INTRACRATER LAYERED DEPOSITS SUPPORT ANCIENT OCEAN ON MARS. K. DeLano[1] B.M. Hynek[2,3], [1]Dept. of Geology, UC Davis, One Shields Avenue Davis, CA 95616, [2]Dept. of Geological Sciences and [3]Lab. for Atmospheric & Space Physics, both at UCB 392, University of Colorado, Boulder, CO 80309.

Introduction: Intracrater layered deposits exist globally on Mars, with a concentration in Arabia Terra [1] (Fig. 1). Here and elsewhere, craters contain up to km-thick stacks of massive to finely bedded layers (Fig. 2). Additionally, some craters exhibit bench or shelf deposits flanking their interior rims (Fig. 2). The generally light toned eroded mounds are in varying states of degradation and are thought to be ancient [e.g., 1]. Multiple hypotheses have been proposed for these materials including deposits from true polar wander [2], ice-cemented materials [3], volcanic ash from the Tharsis region [4], and spring deposits [5-6]. Here, we propose a new model that links these deposits with a putative paleoocean.

The idea of a past ocean on Mars consisted of morphological indicators from Viking data including curvilinear ridges and other potential shoreline indicators [e.g. 7-8]. An ocean implies an active hydrological cycle with neighboring lakes and upslope rivers. Recent analysis of valley networks indicate that most are ancient and at an elevation above -2500 m [9]. Over 50 of these systems have fan deltas at their mouths and 2/3 of these are also around an elevation of -2500 m [10]. Di Achille and Hynek [11] argued that the collective results represent a paleoshoreline from when Mars had a large ocean and seas. They used modern topography to reconstruct an ocean at an elevation of -2540 m (Fig. 1). Hellas and Argye Basins would have also been filled in this configuration.

Many of the intracrater layered deposits (ILDs) are spatially close to the inferred shoreline. The association between a shoreline and intracrater deposits suggests a genetic link. We propose that most of the mounds represent evaporitic salts and cemented aeolian, fluvial, and lacustrine materials that formed around 3.6 Ga, the time of the putative ocean [11].

Methods and Results: We searched along the reconstructed shoreline ±~2 km elevation, corresponding to up to 1000 km from this equipotential. This search encompasses the vast majority of ILDs identified to date on Mars (Fig. 1,3) [1-6]. We searched every crater in this region of interest in search of ILDs. Of the 746 craters investigated, 487 (65.28%) contained no observable deposits (red Xs in Fig. 1). 259 contained intracrater layered deposits (34.72% of the total). 182 of the observed deposits (70.27%) were typical mounds and 77 (29.73%) were shelf/terrace deposits generally ringing the interior of the crater's rim (Fig. 1). A majority of the ILDs were located in Arabia Terra as previously noted [1, 3]. We crater-age dated the largest deposits, typically greater than 100km^2 in area. Two deposits plotted on a 3.75 Ga isochron. The remaining three dateable ILDs were estimated at 3.63 Ga, 3.50 Ga, and 3.45 Ga, using isochrons from [12].

Intracrater layered Mounds: Fig. 2 shows typical ILDs, represented with mounds of material in craters that is layered at fine scale. After Arabia Terra, Nilosyrtis and Nepenthes Mensae, and Isidis Planitia represent regions of highest concentration. The remaining deposits are spread out along the inferred coastline, or are located in Hellas and Argyre Basins (Fig. 1). The average elevation of inte-

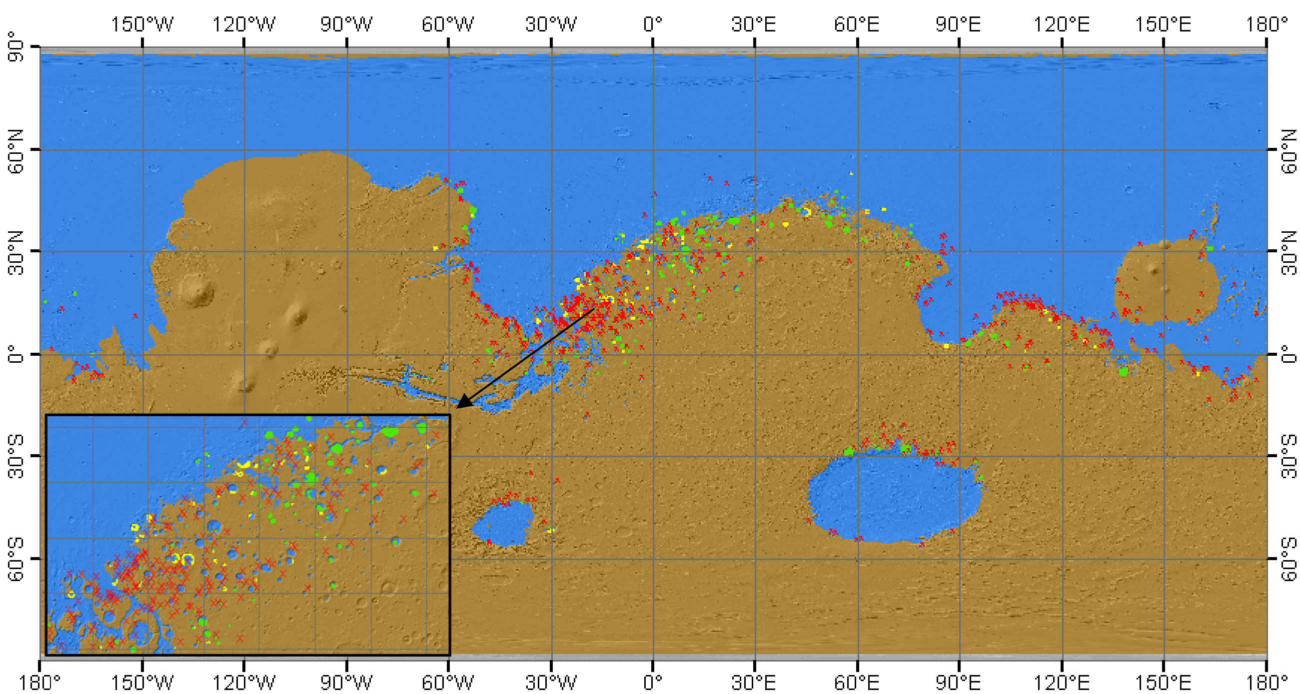

Figure 1. Depiction of the putative ancient ocean of Mars from [11]. Intracrater mounds are shown in green and shelf deposits in yellow. Red Xs denote craters searched for ILDs with no significant deposits. Insert is a blow-up of Arabia Terra ILDs.

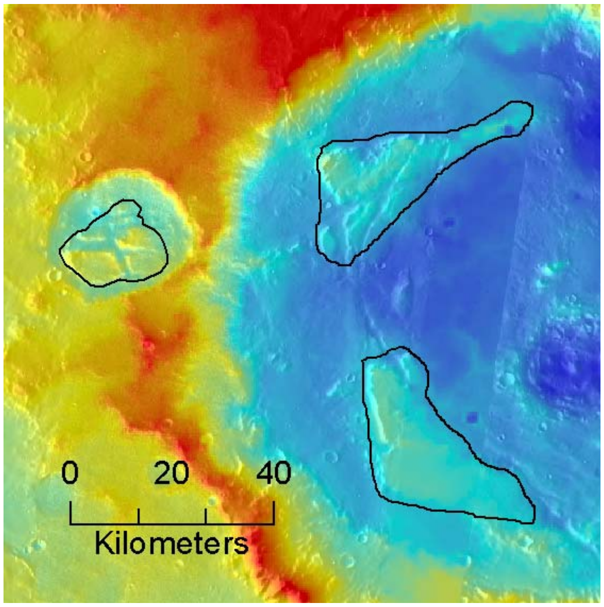

Figure 2. Examples of intracrater layered mounds located at 28°N, 9°E. These specific ILDs are up to 0.5 km in relief.

rior crater deposits is -2712 m (1-σ = 724 m), 152 m below the waterline of the inferred ancient ocean (Fig. 4).

Shelf Deposits: In addition to the crater mounds, bench/shelf deposits were noted ringing the interior rims of many craters. These smooth benches are typically of constant elevation and have an erosional scarp toward the center of the crater. The average elevation of shelf deposits is -2839 m (1-σ = 576 m). Collectively, over 30% of the shelf and intracrater layered deposits are within 200 m of the putative ocean's waterline.

Are the ILDs remnants of lakes? The geographic distribution, ancient age, and constrained elevation suggest a genetic link with the paleoocean of [11]. Most of the ILDs occur within craters that would have been flooded in the ocean model from local groundwater. It appears most of the water around Mars at this time was acidic and contained abundant salts, manifest as sulfate minerals in layered materials [e.g. 13]. We hypothesize that evaporation would result in salt deposits that could cement fluvial, aeolian, and lacustrine sediments. This is similar to the model proposed for Meridiani Planum and Arabia Terra [e.g. 5]; however, in this case the groundwater was sourced from close proximity to the putative ocean's shoreline instead of from up to 1000s of kilometers upslope in the highlands. Cyclic deposition of sediment and fluxing water tables in local lakes would have cemented the sediments into the layered mounds observed at present. Subsequent erosion of these friable materials resulted in mounds and discontinuous shelf deposits.

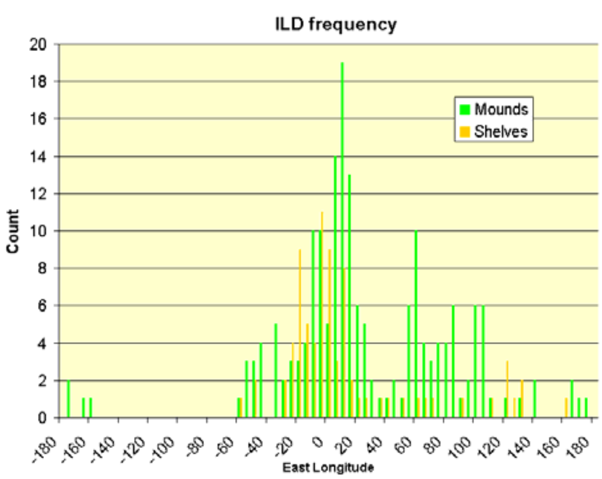

Figure 3. Frequency of intracrater mounds and terraces as a function of longitude.

After the Medusae Fossae Formation, the largest concentration of layered deposits on Mars lies within the Valles Marineris [4]. Valles is thought to have opened in the Early Hesperian [14], around the time of the putative ocean. Thus, we examined all potential shoreline features

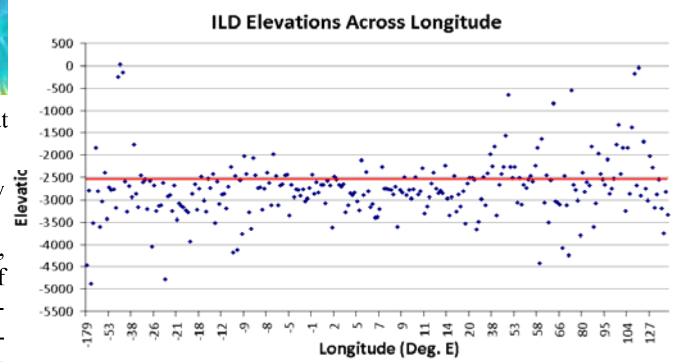

Figure 4. ILD elevations as a function of longitude. Note the nonlinear x-axis due to the abundance of ILDs in Arabia Terra. The red line is the water table of the putative ocean.

near the -2500 m level within the Valles Marineris using the criteria of [8]. We noted eighteen possible coastline features with the majority appearing as possible beach deposits or terracing, although few were very convincing. The average elevation of these features was -3011 m with a standard deviation of 744 m. We conclude that the Valles Marineris features and not likely indicative of a past ocean and either it had not formed by the time of the ocean or it was topographically cut off.

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