174.57°E), shows layers exposed along its southeastern wall between −1899 and −1939 m (corresponding to PL_m elevations). A second crater (Figure 13c), at 14.32°S 175.13°E, shows layers exposed along the entire crater wall at elevations between −1884 and −1898 m. The third crater (Figure 13d) at 14.68°S 175.07°E shows several layers exposed approximately between −1843 and −1926 m.

[39] At least four craters in northeastern Gusev expose layering within the WR_m unit to the northeast of Thira crater. An example is a <0.8 km diameter crater (14.04°S 176.08°E), exposing several layers between −1850 and −1900 m within its crater wall (Figure 13e). Layers are highlighted by shadowing and, in this case, slight albedo differences. Weathering profiles are also accentuated by shadowing effects.

[40] MS_m shows some evidence of indistinct, sub-horizontal layering. One mesa (15.23°S, 175.04°E) shows layers between −1800 and −1875 m, along eastward-facing exposures (Figure 13f).

4. Discussion

4.1. Proposed Surface Units

[41] Comparison of thermophysical and morphologic unit properties shows a strong spatial correlation between many of the two unit types. This supports our approach of using these properties independently to identify prominent surface units. However, it is important to note that the thermophysical properties of a given unit can vary laterally depending on a variety of factors such as grain size, facies changes, extent of cementation, degree of erosion/weathering, etc. Also, TIR data from the Martian surface is only representative of the top few centimeters of exposed material. If units are mantled by aeolian dust, thermophysical mapping can be problematic. Thus, when observing discrepancies between thermophysical and morphologic units and trying to determine true unit boundaries, morphologic delineation is, at the moment, preferred. In many cases, sudden slope changes correspond more closely with morphologic changes rather than thermophysical ones, further supporting use of morphology as the deciding factor for delineating unit boundaries.

[42] Recognizing the correlations between thermophysical and morphologic units, we propose seven *surface units* within Gusev crater. Here we use the term surface unit to define rock or sediment that (1) are laterally extensive or mappable, (2) express similar surface morphologies, (3) possess similar thermophysical qualities, and (4) occur over consistent elevation ranges across the mapped area. Surface unit abbreviations are indicated by the absence of a subscript. A surface unit map for Gusev crater is shown in Figure 14a. The proposed surface units are Thira Rim (TR), Wrinkled (WR), Etched (ET), Lobate (LB), Plains (PL), Mesa (MS), and Ma'adim Vallis (MV).

4.2. Surface Unit Elevations and Thicknesses

[43] MOLA data (Figure 3) provide a means of measuring the maximum and minimum elevations of exposed units within Gusev. Elevation data allows comparison the relative vertical positions of different surface units (Figure 15). For example, Figure 15 shows that the highest exposed surface unit within Gusev is MS, while the lowest exposed units are WR and LB. Topographic relief (calculated from maximum and minimum unit elevations) was assumed to represent minimum unit thicknesses (Figure 15). Marked slope breaks at constant elevations also provided a means of further delineating suspected unit boundaries and identifying exposures of underlying units (Figure 3b).

4.3. Crater Densities

[44] In an effort to determine relative and absolute ages of identified units, crater density measurements were made according to methods of the *Crater Analysis Technique Working Group* [1979]. Results of crater counts, measurements of surface areas, populations of craters ≥1, 2, 5, and 16 km, and age estimates are reported in Table 2 and summarized in Figure 16. Crater density measurements identify many of the units as Late Noachian to Late Hesperian in age, with WR Early Amazonian in age. Because no craters or ejecta are superimposed on low-albedo material and due to their very recent (<25 yrs.) redistribution within Gusev, this material is obviously Late Amazonian in age. Ages are mostly consistent with age estimates by *Kuzmin et al.* [2000].

4.4. Surface Unit Stratigraphy

[45] The combination of surface unit mapping (Figure 14a), elevation data (Figure 15), and crater density ages (Figure 16) provides a means of determining the stratigraphy (Figure 14a) and thus the depositional/erosional history of Gusev crater. Ages based on crater densities for Gusev units should be considered with caution. Planetary surfaces that undergo modification by processes other than impact cratering can give problematic crater ages [*Edgett and Malin*, 2003]. Factors such as erosion by wind or water, infilling, and the duration of exposure can lead to the obliteration of craters and therefore influence age estimates for such surfaces. With the presence of drainage and aeolian features within the Aeolis Quadrangle, age dating surface units is problematic and should only be considered within the context of topographic and other data.

[46] The lowest (elevation) stratigraphic units within Gusev appear to be TR and WR. Exposed TR lies between −1625 and −1900 m and WR is exposed between −1875 and −1975 m. From these elevations, it appears that WR lies below TR. However, WR is deposited against Thira's rim to the north (Figure 17). This indicates that TR existed prior to WR deposition, making TR the oldest unit within Gusev. The absence of superimposed craters (and thus lack of a crater density age) on TR is likely related to prolonged rim modification. The high elevation of TR likely led to an increased likelihood of modification by surficial and atmospheric processes. Also, several collapsed terrace blocks lie along the rim, indicating that Thira has been modified by crater wall collapse.

[47] Both WR and LB lie at comparable elevations, but LB appears to have an older crater density age. A comparison of the state of crater rims within both units (Figure 8) shows WR rims to be more degraded than those of LB, suggesting that WR is actually older than LB. If WR craters had been modified or even obliterated over time, crater density ages would represent the period during which modification took place, rather than deposition of WR. Additional support for an older WR comes from north