PROBING THE PRE-MARIA GEOLOGIC HISTORY OF THE IMBRIUM BASIN USING REMNANT BASIN MASSIFS. B. D. Byron\textsuperscript{1,2}, C. M. Elder\textsuperscript{1}, L. M. Pigue\textsuperscript{3}, J.-P. Williams\textsuperscript{4}, 1Jet Propulsion Laboratory, California Institute of Technology, 2Department of Physics, University of Central Florida (current institution; benjamin.byron@ucf.edu), 3U.S. Geological Survey, Astrogeology Science Center, 4Department of Earth, Planetary and Space Sciences, University of California at Los Angeles.

**Introduction:** The Imbrium basin, located in the nearside Procellarum KREEP terrain, is one of the largest impact basins on the Moon. It experienced multiple phases of volcanic activity over billions of years, including both effusive and explosive eruption styles. The pyroclastic deposits are in some cases emplaced by effusive lava flows, suggesting that evidence for pyroclastic volcanism could have been more widespread prior to the later effusive flows\cite{1}. In this work we investigate the pre-mare geologic history of the Imbrium basin using thermal, radar, and compositional datasets. We focus on several remnant basin massifs around Imbrium as their higher topographic elevation means that they were not blanketed by this ejecta as well, before Imbrian and Eratosthenian lava flows filled the basin and obscured ejecta from the impact. In this case, we see that although Mons Recti do not retain a record of the pre-mare impact history of the region.

**Methods:** We used data from both orbital and Earth-based remote sensing instruments in this work, including thermophysical measurements (Rock Abundance [RA; 2] and H-parameter [3]) from the Lunar Reconnaissance Orbiter (LRO) Diviner Lunar Radiometer Experiment (Diviner), Clementine color-ratio, Kaguya Multiband Imager mineral abundance, and Arecibo S-band circular polarization ratio (CPR).

We additionally analyzed visible-NIR spectra from the Moon Mineralogy Mapper (M\textsuperscript{3}) instrument. We created glass band parameter (GBP) maps for the basin massifs, using the methods of [1,4,5]. The GBP uses the location, depth, and shape of the absorption band near 1 \textmu m to evaluate iron-bearing glass absorption features. In locations where the GBP maps showed evidence for glass signatures, we further analyzed spectra to confirm the presence of glass.

**Results:** The topographically lower portions of Mons Vinogradov have lower RA, higher H-parameter, and lower CPR than surrounding mare, and appear compositionally distinct in Clementine color-ratio (Figure 1a-d). Montes Recti similarly have low RA, high H-parameter, and low CPR, and are mantled by orange material in the color-ratio map in their lower lying portions (Figure 1e-h). However, the two massifs are different in that Mons Vinogradov shows evidence for iron-bearing glass in the GBP map while Montes Recti does not (Figure 2). Iron-bearing glass manifests in VIS-NIR spectra as an “asymmetric shoulder” in the 1 \textmu m absorption band [4]. We see in Figure 2 that the spectra from Mons Vinogradov contain this asymmetric absorption, while the spectra from Montes Recti do not. Therefore, even though both massifs appear to be mantled by relatively rock-poor and fine-grained material that is orange in the color-ratio map (Figure 1), only Mons Vinogradov shows signatures of potential iron-bearing glass.

**Discussion:** There are several pyroclastic deposits south of Mons Vinogradov near Montes Carpatus at the southern edge of the Imbrium basin that have similar color in the color-ratio map and are pre-Eratosthenian in age (<3.2 Ga [6]). We suggest that the glassy deposits mantling Mons Vinogradov are pyroclastic in nature and may be related to these pyroclastic deposits closer to the edge of the basin. Mons Vinogradov is emplaced by mare basalts that are Eratosthenian in age (<3.2 Ga), and the fact that the rock-poor glassy material mantling Mons Vinogradov is confined to the Mons indicates that the material likely covered a greater area surrounding the massif prior to the deposition of the Eratosthenian basalts. The topographically higher Mons Vinogradov deposits would have been emplaced but not obscured, thereby retaining a small part of the pre-mare volcanic record of southwest Imbrium.

While the Montes Recti mantling material is not glassy in nature (Figure 2), it is fine-grained, rock-poor, and compositionally distinct from both mare and typical highland materials. The nearby Montes Jura region north of Imbrium displays a similar orange color in the color-ratio map, suggesting that it may be similar in composition. Similar to Montes Recti, the Montes Jura region appears rock-poor in radar and thermal infrared datasets, which suggests it is mantled by a thick layer of rock-poor ejecta from the Sinus Iridum impact [7]. Given the close proximity of Montes Recti to Sinus Iridum and the Montes Jura region, we suggest that Montes Recti is also mantled by Iridium ejecta. Much of the northern part of Imbrium would have likely been blanketed by this ejecta as well, before Imbrian and Eratosthenian lava flows filled the basin and obscured ejecta from the impact. In this case, we see that although Montes Recti do not contain evidence for pre-mare pyroclastic volcanism, they do retain a record of the pre-mare impact history of the region.
Conclusions: Using datasets spanning visible, infrared, and radar wavelengths, we have found evidence for rock-poor material at several Imbrium basin ring massifs. At Mons Vinogradov we see signatures of iron-bearing pyroclastic glass, and at Montes Recti we see remnants of ejecta from the Imbrium impact. These findings indicate that the basin massifs can retain evidence of materials that originally covered larger areas but were later obscured by mare volcanism, and can provide a window into the pre-maria geologic history of the basin.

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References:

Figure 1: (a, e) LROC NAC mosaics, (b, f) Diviner H-parameter, (c, g) Arecibo S-band CPR, and (d, h) Clementine color-ratio for Imbrium basin massifs Mons Vinogradov (a – d) and Montes Recti (e – h). Both massifs show evidence for a mantling of rock-poor, compositionally distinct material.

Figure 2: VIS-NIR spectra from M^3 and Glass Band Parameter Maps for Mons Vinogradov (top, lat 20.5° – 23° N, lon 31.5° – 33.5° N) and Montes Recti (bottom, lat 47° – 49° N, lon 17° – 23° W). Although both massifs show evidence for rock-poor material, only Mons Vinogradov displays signatures of iron-bearing glass in the in the spectra (i.e., asymmetric shoulder at 1-μm) and in the Glass Band Parameter Map.