PEDESTAL CRATERS, A TOOL FOR ITERPRETING GEOLOGIC HISTORIES AND ESTIMATING EROSION RATES. J.E. Bleacher[1], and S.E.H. Sakimoto[2], [1]Arizona State University, Department of Geological Sciences, PO Box 871404, Tempe AZ, 85287-1404, jake13@asu.edu; [2]Goddard Earth Sciences, at NASA's GSFC, Geodynamics Branch, Code 921, Greenbelt, MD 20771, sakimoto@geodynamics.gsfc.nasa.gov

Introduction: Pedestal craters are defined as impact craters with layered ejecta patterns that are topographically perched above the surrounding terrain [1]. This type of feature was first observed on Mars during the Mariner missions [2]. The predominant proposed theory of pedestal crater formation involved erosional modification of fresh impact craters [2,3,4]. They suggested that a bolide impacting a surface of friable materials that cover a more competent surface, could incorporate resistant blocks from beneath the covering layer in the ejecta. If subsequent regional erosion occurred, threshold drag velocities would be higher within the blocky, continuous ejecta blanket, decreasing the effects of erosion while deflation occurred beyond the ejecta [3]. This model predicts a raised ejecta pedestal bound by a retreating scarp as weaker material below the ejecta blanket is exposed and undercut. Several low-latitude examples were cited [2]. However, other researchers argued that a post impact modification explanation did not adequately explain the morphology of the examples cited [5,6].

This study uses Mars Orbiter Laser Altimeter (MOLA) data to examine crater morphologies within the Parva Member (*Hdv*) of the Dorsa Argentea Formation (DAF) adjacent to the South Polar Layered Deposits [7]. We believe that some pedestal craters located within this area (72° - 79°S and 230° - 275°E) are topographically unlike the examples cited in the low-latitudes and do adhere to the erosional theory of pedestal crater formation [2]. Furthermore, when the implied formational processes of pedestal craters are placed in context with other regional features, they can be used to make geologic history interpretations [8]. The presence of pedestal craters suggests that the region has undergone at least one episode of burial followed by subsequent deflation. Erosion rate estimates based on pedestal heights are presented and they fall within the range of published rates [4,9].

MOLA Observations: The study region is equivalent to the mapped Parva Member of the DAF [7], covering an area of 129,040 km^2. We examined the region using the 1/64° MOLA grid [10] and individual MOLA PEDR files. The *Hdv* is a regional topographic low with a smooth undulating surface containing impact craters and sinuous ridges. *Hdv* is in contact with the Cavi Member (*ANdc*) of the DAF to the east, the Plateau Cratered Units (Npl_1, Npl_2) to the north and west, and the polar-layered deposits (*Apl*) to the south. The DAF members embay the older cratered terrains and are overlain by the polar deposits. Although both are members of the DAF, the *ANdc* is quite unique from the *Hdv*. The *ANdc* is characterized by irregular cavi (or pits) ranging from a few hundred meters to over a kilometer deep. Although topographically higher than the *Hdv*, the age relationship between the two units is difficult to ascertain, with Noachian materials likely exposed in the cavi and buried by Hesperian through Amazonian age deposits [7]. Sinuous ridges exposed in the *Hdv* have been the topic of many interpretations including eskers [11,12], lava flow fronts [13], mud or density flow features [14], and inverted fluvial channels [15,7].

Three distinct crater morphologies exist within the study region, fresh craters with well preserved ejecta and crater rims, craters with poorly preserved rims atop a pedestal hundreds of meters above the surrounding plains, and ghost craters with poorly preserved rims and heavily infilled cavities. The most abundant morphology observed is fresh craters while the least frequent are pedestals. Figure 1 shows the largest of the pedestal craters with a diameter of 16.5 km. The crater rim is degraded and at a distance of 8 to 12 km from the rim there is a 500 m concave outward scarp. The asymmetrical ejecta blanket does not display ramparts, radial striae, or other pristine ejecta features. The elevation of the ejecta blanket is generally equivalent to the surface of the *ANdc* to the east.

Discussion: Previous research suggests that winds have stripped the midlatitudes of aeolian debris and deposited them near the poles [3]. This produced a mantle of fine debris, which is a crucial part of the erosional pedestal crater theory. It is believed that a crater's continuous ejecta blanket is emplaced similar to a debris flow, encouraging the rise of any large blocks that might have been incorporated in the ejecta, creating a resistant layer [4]. The ejecta blanket then protects materials below from aeolian erosion. If deflation occurs beyond the armored ejecta blanket the flanks below are exposed and eroded. The ejecta are undercut and a concave outward scarp forms [3].

The presence of this type of crater form within the *Hdv* (Figure 1) suggests that regional deposition and subsequent deflation has occurred. The presence of ghost crater morphologies has also been suggested to indicate regional exhumation [16,17] supporting this idea. Recently, the sinuous ridges in the *Hdv* have been interpreted, based on MOLA mapping, as eskers remaining after a glacial meltback of a volatile rich polar debris blanket [12], or as inverted fluvial deposits remaining after erosion of a volcani-clastic slurry [7]. Both interpretations suggest regional deflation as implied by the presence of the pedestal craters. Therefore, we believe that the pedestal crater morphologies observed within the *Hdv* are likely produced by post impact modification processes, consistent with the theory put forward earlier [2].

The presence of the ghost craters suggests that some amount of the debris blanket is still present. Ghost crater rim heights can be used to estimate the thickness of the remaining mantling material [8] if measured rim heights are subtracted from calculated rim heights for craters of the same diameter. A similar approach was used to calculate lunar lava flow thicknesses [18]. Calculated rim heights are derived from martian impact crater diameter vs. rim height aspect ratios [19]. This suggests that the mantling material is no thicker than 400 m maximum, as the rims have inevitably undergone erosion. If the mantle is <400 m thick, the pedestal crater cavities in the region are deep enough to have penetrated the mantling layer, excavating blocks from the more resistant underlying layer into their ejecta blankets.

The pedestal crater ejecta blankets preserve the elevation of the preimpact surface. The largest pedestal crater in the *Hdv* (Figure 1) displays the highest topographic ejecta blanket, equivalent to the *ANdc*. If the surfaces preserved by the pedestal craters represent a regionally consistent surface, then the mantling deposit could have extended at a fairly constant elevation across both the *Hdv* and *ANdc*. We use the tallest pedestal to represent the maximum thickness of the mantling deposit and estimate the amount of topography lost. In this way we can derive volume lost and make estimates for regional erosion rates. The episode of deflation that eroded the *Hdv* produced erosion rates ranging from 1.3 to 5.2 x 10^{-7} m/yr depending on the duration of erosion. It is not clear if regional deflation is still active or if it ended with the beginning of polar layered deposit deposition. The estimated rates might be lower than the actual rates because the true amount of material removed from the region cannot accurately be measured. However, the rates presented here are within the range of published erosion rates of 10^{-8} [4] to 10^{-5} [9] m/yr.

Conclusions: Not all previously identified pedestal craters are a result of erosional processes [2,5,6]. However, craters within the *Hdv* that are located on platforms several hundred meters above the local plains suggest that they formed due to regional deflation. If so, their presence, as well as the presence of other features in the area, can be used to interpret the geologic history of the region. Pedestal and ghost craters suggest that the region has been buried by a debris blanket and subsequently, partially deflated with no more than 400 m of the mantling material still remaining. Pedestal surfaces indicate that the debris blanket was at one time comparable in elevation to adjacent DAF deposits and might have been an extension of (or continuous with) that deposit. The period of deflation that eroded the *Hdv* produced erosion rates ranging from 1.3 to 5.2 x 10^{-7} m/yr depending on when deflation actually began and ended. These rates are within the range of published, non-bedrock erosion rates for Mars but might be lower than the actual erosion rates do to annual dust deposition and necessary assumptions of deflation duration and maximum topography removed.

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Figure 1. Viking MDIM Image and MOLA topography profile for the 16.5 km pedestal crater.