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Fractures on comet 67P/Churyumov-Gerasimenko observed by Rosetta/OSIRIS

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Abstract

The OSIRIS experiment onboard the Rosetta spacecraft currently orbiting comet 67P/Churyumov-Gerasimenko has yielded unprecedented views of a comet's nucleus. We present here the first ever observations of meter-scale fractures on the surface of a comet. Some of these fractures form polygonal networks. We present an initial assessment of their morphology, topology, and regional distribution.

1. Introduction

The Rosetta spacecraft was inserted into orbit around comet 67P/Churyumov-Gerasimenko (hereinafter referred to as comet 67P) on Aug 6, 2014. Since then, the comet's nucleus has been extensively imaged and monitored by the Optical, Spectroscopic, and Infrared Remote Imaging System (OSIRIS) [1] at high spatial resolutions reaching ~0.15 m/px. The OSIRIS images have shown the surface of comet 67P to be morphologically complex with several terrain types and numerous intricate features [2,3]. In particular, images of sub-meter resolution, acquired when the spacecraft was orbiting <20 km above the surface have shown that many regions on the comet, especially those composed of consolidated materials [3,4], are fractured forming various patterns. We present these fractures here in detail and give an initial assessment of their morphology, topology and distribution.

2. Fracture settings

Comet 67P has a bi-lobed shape comprising a large lobe connected to a smaller lobe by a short "neck region" [2,3]. A regional assessment of the surface morphology has resulted in the classification of the comet's surface into distinctive regions based on morphological and structural attributes [3,4]. Our initial assessment of the fractures distribution suggests that they are globally present on the surface of the nucleus, particularly in consolidated regions [3], wherever images with high enough spatial resolution are available. These fractures are present in one of four distinctive settings:

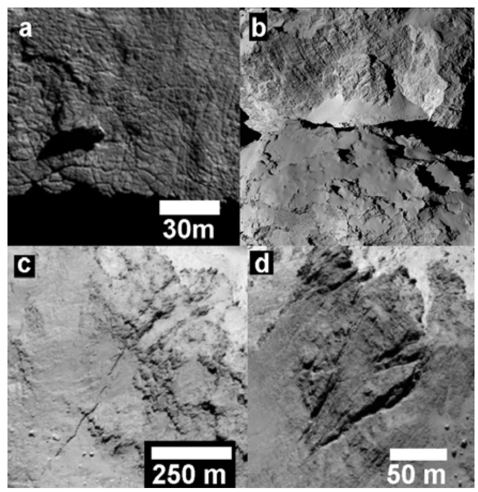

Figure 1. Fractures on the surface of comet 67P. [a] Polygonal patterns in the Apis region. [b] Fractured cliff in the Hathor region. [c] Linear fracture system in the Anuket region close to the neck. [d] The angular fracture system in the Aker region.

2.1. Fracture Networks

This is the most common fracture setting observed on the surface generally on quasi-flat surfaces in variable orientations with respect to the gravitational potential (Fig. 1a). The fractures are generally narrow (sub-meter in width) and resemble mode-I tensile fractures. The fractures create irregular polygonal patterns in many cases. Fractures vary greatly in length from a few meters to ~250 meters in length. Similarly, the angles of intersections of the fractures are variable. However, some locations show orthogonal intersections that are probably indicative of a slowly evolving uniformly stressed system

2.2. Fracture on escarpments

Fractures are similarly observed on the edges of escarpments in a number of regions but are mostly observed in the Seth region in the weakly consolidated units [3,4]. In some locations, the feet of the fracture cliffs are covered by debris deposits, which suggest continuous mass wasting events triggered by the fracturing process

2.3. Fractured boulders

Irregular fractures are observed on a number of large (20–60 m-wide) boulders scattered on the surface of the comet. In some cases, the fractures appear to have pervasively fragmented the boulders, whereas in other cases, they appear to be confined to sharp and polished surfaces, which may represent an erosional sequence where boulders become increasingly fragmented with time.

2.4. Unique/special fracture systems

Apart from the three main fracture settings described above, three unique features are observed on the surface: 1) longitudinal fractures on the cliff of Hathor (Fig. 1b), 2) a ~500 m-long fracture system in the Anuket region (Fig. 1c), and 3) a 200 m-long angular fracture system in the Aker region (Fig. 1d), and. These unique features have already been mentioned briefly in recent publications [e.g., 3].

3. Formation mechanism(s)

The ubiquitous presence of fractures on the surface of the comet's nucleus, in various settings and showing different morphologies suggests numerous formation mechanisms, which include thermal fatigue, orbital-induced stresses (e.g., activity-induced torques or tidal stresses), and possibly seasonal thermal contraction [5]. We plan to present in the meeting a detailed assessment of these mechanisms and their respective roles in creating the observed fractures.

4. Implications

The presence of fractures on a cometary surface is of paramount significance to cometary science and could be a main driver in the surface evolution process and long-term erosion as well as a possible conduit for jet activity [6].

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