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火星のアシダリア平原におけるピッテッドコーンの超高解像度地形解析
HiRISE-based topographic analysis of pitted cones in the Acidalia Planitia on Mars

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The presence or absence of liquid water within the martian sub-surface for the past ~2.0 Gy is still under debate. Low-relief circular mounds with summit pits, called as pitted cones, are commonly identified on the early Amazonian-aged surface in the martian northern lowlands. Although pitted cones are previously interpreted as rootless cones, cinder cones, pingoes, or mud volcanoes [Tanaka et al., 2005], high-resolution images obtained by the recent observations indicate that these pitted cones are likely sedimentary features formed by the fluid flow [Oehler and Allen, 2010]. However, physical characteristics of the materials forming the pitted cones are not critically estimated.

Using the HiRISE stereo pairs, we develop high-resolution (up to 1 m/pix) DEMs (Digital Elevation Models), which enables us to accurately measure the relative heights and basal diameters of the pitted cones. We study 140 pitted cones in the southern Acidalia Planitia, known as the early Amazonian terrain. As a result, we find that these pitted cones have the relative heights of 7 to 64 m (median 22 m) and the basal diameters from 222 to 1377 m (median 579 m).

The high-resolution DEMs are used to calculate the yield strengths and the viscosities of the materials forming the pitted cones. Assuming that the materials have Bingham rheology [Hulme, 1974; Major and Pierson, 1992], we can obtain 10^2-10^4 Pa for the yield strengths and the range of 10^1 to 10^6 Pa s for the viscosities for those materials forming the pitted cones. This result strongly indicates that pitted cones are formed by the mud-volcanic activities. Applying a simple buoyancy model to these potential mud volcanoes [Murton and Biggs, 2003], we estimate that the depths to mud sources range from 27-247 m with a median value of 86 m (std. dev. 40 m). In summary, we conclude that (i) liquid water had been preserved in ~40 m-thick reservoir layers formed about 86 m under the surface in southern Acidalia Planitia and (ii) after that, the fluidized mud erupted from the mud source layers formed mud volcanoes on the surface of Mars.

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