Search of shallow subsurface reflectors in Chryse and Acidalia Planitiae on Mars

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Recurring slope lineae (RSL), one of recent major discoveries on Mars, are surface features which may be linked to current icy processes. These are characterized by narrow dark features which incrementally lengthen down steep slopes, fade in colder seasons, and recur annually. Candidate and confirmed RSL sites are mainly distributed in four regions, (1) southern mid-latitudes (SML), (2) Valles Marineris (VM), (3) equatorial highlands, and (4) northern Chryse Planitia and southwestern Acidalia Planitia (CAP). The RSLs in (2) VM and (4) CAP are more densely located than others, and it may indicate the existence of cryosphere in both regions. For the VM area, Noguchi et al. (submitted) investigated from this point of view. In this paper, we investigated subsurface structures of the other region, CAP, by the subsurface radar data taken by Mars SHAllow RADar sounder (SHARAD) onboard the Mars Reconnaissance Orbiter (MRO). For the geological information, we also used the Java Mission-planning and Analysis for Remote Sensing (JMARS, https://jmars.asu.edu/).
The RADAR frequency of SHARAD is 15-25 MHz with the bandwidth of 10 MHz which corresponds to the depth resolution of 15 m in vacuum. The spatial resolution is 0.3 to 1 km along the track direction and 3 to 7 km along cross-track direction. For the comparison with the SHARAD radargrams, we created virtual radargrams emulating the surface and clutter echoes by the Kirchhoff approximation with the topographic altitude maps from MGS/MOLA data. These emulated radargrams were used for the identification of nadir signals not from subsurface reflectors. We also investigated digital terrain models (DTMs) created on MarsSI (https://marssi.univ-lyon1.fr/MarsSI/) to sample the elevation (or thickness) of crater walls close to the candidates of subsurface reflectors. We produced the stratigraphic columns which were divided into fine, coarse and very coarse layers from each DTM, and then identified their depth in the plane around craters. Those procedures are common with the ones which were adopted in Noguchi et al.
We surveyed over 200 orbits in the CAP region. The confirmed detection of subsurface reflectors were in 10 orbits, and the candidates were in more than 50 orbits. Using geologic map, we try to discuss the subsurface structure and identify what kind of layers they are. For example, one radargram (data ID: 03814501) showed a subsurface reflector at mean depth of 125 m in vacuum (2-way delay time: 831 ns). Another radargram (data ID: 04923501) showed a different reflector at mean depth of 55 m in vacuum (2-way delay time: 367 ns). On the other hand, 2 DTMs near these orbits indicated that the boundary of fine and coarse layers was at the depth of about 50 m. We have not precisely calculated the plausible dielectric constant yet, but it ranges from almost 1 to nearly 8 if the reflection happens at that boundary (e.g. pure water ice: 3.15 [Matsuoka et al., 1997], basalt with no voids: 14.9 [Rust et al., 1999]). It will be tough and difficult to conclude the permittivity in the lack of DTMs.
Our statistical result suggested that the distribution of subsurface reflectors was not correlated with RSL sites, but those reflectors were distributed in close to the boundary of geological unit. Furthermore, these subsurface reflectors located shallower than previous study in other regions (e.g. Arcadia Planitia [Bramson et al., 2015]). Although we do not expect that there is abundant subsurface ice, the characteristics of these reflectors should be deeply studied.

Keywords: Mars, RSL, SHARAD, radar sounding

