CRATER RETENTION TIMESCALES OF MARTIAN BRAIN CORAL TERRAIN RECORDS PAST CLIMATIC CHANGE. A. M. Morgan1, E. Z. Noe Dobrea1, K. A. Pearson2, and A. Altinok2, 1Planetary Science Institute, Tucson, AZ 85719, 2 Jet Propulsion Laboratory, Pasadena, CA 91125 USA

Introduction: Brain coral terrain – so named for its resemblance to the human brain or aquatic brain coral – is a distinctive surface texture found across concentric crater fill (CCF), lobate debris apron (LDA), and lineated valley fill (LVF) terrains. Impact craters on brain coral terrain are rare, and many impact craters observed on brain coral terrain are heavily modified, indicating that these surfaces are young. Previous efforts [e.g., 1-3] to date these surfaces have provided an important groundwork in understanding brain coral terrain but have been hindered by several limitations. Individual brain coral terrain areas are small, and ages derived from crater statistics on small areas are subject to high uncertainties. Furthermore, small count areas require the use of small craters in order to have enough data points for a statistically significant sample. The identification of these smaller fresh craters is challenging due to obscuration by similar-scale brain coral terrain cells, particularly when using data such as MOC, where a 50 m crater can be only several pixels across. The wide availability of high-resolution images from the HiRISE camera and automated methods of landform identification serves as a compelling motivation for further investigation.

Methods: We combine geomorphic mapping and analyses of impact crater size frequency distributions (CSFDs) to interpret the surface ages and resurfacing history of martian brain coral terrains. We began with 456 HiRISE images that a deep learning model identified as containing brain coral terrain [4]. We visually inspected each of these HiRISE images with potential detections in addition to any adjacent HiRISE images which the detector did not identify but were thought to have brain coral terrain based on their proximity with the detected images.

Although HiRISE resolution permits the identification of meter-scale craters, we only included those > 50 m diameter because smaller craters are difficult to identify against the similar scale brain coral terrain cells. We omitted obvious secondary craters based on clustering and orientation patterns. We classified craters as being either fresh, moderately degraded, or heavily degraded (Fig. 1). This scale is inherently qualitative, so to limit the amount of subjectivity we exported images of each crater to view and classify the degradation scale outside of the GIS environment. Each crater was classified three separate times.

Crater data were imported into CraterStats 2 [5] for analysis. We used the assigned degradation state to group the craters into three crater populations: (1) fresh craters only, (2) fresh and moderately degraded craters, and (3) fresh, moderately degraded, and heavily degraded craters. Interpreted ages for each region were derived from the segments of the plots that best matched the [6] production function using pseudo-log binned reverse differential histograms. Absolute model ages were derived using the [7] chronology function. We use the Poisson probability analysis approach of [8], which yields an exact mathematical solution to the model crater chronology function according to the observed CSFD regardless of the bin size, which is useful when deriving statistics for surfaces with a small number of impact craters.

![Fig. 1. Examples of the three degradation classes of craters. All frames are at the same scale and clipped from HiRISE image ESP_044717_2205, illumination is from the left.](image1.png)

![Fig. 2. Location of the three study areas. Each dot indicates a HiRISE image with mapped brain coral.](image2.png)
Fig. 3. Crater size frequency distributions for the four study areas. Blue squares are fresh craters, red triangles are fresh and degraded craters, and green circles are all craters. Unfilled symbols are those data that do not lie along segments that match the slope of the production function.

Results and Discussion: The total mapped brain coral terrain covers a total area of 6,602 km² across parts of the northern lowlands and hemispheric dichotomy (Fig. 2). We focus our attention on the Ismenius Lacus (including Protonilus and Deuteronilus Mensae) as this region contains the largest area of mapped brain coral terrain (5,683 km²). Fresh impact craters on brain coral terrains on all three terrain types in Ismenius Lacus exhibit fits to the production function at ~3 Ma and ~25 Ma (Fig. 3). The multiple fits are indicative of partial resurfacing, whereby some process has removed craters smaller than ~100 m diameter until ~3 Ma, when craters began to reaccumulate in accordance with the production function. The ~3 Ma fit is not at a shallower slope than the production function, indicating that this resurfacing is not ongoing on modern Mars.

Of particular interest is the same ~25 Ma age for fresh craters >~ 100 m diameter and both fresh and moderately degraded craters less than ~100 m diameter on LDA and CCF (Fig. 3a,b). This similarity suggests that some process during the past 25 Ma preferentially moderately degraded craters smaller than ~100 m diameter. The ~3 Ma age closely corresponds with a modeled [9] shift in Mars’ mean obliquity from 35° to 25°. Ice-related landforms would undergo higher rates of resurfacing during these higher obliquity periods.

One possible degradation process that could explain the observed data is deflation of the underlying surface, which is believed to have occurred over the past tens to hundreds of Myr [e.g. 10]. Although the ~25 Ma fit of fresh and moderately degraded craters on LDA in Ismenius Lacus closely matches the slope of the production function, there is a slight decrease in slope for craters <70 m, suggesting that the surface may have deflated enough to erase craters up to about this size from the surface. Assuming a 1:5 depth to diameter ratio, this suggests that the surface has undergone ~10 meters of deflation since ~25 Ma. We suggest that brain coral terrains formed during this deflation, possibly from aeolian infill of polygon edges [1-3] or sorting of surficial boulders [11].

The accumulation of small craters along the ~3 Ma isochron indicates that brain terrain has been largely dormant over the past several million years. Alternatively, brain coral terrain may have been active over the past ~3 Ma but does not modify the surface sufficiently rapidly to modify craters >50 m over ~3 Myr timescales. Future work into the thermophysical properties at the location of brain terrain under different obliquity regimes may provide more insight into whether brain coral terrain could actively form from stone circles over the past 3 Myr, perhaps modulated by Mars ~100 kyr ±5° obliquity cycles.