GEOLOGIC MAPS OF PIT CRATERS IN NOACHIS TERRA, MARS. K. Cairns, H. Hiesinger, and W. Iqbal, Institut für Planetologie, Westfälische Wilhelms-Universität, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany (k.cairns@uni-muenster.de).

Introduction: Craters in the Noachis Terra region exhibit distinctive pits and dune fields of unknown origins. To gain a better understanding of their formation, we produced detailed geological maps of Proctor crater and two unnamed craters in the same region. We labeled the two unnamed craters, crater A (77 km southeast of Proctor) and crater B (120 km southwest of Proctor). These craters show two fundamental geologic features: (a) fine-scaled layering within the pits, which is most likely exposed by a regional degradational process inside the craters [1], and (b) widely distributed dune fields. We investigated the stratigraphy of these craters to understand the time scale in which these processes took place, along with potential geomorphological differences among the studied pits.

Methods: We performed geological mapping in ArcGIS, using CTX images that were selected using the MUTED (Multi-temporal Database) [2]. CTX images are ideal for mapping geological features in detail (6 m per pixel). We identified several exposed units based on their distinct morphological features (e.g., surface smoothness, color, occurrence of resurfacing materials).

Geologic Setting: The studied area is located in Noachis Terra on Mars. The area is known for the high occurrences of intracrater dune fields [3]. Previously mapped units of the area include the heavily degraded Middle and Late Noachian Highland units [4], as well as some Amazonian and Hesperian impact units. Within the craters volcanic, fluvial and basin materials are exposed [3].

Geomorphological Features: The co-occurrence of dune fields and pits on a large scale is thus far unique for Noachis Terra.

Dune fields are located on the crater floors of Proctor (Fig. 1) and crater A. The dune fields are one of the most distinct features on the crater floors, due to their large extent and dark albedo. They tend to be located in the central to eastern parts of the craters.

Pits are found in all mapped craters. The pits are located to the west on the crater floor. The large pit in Proctor (Fig. 1) is approximately 90 km long (North to South) and 21 km wide (East to West). The shape of the pit extends somewhat along the crater rim. This feature is mainly seen in Proctor (Fig. 1). The pit in crater A is approximately 11.5 km long (North to South) and almost 8 km wide. It has two distinct depressions. The pit in crater B is 23 km long (Northwest to Southeast). All pits show a rugged, eroded surface with possible aeolian influence.

Mapping Units: In our mapping areas, we defined several geomorphological units. These units include: Noachian-Hesperian furrowed material *(NHrf*), Mantling material *(Am)*, Hesperian-Amazonian rugged material (*HArm*) and Amazonian dark transversal dune fields (*Adtd*). The unit *NHrf* has a smooth surface with furrows that traverse the inner part of the wall. *Am* is a very smooth unit covering local depressions. The unit *HArm* seems to have a rough surface, on which dark dune material has accumulated. It is often adjacent to *Adtd.* Only Proctor and crater B show unit *Adtd.* It exhibits material with a dark albedo, which represents the large dune fields.

Unit Interpretations:

NHrf: Due to the location of *NHrf* at the rim of the crater, we suggest that this unit represents the rim of the crater resulting from an impact.

Am: It is suggested that this unit is an ice-dust mantle, which is probably related to the accumulation of atmospheric volatiles that were deposited due to recent climate changes [5].

HArm: The dark material implies a source related to that of the dune fields (*Adtd)*, due to the similarity in albedo and location within the crater.

Adtd: Considering that the material is mostly mafic [6], the origin of the sediments must be volcanic from underlying volcanic deposits in either the pits or the intercrater plains [7]. The observations lead to the assumption that material must have gone through depositional events that occurred on a regional scale because of the widespread distribution in Noachis Terra.

Possible pit and dune formation: The characteristics of other units found across Noachis Terra studied by Fenton (2005) [3], imply that a series of region-wide depositional events took place and led to the formation of the mafic deposits in the pits present on crater floors as well as on the intercrater plains. This indicates a local and regional source for the dune field-forming material [3]. The pits and dunes are two of the most prominent features of the craters and take up a large area of the crater floor. The pits in Proctor crater show two very different morphologies [Fig. 1]. The pit in the western part is much bigger and deeper and seems to have gone through two major formation processes. The studied pits may have formed due to sublimation of CO_2 [8]. The other formation process proposed for the western pit of Proctor is the “backwind”

effect [9]. This describes a type of aeolian erosion, where wind flows around the crater rim and enters the crater due to flow dynamics. This results in the excavation of material by aeolian erosion [9]. Crater A shows evidence that it was shaped by a combination of CO_2 sublimation and aeolian erosion [8]. The "backwind" effect is indicated by the two depressions in the pit of crater A. The more elongated shape of the pit in Proctor indicates that the aeolian erosion is more progressive than in crater A. The pit in crater B appears to be shaped mainly by degradation (Fig. 2). The pit rim of crater B seemss to be more smoothened-out. However, a formation process by sublimation of CO_2 should not be excluded.

The pits are a possible source for the materials that form the dark dune fields [1], although the size of the pits as well as their albedo imply that only a limited amount of material potentially derives from the pits. Theoretically, a wider regional volcanic source could be an alternative source for the dark dune material [10]. However, no sand transport pathways are visible in the Noachis Terra region of Mars [7]. The mafic material on Mars may originate from volcanic, water, aeolian, glacial or impact processes [3]. The growth of the pits may have been triggered by the formation of a depression in the crater floor, either by an impact or erosion of material. This could lead to the start of sublimation of CO_2 that may cause the pit to grow in size, in combination with aeolian erosion.

References: [1] Hiesinger et al. (2018) LPSC 49, 2001; [2] Heyer et al (2018) PSS 159, 1-10; [3] Fenton (2005) JGR 110, 1–27; [4] Tanaka et al. (2014) USGS IMAP 3292; [5] Wilmes et al. (2012) Planet. Space Sci. 60, 199-206; [6] Tirsch et al. (2018) EGU, 19598; [7] Fenton et al. (2005) JGR 110, 1–18; [8] McKeown et al. (2017) Sci. Rep. 7, 1–15; [9] Berndhardt (2018), Personal. Communication; [10] Fenton et al. (2003) JGR 108 (E12), 1–39.

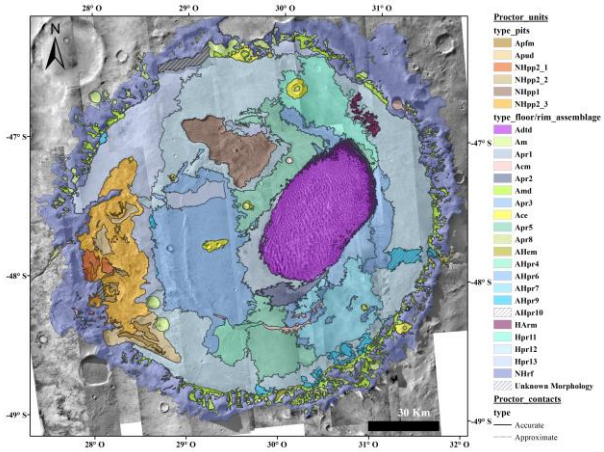

Figure 1: *Proctor crater in Noachis Terra. The figure shows various geologic units including the dunes in the eastern part and the large pit in the western part of the crater.*

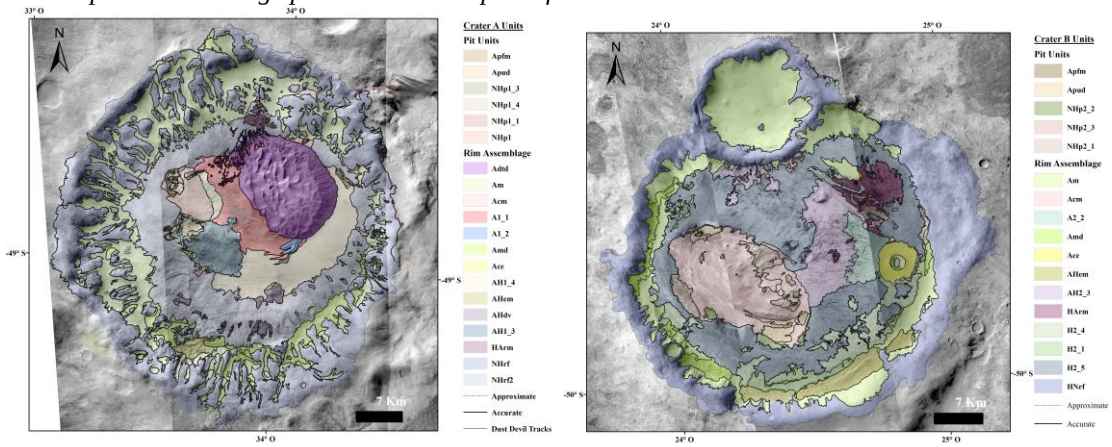

Figure 2: *(left) Geologic map of crater A 77 km southeast of Proctor crater in Noachis Terra. The pit in the West of the crater floor shows a similar shape to that of the western pit in Proctor crater. (right) Geologic map of crater B ca. 120 km southwest of Proctor crater, showing geologic units mapped in CTX images.*