EPSC Abstracts
Vol. 17, EPSC2024-1058, 2024, updated on 29 Apr 2025
https://doi.org/10.5194/epsc2024-1058
Europlanet Science Congress 2024
© Author(s) 2025. This work is distributed under
the Creative Commons Attribution 4.0 License.

Potential of drone usage to study viscous flow features on Mars and their analogues on Earth

Osip Kokin[1,2], Akos Kereszturi[3], Aino Kirillova[2], Pascal Allemand[4], Daniel Mège[5], and Gian Gabriele Ori[1,2]

[1]D'Annunzio University, Department of Engineering and Geology, Italy (osip.kokin@gmail.com)
[2]International Research School of Planetary Sciences, Pescara, Italy
[3]Konkoly Astronomical Institute, Research Centre for Astronomy an Earth Sciences, HUNREN, Budapest, Hungary
[4]Universite Claude Bernard Lyon 1, ENS Lyon, Université Jean Monnet Saint-Étienne & CNRS, Laboratoire de Géologie de Lyon, Terre Planètes Environnement, Villeurbanne, France
[5]Centrum Badań Kosmicznych Polskiej Akademii Nauk (CBK PAN), Warszawa, Poland

On April 19, 2021, the first controlled extraterrestrial flight of a drone, or unmanned aerial vehicle, took place on Mars. This drone, also known as the Mars helicopter, was produced as part of NASA's Mars2020 mission and is called Ingenuity, nicknamed Ginny. It demonstrated that flight is possible in Mars' extremely thin atmosphere, ushering in a new stage of exploration of Mars (drone-based stage). Currently, drones such as Mars Sample Recovery Helicopters (NASA) and Martian Boundary Layer Explorer (MARBLE; Indian Space Research Organization) are being developed for use in upcoming missions. It is obvious that the use of these drones in particular and drones in general in the exploration of Mars will provide new information and data, and perhaps even revolutionize certain areas of research.

This paper discusses the potential of drone usage to study so-called viscous flow features (VFFs) which are widespread in the mid-latitudes of Mars with the maximum density between □30° and □50° N and S. This term is used as “an umbrella term for all glacial-type formations exhibiting evidence of viscous flow” (Souness et al., 2012). Their surface morphology is represented by lineation, ridges, troughs, mounds and pits (oriented both parallel and transverse to the slope). Rock glaciers and debris-covered glaciers are considered analogues of the VFFs on Earth (Squyres, 1978; Holt et al., 2008).

Results from the Shallow Radar (SHARAD) on board the Mars Reconnaissance Orbiter showed that the bulk of the LDA reveal radar properties entirely consistent with massive water ice (Holt et al., 2008). This fact makes VFFs part of the Martian cryosphere, so their study is one of the most important issues in the research of Mars, and they also could be a source of water for future human exploration in situ, as well as a source of hydrogen and oxygen for fuel. Besides, ice contains historical records of climatic and geologic changes and can preserve ancient microbial life or even living organisms. However, there are still no detailed studies on the thickness and structure of the VFF cover. The use of drones, or unmanned aerial vehicles (UAVs), on Mars, could partially fill this gap and also help in preparing the future missions to drill interpreted VVF ice at further stages of the Mars exploration. Therefore, in this work we discuss what types of observations could a drone make on mid-latitude VFFs.

1. High-resolution images (aerial view). Currently, the highest-resolution images of VFFs are HiRISE images (0.25 m/pixel). Thus, only large boulders and blocks can be identified on them. The main disadvantage of HiRISE images is the limited spatial coverage, which does only partially cover VFFs. The use of drones at further stages of the Mars exploration could improve resolution and partially solve the problem of limited spatial coverage. UAVs makes possible acquisition of images of resolution up to several centimetres per pixel (and even more detailed, depending on the camera and survey height). It makes possible to estimate the proportion of coarse fractions (pebbles and small boulders) in the surface sediments covering the supposed ice. Spatial coverage encompasses the entire object of interest, not just part of it, but only in the area of rover landing and/or operation. An important advantage is that the drone can fly over places that are inaccessible to rover exploration.

2. Digital terrain models (DTMs) and 3D topography. Typically, DTMs derived from HiRISE imagery can achieve vertical resolution ranging from a few meters, depending on the specific terrain and the accuracy of the processing methods. Horizontal resolution is generally determined by the original imagery's resolution, which is around 50 centimetres per pixel for HiRISE images. DTMs generated from high-resolution drone imagery are able to achieve better resolution (from a few centimetres to several decimetres both vertical and horizontal). The main advantage of drones is the ability to use ground control points with known coordinates and elevations for georeferencing of images and elevation data. Geometrically corrected aerial images (orthophotos) draped over the DTMs will create informative and visually appealing high-resolution 3D topography. DTMs and 3D topography generated from drone imagery can be used for accurate and detailed measurements as well for studying small-scale landforms of VFF surfaces. They will provide new information on the processes and dynamics of VFF deposits formation and will allow a better understanding of their cover origin.

3. Ground penetrating radar (GPR) profiling. This is probably one of the main tasks on the way to searching for subsurface water and ice on Mars. Radar data on the structure of the upper part of the crust obtained from orbit (SHARAD, MARSIS) provide information only deeper than 15-50 m from the surface. Metre – decimetre scale spatial resolution of radar data for studying the uppermost subsurface is challenging and could not be gained from orbit, but close to the surface. However, the mobility of rovers is limited, and their scanning capabilities are limited to thin lines over a moderate distance. In contrast, a drone-based GPR survey has the potential to overcome these limitations. It can cover larger areas and provide more flexibility in data collection. GPR survey will provide information on the thickness of sediments covered the ice, the thickness and internal structure of the ice, as well as stratigraphic correlation with adjacent units.

All these types of observations will be useful for choosing site to drill ice at further stages of the Mars exploration. In addition, they will provide a better understanding of VFF origin. To implement them, there is a number of challenges related primarily to the remote control of the drone and limitations on the data transmission rate between the drone, the rover, and Earth. However, the first experience of using a drone on Mars (Ingenuity) shows that these challenges can be partially resolved.

Acknowledgement

This work was supported by the FlyRadar EU Horizon 2020 project (grant agreement No 101007973).

References

Holt et al. 2008. Science, 322 (5905).

Souness et al. 2012. Icarus 217, 243–255.

Squyres 1978. Icarus, 34 (3). 600–613.