A bird's-eye view of geology: The use of micro drones/UAVs in geologic fieldwork and education

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INTRODUCTION

The past few years have seen the rapid development and availability of unmanned aerial vehicles (UAV). Popularly called "drones," they are remotely operated vehicles that can be fixed-wing aircraft or helicopters. UAVs are being developed for use in everything from product delivery (e.g., Albright, 2014) to farming (e.g., Papadopoulos et al., 2014).

Especially popular are micro UAV helicopters, which are usually in the form of small aerial platforms that have four or more propellers (Fig. 1). This configuration provides great maneuverability, stability, and control. Newer UAVs have built-in GPS systems that provide even greater control and make it easy for an inexperienced person to quickly learn the basics of flying. Their size also makes them easy to transport to even the most remote areas (Fig. 1). They require very little launch and recovery space, and the cost of a basic unit is such that even the total loss of a vehicle is not financially catastrophic (Carrivick et al., 2013). Their low cost also means that multiple UAVs can be used, providing for redundancy if one is lost or damaged.

Figure 1. An example of a micro UAV, a DJI Phantom 2. The drone has a GoPro camera mounted between the landing gear.

USES OF MICRO UAVS IN GEOLOGIC RESEARCH AND TEACHING

Although smaller and limited in their instrumentation carrying capacity compared to larger UAVs, the potential use of micro UAVs in geologic research is great, while their small size and simplicity also make them valuable in educational settings. Aerial surveys, field mapping, and monitoring can be done in real time via telemetry, or the collected data can be rapidly downloaded at the end of a flight. In addition, with the ever-shrinking sizes of sensors, an ever-expanding range of instruments makes the potential uses of micro UAVs even greater.

UAVs provide access to areas that are hard to reach and/or dangerous, such as vertical or overhanging rock outcrops or gas-rich and unstable volcanic areas (Fig. 2) (e.g., Ohminato et al., 2011). They can be used to survey or map disaster areas during and after events, such as flooding or mass wasting (e.g., Delacourt et al., 2007; Niethammer et al., 2012). They have already been used for such things as bathymetric and topographic mapping of river channels (Lejot et al., 2007), 3-D mapping of geologic structures (Vasuki et al., 2014), generating paleoseismology models (Bemis et al., 2014), and surveying post-earthquake land changes (Gong et al., 2012). They can give a broad, aerial perspective of geoarchaeological sites (e.g., Eisenbeiss and Sauerbier, 2011) and be used in coastal and reef surveys. They have even been flown inside caves for karst research (McFarlane et al., 2013).

In educational settings, mapping exercises can be established during which students collect their own aerial images and then interpret them. Unlike Google Earth or regular aerial photos, structures imaged by UAVs provide greater detail at small scales (Helmke et al., 2007). Such exercises also provide students with experience in using technical instrumentation, data collection, data analysis, and interpretation—all critical career skills. The use of UAVs is also expanding in industry, making familiarity with them a résumé skill (e.g., Muttin, 2011; Morgenthal and Hallermann, 2014). Because of the ease of use and accessibility, they can be especially useful in undergraduate research.

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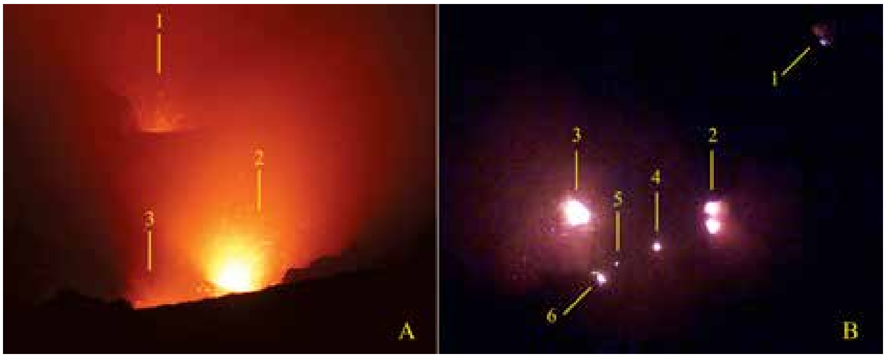

Figure 2. View of from crater rim of Mount Yasur Volcano. (A) From the rim, only three vents are visible. (B) From a micro-UAV image taken directly over the crater, six vents (1–6) are apparent (vents 1–3 correlate with the same numbered vents in [A]). It is also possible to see that vent 2 is obstructed.

One example of the benefits of using a micro UAV in the field comes from the 2014 field season at Mount Yasur Volcano on Tanna Island, Vanuatu. A UAV was flown directly over the active vents and within the gas plume of the volcano. Observations from the rim of the main crater found that there were three active vents emitting lava (Fig. 2). However, an analysis of the video and photographs collected from the UAV indicated that there were actually six active vents—three large vents and three smaller ones. It was also evident that the most active vent was partially obstructed. In addition, the ability of the UAV to fly directly into the gas plume makes it a safe and valuable platform for collecting samples of volcanic gas (cf. Shinohara, 2013).

CHALLENGES IN USING MICRO UAVS

The challenges in using micro UAVs can be divided into three categories:

1. Natural;
2. Technological; and
3. Legal.

In the first case, the biggest challenge to using micro UAVs concerns the weather. High winds (>30 km/h) can severely limit control or flight time, due to loss of battery power as the UAV tries to maintain its position. This was a significant issue at Mount Yasur. Strong winds can blow the UAV off course, into obstacles, and/or beyond areas of recovery and reduce fine control of the UAV. Current micro UAVs are not waterproof, which also limits their use in rainy conditions. Their small size also makes them difficult to see at great distances.

Technologically, UAV flight times are limited by their power source, which, given the size of the UAVs, are also small. High winds at Mount Yasur limited flight time to less than eight minutes. Many UAV cameras (such as a GoPro) use a fisheye lens that distorts the image. This can be solved by using a replacement camera model that does not have the distortion or by post-flight corrections (see James and Robson [2014] for one method). Another issue is determining the scale of view from the UAV images. The simplest way to solve this is to have a ground-based scale (e.g., measuring tape or an object of known size).

Finally, the ready availability and proliferation of micro UAVs has led to a sort of legal gray area in which governments are scrambling to try and regulate their use. Users of UAVs have been found, intentionally or otherwise, to aggravate wildlife (Robison, 2014), disturb natural features (Lowy, 2014), nearly collide with planes (Betelho, 2014), and cause privacy concerns (Flacy, 2014). It is important for researchers and educators who use them to do so responsibly and train students in the ethics of their use.

THE FUTURE

Micro UAV use in geologic field work and teaching has enormous potential. The example cited in this article collected only visual data; however, micro UAVs can be potentially modified to collect many other forms of data, such as ambient weather data, thermal imaging, gas measurements, mapping and surveying data (including generation of 3-D models), long-term aerial monitoring, sample collection, vertical outcrop imaging for stratigraphic surveys, and countless other possibilities that have not been thought of yet.

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