Rootless Cone? Pingo? or Mud Volcano? in Central Elysium Planitia, Mars
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Introduction

Central Elysium Planitia (CEP) is one of the most focused regions on Mars in terms of interpretation of its geological context. The unique characteristic of this area is Cerberus Fossae. It is clarified that Cerberus Fossae released flood lava and aqueous flood in the past. These flows and lava flow from Elysium Mons constructed ground of Central Elysium Planitia. In this area, there is high possibility of ground ice/water[1]. In the last 100Ma [1], several large flows flushed out from Cerberus Fossae. It has been discussed weather this youngest large flow is lava or mud flow[2,3]. Even by using high resolution images, there still remain two conflicting interpretations unsolved about basic constructs in this region, that is an issue about the origin of flow structures[4]. One considers aqueous flood such as a mud flow configures basic landscape in this region and associated cone-like structure is interpreted as a pingo, a manifestation of periglacial process[5], while the other considers magmatic lava flow and cone-like structure is interpreted as a rootless cone, a manifestation of magma/ice interaction[6]. Since this geological unit is quite recent its interpretation is critical in the evolution of martian interior. If it is a magmatic origin its highly fluidic morphology indicates the magma of small viscosity[7]. This means at least some part of the present martian mantle can be characterized by a temperature close to liquidus. These two conflicting interpretations critically rely on the interpretation for the origin of cone-like structure. In CEP there exist a lot of small scaled cone-like structure (100m)

In this study, we focused on small cone-like landforms found in CEP based on high resolution images such as MRO’s Context Camera (CTX) and HiRISE. We have surveyed its spatial distribution as well as morphological characterizations to constrain its origin.

On Earth, we can observe rootless cones in many place where lava flow meets water. For example, around Lake Myvatn, in Iceland, there are many rootless cones (Fig.1). Lake Myvatn, having formed about 380 years ago when an enormous lava flow from the Kefildyngja shield volcano, 25km SE of Myvatn, flowed over the area and dammed its outlet. And the rootless cones were formed as a result of steam explosions when the younger Laxa lavas overflowed older water-saturated lavas [5].

Therefore, existence of rootless cones suggests occurrences of phreatomagmatic eruption in the past.

Fig. 1: Rootless cone around Lake Myvatn, Iceland (Image : National Geographic)

Fig. 2: Cone-like morphological feature (CLF) in CEP. (HiRISE : ESP_012524_1855_RED)

Cone-like morphological features in CEP In Central Elysium Planitia, there are large numbers of cone-like morphological feature (CLF, fig.2). This landform identity have been discussed, whether rootless cone, pingo, or mud volcano [8,9,10].
Description of CLF

We described cone-like morphological feature (CLF) in CEP (2°N?12°N?150°E?170°E) by using high resolution image (HiRISE image).

Distribution of CLF

Fig. 3: Distribution of cone-like landforms in CEP. The basemap is a geologic map from [1]. Peach color is young flow region, and brown region is original ground. Pink box shows taken HiRISE images, and red box shows HiRISE images which found CLFs.

Distribution of CLF

The distribution of cone-like landforms is expected to indicate process of formation. They are mostly localized in the periphery areas of lava flows between original plain (Fig.3). They are also aligned in lines, which are parallel to the flow directions.

Morphology

The morphology of CLF looks similar to Icelandic rootless cone. The diameter are 30-100m. The surface of CLF seems to have a little bit different albedo from the surrounding area. CLF has four characteristics: 1) conical edifice, 2) circular summit vent, 3) moat around the edifice, 4) double cone structure (Fig.2). Moats have peripheral rise. Some CLF have double cones: outer cone and inner cone, which are unique in this region. Inner cone also has circular summit vent, and it does not have moat. Some have several inner cones.

Discussion

Identity of CLF in CEP

CLFs in CEP are thought to rootless cones. As for the origin of CLF there exist three candidates proposed: rootless cone, pingo, and mud volcano. It is important to determine whether the CLF in CEP are rootless cone, or pingo, or mud volcano for martian magmatism and climate evolution. The existence of central pit in fresh-looking cones supports rootless cone origin because only old degraded pingo has a central depression. The absence of radial cracks on the edifice is inconsistent with pingo origin. The distribution of CLF, the preference to the peripheral areas is consistent with terrestrial rootless cones observed in iceland [ref BV]. Linear alignment parallel to the flow direction also strongly supports rootless-cone origin. Some of the cones are elongated and open to the down-flow direction. These features are difficult to explain by pingo formation. As a conclusion over-all morphology seems to support rootless-cone origin.

Formation process of CLF in CEP

The formation process of CLF in CEP is a little bit different from terrestrial rootless cone, for moat and double cone structure. Main cause of this difference is environment of CEP. CLFs in CEP are formed by following processes: 1) Lava from Cerberus Fossae flowed in CEP where the surface consists of frozen ground with water ice. 2) Lava flowed and formed lava tube. Lava should ponded where original plain denting. 3) Primary rootless cone were formed as a result of lava-water interaction in lava tube and lava ponded area. In lava tube area, rootless cones along the lines of lava tube direction, and in lava ponded area, rootless cones are formed in randomly. 4) Secondary/thirdly rootless cone were formed. 5) Ground could not support the surface loading of rootless cone, ground around rootless cone dented.

References: