COMPARING GEOLOGIC DATA SETS COLLECTED BY PLANETARY ANALOG TRAVERSES AND BY STANDARD GEOLOGIC FIELD MAPPING: DESERT RATS DATA ANALYSIS

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Introduction: Geologic mapping involves interpreting relationships between identifiable units and landforms to understand the formative history of a region. Traditional field techniques are used to accomplish this on Earth. Mapping proves more challenging for other planets, which are studied primarily by orbital remote sensing and, less frequently, by robotic and human surface exploration. Systematic comparative assessments of geologic maps created by traditional mapping versus photogeology together with data from planned traverses are limited [1]. The objective of this project is to produce a geologic map from data collected on the Desert Research and Technology Studies (RATS) 2010 analog mission using Apollo-style traverses in conjunction with remote sensing data. This map is compared with a geologic map produced using standard field techniques [see Bleacher et al.; Skinner et al.; Eppler et al.; this session].

Background: The Apollo missions (1961-1972) yielded data that revolutionized our understanding of lunar geology. No subsequent planetary human exploration has been conducted; consequently, there has been no opportunity to field check Apollo results with more detailed field investigations. The Desert RATS missions (1997-present) have been conducted in northern Arizona to exercise science operations, test multimission space exploration vehicles (MMSEVs) and extravehicular activity (EVA) protocol to prepare for future human exploration [2]. Since 2009, these analog tests have used “Apollo-style” traverse planning and EVAs to understand regional geology and sample conjectured geologic units [3-4], but the strengths and weaknesses of this style of planetary exploration have yet to be examined.

The most extensive RATS mission was completed in 2010 in the San Francisco Volcanic Field north of Flagstaff, AZ. Over the course of 14 days, a 580 km^2 area was explored by 2 prototype pressurized rovers with crews of astronauts and geologists [4]. 448 samples were collected from 69 EVA stations [5]. This study took a 15 km^2 field area adjacent to SP mountain in order to evaluate in further detail using RATS data and data derived from standard geologic mapping techniques. Although this area has been studied at a reconnaissance scale [6-7], detailed geologic mapping has not been carried out on this volcanic center.

Methods: Much like the Apollo Missions, RATS yielded samples, photographs, and crew videos for further study with remote sensing data. In our study area, 19 EVA stations from 5 days contributed to 122 samples. Sample locations were georeferenced using crew videos, field photos, and GPS data from the EVA backpacks using Google Earth and Picasa. These locations, as well as crew and rover traverses, were mapped for each station in ArcMap (Fig. 1). Sample contexts and compositional characteristics (from hand sample examination) allowed for the differentiation between different sedimentary and volcanic units. The age relationships of the units were finally determined by geomorphologic relationships and relative weathering of the samples.

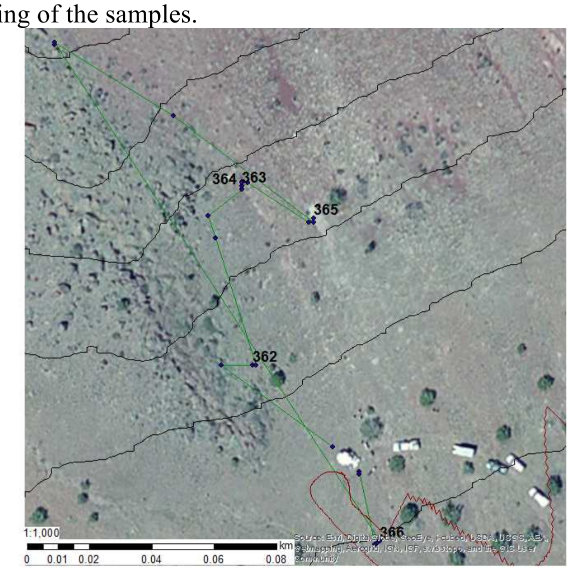

Figure 1: 1:1500 image of site 25B with sample numbers, EVA track (green), rover track (red). The basemap is ESRI world imagery, including an aerial view of the MMSEV.

Results: The 1:24,000 scale product map (Fig. 2) was created in ArcMap 10.1. The photogeologic premission units [3] were re-evaluated using RATS 2010 data.

The field area included a basement sedimentary unit, several volcanic flows, and cinder cones. The sedimentary basement units, originally mapped as two distinct units [3], were determined to be one unit of limestone (ls). Distinguishing between the different volcanic flows and cones proved more difficult. The oldest identifiable basalt flow (b1) was interpreted by photo-interpretation; however, due to the lack of samples and distinguishing topography, the number of flows is indeterminate. The b1 flow was inferred to be older than the other basalt flows by superposition.

The central volcano complex was mapped as two cones. On the basis of RATS 2010 samples, the northern cone (p1) includes massive lava flows with olivine and pyroxene phenocrysts, while the southern cone (p2) is composed of pyroxene- and plagioclase-phenocryst dominated agglutinates. The topography and sample compositions suggest that p1 is related to and constructed on top of the adjacent flow (b2).

The southeastern corner of the study area was interpreted as an older, weathered flow (b4) of a plagioclase-rich agglutinate basalt. The west side of the study area comprises another basalt flow (b3) composed of massive, vesicular basalt rich in olivine and pyroxene phenocrysts. The morphology of the b3 flow suggests that it is younger than b4. The clear lobate features of both the b3 and b4 flows supports that the flows are relatively younger than the adjacent central cone complex. SP flow (b5) and SP mountain (p3) are the most recent volcanic features in the study area. Both units are composed of massive and vesicular basalt rich in olivine and plagioclase. The map boundaries for these units remain unaltered from the pre-mission map.

The interpreted boundaries and types of the surficial units (originally referred to as surficial plains) were difficult to validate based on the RATS data. The limited data and photo-interpretation results suggest that the units include alluvium (al) and colluvium (cl) possibly eolian deposits and ashfall.

Discussion: The RATS 2010 data is spatially limited, as manifested on the map (Fig. 2). Mapping the study area has therefore involved interpolation of rock mineralogies and unit boundaries through photo interpretation. However, our detailed analysis of the RATS data indicate the high quality and efficacy of the pre-mission mapping and traverse planning [3-4]. The compositional study of the limestone basement and differentiation between lava flows and cinder cones reflects that the pre-mission process of identifying traverse and sampling locations was successful. At the same time, there are regions that were not sampled or visited by the RATS 2010 traverses that might have improved our maps and understanding of the geology of the area. These limitations to the Desert RATS data set create discrepancies between our map and the map constructed by the field team.

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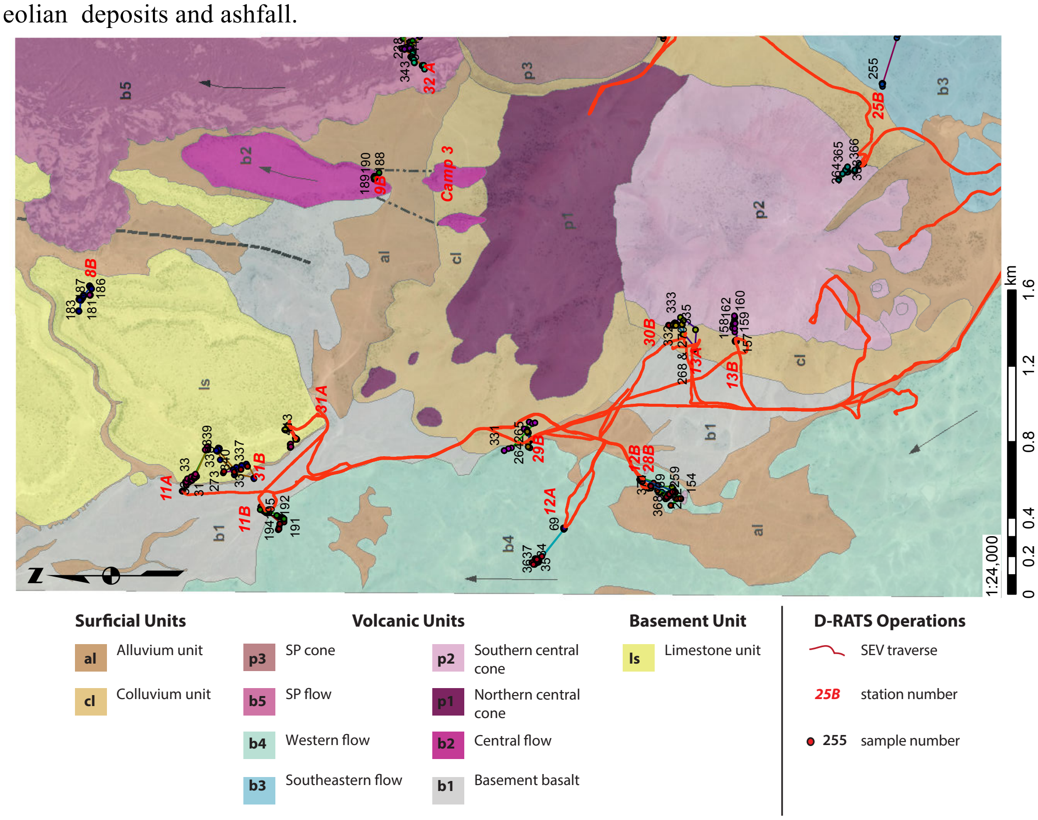

Figure 2. A 1:24,000 map of the study area with units, sample numbers, EVA and rover tracks.