PLANET FOUR: TERRAINS – ARANEIFORM IN THE SOUTH POLAR REGION OF MARS C. J. Hansen[1], M. E. Schwamb[2], G. Portyankina[3], K.-M. Aye[3], [1]Planetary Science Institute, 1700 E. Fort Lowell, Suite 106, Tucson, AZ 85719, cjhansen@psi.edu, [2]Gemini Observatory, Hilo, HI, [3]Laboratory for Atmosphere and Space Physics, University of Colorado, Boulder, CO.

Introduction: The south polar region of Mars hosts a uniquely martian landform featured by dendritic channels, usually radially-organized. The channels are carved a bit wider and deeper every year by the dynamic seasonal activity associated with spring sublimation of the seasonal CO_2 polar cap. As the seasonal cap sublimates a variety of phenomena are observed, well-described by the Kieffer cold jet model [1]. In the Kieffer model penetration of sunlight through translucent impermeable CO_2 ice warms the surface below, which leads to basal sublimation of the ice layer. Trapped gas escapes through ruptures at weak spots, entraining surface material which then settles out in fan-shaped deposits oriented by wind or slopes on top of the ice. Gradually dendritic or tortuous troughs are eroded in the surface, often radially organized, or sometimes connected in networks [2, 3, 4]. These landforms are known colloquially as "spiders" (often used to describe a single landform) and more rigorously as "araneiform terrain" (which broadly describes a surface with the tortuous channels characteristic of the unique type of erosion associated with sublimation jets).

This process has been studied over multiple years using images from the High Resolution Imaging Science Experiment (HiRISE) on the Mars Reconnaissance Orbiter (MRO) [4]. Many of the sites HiRISE images regularly are clustered in the cryptic terrain (a region that remains at the CO_2 ice temperature in spite of its dark albedo in the spring [1]). Scientifically however, more widely distributed coverage will allow us to improve our maps of where araneiform terrain forms and what conditions are key to its development. We can compare the properties of the regions to find trends associated with weather, types of terrain, erodibility of the ground, latitude, etc. This was the motivation for our citizen science project Planet Four: Terrains (P4T), found at http://terrains.planetfour.org.

Planet Four: Terrains: In June 2015 we started the P4T citizen science project. The goal is to use MRO's Context Camera (CTX) images to find interesting new places to observe seasonal processes. HiRISE images are very high resolution (~0.5m) but cover only ~6 x 12 km. CTX images cover 30 x 60 km with a spatial scale of ~6 m. The objective of P4T is to identify more sites, to broaden the overall number and distribution of sites of interest in Mars' south polar region for HiRISE to image. Figure 1 shows current HiRISE monitoring sites, compared to the widely distributed CTX images selected for this study.

Volunteers are asked to identify the following features in the CTX images: spiders, baby spiders, networks of channels, craters, and/or swiss cheese terrain. At this time over 16,000 volunteers have made over 800,000 feature classifications. Once 20 volunteers have evaluated a sub-image it is retired, and to-date over 37,500 cutouts have been retired.

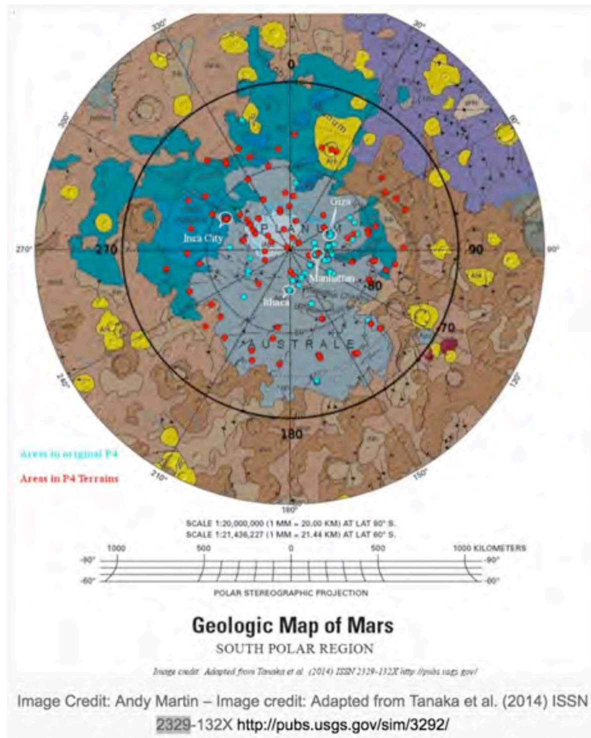

Figure 1. Blue dots mark sites that HiRISE images routinely every year. They tend to be clustered in the cryptic terrain. Red dots mark the CTX image locations selected for this project to broaden the sample distribution across the south polar region.

Results to-date: By the start of southern spring in July 2016 a number of CTX images had been identified by citizen scientists that potentially showed the features of interest. This process has led us to image a number of very interesting sites with HiRISE. Folllow-up imaging with HiRISE has verified spiders at most locations identified by the public. Baby spiders tend just to be pits or gouges in the terrain without the characteristic dendritic channels indicative of CO_2 gas erosion, so they may not represent immature araneiform terrain after all.

Araneiform terrain distribution. We are particularly interested in spiders forming on terrain types not previously analyzed, or at locations away from the current collection of HiRISE monitoring sites. This study shows that araneiform terrain is not confined to the South Polar Layered Deposits (SPLD) as previously assumed [2]. In this regard, the location of araneiform terrain shows where conditions are consistent with formation of a translucent impermeable ice sheet at some point in the spring. It is also giving us new insights into the terrain conducive to erosion by this process.

Terrain types hosting araneiform terrain. Araneiform terrain is typical on surfaces that are less consolidated due to layering or have other easily eroded weaknesses. Patterned ground channels often develop the tortuousity associated with CO_2 gas erosion. The SPLD has numerous spiders on its surface, and this study shows that they also form right along the edge of the SPLD. Crater ejecta blankets off the SPLD also often host spiders. An interesting future investigation will be to model the thermal characteristics of layered vs. non-layered surfaces, and porosity of the ground. It may be that the thermal environment is also a factor in forming and breaking slab ice. Figure 2 shows a cluster of araneiforms on the ejecta blanket of a large nearby crater.

Figure 2. Image ESP_048924_1010, at 78.9S / 22.8E, shows how CO_2 gas has exploited the weakness of the patterned ground on a crater ejecta blanket to erode araneiform channels. The stratigraphic sequence is 1) formation of the crater, then 2) development of patterned ground, followed by 3) erosion of araneiform channels.

Figure 3 shows an example of boulders at the center of spiders. This association has previously only been identified at a location known informally as Inca City [5]. The boulders have their own thermal microenvironment, and can also provide an easily-ruptured weak spot in the ice sheet for gas to escape [5].

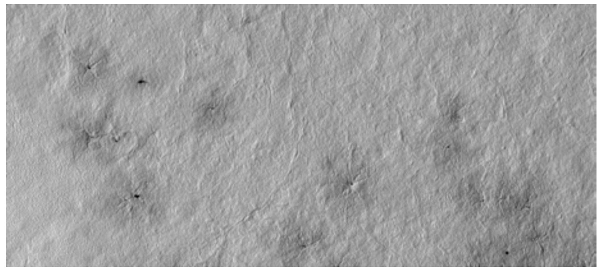

Figure 3. Boulders are at the center of spiders in ESP_046948_1050 at 74.8S / 331E.

Both of these examples came from the P4T citizen science project. The P4T has so successfully met its objectives that we have decided to extend it indefinitely, adding more CTX images to the site. The new set of CTX images added widens the distribution to 70S, adding a latitudinal zone that can be imaged by the Color and Stereo Scientific Imaging System (CaSSIS) camera on the ExoMars Trace Gas Orbiter.

Citizen Science of Planet Four. Planet Four: Terrains is an offshoot of the original Planet Four citizen science project, which engages the public in the task of cataloguing fans in images from the first 4 southern springs on Mars imaged by HiRISE. Planet Four is hosted by the zooniverse, a group dedicated to involving the public in science and data analysis. They provide the web portal, technical expertise, and project builder platform for involving large numbers of volunteers in research projects online (described at http://www.zooniverse.org).

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References: [1] Kieffer, H. H. (2007), JGR 112, E08005; [2] Piqueux, S. et al. (2003) JGR 108, (E8):3-1; [3] Piqueux, S. and P. Christensen, (2008) JGR 113, E02006; [4] Hansen, C. J. et al., (2010) Icarus 205:283-295; [5] Thomas, N. et al., (2010) Icarus 205:296-310.