MEGAFANS AND PALEO-MEGAFANS IN AMAZONIS AND NORTHWEST THARSIS: IMPLICATIONS FOR FLUVIAL PROCESSES, SURFACE GEOLOGY, AND SPREADING OF THE OLYMPUS MONS VOLCANO.

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Megafans—definition: Megafans have been characterized [e.g. 1, 2, 3] as partial cones of fluvial sediment, of very low slope, with diverging channels, and dimensions that can reach hundreds of km—in one very large case reaching 210,000 km^2 [3] (megafans are thus not small, classical alluvial fans). Megafans are located immediately downstream of highlands, with the fan apex located where a highland-sourced river exits the highland, and the fan sedimentary body located *notably distant* from any major waterbody (and thus not classical deltas). Topographic roughness signatures indicate that the flattest plains on Earth with areas 10^4–10^6 km^2 are overwhelmingly megafan surfaces [1]—**Fig. 1**. For comparability, roughness maps of parts of Earth—based on an algorithm first applied to Mars [4]—were constructed from SRTM data to examine geomorphic similarities to Amazonis Planitia [5]. Although the significance of megafans has only been recognized recently, this scale of depositional feature is as yet poorly understood. The megafan model has been applied to rocks of Sinus Meridiani [6], the Maja Valles fluvial cone [7], as well as paleogeographic reconstructions of S America's Amazon basin [2] and as the basis for new non-biologic models of fish speciation [1].

Amazonis Planitia as a megafan-dominated lowland through time: Modern Amazonis Planitia comprises the "smoothest plains on Mars" with most of the surface interpreted as fluvial sediments [8], even displaying diverging channels [8]. At length scales of 10^2 km, all the abovementioned characteristics are associated with the plains of Amazonis Planitia: in combination these suggest *pristine remnants of a relatively recent fluvial megafan* [5]—**Fig. 2**. Location is immediately downstream of a highland-sourced channel in Marte Valles, mirroring the terrestrial analog. The existence of megafan surfaces implies (i) an underlying sedimentary mass, probably fine-grained, since distal terrestrial megafan slopes are generally fine grained. Distal parts of the likely megafan, i.e. in eastern Amazonis Planitia, *lie immediately adjacent to the Olympus Mons aureole*. (ii) Distal megafan slopes, during non-arid episodes, are also characterized by water accumulation [7]. A major Late Hesperian (pre-aureole) lava flow [8], together with a buried crater rim [8], and the Olympus Mons aureole itself, are features that will have acted to dam sediment which forms the plains of Amazonis Planitia [8]. Low slopes will also have aided local water accumulation.

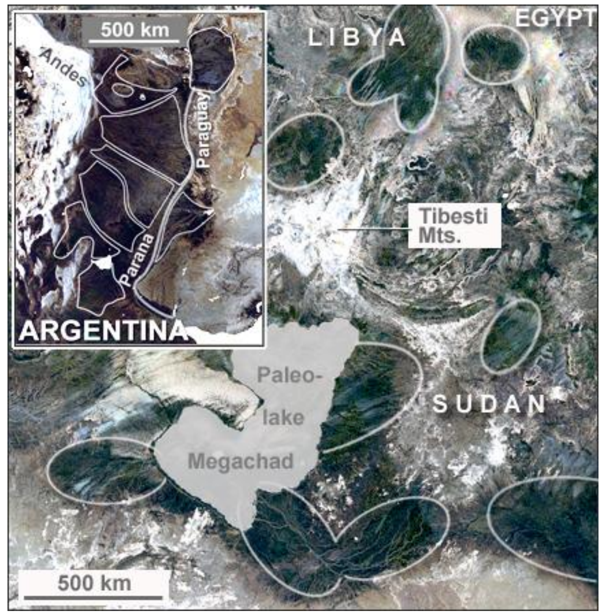

Fig. 1. Roughness maps of Earth in which darkest tones indicate large areas of low slope, smooth topography (note scale bars). All are megafan surfaces (outlined). Rougher surfaces such as mountains and dune fields are light-toned. ***Main panel****—Cratonic (Mars-like) tectonic environment—eastern Sahara where known megafans occupy basins and swell margins.* ***Inset****—Andean foreland basin of Argentina and Paraguay—smooth modern topography dominated by megafans over hundreds of km.*

Having established the good resemblance of the smooth, young plains of Amazonis to terrestrial megafans, we consider the implications of prior megafan emplacement, stretching back into early Martian history. As described above, the current smooth surface units in Amazonis (of Amazonian age, naturally!) were influenced by topography to the north and east that was in place by the late Hesperian [8, 9]. The sediments constituting this unit were most likely derived from the highlands and transported through Mangala and Marte Valles [8]. Given the large distance (>1200 km) between the highland/lowland dichotomy boundary and the exit of Marte Valles into the Amazonis Plains, *it is plausible that paleo-megafan deposits lie beneath both* *southern Amazonis and the Hesperian ridged plains between Amazonis and the highlands*. Such an inference is supported by the expectation that fluvial and erosive processes in general on Mars were progressively more vigorous with increasing age, and most vigorous in the Noachian [e.g., 10]. Under such conditions, megafan formation on the flanks of the Tharsis Rise (and elsewhere on Mars) may have been vigorous, and megafan sediment bodies may have constituted more prominent and extensive surface units in that epoch.

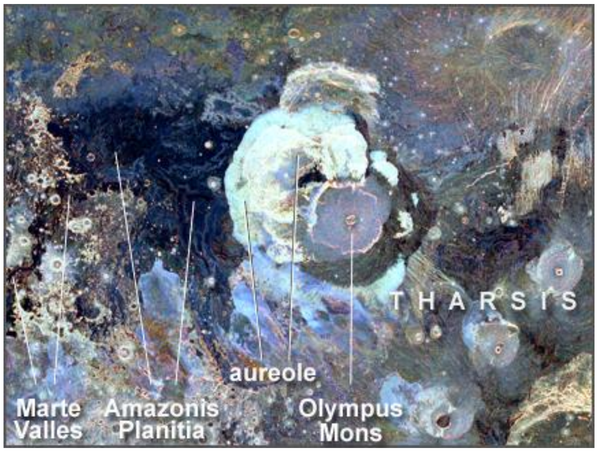

Fig. 2. *Tharsis and Amazonis Planitia roughness map. The same algorithm and color conventions were used to generate the Tharsis roughness map as used in* ***Fig. 1****—dark surfaces of Amazonis represent lowest-angle, smoothest landscapes. Amazonis plains match megafan roughness signatures in* ***Fig. 1*** *(see text). Amazonis plains are juxtaposed against the aureole mass. Similar though less extensive smooth surfaces appear east of Olympus Mons. Simple cylindrical projection.*

Olympus Mons: The potential existence of ancient megafans off the flanks of Tharsis has important implications for the development and evolution of the Olympus Mons volcano. Olympus Mons most likely started erupting on the flank of the ancient [11] Tharsis rise during the Hesperian, as evidenced by the late Hesperian age for the pre-aureole "proto-Olympus Mons flow" unit [8, 9]. If so, it would have been emplaced atop whatever materials, sedimentary or volcanic, that had been deposited previously on the flank of Tharsis. Analysis of the topography and tectonics of Olympus Mons indicates that the edifice is spreading outwards [e.g., 12, 13, 14]. McGovern and Morgan [14] proposed that clay sediments produced during a period of favorable conditions during the Noachian [15, 16] were subsequently deposited to form an overpressured basal decollement beneath Olympus Mons, and that the combined effects of downslope-increasing sediment thickness and flexure-modulated (depth-dependent) decollement conditions produced the distinctive shape and tectonism of the edifice, as well as the flank landslides (aureole deposits) surrounding it. Paleo-megafans, deposited on the flanks of northwest Tharsis during the Noachian and Hesperian epochs, are appealing candidates for the proposed decollement materials, being composed of sediments and saturated with water.

The decollement scenario [14] postulates *pre-existing* saturated sediment (i.e., megafan) layers beneath Olympus Mons and its aureoles. The likely existence of distal fluvial environments beneath the whole region spanning Amazonis to Olympus Mons generally supports the idea that fine-grained sediments have greatly influenced the evolution of Olympus Mons and its aureoles.

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