regime could account for the changing morphology of MV from Ma'adim to Gusev. The linear ridges parallel to the long axis of Ma'adim Vallis continue until the breach in Gusev's southern rim. Once inside Gusev, the characteristic MV texture is lost. This could indicate constrained valley flow toward the crater rapidly changing into flow across the broader plain of the crater floor. Another moderate rise in base level could account for sub-lacustrine modification of WR during the Early Amazonian. Eventual evacuation of water from Gusev would have led to the present-day aeolian regime. Under this model, fluvio-lacustrine activity would have dominated during the Hesperian, suggesting a period of hydrologic activity of <1 Ga, as opposed the <2 Ga period proposed by *Grin and Cabrol* [1997b] and *Cabrol et al.* [1998]. However, standing lake levels as late as the Early Amazonian may have occurred, modifying WR, extending this period to <2 Ga.

[61] Thermal inertia values for surface units, under a fluvio-lacustrine regime, should be expected to correlate with values expected from sediment or sedimentary rock. Interpretations of surfaces covered by $\leq$ sand-sized particles for two surface units (PL and WR) and low-albedo material are consistent with this. However, these thermal inertias are from the uppermost regolith and may not be representative of the entire surface unit. Also, under this model, thermal inertias of units (such as MV or PL) extending from Ma'adim into Gusev should consistently change as depositional energies (and thus particle size distribution) change. This trend is not readily observable in TES data, but may be masked by dust covering surface units.

[62] Our consideration of the fluvio-lacustrine hypothesis does not preclude the role of aeolian deposition within Gusev. Aeolian erosion and deposition are the only processes that presently occur. Wind streaks, dust-devil tracks, and small dune fields have been observed superimposed on surface units, indicating more recent activity. We have not yet observed "fossil" aeolian bedforms within surface units or their layers; however, current data sets lack the resolution to identify and distinguish between "fossil" aeolian and fluvio-lacustrine sedimentary structures.

[63] A volcanoclastic model may also account for the distribution and orientation of some units and layering within Gusev. Horizontal layering occurs in many terrestrial and Martian lava flows and ash deposits. Apollinaris Patera, to the northeast, would be a candidate source area for such material. Surface types 1 and 2, thought to represent volcanic lithologies [*Bandfield et al.*, 2000; *Hamilton et al.*, 2001; *Wyatt and McSween*, 2002], have been detected in low-albedo material in Gusev; however, visible imagery and TES thermal inertia data suggest that these are likely aeolian sand. Observations of the northwestern rim of Gusev (Figure 1a) suggest that Apollinaris lava flows did not extend as far as Gusev. Nevertheless, explosive volcanic episodes during the Hesperian may have deposited ash within Gusev [*Robinson et al.*, 1993]. Surface unit ages do correspond to the timing of Apollinaris volcanic activity. Prevailing winds at the time of eruption could have carried ash fall southeastward toward Gusev. Under this model, variability in layering weathering profiles could be explained by ash compositional variability or the degree of induration of ash falls. However, comparisons of slope angles for Apollinaris Patera with other Martian phreatomagmatic and shield volcanoes, suggest less-energetic explosive activity and thus fewer distal fall deposits [*Thornhill et al.*, 1993]. This model alone cannot account for the localized deposition of units such as LB, MS, MV, and potentially ET and PL, but may account for deposition of WR and the low-albedo material. Because this model considers Apollinaris Patera the most likely volcanic source area, volcanoclastic deposits would thus thicken northwestward across Gusev. Presently, there is no indication that such thickening occurs. If such thickening once existed, it may have been subsequently modified by erosional processes.

[64] Because neither of the above models provides a unique solution for deposition within Gusev, a combined volcanoclastic-sedimentary model is considered. This model proposes syndepositional and/or alternating volcano-sedimentary deposits within Gusev. It evokes fluvial and/or aeolian processes for localized deposition, while lacustrine and ash-fall activity could account for basin-wide deposition. Pronounced weathering profiles could also be explained by changes in rock type or other factors mentioned above.

[65] With the limitations placed on the volcanoclastic model, it is the least favored of the three. The volcanoclastic-sedimentary model is the most preferred because it accounts for both localized and widespread deposition within Gusev and recognizes the potential influx of ash-fall deposits from nearby Apollinaris Patera. Even if explosive activity were less energetic, leading to lower plume heights, prevailing wind patterns could serve to transport ash over 350 km to Gusev crater. With such minimal activity and long transport distances, the role of volcanic deposition is diminished as compared to sedimentary processes. While the results of our study are consistent with Gusev as a fluvio-lacustrine depocenter, we have yet not identified features that are uniquely lacustrine.

4.7. MER Testable Hypotheses

[66] Regardless of the exact depositional/erosional history of Gusev crater, this study has demonstrated the geologic variability of the site (five or more of the seven surface units mapped in this study lie within the MER-A landing ellipse). With such heterogeneity, the possibility of sampling materials transported from proximal units (by aeolian, fluvial, or impact processes) during MER rover traverses (<1 km) is high relative to other candidate landing sites.

[67] A MER rover in Gusev would provide an opportunity to calibrate remote-sensing data collected by the orbiting THEMIS and TES instruments. Mini-TES will have the ability to measure albedo, thermal inertia, and temperature, as well as the capability of collecting spectra from dust-free surfaces, which could be used to compare surface compositions derived from the THEMIS and TES instruments. The ability to "ground-truth" remote-sensing data may lead to more accurate interpretations of Gusev geology.

[68] Instruments on MER provide a means of testing depositional models and determining stratigraphic relationships of units within Gusev. Spectral analyses from Mini-TES and APXS may provide data with which to identify rock types and thus clarify depositional regimes. Pancam and Microscopic Imager could reveal textures within strata indicative of depositional parameters (i.e., energy of environment). Pancam, APXS, and Mini-TES could discriminate rock types, thus noting contributions from various deposi-