EPSC Abstracts
Vol. 10, EPSC2015-735, 2015
European Planetary Science Congress 2015

Reconstructing the infilling history within Robert Sharp Crater, Mars: Insights from morphology and stratigraphy

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1. Introduction

Robert Sharp (133.59°E, -4.12°N) is a 150 km diameter impact crater, located in the equatorial region of Mars, near Gale Crater, where the MSL rover Curiosity landed in August 2012. Using orbital data, an iron chlorine hydroxide named akaganéite that typically forms in highly saline and chlorinated aqueous environments on Earth has been detected in Robert Sharp crater [1]. Interestingly, akaganéite has also been detected in Gale Crater from the ground [2,3]. In order to reconstruct the paleo-environments in the region, we produce a geological map of Robert Sharp (Fig. 1). Crater counts provide time constraints on its infilling history.

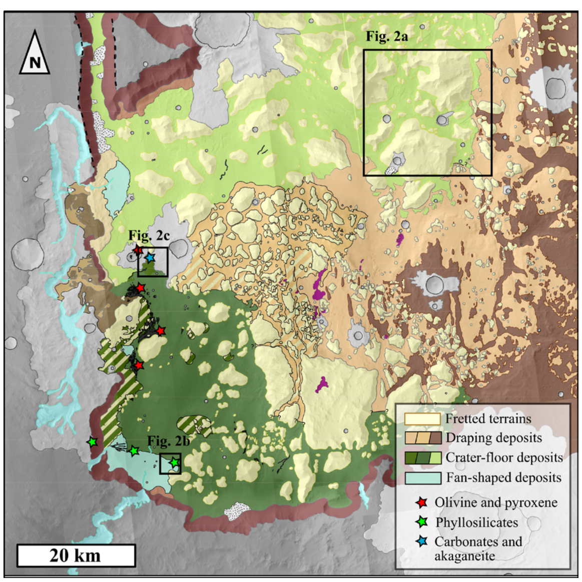

Figure 1. Geological map of Robert Sharp crater, displayed on a mosaic of CTX images. Locations of figures 2a-2c are indicated.

2. Physiography

Robert Sharp crater displays a varied and complex physiography. It is an open basin towards the northern plains (Fig. 1); its northern rim being entirely degraded. Its eastern rim is not exposed at the surface and appears to be buried under deposits. No central peak is visible in Robert Sharp. Instead, numerous knobs and mesas of varied sizes and shapes, that are representative of the fretted terrains [4,5] crop out in the crater (Fig. 2a) and display a rather heterogeneous distribution. Overall, the eastern part of Robert Sharp raises 1.5 km higher than its western part that results into a west-east asymmetry. Nevertheless, the western rim is higher than the eastern one, with about 500 m and -1000 m of elevation respectively. As a result, Robert Sharp shows a physiography significantly different from its neighbors, Gale crater and Knobel crater, suggesting a different geological history.

3. Geologic Mapping Results

The geological units of the Robert Sharp crater are defined according to their localization, physical characteristics (e.g. thermal inertia), morphology, geometry, and mineralogical composition.

Valleys are incised in the western and southwestern crater rim of Robert Sharp, i.e. the lower rims. They are several tens of kilometers long, mostly linear and do not show any hierarchization. Fan-shaped deposits with flat-topped surfaces are located at the outlet of these valleys and may be interpreted as fan deltas. Detection of phyllosilicates at the foot of these fan deltas (Fig. 2b) as well as on the surrounding plateaus suggest that clay was transported from the plateaus and deposited within the crater, or just formed in situ during an episode of aqueous activity [6].

Draping deposits partly fill the crater in the eastern part and cover the fretted terrains, as well as the surrounding plateaus at the east. These draping deposits are subdivided into 3 units based on their surface texture (rough, smooth and hummocky embaying fretted terrains).

In the western part of Robert Sharp crater, the floor is covered by deposits which are posterior to draping deposits and fretted terrains. These crater-floor deposits consist of alluvial deposits, and fluvio-lacustrine deposits, which expose dune-fields of dark-mafic materials (olivine and pyroxene) in some locations. Additionally, significant signatures of Fe-rich carbonates and traces of akaganéite have been detected on these crater-floor deposits [1], as shown in Fig. 2c.

4. Age Determination Results

The estimated ages of the southwestern and western fan-shaped deposits are ~ 1.30 ± 0.37 Ga and 501 ± 69 Ma, respectively, which corresponds to Amazonian ages. The crater-floor units have been formed at ~ 3.5 Ga, during the early Hesperian epoch. Additionally, we perform crater counts on chloride-rich deposits [7-9] (Fig. 2d), located in a basin on the surrounding plateaus at the south of Robert Sharp (131.94°E, -6.4°N). This basin shows an Amazonian age, about 1.12 ± 0.33 Ga, which is similar to the southwestern fan-shaped deposits. It suggests a synchronous formation of these chloride-rich deposits and the fan-shaped deposit. Moreover, our measurements are consistent with those of recent studies [6,10].

5. Timing of events and Conclusion

Our work shows that the Robert Sharp crater underwent a variety of geological events. We suggest the following timing of events: After the impact that formed the crater in the late Noachian epoch [11], Robert Sharp crater experienced the deposition and erosion of the fretted terrains, followed by the aeolian/aerial deposition of the draping deposits during the Hesperian epoch [4,5]. The presence of valleys and possible fan deltas as well as hydrous minerals in the region (i.e. chlorides [7-9], phyllosilicates [6], carbonates, and akaganéite [1]), suggests the occurrence of fluvio-lacustrine episodes. Akaganéite precipitates from acidic, highly saline, iron and chlorine rich fluids. Detection of akaganéite suggests that Robert Sharp has experienced an acidic and oxidizing environment during the last alteration phase of a drying lake within the crater. The lacustrine phase is likely related to the aqueous activity that formed the chloride-rich deposits on the plateaus [7-9]. The last episodes of aqueous activity may be as recent as the early-middle Amazonian period. As shown in the Robert Sharp crater, Mars has known aqueous phase activities well after the late Noachian/ early Hesperian boundary.

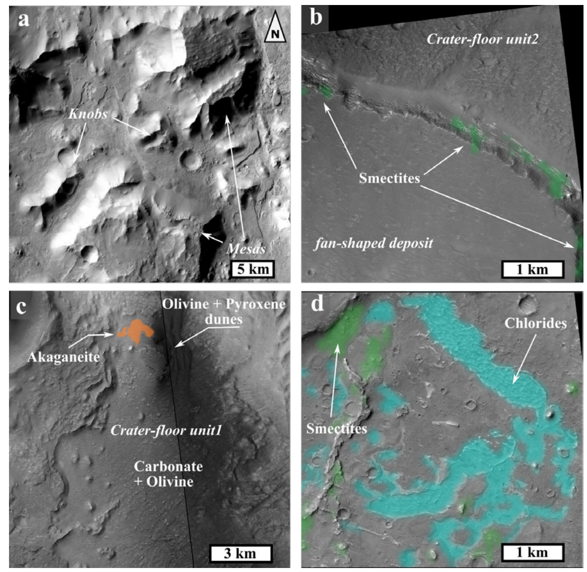

Figure 2. a/ Fretted terrains (i.e. mesas and knobs). b/ Phyllosilicates detected at the foot of the southwestern fan delta [6]. c/ Akaganeite and carbonates detected on crater-floor units within the crater [1]. d/ Chloride-rich deposits detected on the surrounding plateaus [7-9].

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