Research Highlight

The Fluid Case of Ancient Mars

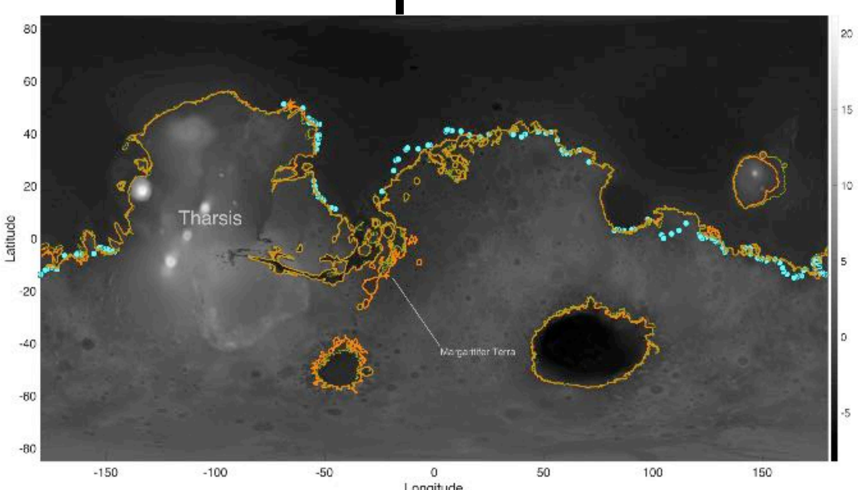
Dr. Erik Chan *is a postdoctoral fellow in* **Prof. Natalya Gomez's group.** *His research includes planetary structure, tidal deformation, mass loads, and rotational dynamics.*

Was there an ancient ocean on Mars? Water exists on Mars today mostly as ice, either below the surface or in the polar ice caps. Billions of years ago, its liquid form also sculpted the Martian surface, producing features such as sediment deposits, valley networks, and even possible shorelines. Some of the possible sea-level markers trace out shorelines that vary greatly in elevation, which historically led to them being dismissed as evidence of an ancient ocean. However, a prior study showed that a wandering rotation pole which causes the equatorial bulge to readjust itself (a process called "true polar wander"), could lead to shoreline features becoming vertically deformed, resulting in the observed elevation differences. Subsequent analysis into deltaic deposits led to a contrasting conclusion: the deltas already lie along an ancient sea level, without any vertical deflection by true polar wander.

Why this is important

Whether or not liquid water persisted on ancient Mars has important implications on its early climatic condi-tions. Was it ever as habitable as the Earth? If Earth and Mars were similar, what led to the stark differences ob-served today? The apparent conflict between a "cold and icy" and a "warm and wet" Mars is an important piece of the puzzle.

MSI postdoc Erik Chan and colleagues, including MSI Prof. Natalya Gomez, used multiple satellite-derived data sources to compile a dataset of valley networks that could have drained directly into an ocean in the northern plains of Mars. This set of valley networks serves as another independent marker of ancient sea level. The results of their analysis, now published in the Journal of Geophysical Research: Planets, favoured the true polar wander scenario. In fact, the true polar wander scenario also better explained the locations of the deltas, despite their not being included in the calculations. While their article was in peer review, however, a newly published study showed another scenario that could have deformed the ancient shorelines: the formation and growth of the massive volcanic province of Tharsis. Chan and colleagues quickly incorporated this new, "Tharsis-growth" scenario into their analysis and found it almost equally consistent with the data, albeit with unaccounted for telltale signs of true polar wander. The geological key to distinguishing between the true polar wander and the Tharsis-growth scenarios lies in a region called Margaritifer Terra. Future investigations into the relative ages of the fluvial features in that region could shed more light into this conundrum.



Topographic map of Mars (the gray scale colors reflect present-day topography in km. The cyan dots represent the valley network termini (VNT) that could have drained into a northern ocean. The orange contours show the reconstructed shore-line of an ancient Martian ocean in the true polar wander scenario. The light green dotted contour shows the shore-line under the Tharsis-growth scenario.

Despite abundant evidence that water once flowed on the Martian surface, most climate models indicated that early Mars wasn't warm enough to continuously sustain liquid water (let alone an ancient ocean). This led to suggestions of "episodic melting" events, which could have been caused by orbital variations, volcanic activities, or meteor impacts and could have lasted thousands to hundreds of thousands of years. To investigate the potential surface manifestation of these episodic events, Chan and Gomez are adapting and running simulations of ice-age sea level on various melting scenarios. The results could highlight which class of geological evidence could validate or constrain the duration and extent of possible episodic melting events.