TARs on Mars: A study of the spatial variability and physical characteristics of Martian Transverse Aeolian Ridges.

A.D. Jessar[1], J.R. Zimbelman[2], and L.A. Hennig[3]; [1,3]Astronomy and Astrophysics Research Laboratory, Thomas Jefferson High School for Science and Technology, Alexandria, VA 22312; [1]2015ajessar@tjhsst.edu, [3]LAHennig@fcps.edu; [2]CEPS/NASM MRC 315, Smithsonian Institution, Washington, D.C. 20013-7012; zimbelmanj@si.edu

Introduction: Transverse Aeolian Ridges (TARs) are wavelike formations of sediment, similar in appearance to terrestrial ripples, which form in groups across the Martian surface. TARs resemble Martian dunes and ripples but have not been studied as extensively as some other aeolian bedforms. It is generally recognized that TARs are smaller than dunes and larger than ripples. However, previous studies have determined that there are different types of TARs, and some of them resemble dunes, while others resemble ripples [1, 2]. Research to date has focused on the spatial variability of TARs (that is, how TAR concentration varies across the Martian surface) and, more generally, on the factors hypothesized to influence TAR formation, including latitude, elevation, and local geology [3]. Such research helps to develop an understanding of TARs in Martian geology, specifically with respect to dunes and ripples.

In this study of images taken by the High Resolution Imaging Science Experiment (HiRISE), we confirmed that, as previous studies have indicated, TARs come in various shapes and sizes and with differing degrees of topographic dependence [1, 2]. Although too few images had been analyzed at the time of this writing to warrant conclusions based on numerical data, we expected to find latitude as a major determinant of TAR concentration. Over the course of this study, new methods of image analysis were developed that should allow for more quantitative studies of the spatial variability and diverse physical characteristics of TARs.

Data Collection: This study focused on HiRISE images from the longitudinal swath extending from 70°E to 80°E, a region selected because it includes part of the Hellas impact basin. This depression is the site of the lowest elevations on Mars and is an appropriate choice for examining how altitude and local terrain affect TAR concentration. Thumbnails of the HiRISE images were accessed online through Arizona State University's map of HiRISE images. The full-resolution images were downloaded into the HiVIEW analysis program from the University of Arizona's HiRISE website.

Once an image was opened in HiVIEW, the zoom function was used to examine the surface in greater detail. The total TAR coverage, defined here as the percentage of a given image covered by TARs, was then estimated. The coverage estimate was entered into an Excel spreadsheet, along with the latitude and longitude of the center of the image and next to qualitative notes about the physical characteristics of the TARs in the image.

After analysis of about 90 images, a sampling technique was developed to avoid the unnecessary analysis of many similar images within small surface areas. The sampling was governed by selecting one image from each 1° x 1° (lat. - long.) square in a grid superimposed on the surface (part of the grid is illustrated in Figure 1).

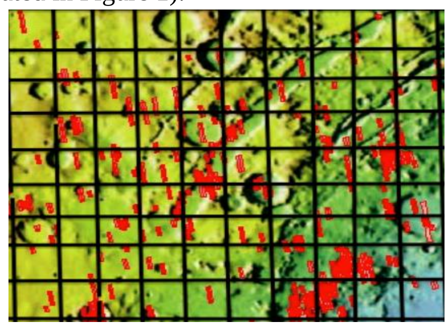

Figure 1: Part of the sampling grid. Squares run from 70°E to 80°E and about 17°N to 25°N. Red dashes represent HiRISE images on Arizona State University's HiRISE Camera Image Map.

After analysis of about 100 images, the TARs were divided in all of the ensuing images into three categories (based on their physical characteristics) that seemed representative of all the TARs observed in the first 100 images. These TAR types were designated as "patchy" TARs, "well-defined" TARs, and "superimposed" TARs (see "Analysis" section below for a description of these kinds of TARs). For a given image, the percent coverage of each of the three TAR types present in the image was estimated, so that each image was associated with four estimates instead of just one (the three specific estimates and the total coverage estimate). By definition, the three "type concentrations" added up to the total coverage estimate of the image. Estimates of the type concentrations were made more consistent with the HiVIEW "distance tool," which was used to circle TAR deposits of a given type and calculate their areas. These areas were added together to get the total area covered by a TAR type. The total area was divided by the area of the entire image and multiplied by 100% to give the type concentration. This numerical approach reduced dependence on a solely visual estimation method. The type concentration technique offered a new way to analyze physical characteristics and spatial variability of TARs at the same time, since it enabled differentiation between TARs throughout the swath.

Analysis: The names “patchy,” “well-defined,” and “superimposed” were devised based on observations of TARs’ physical characteristics, which were recorded in the Excel spreadsheet. “Patchy” TARs are formations that form in large groups and cover significant surface area. “Well-defined” TARs are high-albedo formations that often form in craters and valleys. “Superimposed” TARs are more spread out relative to one another and seem to lie on top of local terrain. Figure 2 shows examples of the three types of TARs.

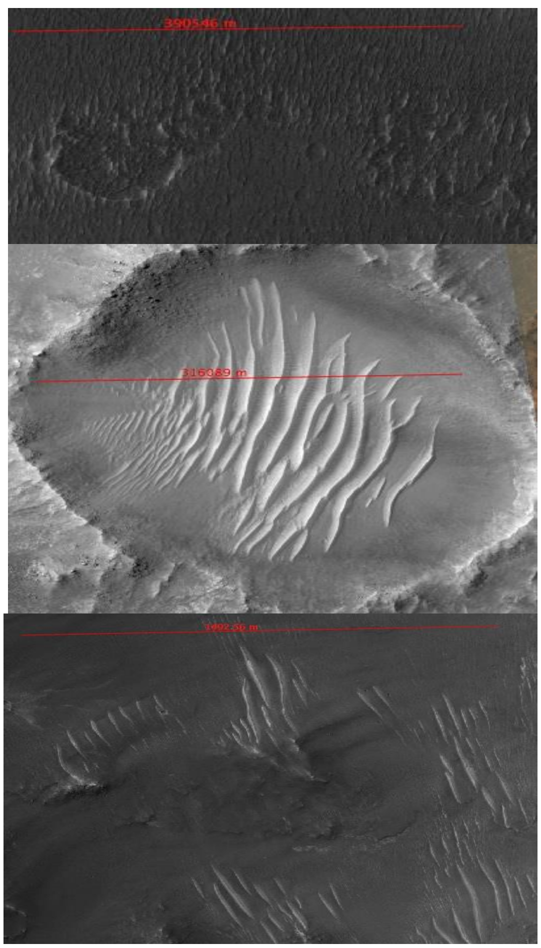

Figure 2: The top image shows “patchy” TARs (the scale indicated by the red distance tool is 390546 meters). The second image shows “well-defined” TARs within a crater (the distance reading is 316089 meters). The third image shows “superimposed” TARs (the distance reading is 1492.56 meters).

The average total TAR coverage was calculated and recorded for each 10° latitudinal zone within the swath. For each of these zones a histogram of all coverage estimates was constructed. These calculations were repeated for the type concentrations (“patchy, well-defined, and superimposed”) in each zone except the 10°N-20°N region (which had already been examined before the decision to divide total estimates into estimates based on TAR type). The only difference in this second set of calculations was that three averages and three histograms were produced for each zone, instead of one average and one histogram (since there were three types of TARs).

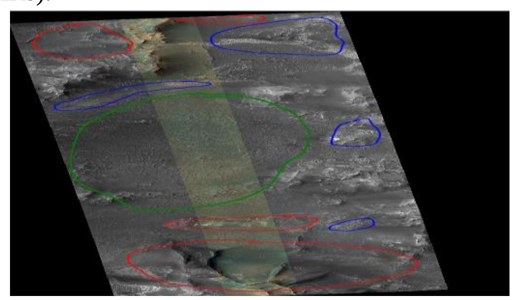

Figure 3: TARs circled by red, blue, and green ovals are “patchy,” “well-defined,” and “superimposed” TARs, respectively. The horizontal edge of the image is approximately 5300 meters long. The side is approximately 14300 meters long.

Conclusions: At the time of this writing, only the 10°N-20°N had been completed. Thus, conclusions were not yet formulated, but they will be presented at the workshop. Preliminarily, we expected to find that the latitudinal zones closest to the equator would have the highest average total coverages, since previous research found that TARs were most prevalent at low latitudes [3]. We also expected to find high TAR concentrations in the Hellas impact basin, since earlier studies also found that TARs were most concentrated at low elevations [3]. Analysis of more images over the swath should determine whether these expectations were well-founded. The coverage estimate data and qualitative notes from this study should be a valuable addition to the developing science techniques of studying Martian TARs.

References: [1] Balme, M., Berman, et al. (2008). Transverse Aeolian Ridges (TARs) on Mars. Geomorphology, (101), 703-720. [2] Zimbelman, J. R. (2010). Transverse Aeolian Ridges on Mars: First results from HiRISE images. Geomorphology, (121), 22-29. [3] Ebinger, E. K., & Zimbelman, J. R. (2015). Geospatial classification of Transverse Aeolian Ridges on Mars. *LPS 46*. (retrieved from http://www.hou.usra.edu/meetings/lpsc2015/pdf/1137.pdf)