NOTHING OLDER THAN THE BOREALIS BASIN ON MARS? H. V. Frey, Geodynamics Branch, Goddard Space Flight Center, Greenbelt, MD 20771, Herbert.V.Frey@nasa.gov, and D. Y. Shi, River Hill High School, Clarksville, MD

Summary: Large impact basins inside and outside the proposed Borealis Basin (BB) on Mars provide a way to determine the minimum crater retention age of the giant impact basin. Cumulative frequency curves for basins > 500 km show no real difference inside and outside of the BB, and those areas not likely affected by the largest impact basins have crater retention ages no older than most of the very large basins. This suggests that either very large basins have significant effects out to great distances, or the Borealis Basin, if real, completely reset all the crustal crater retention ages everywhere on Mars.

Introduction: We previously used 28 very large (D > 1000 km) impact basins on Mars [1] to estimate the minimum crater retention age [2] of the proposed Borealis Basin (BB) [3]. Figure 1 shows a distribution of ages for these basins color coded for those inside (blue) and outside (red) the BB. At the very least Borealis must be older than the oldest large basin superimposed on it (inside the BB), which is basin "F" and which has an N(300) crater retention age (CRA, cumulative number of basins > 300 km diameter per million square km) of 4.08.

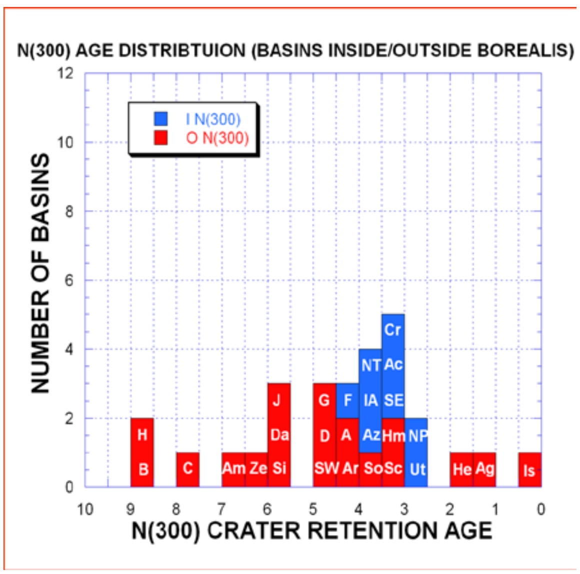

Figure 1. Distribution of N(300) CRAs of very large impact basins (D>1000 km) inside (blue) and outside (red) the proposed Borealis Basin on Mars. Borealis must be older than the oldest basin inside it, basin "F".

But cumulative frequency curves shown in Figure 2 for all the basins > 1000 km in diameter inside and outside the BB are, within their errors, the same [2], suggesting the Borealis Basin has an N(1000) CRA of ~0.218 (inside = 0.202 +/- 0.058, outside = 0.233 +/- 0.051), and may have completely reset the crater retention ages for the entire crust of Mars. If so, then the BB is older than the oldest very large impact basin anywhere on Mars, basin "B" in our inventory [1], which has an N(300) crater retention age of 8.94 [2].

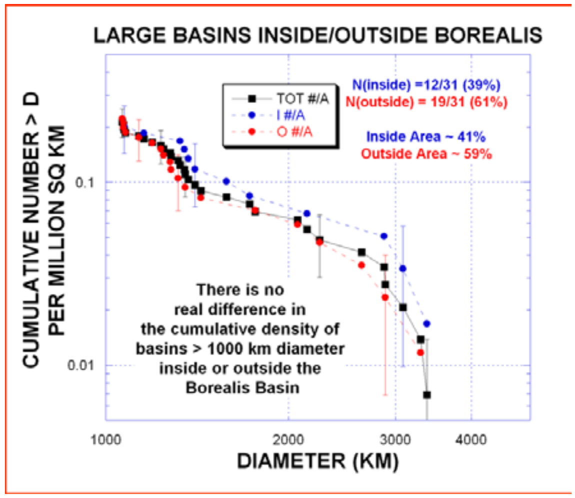

Figure 2. Cumulative frequency curves for very large basins inside (blue) and outside (red) the Borealis Basin, and for all of Mars (black) are the same within the errors.

To test this we extended the cumulative frequency curves in Figure 2 down to 500 km diameter for basins inside and outside of the BB (Figure 3). We then searched for areas not likely affected by the very large impacts that formed after the BB to see if crust older than the BB might still exist.

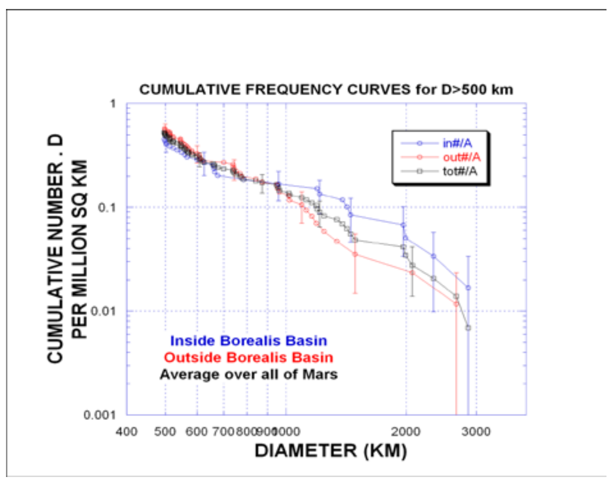

Figure 3. Cumulative frequency curves for basins > 500 km diameter inside (blue) and outside (red) the Borealis Basin and for all of Mars (black). Within their errors all three curves are the same, suggesting the crater retention ages inside and outside the BB are the same as that averaged over all of Mars.

Basins > 500 km diameter inside and outside the Borealis Basin. One of us (DYS) conducted an independent search for large impact basins in the 500-1000 km diameter range. This involved mapping Quasi-Circular Depressions (QCDs) from MOLA data and Circular Thin Areas (CTAs) from model crustal thickness data, using the most recent model by Neumann et al. [4]. He found 38 basins (68%) in this diameter range outside the BB and 18 (32%) inside compared with an area outside (inside) that is 59% (41%) of the surface area of Mars. That these relative ratios are not the same is not surprising: with decreasing diameter the preservation of basins outside the BB should increase relative to those inside, because the area inside BB contains all of the northern lowlands of Mars which may have more readily obscured some of the smaller (D~500 km) members of this population. When plotted as cumulative frequency curves for the entire range D>500 km (including the basins > 1000 previously determined), there is essentially no difference in the inside/outside curves, within the errors (Figure 3).

Mars crust possibly not affected by very large impacts. The current inventory of large basins covers a substantial portion of the surface area of Mars. It is reasonable to expect significant effects of large basin impact (substantial heating, pressure, likely resetting of crater retention ages) to extend well beyond the actual basin diameter. We mapped how much "unaffected" crust there might be on Mars if the major effects extend out 50% further than the radius of the basin. Figure 4 shows 5 areas that total 23.81 million square km that lie outside these extended basin effect areas. Two of these (areas 4 and 5) lie mostly inside the Borealis Basin and therefore cannot predate it. Areas 1, 2 and 3 are potentially older, but area 3 is downrange from the elliptical Hellas impact and may have been affected by that. Areas 1 and 2 are the best candidates for having very old crust on Mars; area 2 has over half the "unaffected" area at 11.8 million square km.

Ages of "unaffected areas. Preliminary counts of visible basins, QCDs and CTAs in areas 1 and 2 reveal N(300) crater retention ages no older than the N(300) CRAs of the very large basins which post-date the BB. .In particular, we see no evidence for crust anywhere on Mars with an N(300) crater retention age older than that of the oldest basin, basin "F", which has N(300) = 8.93. If real, the Borealis Basin may have completely reset the crater retention ages of the entire crust of Mars sometime prior to N(300) = 10, about the latest it could have formed. Alternatively, the later forming very large impacts may have reset the crust over most of Mars if their ability to do so extend beyond that assumed here.

Conclusions: Even though there MUST have been older crust present at the time the Borealis Basin (if real) formed in order for its imprint to have survived (in the form of the crustal dichotomy [3]), there is no indication that a record of that older crust survives in the crater retention ages of the exposed surface of Mars. Even surfaces lying outside the areas likely affected by very large (D>1000 km) basins, all of which are likely younger than the BB, have N(300) crater retention ages comparable to the ages of the very large basins, not older than them. The Borealis Basin, or perhaps the later forming very large basins, or both, may have completely reset the crater retention ages everywhere on Mars.

References. [1] Frey, H.V. (2009) *LPSC 40* Abstract #1123. [2] Frey, H.V. (2010) *LPSC 41* Abstract. #1136. [3] Andrews-Hanna, J., M.T. Zuber and W.B. Banerdt. (2008) *Nature 453*, 1212-1215. [4] Neumann G.A., F.L. Lemoine, D.E. Smith and M.T. Zuber (2008) *LPSC 39* Abstract # 2167.

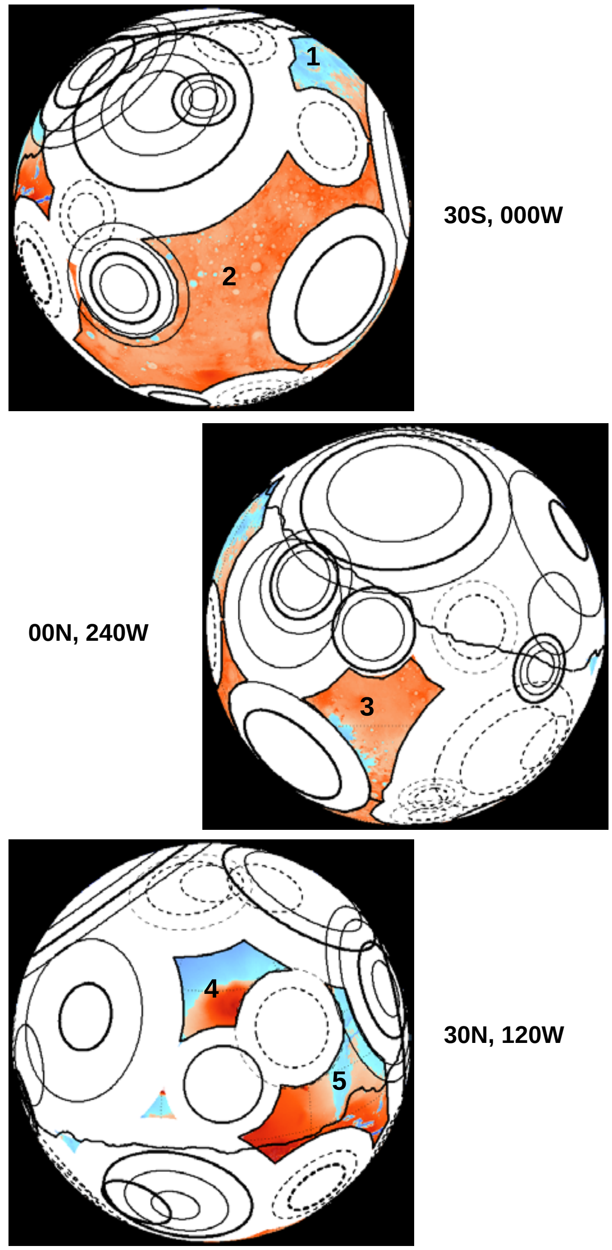

Figure 4. Possible very old crust on Mars. White: Areas lying outside the effects of very large basin impacts, assuming those extend to 1.5 x the basin radius. Black Rings: Basin rings; thickest line is inferred diameter. The Borealis Basin rim is the non-circular black line running across each globe. Areas 4 and 5 lie inside the BB and so cannot predate it. The other areas are potentially older, but preliminary N(300) ages for each suggests they are not significantly older than the oldest very large basins.