THE FORMATION OF COLUMNAR JOINTS ON EARTH AND MARS. M.P. Milazzo, L.P. Keszthelyi, A.S. McEwen, and W. Jaeger , Lunar and Planetary Lab., University of Arizona, Tucson, AZ. mmilazzo@pirlmail.lpl.arizona.edu

Introduction: It is hypothesized that volcanic eruptions on Mars may trigger major outbursts of liquid water. Since the lava and the water will follow the same paths, it is plausible that water flowed over some Martian lava flows while they were hot. Such lava-water interactions should produce morpohologic features such as columnar jointing, hyaloclastites, and possibly pillows. The size and frequency of such features are an indication of the amount of water interacting with the lava. It would be highly desirable to estimate the volume of water that flowed over Martian lava flows that exhibit these features.

In this abstract we focus on the formation of c o-lumnar jointing and estimating the cooling rate by water necessary to produce various column sizes. From the estimated cooling rate, we can estimate the flux of water, which will be an indication of the minimum flux of water across the lava flow. It will be possible to apply this model by looking at the jointing within Martian lava flows with very high resolution imaging from rovers, aerial vehicles, and possibly even from orbit. Even where the joints themselves are not visible, the size of blocks falling from cliffs of frozen lava provide a good sense of the spacing of the joints.

Current Modeling: Creation of columnar jointing on the Earth requires liquid water to infiltrate the cracks to provide a relatively constant cooling rate. This cooling rate determines the diameter of the columns, as well as their length. Currently, there are well developed mathematical models for the cooling of lava flows [e.g., 1], and also for the creation of joints in lava flows using simple cooling models [e.g., 2]. Our goal is to combine the two types of models into a single integrated numerical model. We started with the Keszthelyi and Denlinger [1] model for the cooling of a relatively quiescent lava flow. This model has only one spatial dimension but includes the temperature dependent thermal properties of the lava and the effects of vesicles and bubbles. It uses a simple finite difference method and has been successfully tested against field data from active flows in Kilauea. We have modified this model by adding cooling by a constant flux of infiltrating water and a simple crack propogation model.

The removal of heat by water is assumed to be achieved by boiling of water percolating down the crack(s). As such, heat is removed from the portion of the crack that is hotter than 100 °C. The effect is to remove heat from relatively deep within the flow, very greatly increasing the rate at which the solid crust grows when compared with subaerial cooling.

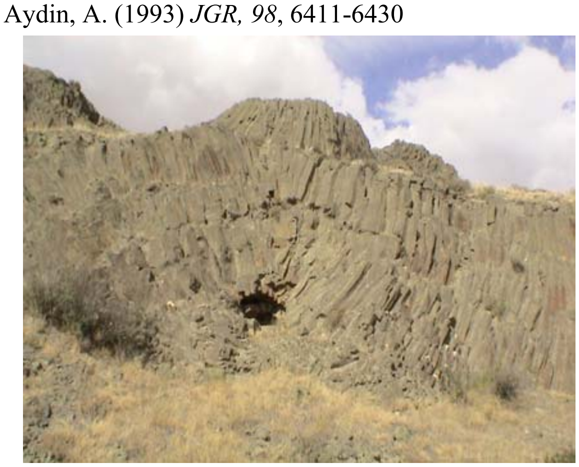
The crack propagation model is a simplified version of a crack propogation model from Degraff and Aydin [2]. At this stage we do not include the effects of the microphysics of stress concentration at the tip of a crack and only require that the stress in the solidified (but uncracked) lava exceed the strength of the lava. We also use the empirical observation that the distance a crack advances during a propogation event is about 1/8 of the width of the resulting column.

The combined cooling and crack model allows us to estimate the cooling rate necessary to produce a joint of a given diameter. Using this cooling rate, we can estimate the minimum flux of water across the lava flow necessary to cause this cooling.

Future Application: Our first step will be to apply the model to terrestrial lava flows that we know have been cooled by water. These include the lavas confined within the Little Colorado River at Grand Falls, Arizona and columnarly jointed entablatures within the Columbia River Basalts in Washington (see figure). After we have confirmed that the model is able to reproduce the terrestrial observations, we will translate it to Mars.

If eruption of lava caused large outbursts of liquid water, which subsequently flowed over hot lava flows, we can use various remote sensing techniques (rovers, aerial vehicles, orbiters), to be able to detect the jointing caused by such outbursts. The column diameter, joint length, and volume of such features will allow us to estimate the amount of heat extracted by water, which will provide a lower limit on the flux of water across the lava flow. Such knowledge will allow us to test various hypotheses concerning the amount of liquid water available on Mars at the time these lavas erupted.

References: [1] Keszthelyi, L. and Denlinger, R. (1996) *Bull. Volcanol., 58* 5-18. [2] Degraff, J.M. and Aydin, A. (1993) *JGR, 98*, 6411-6430



(Fig 1) Columnar jointing in the Columbia River Basalts, Washington.