ISDIS IMPACT MEGABRECCIA COMPOSITION, SIZE, AND FORMATION HISTORY E. L. Scheller[1] and B. L. Ehlmann[1,2], [1]Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA, USA [2]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA (eschelle@caltech.edu).

Introduction: Megabreccia occur throughout the Noachian basement on the western rim of the Isidis impact structure on Mars.[1-3] Previous literature links their formation to Isidis basin formation processes.[1] Stratigraphic relationships show that megabreccia represent lithologies that could predate formation of the Isidis basin and most other units in the Noachian stratigraphy present in Nili Fossae and NE Syrtis.[4] Analyzing the Isidis impact megabreccia provides an opportunity to understand both the composition of Pre-Noachian to Early Noachian materials and the formation of megabreccia through basin scale impact processes. We undertook systematic mapping of 173 megabreccia outcrops in the Noachian basement.[4] The mapping included investigating the distributions and variety of textures, compositions, block sizes, and stratigraphic relationships of megabreccia.

Composition of megabreccia: The compositon of megabreccia can be analyzed using CRISM data and HiRISE color data. CRISM infrared spectra show megabreccia blocks can contain LCP and Fe/Mg-smectite.[1,4] However, only 11 of 173 megabreccia outcrops have blocks of large enough size to be analyzed with CRISM data. Hence, we perform a compositional analysis using HiRISE color data to obtain different endmember compositions and lithologies of megabreccia blocks from their color properties. Specifically, we use color band ratios and 3-color spectra angle, slope, and area parameters to investigate the variable color properties of megabreccia that typically vary due to absorptions associated with Fe^{2+} and Fe^{3+} in minerals.

From our analysis of pixel density plots of 8 different megabreccia outcrops, we observe at least 4 different compositional endmembers (Fig. 1). These 4 endmembers in the HiRISE color parameter space correspond to four different false color classes: yellow/white, beige, blue, and purple (Fig. 1). From direct comparison between CRISM and HiRISE color images, yellow/white materials appear to be Fe/Mg-smectite whereas blue materials appear to be LCP with particularly strong Fe^{2+}-absorptions. The composition of beige and purple color megabreccia blocks is unknown due to the lack of CRISM coverage of megabreccia blocks.

Our study also examined the composition of the regional basement units in the same HiRISE color parameter space (Fig. 1). We analyzed three HiRISE color images that included Noachian basement and olivine-carbonate units.[1-3] Megabreccia do not appear to be composed of exactly the same materials as the main parts of

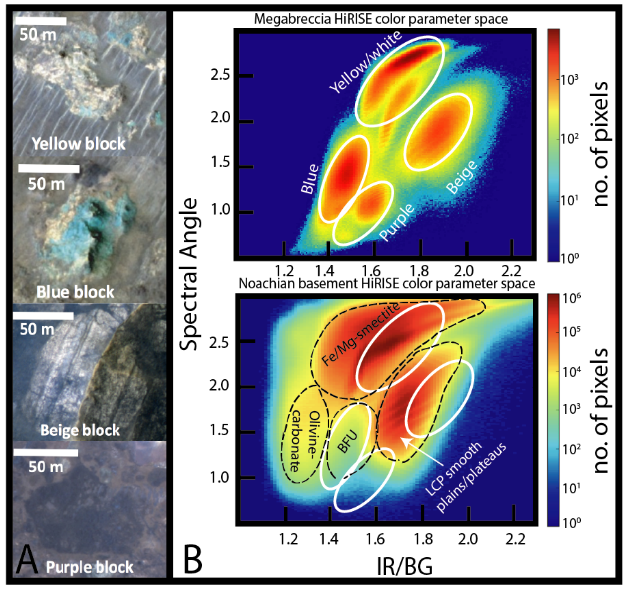

Fig. 1: A) Four different colors of megabreccia observed in HiRISE color. B) Composition of megabreccia and Noachian basement units in HiRISE color parameter space. Notice 4 compositional endmembers associated with 4 colors of megabreccia.

the analyzed Noachian units. However, yellow/white megabreccia blocks have compositional similarities to Fe/Mg-smectite, and blue megabreccia materials have compositional similarities to units of fractured blue LCP (BFU) with strong Fe^{2+}-absorptions in CRISM. Beige materials may be compositionally similar to some parts of the LCP-containing plains or plateaus with less strong Fe^{2+}-absorptions in CRISM.[5]

Block sizes of megabreccia: Megabreccia blocks are typically subangular-subrounded suggesting either ballistic or gravitational flow transport. We sought to constrain if block size distributions could distinguish between these two processes. Hence, we mapped 4600 blocks at different distances from the Isidis crater center. The block sizes have a diameter range of 1.3-433 m and median of 11.5 m. We investigated trends in block sizes with variations in distance from crater and MOLA elevation (Fig. 2). However, we observe that block sizes generally appear to have similar characteristics (median, quartiles, and ranges) at different distances and elevation intervals (Fig. 2) with no apparent trends. This suggests that megabreccia were not formed through ballistic transport that generally causes a grain size fining with further distance from crater center.[6]

Megabreccia formation: Megabreccia can form through tectonic, glacial, volcanic, and impact processes. Our studies agree with an impact origin for the following reasons: 1) megabreccia are distributed

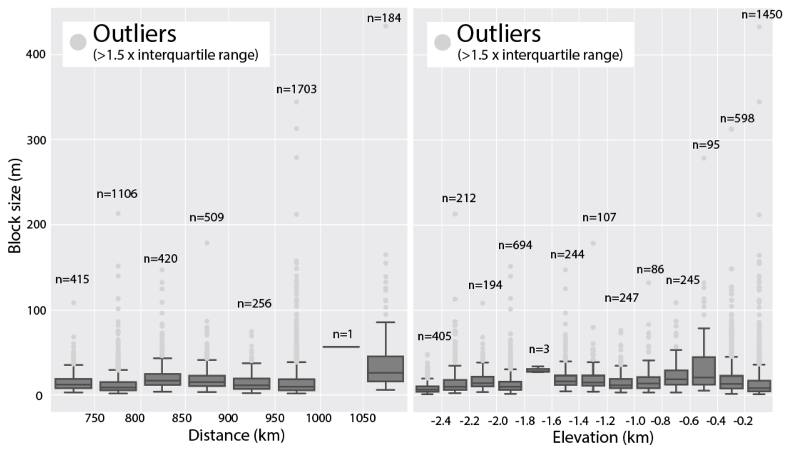

Figure 2: Boxplots of megabreccia block sizes binned according to MOLA elevation and distance from Isidis crater center.

within the Western part of the Isidis structure in the lowermost exposed strata, 2) megabreccia disappear outside the impact structure, 3) megabreccia appear to have the same stratigraphic age as Isidis basin, 4) hundred meter scale block sizes are consistent with sizes of impact-induced brecciation[7-8], 5) composition of megabreccia blocks appears in part to reflect locally sourced Noachian basement materials, and 6) there is no other evidence for tectonic processes, calderas, and glacial erosion. Megabreccia have been suggested to form in a variety of processes associated with impacts. Conceptual models based on field studies predict gravitational flows to occur due to inward-collapsing walls of the transient crater (Fig. 3).[9] On the other hand, recent hydrocode models suggest instead that basin-scale impact structures are largely overprinted by gravitational flows during outward collapse of the central peak (Fig. 3).[10-11] Several observations made in our study, including rounding of blocks, large variation in megabreccia composition and texture within a single outcrop, and the random distribution of block sizes with elevation and distance from the crater center, are all consistent with formation through gravitational flows.

Through in-situ or sample return analysis of megabreccia materials it may be possible to test between different models for impact basin formation, including hydrocode models and variations of the conceptual model. This is primarily because hydrocode-based model predict a much deeper excavation depth of megabreccia (mantle-like) compared to the conceptual model prediction of relatively shallow crustal excavation which may have significant effects on the variation of shock levels and composition/structure of megabreccia materials.[9-10]

Conclusions: Our study finds that megabreccia blocks contain at least 4 different pre-Isidis lithologies. Block sizes of megabreccia have a range of 1-433 m with median of 11.5 m, independent of variations in elevation and/or distance to the crater center of the Isids basin. The lack of trends in block size distributions, the general position and distribution of megabreccia, the large variety of juxtaposed megabreccia compositions and textures, and sedimentological properties of megabreccia are all consistent with formation of megabreccia through gravitational flows from collapse of the transient crater during impact basin formation.

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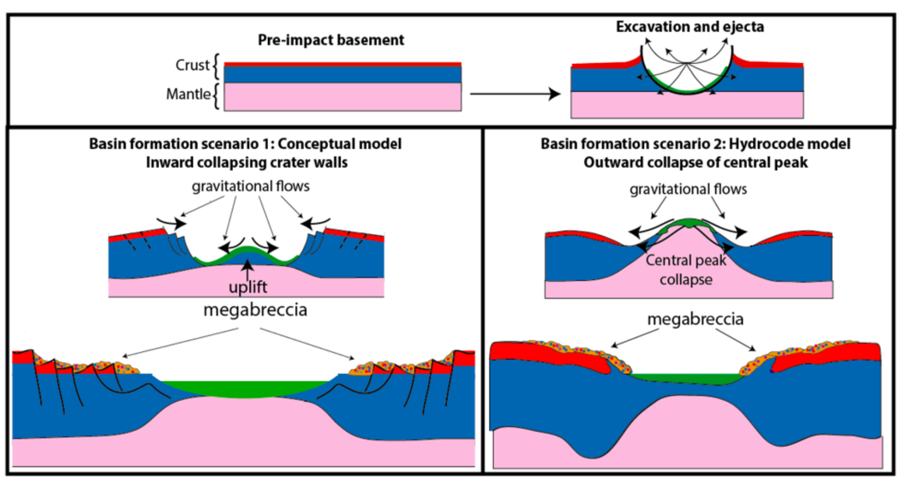

Figure 3: Schematic illustrating megabreccia formation through gravitational flows during transient crater collapse in two different existing models: Conceptual and Hydrocode model. Green=impact melt, orange=megabreccia matrix, red=LCP-rch crust, blue=Fe/Mg-smectite-rich crust.