THE SIGNIFICANCE OF A MARS HYDROGRAPH: SHORELINE SYNTHESIS CONSTRAINED FROM INTEGRATED TERRESTRIAL ANALOG STUDIES.

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Introduction: Terrestrial analogs continue to be critical tools for interpreting planetary surfaces [1]. A persistent controversy in the Mars planetary science community is whether or not there was an ancient "ocean" on Mars [2]. The recent reports of the global distributions of deltas and valleys [3] re-open the debate.

Geomorphic evidence for a Mars ocean includes both putative and debatable shoreline features along the lowland margins of the northern plains, as well as supporting evidence of large lakes in craters [e.g., 4, 5, 6, 7, 8, 9, 10, 11] Shorelines are key elements for interpreting the record of ancient water fluctuations on the surface of both Earth and Mars.

A central question to the ancient "ocean" controversy is: What are the exact criteria for shoreline recognition and why are they important? New imagery of Mars using higher resolution datasets offers the opportunity to address this controversy, and the context of terrestrial analog data in combination with ground-truth is vital to a robust interpretation of Mars shorelines.

Paleolake Bonneville-Great Salt Lake as a Mars Analog: The Bonneville-Great Salt Lake (GSL) system of the Great Basin in the SW USA is an appropriate analog for many reasons:

1. Although Earth's oceans typically have significant tides, but the smaller waterbody size of Lake Bonneville delimited the tidal effects. As such, Lake Bonneville is a more direct analogue for a potential Mars ocean, which lacks lunar tides and experiences relatively weak solar tides.
2. There are a wide range of landforms (e.g., shorelines, deltas, spits, fans, gullies, etc.) and processes (e.g., depositional, erosional, and modifying) spanning the Pleistocene to the present. These all provide comparative examples for Mars [12].
3. Rapid climate change since the Last Glacial Maximum (LGM) and modern aridity has preserved shore morphology dating to the Pleistocene.
4. Current imagery (e.g. digital elevation model – DEM) is available for the Bonneville basin at scales similar to MRO HiRISE.

Study Approach: This paper focuses on some of Earth's best shorelines preserved in Pleistocene Lake Bonneville and its modern remnant, the Great Salt Lake (GSL) (Fig. 1),) although we plan to expand the study to other well-known paleolakes with shoreline features (e.g. Pleistocene Lake Agassiz). The features at Lake Bonneville and the GSL comprise a world-class terrestrial analog for Mars that can be used to constrain geomorphic and surficial processes. The shorelines represent the edge of the water body and allow estimation of its volume at specific points in time. Distinctive constructional and erosional features in the terrestrial ancient shorelines show visible differences in profile cross-sections. These data enable reconstructions of the geomorphic effectiveness of water and wind. Our integrated studies build direct comparisons of shoreline features and their morphometrics at the meter-scale using new high-resolution DEMS (LiDAR and photogrammetry) of the Lake Bonneville-GSL basin, and recently released CTX and HiRISE imagery for Mars.

Fig. 1. Examples of well-preserved, multiple shorelines of Pleistocene Lake Bonneville, Utah.

Importance: The terrestrial sea level curve and the development of sequence stratigraphic models (i.e., genetically related stratigraphic units) in the 1980s-90s were truly transformative [e.g., 13, 14 ,15, 16, 17]. On Earth, the global sea level curve enables worldwide correlations based on linkages of tectonics, eustasy, and climate. Sequence stratigraphic models developed in context of the global sea level curve provide powerful predictors of facies and stratal architecture at wide-ranging spatial and temporal scales. Successful petroleum exploration and exploitation, as well as all recent stratigraphic and hydroclimate studies, are now placed in context of the global sea level curve [e.g., 16, 18, 19].

Lakes are particularly sensitive systems that record cycles correlative to ocean dynamics and the global water budget [e.g., 20, 21, 22]. The significance of Earth's global sea level curve cannot be overstated -- it is the key paradigm through which we now understand our planetary dynamics, and relate climate, biogeochemistry, tectonics and volcanism, and the evolution of life and the entire history of sedimentation on Earth. Assuming that an ocean existed on Mars, the implications for understanding these Martian processes could be equally significant.

Summary: We have begun to develop a detailed correlation and synthesis of shoreline features in order to generate a Mars hydrograph that can provide a crucial planetary reference datum for Mars. Defining global Noachian to Hesperian hydroclimatic oscillations, periods of water stability, and the relative geomorphic relationships of shorelines and landforms of the Mars putative ocean base level can be truly transformative, in the same way that the eustatic sea level curve on Earth provides the defining reference for all sedimentary deposits. The cumulative impact of our preliminary study generates an initial planetary Mars hydrograph that provides a testable framework to evaluate boundary conditions for ancient global water abundance, and provides a systematic model of facies and depositional environments that can guide future mission explorations and landing site selections.

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