

**ARABIA TERRA LAYERED DEPOSIT STRATIGRAPHY AND DISTRIBUTION: EVIDENCE FOR EARLY MARTIAN EXPLOSIVE VOLCANISM?** P.L. Whelley<sup>1,2</sup>, A. M. Novak<sup>3</sup>, J. Richardson<sup>1,2</sup>, and J.A. Bleacher<sup>2</sup>, <sup>1</sup>University of Maryland, College Park, Department of Astronomy, <sup>2</sup>NASA Goddard Space Flight Center (patrick.l.whelley@nasa.gov), <sup>3</sup>Johns Hopkins University/Applied Physics Laboratory

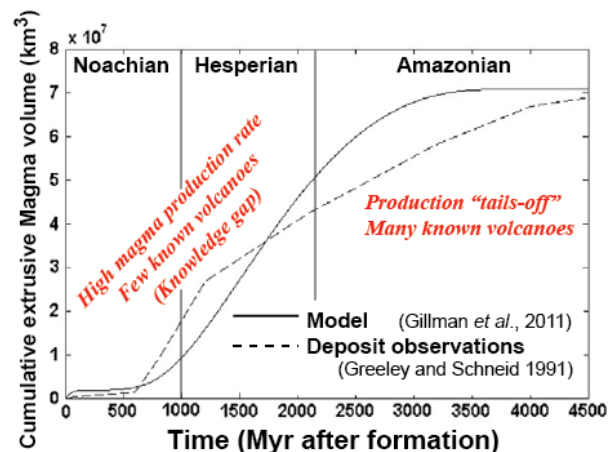
**Introduction:** Volcanism is a fundamental process involved throughout Mars' history [Fig 1] and in nearly every aspect of Mars' evolution [1-3]. Our understanding of explosive volcanism (*i.e.*, violent expulsions of ash, pumice and rock fragments) on Mars continues to evolve as numerous, small (10s km diameter) and dispersed volcanic centers are recognized throughout the Tharsis region [4-9] and degraded, ancient volcanic centers are recognized in the southern highlands [10-13]. While volcanic deposits have been suggested to exist in Arabia Terra [*e.g.*, 14], few vents are identified in the region. The fretted terrain is a landform type within Arabia Terra defined as smooth low-lying plains separated from complex plateaus by steep uniform cliffs [15] forming a polygonal network of slot canyons [Fig.2]. It is an enigmatic geological unit composed of altered, fine-grained, layered, clay- and sulfate-bearing sediments suggested to be eroded ancient explosive volcanic deposits [*e.g.*, 14, 16, 17]. However, this explanation remains unconfirmed because it has two important deficiencies: (1) a logical source [18] and (2) direct morphologic evidence of volcanic deposits. Michalski and Bleacher [19] proposed that several large and irregularly shaped depressions in Arabia Terra [Fig. 2] are calderas that produced colossal explosive eruptions (*i.e.*, supereruptions) that could have been the largest to ever occur on Mars. Consistent with past mapping [20], if these features are indeed explosive calderas, ash dispersion modeling [*e.g.*, 21; 18] suggests extensive ash deposits, carried by ancient westerlies, should be common throughout the region. The km-deep canyon walls within the fretted terrain should therefore expose evidence for Noachian-Hesperian era volcanic deposits.

This work is cataloging the layered deposits exposed in these canyon walls to study their **mineralogy** using CRISM (Compact Reconnaissance Imaging Spectrometer for Mars) data, **morphology** using HiRISE (High Resolution Imaging Science Experiment) and CTX (Context Camera) data, thermal inertia using THEMIS (Thermal Emissions imaging system) data and distribution using a GIS (geographic information system). Through this work we are assessing if Arabia Terra could have been the site of early martian supereruptions. Even if this hypothesis is not supported, our team is collecting a new set of observations relevant to understanding the origin of the layered material in Arabia Terra. In addition, the Mars 2020 Ro-

ver landing site (Jezero) is within the potential ash dispersion reach of the suggested calderas [Fig. 2], giving this work the potential to comment directly on the geology of the selected landing site.

**Methods:** To test the caldera hypothesis we have assembled a team of planetary geologists, volcanic geomorphologists, modelers, GIS scientists and remote sensing experts familiar with identifying, cataloging, and describing explosive volcanic deposits. The project is enabled by recent increases in data coverage of Arabia Terra (particularly of CRISM and HiRISE data).

**GIS Survey:** Our team is performing a regional sur-



**Figure 1:** Cumulative magma volume over Mars' history [after 22]. The suggested calderas [19] might explain early volcanism predicted by past observations and modeling. We are studying the morphology, mineralogy, and distribution of layers of Noachian-Hesperian rock exposed in Arabia Terra canyons for evidence of volcanic origin to fill the volcanic knowledge gap.

vey to identify the subset of image, spectral and topographic data that 1) are not dust covered, 2) contain canyon walls, and 3) overlap each other. Identified data will be used in detailed analyses

**Clay Mineralogy:** Our team is investigating the variety of minerals exposed in Arabia Terra Canyon walls. Altered volcanic ash produce a unique suite of minerals (*e.g.*, jarosite, smectite, and zeolite) now observable with CRISM data. We are identifying their abundance.

**Layer Morphology:** Our team is investigating layer thickness, block abundance, competence and spatial distribution in image and topography data. Explosive eruptions produce deposits with unique morphologies

(e.g., thin from source, proximal resistant layers with blocks, distal friable layers that conform to topography) now identifiable in cross-section with HiRISE data. We are identifying the spatial trends and morphology of layered deposits.

**Spatial Distribution:** Alone, neither the mineralogical nor the morphological study can definitively distinguish volcanic layers from other types of rock. Our team is also assessing layer spatial variability. Using these three aspects together our team is evaluating the hypothesis of calderas in Arabia Terra.

**Conclusions:** This project is testing a provocative hypothesis that calderas in Arabia Terra produced wide spread ash deposits, which could suggest that an early phase of explosive volcanism accounts for the disconnect between modeled magmatism and the observed volcanic record. In addition this work has implications beyond martian volcanology. This work could be used to constrain future climate models as ash dispersion patterns could be used to constrain ancient atmospheric pressure. Furthermore, as volcanic eruptions produce gasses as well as ash, this work contributes to the discussions regarding the composition of Mars' atmosphere. We will also illuminate weathering products and the distribution of clay minerals in Arabia Terra. This information will contribute to a better understanding of the climate history of Mars following the emplacement of the material that makes up Arabia Terra.

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**Figure 2:** A Mars Orbiting Laser Altimeter (MOLA) color hill-shade of Arabia Terra with suggested calderas [19] filled in with red. The black line shows the outline of the Arabia friable layered deposit, a suggested ash-fall unit [after 18]. The canyons that dissect the northern boundary of this unit make up the fretted terrain. White arcs indicate the distance from the calderas. The selected landing sites for the Mars 2020 rover is indicated with a white stars adjacent to the study area. We are investigating chemical and morphological evidence for volcanic deposits in cliff walls at different distances from the potential calderas.

