Evidence for low energy coastal environments on Mars: Implications for the in-situ exploration of extraterrestrial submarine deposits

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The Martian northern plains include an extensive ice-rich sedimentary deposit interpreted to contain large amounts of marine ice residual from an ocean that likely covered most of the planet’s northern hemisphere approximately 3.4 Ga. However, the plains’ sedimentary and volatile compositional make-up is also the result of a long history of younger resurfacing events by widespread wind, glacial, periglacial, volcanic processes; thus the precise distribution of relict sea floor materials at the surface remains unresolved in current investigations. The recent identification of debris deposits of probable tsunami emplacement, and which exhibit no noticeable evidence of secondary resurfacing, implies that we are now able to pinpoint the locations of sedimentary materials that have a significant compositional component consisting of sea floor and coastal materials. However, these materials are risky landing sites because they include abundant multi-meter scale bounders. Furthermore, there is no way to determine whether a specific landing site would be in close proximity to submarine materials (versus rocks captured and transported during the run-up overland phases). Here, we present our discovery of previously unrecognized paleo-shoreline features in the northern plains, which, we have found, might constitute some of the planet’s best preserved early Mars coastal areas. The features include sedimentary deposits that are topographically bounded by a constant upper elevation, and which lack bedforms diagnostic of significant horizontal motion. We interpret these characteristics as consistent with an emplacement origin within a low energy submarine environment. While these materials are marked by polygonal trough systems characteristics of surface periglacial resurfacing of ice-rich sediments, the magnitude of resurfacing that they have endured has not been sufficient to modify their upper boundaries and overall morphologic consistency. We are currently selecting potential landing sites, in which, we find, the proposed sea floor materials exhibit sharp and abrupt boundaries at a decameter scales. Our discovery also has important paleo-climatic implications. The occurrence of the proposed sea level stand took place during the early stages of outflow channel activity; and thus it likely occurred under low atmospheric pressures and surface temperatures. The long-term effect of the ocean’s emplacement has been proposed to have resulted in temporary global climate warming; however, this most likely took place much later in the ocean’s history and following the end of peak outflow channel activity. Our discovery opens up the potential for in-situ exploration of early Mars marine sediments, which does not require the implementation of technologies that lie beyond our current reach.

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