A New Look at Cooling Models for Martian Flood Basalt Columns. David K Weiss[1, 2], Brian Jackson[1, 4], Moses P Milazzo[3], Jason W Barnes[5], [1]NASA Goddard Space Flight Center, Greenbelt, MD, United States, [2]Geology and Environmental Geosciences, College of Charleston, Charleston, SC, United States, [3]Astrogeology Science Cente, US Geological Survey, Flagstaff, AZ, United States, [4]Carnegie DTM, Greenbelt, MD, United States, [5]Physics, University of Idaho, Moscow, ID, United States.

Introduction: Columnar jointing in large basalt flows have been extensively studied and can provide important clues about the emplacement conditions and cooling history of a basalt flow. The recent discovery of basalt columns on Mars in crater walls near Marte Vallis provides an opportunity to infer conditions on early Mars when the Martian basalt flows were laid down. Comparison of the Martian columns to Earth analogs allows us to gain further insight into the early Martian climate.

The Columbia River Basalt Group (CRBG) in eastern Washington is one of the youngest (< 17 Myrs old) and most studied basalt provinces in the world, covering 163,700 km² and 1 km thick in some places. The morphologies and textures of CRBG basalt columns suggest that water may have seeped into column joints, helping to speed and homogenize cooling rates. At the resolution of the orbiting HiRISE camera (0.9 m), the Martian columns resemble the CRBG columns in many respects, and so inferences linking the morphologies of CRBG columns to their thermal histories may be extended to the Martian columns.

We describe our analysis of HiRISE images of the Martian columns and preliminary inferences about their thermal histories and emplacement conditions. We also report on a field expedition to the CRBG in eastern Washington State, during which we surveyed basalt column outcrops on the ground and from the air using Unmanned Aerial Vehicles to compare ground-truth and remote measurements of the columns to assess the limitations and biases inherent in remote-sensing data.

Column formation: When large basalt flows cool uniformly, the resulting tensile stress can give rise to regular jointing and formation of hexagonal basalt columns. As a cooling front penetrates the flow from its exterior, these joints advance intermittently, in jumps typically of several cm [1]. This jointing leaves subtle bands encircling the columns, called striae (see Fig. 1).

The distances over which sufficiently large tensile stresses to joint the rock depends on the rate of cooling: for more rapid cooling, large tensile stresses quickly develop over short distances, and joints propagate in shorter jumps. Consequently, measuring the width of basalt column striae can allow inference of the basalt cooling rate [1].

Basalt flows that host columns also usually exhibit more complex and less well-defined morphologies, from wavy, arcuate columns to rubbly, poorly-defined rock jumbles. The various morphologies and textures relate to the cooling rates and emplacement environment for the basalt flows. However, the relationship between morphology and emplacement conditions is still unclear. Basalt columns can be commonly observed on Earth in flood basalts. Basalt columns were recently discovered on Mars [2], in the margins of impact craters, particularly near Marte Vallis.

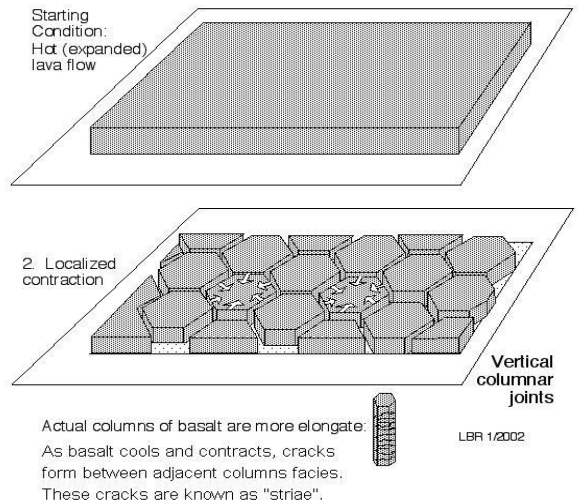

Figure 1: Formation of basalt columns and striae [3].

Methodology: Ground measurements of striae height and column width were performed in The Channeled Scablands of Washington, a Mars analogue site (See Fig. 3). These measurements were important in determining the relationship between striae height and column width. Measurements of the Mars columns were acquired from the HiRISE Imagery. Aerial imagery of the columns was collected against which we compared ground measurements (see Fig.2).

The relationship between striae height and column width on Earth is important because striae are not visible from the HiRISE imagery, and must be inferred from the terrestrial striae-column width relationship.

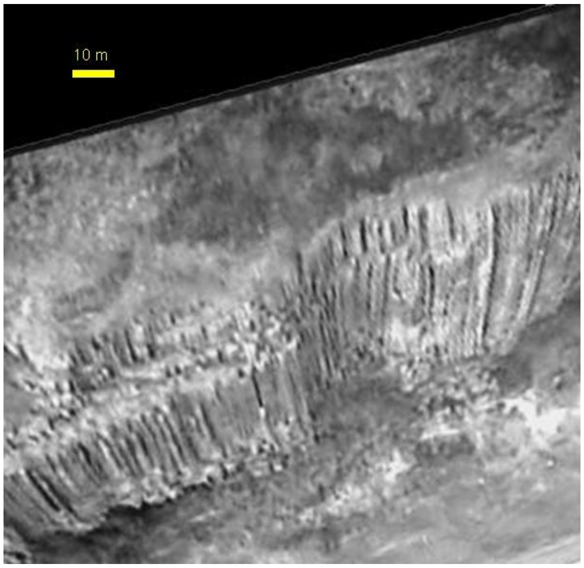

Figure 2: Aerial image of a basalt column outcrop in the Snake River Valley near Clarkston, WA. Aerial measurements of CRBG basalt columns were obtained from images like this one.

Figure 3: Column width being measured. Striae are marked with chalk.

Figure 4: The Hexacopter equipped with a video camera captures images of the columns from a variety of altitudes.

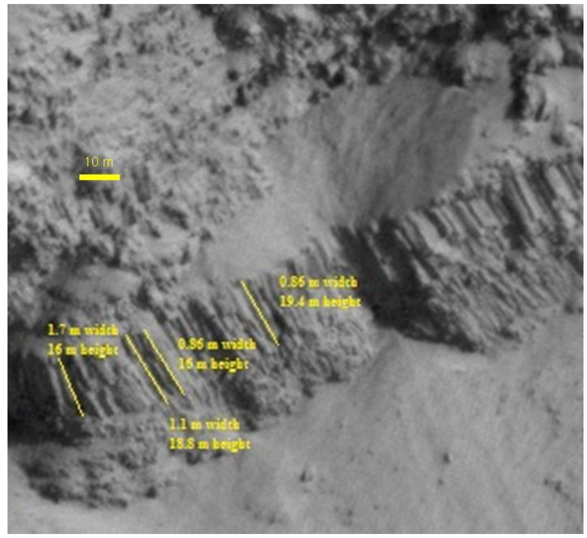

Figure 5: Mars Reconnaissance Orbiter HiRISE image of a basalt column outcrop on Mars. Measurements of Martian basalt columns were obtained from HiRISE images like this one.

Results and Conclusions: Assuming emplacement temperatures and similar cooling models apply, we find cooling rates for the Martian columns seen in Fig. 5 are consistent with rates for the CRBG columns seen in Fig. 2. Future research will seek to remove the effects of foreshortening from the HiRISE imagery and will include detailed modeling of cooling rates, their relationship to the column morphologies, and a comparison to field measurements.

References:

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