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Geological analysis of Gale Crater on Mars

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1. Introduction

Gale crater is an impact crater of 150 km in diameter, formed at Late Noachian/Early Hesperian [1] located close to the dichotomy boundary and to the Medusae Fossae Formation. This crater is partially filled by a crescent-shaped mound of layered deposits up to 5 km thick and 6000 km^2 in area [2], for which several origins have been proposed including volcanic [1, 3], eolian [1-4], and fluviatile and lacustrine processes [1, 2, 4, 5], precipitation as spring deposits [6], and a combination of several origins [4, 7]. The past presence of water is attested by the occurrence of many channels carved into the deposits and the crater rim, and of phyllosilicates and sulfates located in the lowest part of the deposits [8]. Hence, Gale crater is of high interest to understand the evolution of the geochemical and climatic environment of the region through time. In order to better constrain the history of Gale and the origin of its deposits, we produce a geologic map of Gale crater based on the analysis of a CTX mosaic (~ 6 m/pixel) and HiRISE images (25-32 cm/pixel). We also measured the geometry of the layered deposits from HiRISE DEM. Hereafter, we present our first results and investigate the possibility that a shallow lake existed at a time when some of the mound units were already formed.

2. Geologic mapping results

We defined four groups of geological units and landforms according to their location, physical characteristics, albedo, erosion patterns, and mineralogical composition (Fig. 1a). We identified 5 main units within the mound of layered deposits. The small yardang units (Syu1-2) are moderate to dark-toned materials forming yardangs and incised by several large canyons. They consist of parallel beds, which are more or less erodible of varying thicknesses (<2 m to ~30 m in the northeast part of the unit Syu_1, Fig.1a-b).

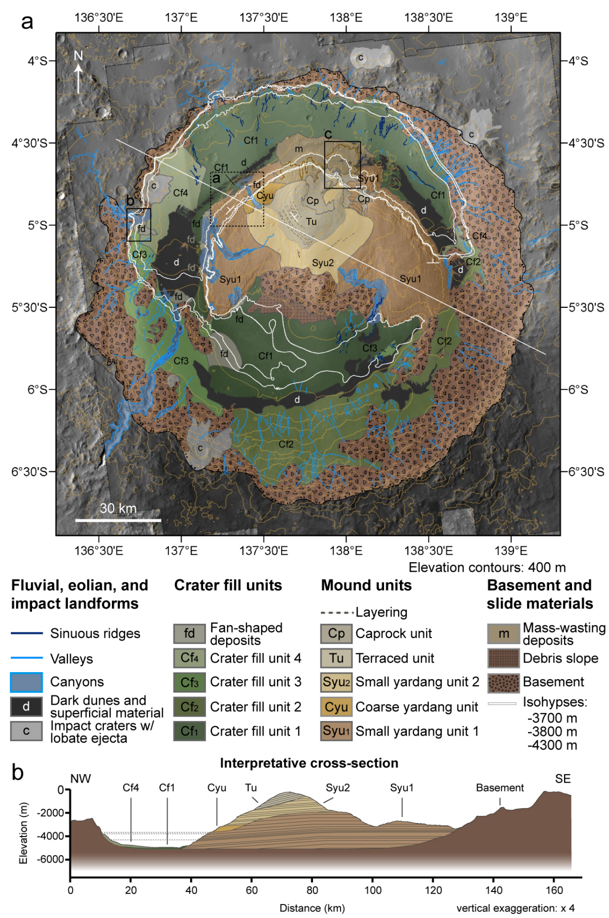

Figure 1: (a) Geologic map of Gale crater on a CTX mosaic. (b) Interpretative section across the crater (topographic profile drawn from an HRSC DEM).

They dip ~2-4 ºNW in the northwest [8], and ~3ºN in the northeast, suggesting that the layers drape the pre-existing topography. Anderson and Bell [7] noticed the presence of polygonal ridges in this unit interpreted to be filled or cemented fractures consistent with fluid flowing through fractures. The identification of phyllosilicates and sulfates [8] in the

Syu_1 unit provides additional evidence that alteration processes occurred in the Syu unit. Syu could consist of airfall (possibly ice-rich volcanic ash/dust) or lacustrine material. The coarse yardang unit (Cyu) consists of light-toned and very finely layered material lying unconformably on the Syu_1 unit. Cyu could be airfall or localized spring deposits associated with fluid flows. The terraced unit (Tu) corresponds to stacks of regularly spaced layers displaying possible crossbedding on benches of layers that could be aeolian in origin [7]. The mound is capped by the caprock unit (Cp), which drapes the pre-existing topography and probably corresponds to airfall material. North of the mound, we observe linear lobate features and a fan-shaped feature that might have resulted from mass-wasting processes (i.e., landslides, debris flows, or viscous flows) (Fig. 2c). Finally, the crater fill units (Cf_{1}-$_4$) correspond to deposits located on the rims and on the floor of the crater. They are incised by many valleys and superposed by sinuous ridges, interpreted as fluvial channels and inverted channels respectively. We interpret these crater fill units as alluvial deposits. Fan-shaped deposits are located at the outlet of canyons incised into the mound and the crater rim that we interpret as alluvial fans and/or fan deltas (Fig. 2b).

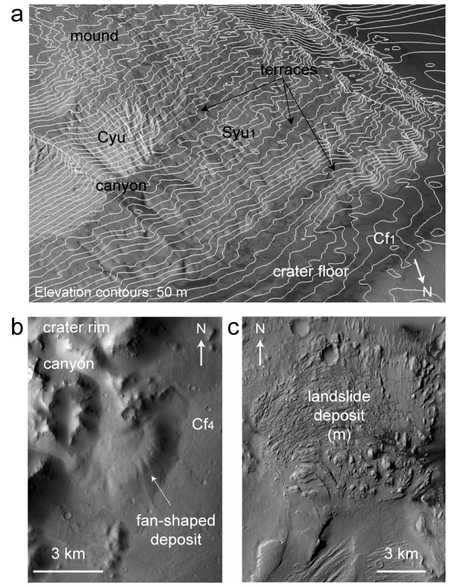

Figure 2: Close-up views of possible evidences of a paleolake. Locations are indicated in Fig.1. (a) Perspective view of subhorizontal terraces (CTX mosaic, vertical exaggeration: x 2). (b) Possible combined stepped- and Gilbert-type fan delta (CTX P04_002530_1745). (c) Landslide deposit (CTX P04_002464_1746). The landslide may have been triggered by the level lowering of a lake.

3. A shallow paleolake?

Several authors suggested the presence of a paleolake within Gale crater. This hypothesis is supported by the occurrence of valley networks and inverted channels, the subhorizontal layering and the composition of the mound lower unit (Syu unit), as well as subhorizontal terraces observed along the Syu_1 unit [2, 4, 5] (Fig.2a). Some of the fan-shaped deposits present morphological characteristics of fan deltas (Fig. 2b). Interestingly, all these landforms are located in the same elevation range, roughly between -3700 m and -4300 m in elevation (Fig. 1). A lake of -3700 m in elevation would have had a depth of ~ 1380 m at maximum. The paleolake could have also played a role in the triggering of the mass-wasting to the north of the mound (Fig. 2c). Indeed, on Earth, landslides along the Dead Sea coast were triggered by the lake level lowering [9].

4. Conclusions

Gale crater is characterized by various landforms and deposits, which attest to its complex history. The central mound of layered deposits probably consists mainly of airfall material including aeolian dunes (Tu unit) and possibly lacustrine material (Syu unit), while the crater rim and floor is filled of alluvial deposits. Subhorizontal terraces, fan deltas, valleys and canyons, phyllosilicates and sulfates as well as mass-wasting deposits could be related in origin to a shallow lake that existed at a time when some of the mound units were already formed.

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References

[1] Greeley, R., and Guest, J.E.: USGS Misc. Map I-1802-B, 1987. [2] Malin, M.C., and Edgett, K.S.: Science, 290, 1927-1937, 2000. [3] Hynek, B. M., et al.: JGR, 108(E9), 2003. [4] Thomson, B. J., et al.: Icarus, doi:10.1016/j.icarus. 2011.05.002, 2011.[5] Cabrol, N. A., et al.: Icarus, 139, 235-245, 1999. [6] Rossi, A. P., et al.: JGR, 113, E08016, 2008. [7] Anderson, R. B., and Bell, J. F.: Mars, 5, 76-128, 2010. [8] Milliken, R. E. et al.: GRL, 37, L04201, 2010. [9] Closson, D., Karaki, N. A., and Hallot, F.: Environ. Earth Sci., 59, 1417-1430, 2010.