OLD OR NOT SO OLD: THAT IS THE QUESTION FOR DELTAS AND FANS IN XANTHE TERRA, MARS.

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Introduction: Xanthe Terra is part of the ancient highlands of Mars and is dominated by Noachian terrain. A part of it, north of the equator between Maja Vallis to the west and Shalbatana Vallis to the east, hosts a number of sedimentary deposits, such as Gilbert-type deltas, fan deltas dominated by resedimentation processes, and alluvial fans (Fig. 1) [1]. Sediments were provided through deeply incised valleys, which were probably incised by both runoff and ground water sapping, although sapping appears to have dominated. Hydrologic modeling indicates that the deposit were probably formed in geologically very short timescales [1,2]. An earlier study dated the valleys by crater counting the crater ejecta deposits that are superposed on the valleys and found valley ages of late Noachian to Early Hesperian age [1]. At that time, it was thought that the deposits at the mouths of the valleys would be equally old. Newly available CTX images enable to date the surfaces of the deposits directly and to identify hitherto unknown deposits. We revisited the Xanthe Terra deposits and report on our findings with respect to their ages, formation mechanisms, and associated alteration mineralogies.

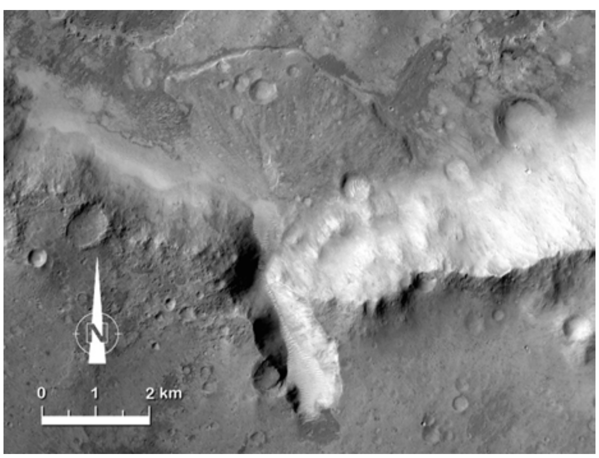

Fig. 1. Small fan on crater floor (CTX P20_008813_1911, near 11.4°N/308.7°E). The fan was fed by a short valley without tributaries, which is morphologically similar to terrestrial sapping valleys. The valley was eroded backwards from the crater floor through the rim to the south. This pattern is not indicative of precipitation.

Data and methods: We use CTX images, which are ideally suited for crater counting due to their good contrast, high resolution (5-6 m/pixel), and wide coverage). Topography was extracted from HRSC stereo data and MOLA laser shots. CRISM FRT cubes were analyzed for multispectral information.

Results: While the deposits in the south of the study area are located in ancient, deep impact craters, the north of the study area is characterized by smooth plains, which fill the floors of all large impact craters. Deltas and fans in the north are superposed on top of these smooth plains and, therefore, post-date them. We determined the ages of the delta at the mouth of Sabrina Vallis, at the boundary between Xanthe Terra and Chryse Planitia. Surprisingly, the age of the delta is only ~1.7 Ga, with a later resurfacing event at ~34 Ma, much younger than thought earlier [1] (Fig. 2). This is consistent with the age of the smooth plains of the adjacent crater floor (~1.35 Ga, the statistical error bars of both ages overlap).

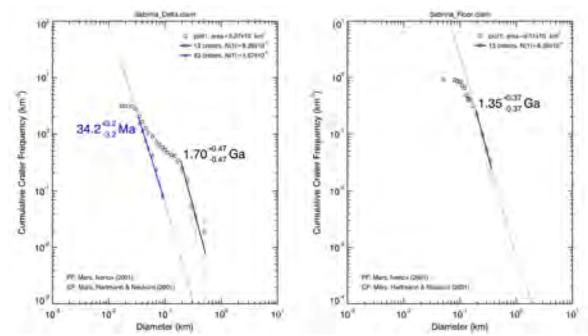

Figure 2. Absolute model ages derived by crater counting and size-frequency distribution analysis of the surface of the Sabrina delta (left) and of the crater floor next to it (right). For locations of mapped counting ares, see Fig. 3 on next page.

It appears that the large valleys themselves have been mainly carved on early Mars, but have been reactivated later, which led to local fluvial activity with lacustrine sedimentation. Local fluvial activity in the Hesperian has often been observed before [3, and references therein], and it has been attributed to the effects of impacts [e.g., 3,4], volcanism [5], and/or short-term climate excursions due to external forcing. The inspection of the regional context of the Sabrina delta reveals that a large crater to the North is filled with smooth material and hosts several cones with partly breached rims, which are aligned on the floor along its interior wall. These cones do not resemble impact craters, and their floors are at the same level with their

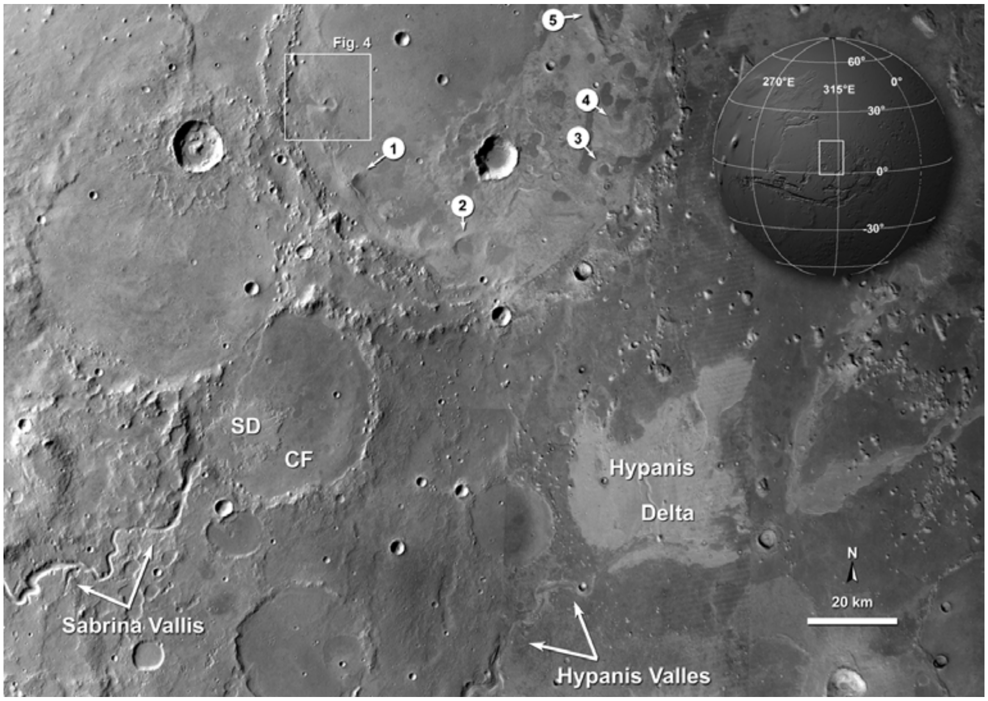

Figure 3. Regional context of the Sabrina and Hypanes deposits (HRSC image mosaic; inset in upper right shows global context). The deltas (SD = Sabrina Delta) are located at the mouths of valleys on top of smooth plains. A filled crater nearby (upper center) displays several cones aligned on the crater floor near the inner wall (1-5). Another cone is shown in Fig. 4 (see white box for location). Areas of crater counts are SD and CF (=crater floor). The boundary between Chryse Planitia and Xanthe Terra runs approx. from the upper left to the lower right.

surroundings. They are morphologically very similar to cones in the.northern Amenthes region (southern Utopia Planitia) that are interpreted as hydrovolcanic cones (e.g., tuff cones) (Fig. 4) [6]. Some distinct flow fronts of a dark materials suggest that lava flows embay the outer crater rim. We suggest that volcanic lava flows in the Hesperian and Amazonian flooded the topographically lowest portions of Xanthe Terra and filled the ancient, rimless craters. The contact of the lavas with ice-rich substrate in some craters might have triggered phreatomagmatic explosions (Fig. 4). The heat wave that penetrated the adjacent ancient terrain might have melted ground ice and released short-lived water floods that eroded, transported and deposited material.

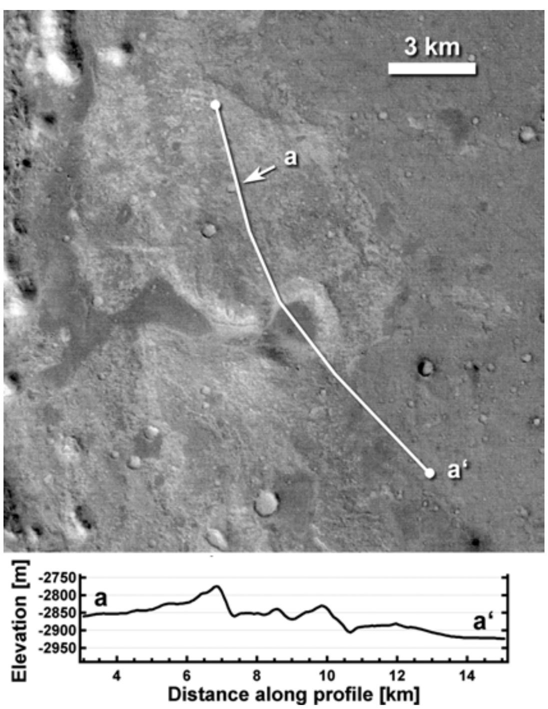

Figure 4. Possible breached volcanic cone (for location see Fig. 3). Floor is at the same level as surroundings, perhaps favoring a formation as hydrovolcanic cone, rather than as a cinder cone.

Conclusions: Contrary to earlier reports, at least some fluvial activity in Xanthe Terra post-dates the Late Noachian-Early Hesperian era. Volcanic heating might have released ground ice as melt water to form short-lived erosional and depositional processing (involving the formation of small sapping valleys). Care has to be taken in dating such landforms, and we predict that other "ancient" valleys and deltas might also be younger than widely believed. If these conclusions are true, the global distribution of deltas may be a unreliable indicator for an ancient ocean [7], and a detailed global dating of deltas and fans using high-resolution images is recommended.

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