MARTIAN VALLEY FORMATION DUE TO BASAL MELTING OF ICE SHEETS AT HIGH OBLIQUITY.

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Introduction: The presence of water on Mars remains puzzling. The abundance of valley networks on the planet's surface strongly suggest that there must have been surface runoff carving out these valleys in the past. Therefore, it was long expected that the early climate was "warm and wet" and potentially even habitable for life, but climate simulations do not retrieve temperatures above the water freezing point. Instead, a mean annual temperature of ~225K and significant ice sheet coverage are found for Early Mars [1, 2]. Moreover, low surface pressures are found for long periods during the history of Mars, meaning that liquid water in contact with the planet's atmosphere would have been unconditionally unstable [3]. This has led to the consideration of subglacial river systems as an explanation for observed valley networks. In order to assess the possibility of subglacial erosion as the cause of valley formation, an ArcGIS map showcasing valley networks and glacier-like landforms is compared to climate and ice sheet simulations for a high obliquity of 60°.

Subglacial erosion: It was first proposed that Noachian fluvial features could have been formed by basal melting of ice sheets as early as 1983 [4]. For basal melting of ice sheets to occur, the climate would have to be in a "cold and wet" state with temperatures below 273K and transient liquid water on the surface [5]. Assuming that surface temperatures have indeed stayed below 273K, Mars would have been in such a state for a considerable period [6]. Widespread and well-developed eskers in the Dorsa Argentea Formation prove indeed that basal melting and wet-based glaciation occurred [1]. Additionally, multiple valley networks with similar geomorphological characteristics to terrestrial subglacial river systems have been observed [7]. Subglacial river systems would avoid the problem of surface pressures being too low for stable liquid water, as the overlaying ice sheets would prevent contact between water and atmosphere.

High obliquity: Obliquity changes have been found to have led to glacial deposits at tropical latitudes (see MEX HRSC) [8,9,10]. In a high obliquity regime, the atmospheric water content will increase and the circulation is amplified, increasing the likelihood of ice sheet formation. Earlier high-resolution climate simulations using the global climate model Laboratoire de Météorologie Dynamique (LMD) for an obliquity of 45° retrieved ice accumulation in regions where glacier-like landforms are indeed observed [11]. As Mars' orbital parameters are strongly chaotic and the probability for Mars' obliquity to have reached more than 60° over the last 3Gyr is almost 90% [12], it would be valuable to repeat these simulations for an obliquity of 60°.

Method: To simulate the Martian climate at 60° obliquity, the LMD Mars model is used. This model is meant to simulate present-day conditions on Mars, but can be altered to a higher obliquity. To exclude the effect of other orbital parameters, they will be set to zero.

The simulated surface ice will then be compared to an ArcGIS map showing valley networks which have been classified according to their most likely cause of formation by [7]. As the differences between fluvial and subglacial valleys are small, glacier-like landforms are also included on the map as given by [13] in order to spot potentially wrongfully classified fluvial valley networks. Including these glacier-like landforms and the potentially verifying ice sheet simulations will help classify other valley networks. By comparing the ice sheet simulation for 60° obliquity and the geomorphological evidence for glaciation, the likelihood of past high obliquity regimes causing the formation of subglacial river systems and thereby current-day valleys will be assessed.

Perspective: As of now, the geomorphological map has been prepared and the climate simulations are underway. These simulations are expected to find significantly more ice sheet coverage than in the earlier simulations with a 45° obliquity. Looking forward, it would be beneficial to research terrestrial subglacial river systems and describe their similarities and differences with fluvial river systems explicitly. This could help enlighten how different valley networks on the Martian surface were formed.

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