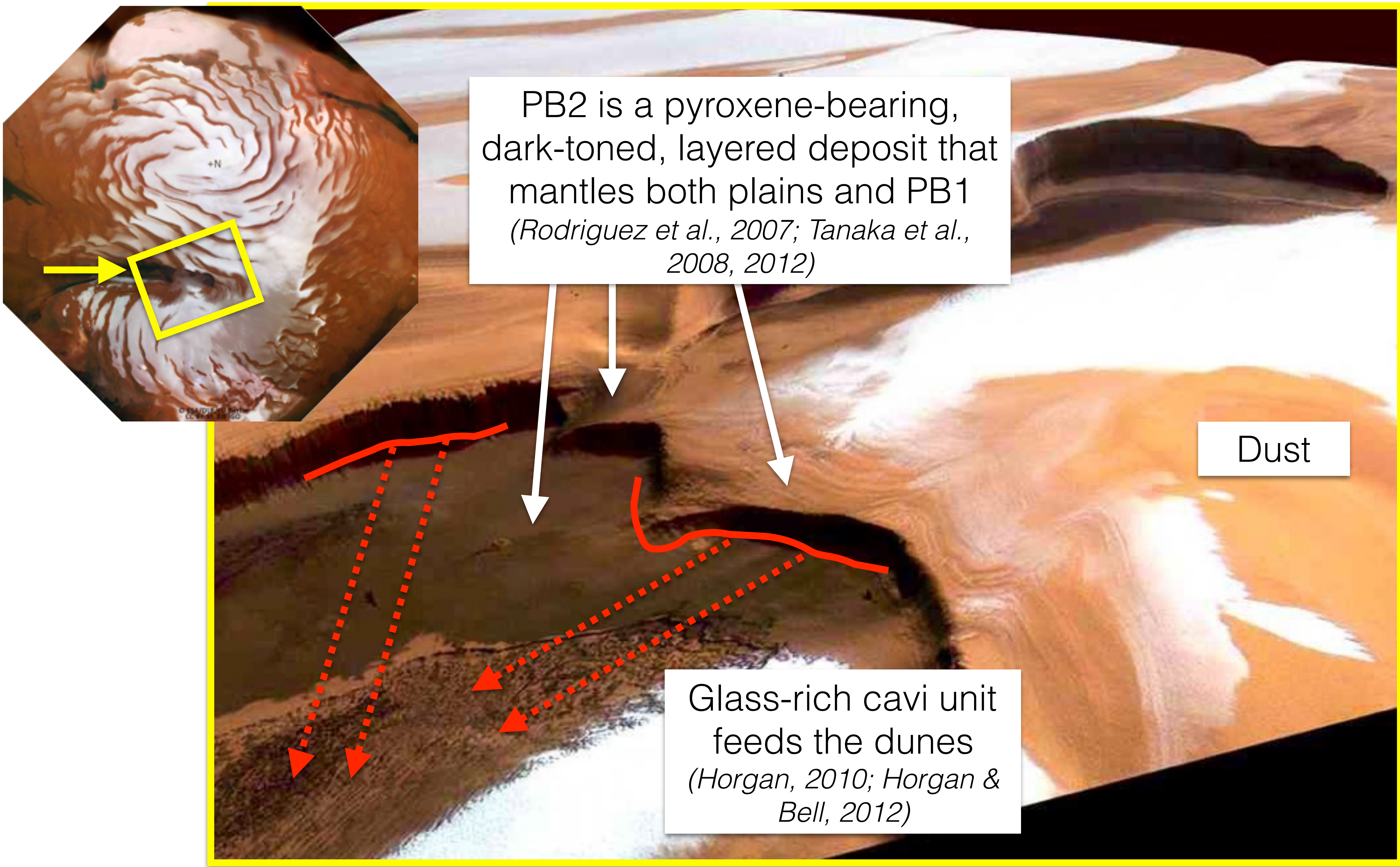
(Horgan et al, 2016)



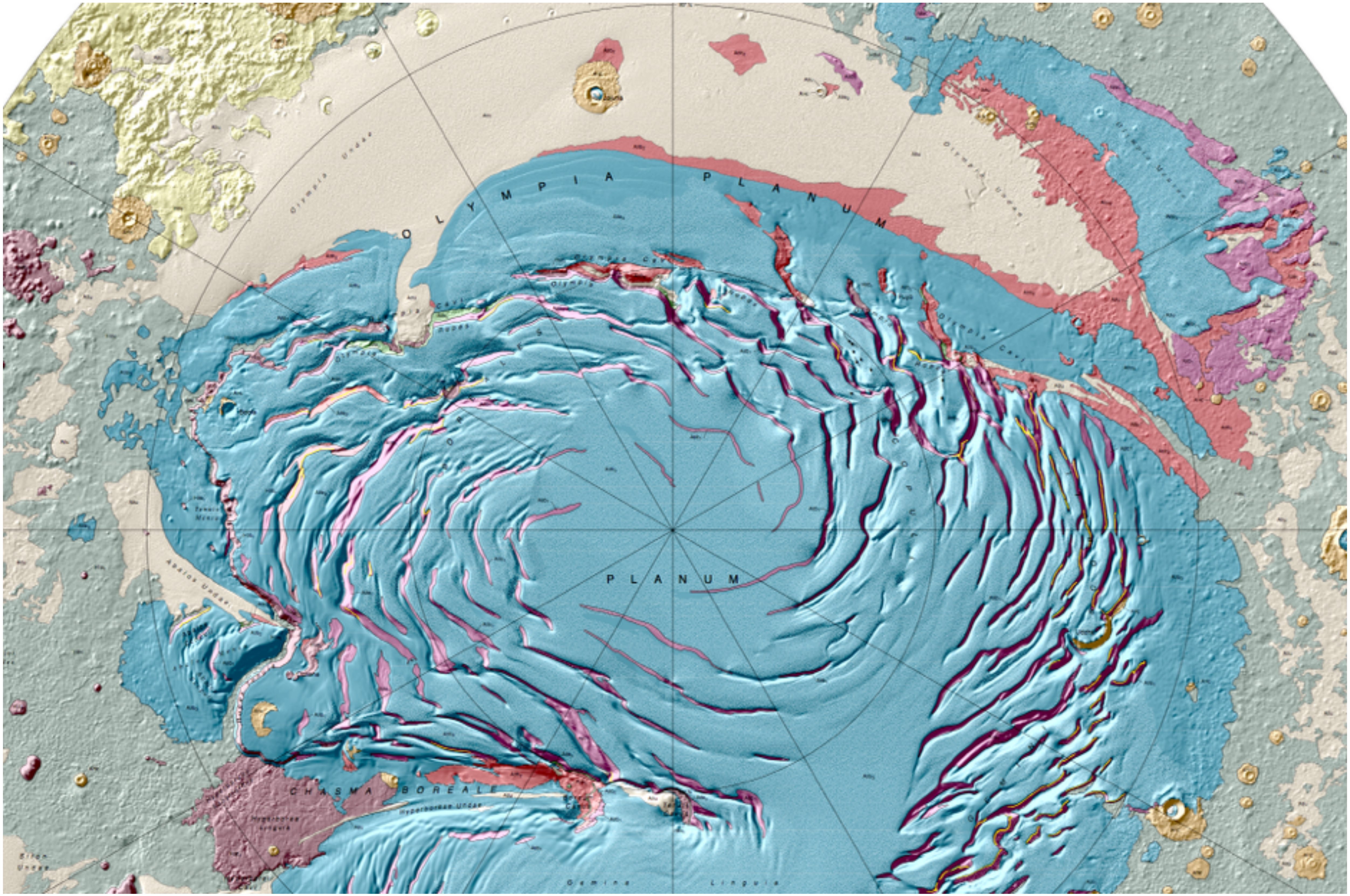




Compared to dust and the cavi unit, PB2 is a compositionally distinct mantling unit deposited on a PLD unconformity.



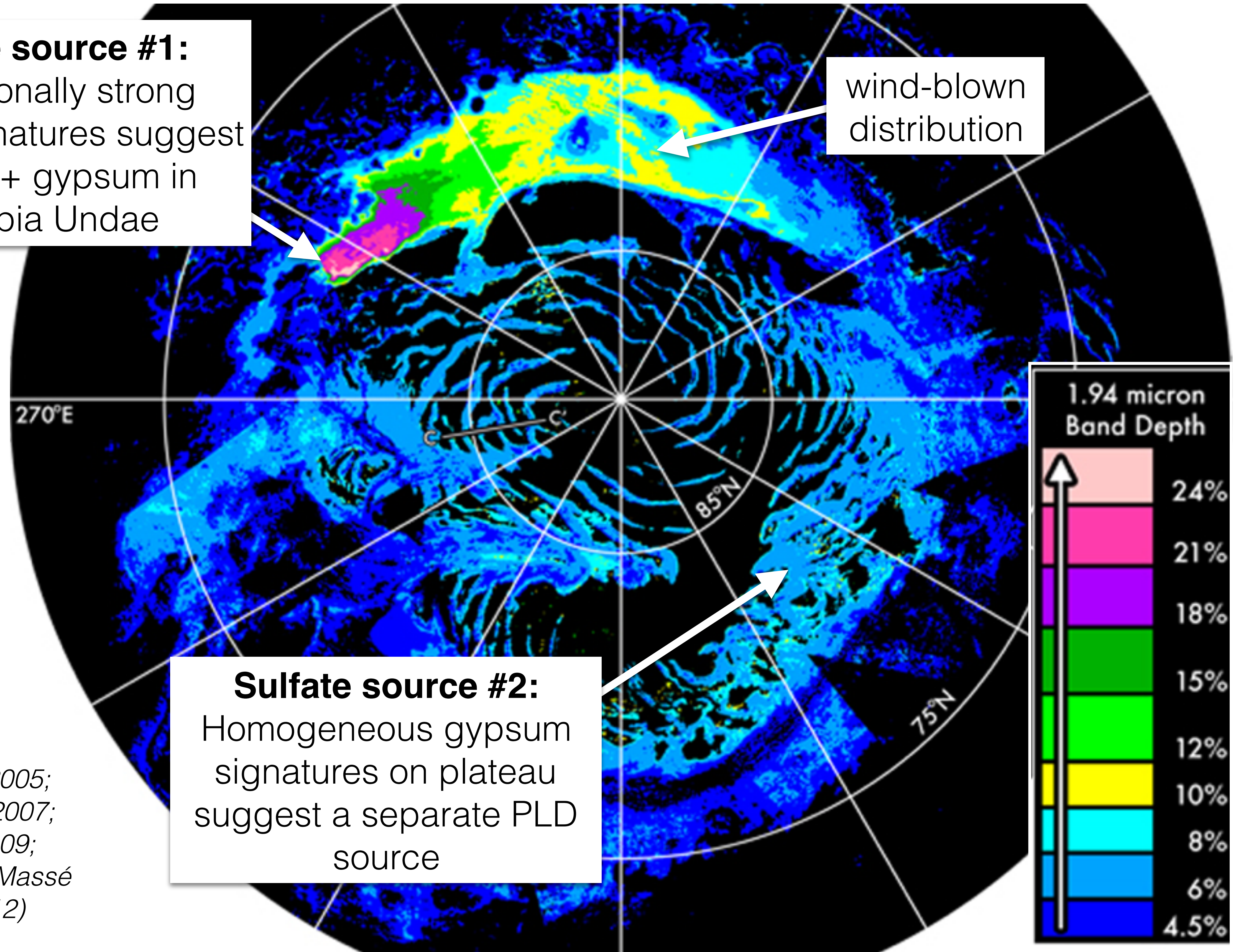
PB2 is also extensive across the region. How did it form? Did it affect the stability of the PLD? Could it be a datable unit?



Sulfate salts are present throughout almost all polar surface sediments and are concentrated in parts of the dune sea

Sulfate source #1:
Exceptionally strong sulfate signatures suggest 20 wt.%+ gypsum in Olympia Undae

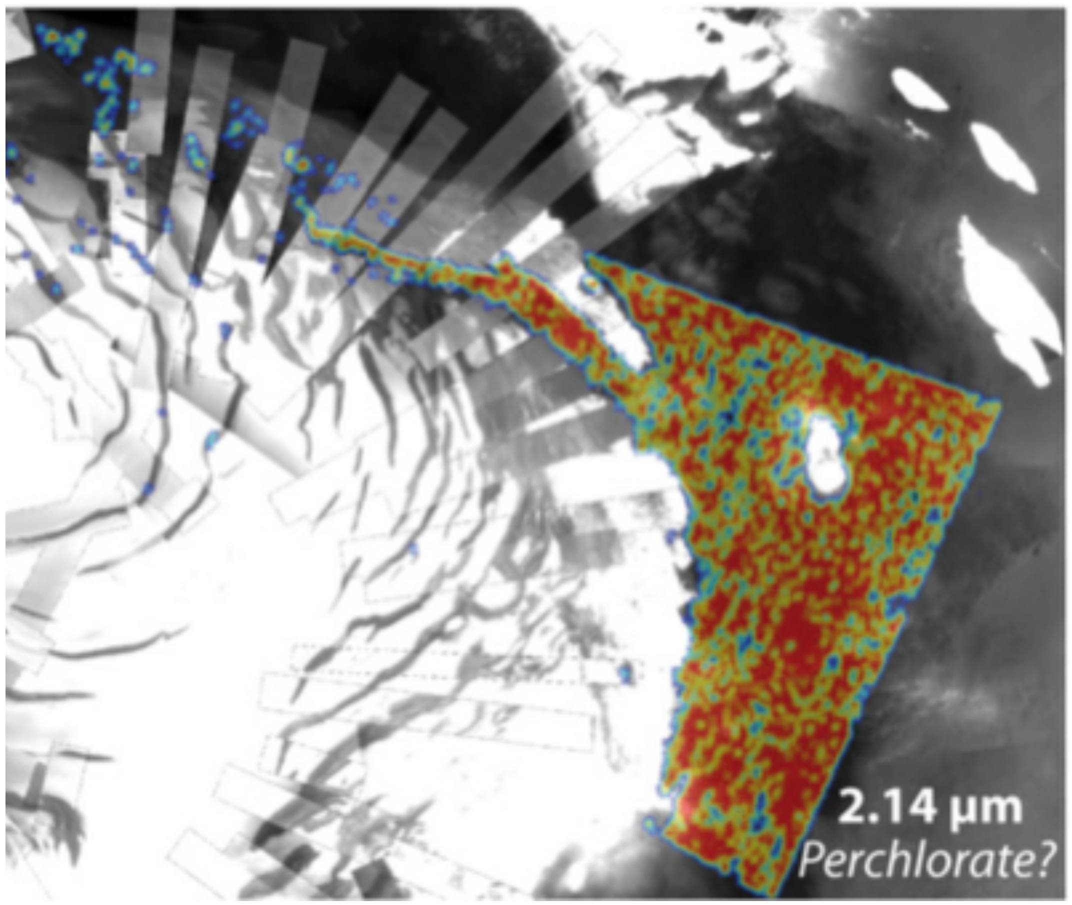
wind-blown distribution

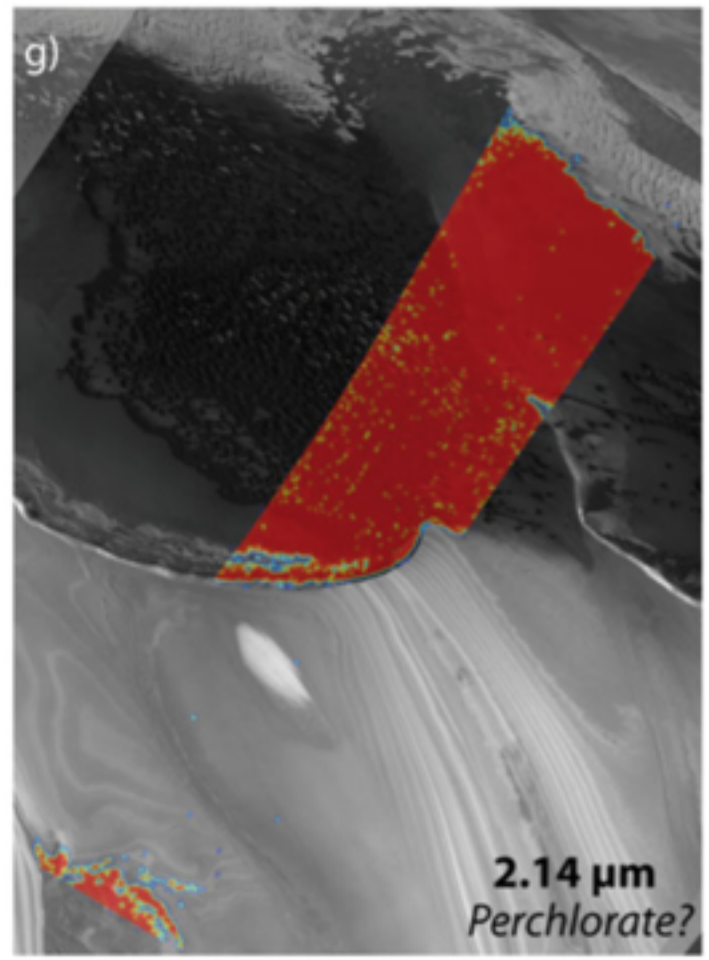


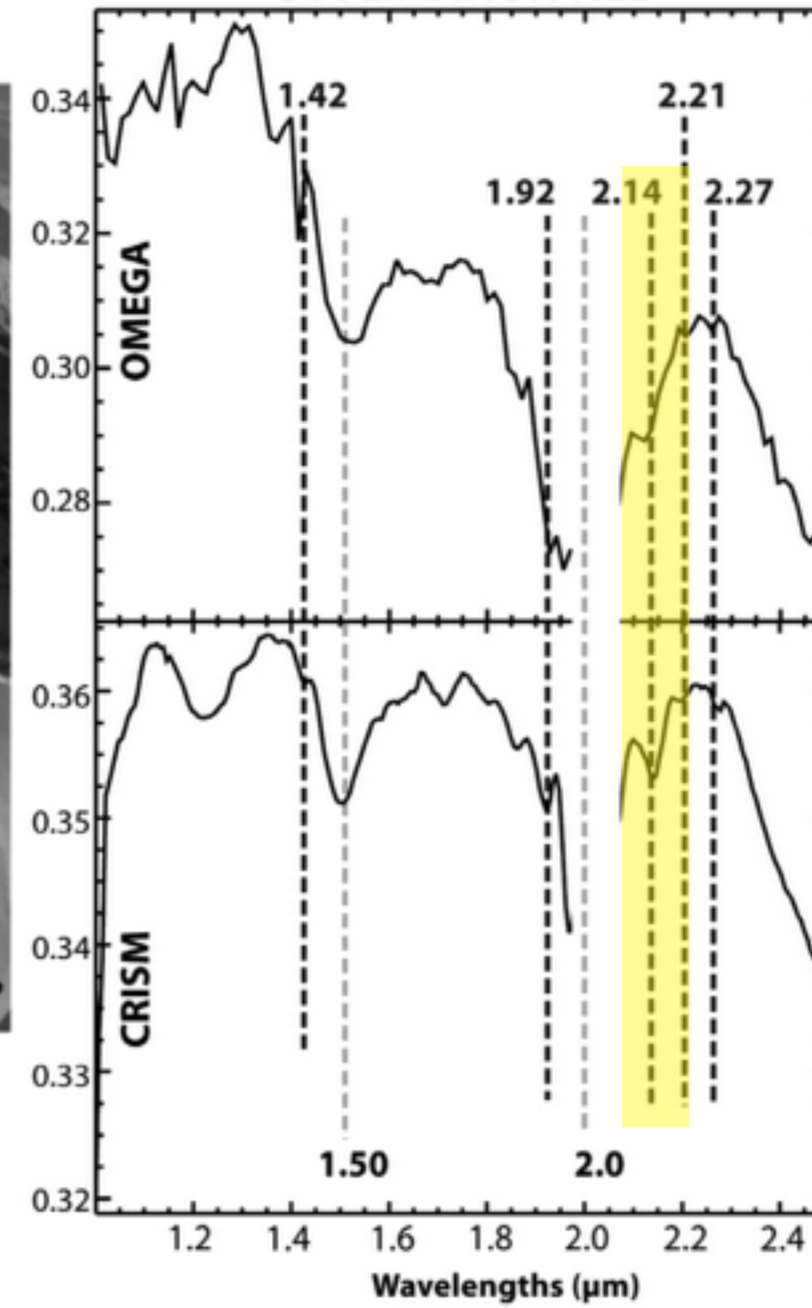
Sulfate source #2:
Homogeneous gypsum signatures on plateau suggest a separate PLD source

(Langevin et al., 2005; Fishbaugh et al., 2007; Horgan et al., 2009; Calvin et al., 2009; Massé et al., 2010, 2012)

Possible perchlorates have been detected in the dunes and PLD surface sediments



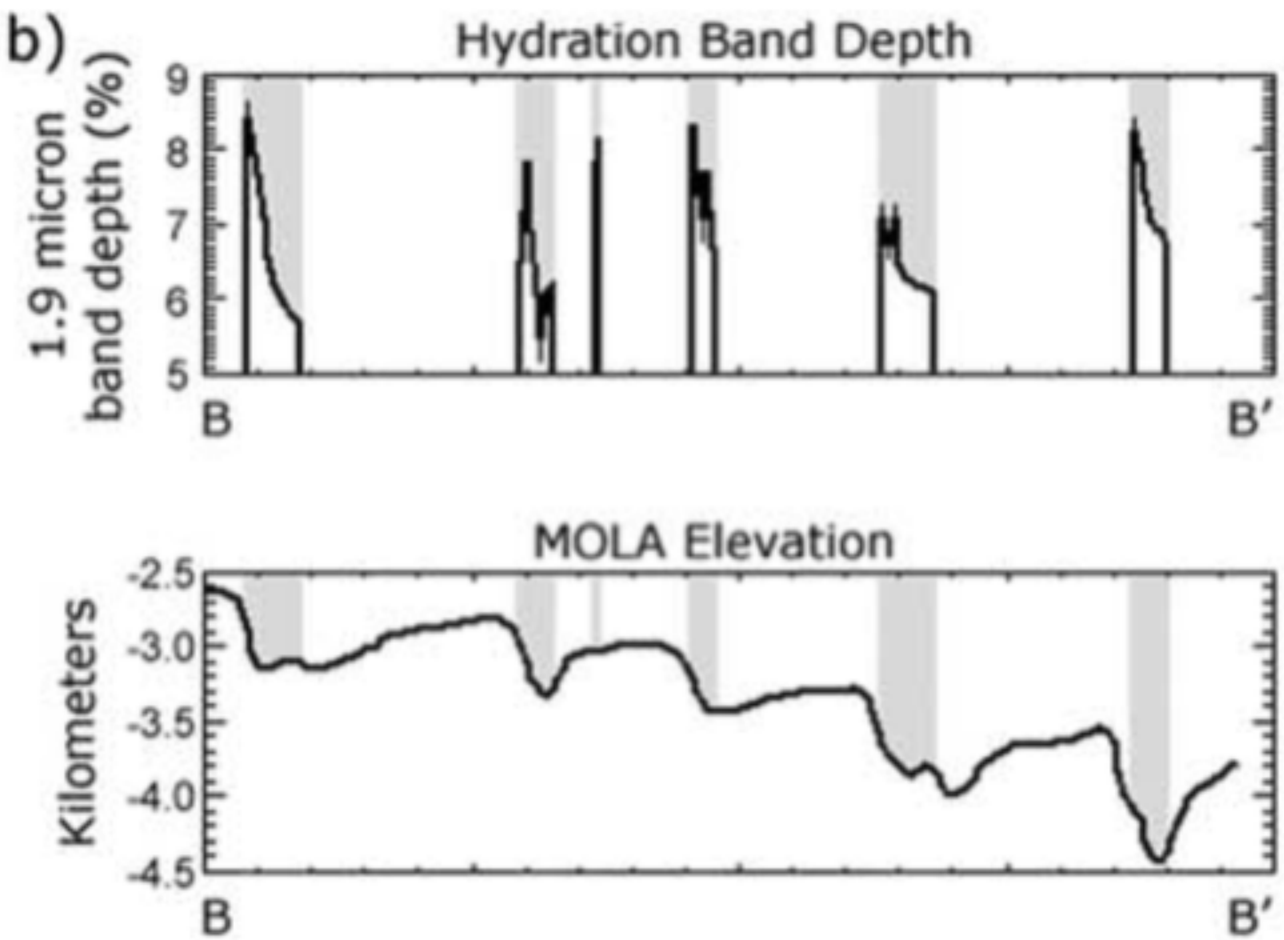




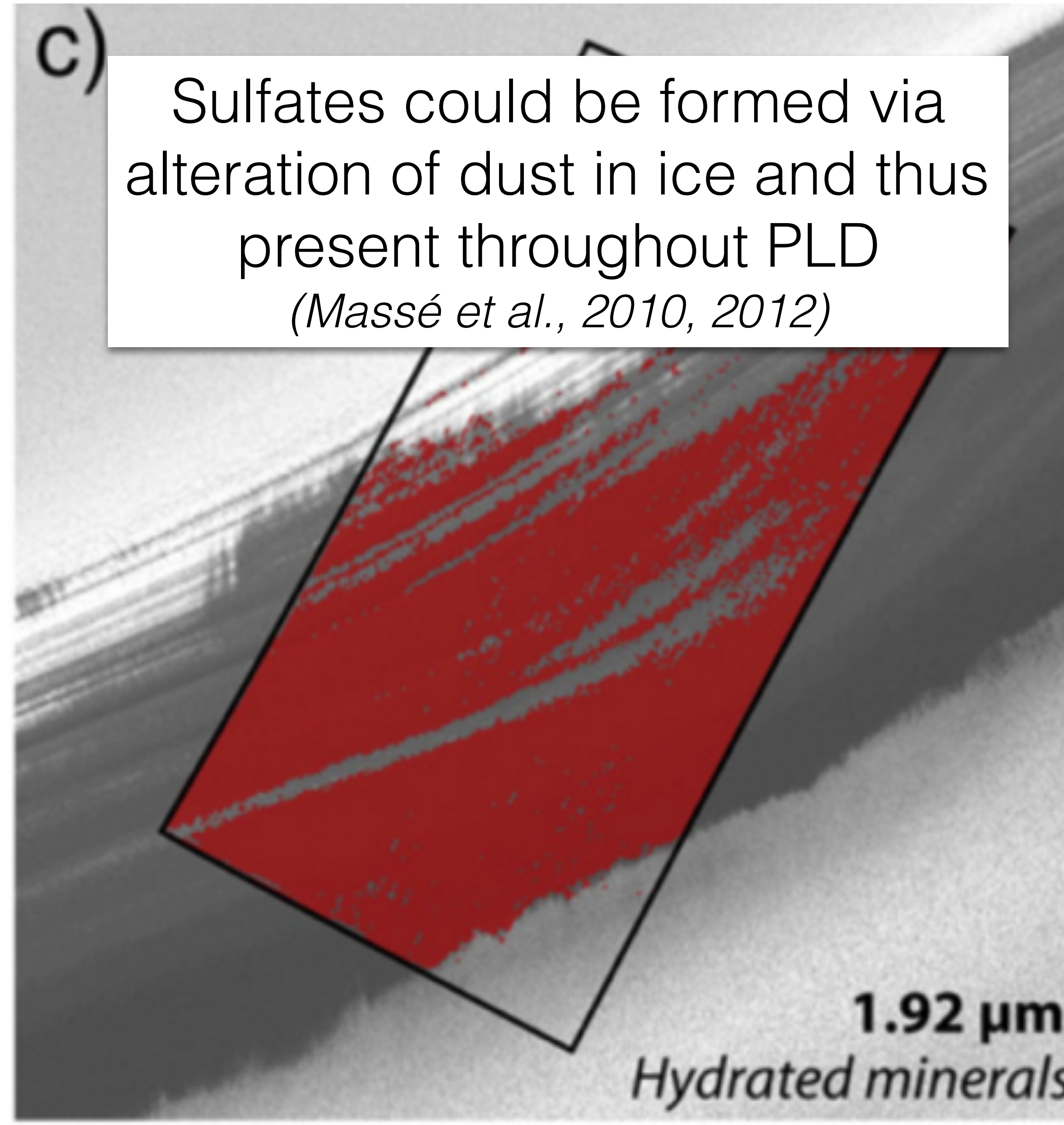
(Massé et al., 2010, 2012)

Origin of salts could be related to atmospheric deposition, alteration within ice cap, or surface alteration

Concentration of sulfates near tops of troughs could suggest specific source unit
(Horgan et al., 2009)



Sulfates could be formed via alteration of dust in ice and thus present throughout PLD
(Massé et al., 2010, 2012)



What can the PLD teach us about the origin of these minerals globally? Could atmospheric deposition of salts or dust be a proxy for time?

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