Microbes play an important role in the alteration of oceanic crust
Thorseth et al. 1995

Microbial activity in the alteration of glass from pillow lavas from Hole 896A
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Staudigel et al. 2008
Nutrient source
Easier tunneling
UV protection
MICROBES

❤

IMPACT GLASS?

Sapers et al. 2014, and see talk in this session
Distal glasses emplaced on water or land  
(Bouska and Bell 1993; Schultz and Mustard 2004; Wrobel and Schultz 2007)

Groundwater flow through porous regolith  
(Agee et al. 2013; Humayun et al. 2013)

Crater lakes & hydrothermal systems  
(Cabrol and Grinn 1999; Osinski et al. 2013)
Synthetic martian basaltic glass

Fe_{VI}^{2+}

Fe_{IV}^{2+}
Remote dataset (e.g., CRISM) → Spectral mixing model → Endmember spectral fractions

Olivine spectral fraction
Crater lakes & hydrothermal systems (Cabrol and Grinn 1999; Osinski et al. 2013)

Groundwater flow through porous regolith (Agee et al. 2013; Humayun et al. 2013)

Distal glasses emplaced on water or land (Bouska and Bell 1993; Schultz and Mustard 2004; Wrobel and Schultz 2007)
Preserved glass-rich impactites on Mars

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ABSTRACT

Quenched glass formed by hypervelocity impacts can encapsulate and preserve biosignatures on Earth, demonstrating the fossilization potential of glass-rich impactites on Mars. However, definitive spectral signatures of impact glass have not been identified on the martian surface from orbital remote sensing. Here we present a remote compositional survey of probable impactites in well-preserved craters, using data from the Compact Reconnaissance Imaging Spectrometer for Mars. These units are composed of mafic glasses mixed with crystalline phases including olivine and pyroxene, determined by radiative transfer Hapke modeling followed by spectral mixture analysis. This glassy material likely formed from impact-induced melting of the target rock with rapid quenching and minor subsequent devitrification or chemical alteration. The metastable glass has been preserved by the cold and dry martian climate during the Amazonian period, and this preservation—as confirmed here across the planet—provides a means to trap signs of ancient life on the accessible martian surface. Our results lend concrete support to theoretical arguments suggesting that impact glass has formed in abundance on Mars, both inside of craters and as spherules in distal strewnfields. Contrary to previous ideas, martian impact products are not destroyed by interaction with volatiles during the impact process.

The Mars Reconnaissance Orbiter spacecraft. Many primary and secondary minerals have been identified with CRISM data based on the presence of their diagnostic absorption features (e.g., Mustard et al., 2008; Skok et al., 2012), but not mafic glasses. The spectral signature of these glasses at VNIR wavelengths is broadly similar to that of other Fe-bearing phases like pyroxene and olivine: they have wide crystal field absorptions near 1.15 μm and 2.0 μm, and unaltered glass has a positively sloped spectral continuum. The presence of glass in a VNIR spectrum can be obscured when pyroxene and olivine are also present because of highly nonlinear mixing behavior; therefore, we used the Hapke radiative transfer model (Hapke, 1981) to account for
Balvicar Crater (D = 20 km)

from Cannon and Mustard 2015, Geology
Olivine   Glass   Pyroxene

Toro Crater (D = 41 km)
Marzo et al. 2010

from Cannon and Mustard 2015, Geology
Distal glasses emplaced on water or land
(Bouska and Bell 1993; Schultz and Mustard 2004; Wrobel and Schultz 2007)

Groundwater flow through porous regolith
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Crater lakes & hydrothermal systems
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Crater lakes &
hydrothermal systems
(Cabrol and Grinn 1999;
Osinski et al. 2013)
Range of igneous rock clasts
- Santos et al. 2015

Impact melt clasts/spherules
- Udry et al. 2014

Sedimentary clasts
- McCubbin et al. 2014

Alteration phases, sulfides
- Lorand et al. 2014

Up to 6000 ppm water
- Agee et al. 2013

4.43 Ga zircons
- Humayun et al. 2013
Evidence for a widespread basaltic breccia component in the martian low-albedo regions from the reflectance spectrum of Northwest Africa 7034

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Abstract
Northwest Africa (NWA) 7034 is the first breccia meteorite from Mars, and unlike the shergottite, nakhlite, and chassignite (SNC) martian meteorites, it matches the estimated chemical composition of martian crust. Here we show that the visible-infrared reflectance spectrum of NWA 7034 is unique compared to other SNCs and is more similar than them to remotely sensed data from Mars, suggesting the martian regolith may contain significant brecciated material produced during heavy bombardment of the crust.

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Crater lakes & hydrothermal systems (Cabrol and Grinn 1999; Osinski et al. 2013)
Final Thoughts

Glass-rich impact materials have been produced in abundance on Mars, and are still preserved on the surface. No reason to assume all glass on Mars is volcanic.

These glasses were likely in intimate contact with fluids or a humid atmosphere in various environments on Mars.
Final Thoughts

Glass-rich impact materials have been produced in abundance on Mars, and are still preserved on the surface. No reason to assume all glass on Mars is volcanic.

These glasses were likely in intimate contact with fluids or a humid atmosphere in various environments on Mars.

Future Work

Exploring the UV protection versus PAR tradeoff for various glass compositions and redox states.

Contributing glasses for in-situ microbial experiments.