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Introduction

Data obtained from Mars Global Surveyor (MGS) and Mars Reconnaissance Orbiter (MRO) has vastly increased knowledge of Martian surface mineralogy and in particular aqueously altered phases. As such, there is a need for regolith simulants that better represent these phases both chemically and mineralogically.

The goal of this study was to create multiple simulants based on current understanding of the chemistry and mineralogy of certain deposit types found on Mars. These simulants will be used to explore the potential fertility and toxicity of Martian regolith as an *in situ* resource. Such information is key to developing concepts for the exploration and potential colonization of Mars

Methodology

To produce simulants, a combination of synthetic and field-collected samples were collected. Five different simulants assemblages were made: 1. Basalt (unaltered), 2. Sulfate 3. Phyllosilicate I, 4. Phyllosilicate II, and 5. Carbonate. These components will be combined at ratios on data from Mars Curiosity Rover, MRO and MGS missions, and Earth-based Martian analogs.

The simulant assemblages will be treated to eliminate organic matter and sterilized. The simulant assemblages will be examined using XRD Rietveld analysis, XRF, Mössbauer spectroscopy, and imaging spectroscopy to refine ratios and ensure they adequately represent current understanding of Martian chemistry and mineralogy for the intended application.

Simulants

- **Regolith 1: Basalt (unaltered).** The basalt (unaltered) simulant represents deposits that have not been exposed to extensive aqueous alteration.
- **Regolith 2: Sulfate.** The sulfate simulant reflects the mineralogy of sulfate-rich deposits found in Valles Marineris, Terra Meridiani and Aram Chaos.

Simulants

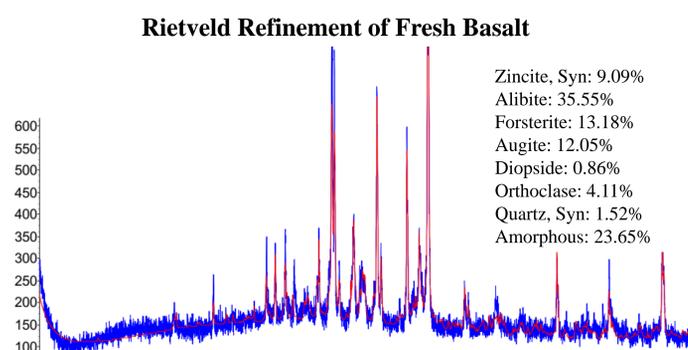


Figure 1: Rietveld refinement of the fresh basalt used in Regolith 1. Comparable to Rocknest sample examined by Mars Curiosity Rover. Prepared with ZnO (Zincite) added as internal standard. All individual components and assembled simulants will be examined similarly.

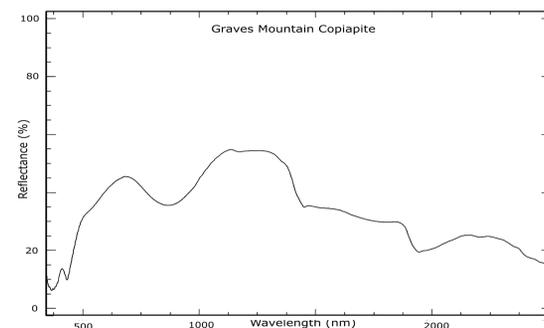


Figure 3: Spectral signature of copiapite used in Regolith 2 Sulfate. All assembled simulants will be examined similarly



Figure 2: Fresh Basalt collected from New Mexico for use in Regolith 1



Figure 4: Copiapite collected from Graves Mountain, Georgia for use in Regolith 2

Table 1: Martian Regolith Components

	Components	Regolith 1: Basalt (unaltered)	Regolith 2: Sulfate	Regolith 3: Phyllosilicate I	Regolith 4: Phyllosilicate II	Regolith 5: Carbonate
Mineralogy	Basalts and Primary Silicates	Fresh basalt ¹	Non-Fresh basalt ²	Non-Fresh Basalt ²	Non-Fresh Basalt ²	Non-Fresh Basalt ²
	Phyllosilicates	-	-	Nontronite ^{2,3}	Nontronite ^{2,3} Chlorite ³	Nontronite ^{2,3}
	Sulfates	-	Copiapite ⁴	-	-	-
	Carbonates	-	-	-	-	Magnesite ³
	Amorphous	Volcanic Glass ¹ and/or Nano-phase ferric oxides ⁴	Hydrated silica ³ and Nano-phase ferric oxides ⁴	Allophane ³ and/or Hydrated silica ³ and/or Nano-phase ferric oxides ⁴	Nano-phase ferric oxides ⁴	Hydrated magnesium silicates (Deweylite)
	Salts	Anhydrite ⁵ Perchlorate ⁵	Anhydrite ⁵ Perchlorate ⁵	Anhydrite ⁵ Perchlorate ⁵	Anhydrite ⁵ Perchlorate ⁵	Anhydrite ⁵ Perchlorate ⁵
	Iron Oxides	-	Hematite ^{3,4}	-	-	-
Mars Type Location		Rocknest: Gale Crater	Valles Marineris, Terra Meridiani, Aram Chaos	Jezero Crater, Mawrth Valles, East Nili Fossae	Noachian Highlands, Walls of Nili Fossae and Valles Marineris	Isidis Basin
Approximate Ratios		68% Primary Minerals 30% Amorphous 2% Salts	48% Primary Minerals 20% Sulfate 30% Amorphous 2% Salts	48% Primary Minerals 20% Phyllosilicate 30% Amorphous 2% Salts	38% Primary Minerals 30% Phyllosilicate (clay and chlorite) 30% Amorphous 2% Salts	38% Primary Minerals 30% Carbonate 30% Amorphous 2% Salts

¹Collected in New Mexico, ²Nontronite containing-Basalt collected in Eastern Washington, ³Obtained from University of Georgia, ⁴Collected from Graves Mountain, Georgia, ⁵Obtained from Fisher Scientific or other reputable facilities

Simulants

- **Regolith 3 and 4: Phyllosilicate I and II.** A variety of phyllosilicate deposits are found on Mars associated with different formation processes. These are the most common type of aqueously altered deposit
- **Regolith 5: Carbonate.** This simulant represents carbonate deposits found on Mars. This is the least common of the represented deposit types, but very relevant in understanding Mars past geochemical conditions

Future Goals

The simulants developed will be used for future work in exploring the use of Martian regolith as an *in situ* material for planetary exploration. The most relevant and reproducible simulants will be used in plant growth experiments that seek to address some of the challenges faced in supporting a manned mission to Mars. The ultimate goal being to use simulants to address issues of toxicity and fertility of Martian regolith and understanding potential for past habitable environments on Mars.

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