LUNAR SINUOUS RILLES: REASSESSING THE ROLE OF EROSION BY FLOWING LAVA. D. A. Williams\textsuperscript{1}, W. B. Garry\textsuperscript{2}, L. P. Keszthelyi\textsuperscript{3}, R. C. Kerr\textsuperscript{4}, W. L. Jaeger\textsuperscript{5}, \textsuperscript{1}School of Earth & Space Exploration, Arizona State University, Tempe, AZ 85287-1404 (David.Williams@asu.edu), \textsuperscript{2}Center for Earth & Planetary Studies, Smithsonian Institution, Washington, D.C. (GarryW@si.edu), \textsuperscript{3}Astrogeology Team, U.S. Geological Survey, Flagstaff, AZ (laz@usgs.gov, wjaeger@usgs.gov), \textsuperscript{4}Research School of Earth Sciences, Australian National University, Canberra, Australia (Ross.Kerr@anu.edu.au).

Introduction: Erosion by flowing lava is known to incise relatively shallow (meter-scale) troughs into substrates ranging from basalt to carbonatite and sulfur [e.g., 1-3], and is thought to have carved larger (tens to hundreds of meters deep) channels in some historic basalt lava tubes [4] and prehistoric komatiite lava channels [5-6]. Previous workers suggested that low-viscosity lunar mare lavas, rheologically similar to terrestrial komatiites, could have produced the lunar sinuous rilles by lava erosion, either under the turbulent [7] or laminar [8] flow regimes. Two of us have developed more rigorous analytical-numerical models to constrain erosion by lava in either flow regime [9, 10] which, when constrained by appropriate field data (e.g., flow thickness, channel dimensions, lava and substrate compositions and degrees of consolidation), can provide useful estimates of erosion depth, degrees of contamination, and other parameters as a function of flow rate and distance downstream. We propose that the Lunar Reconnaissance Orbiter Camera’s (LROC) Narrow Angle Camera (NAC) target portions of selected lunar sinuous rilles to obtain stereo images of channel widths and depths, and potential outcrop layer thicknesses, in specific sinuous rilles to constrain lava flow rates for our modeling. In this abstract we discuss our approach, focusing on one already high-priority LROC target, Schröter’s Valley on the Arcturus Plateau (Fig. 1), which can be used to assess erosion by mare lava over both highlands and pyroclastic substrates.

Previous Modeling: Our analytical-numerical models were developed to assess the degree of erosion by low-viscosity, turbulently-flowing terrestrial komatiites [9, 11] and laminarily-flowing basalts and carbonatites [10, 12] lavas over a variety of substrates. The turbulent flow model of Williams et al. was adapted to assess erosional lava channel formation on Io, Mars, and for the Moon, in the latter case focusing on erosion by mare basalt lavas on mare basalt substrate [13]. An aspect of lunar sinuose rille formation that has not been studied is the nature of erosion by a mare basalt lava flowing over highlands material of different composition, or erosion of a glassy pyroclastic deposit. Our models were previously adapted to examine these scenarios on Earth [11, 12], and can be modified relatively easily to assess these scenarios on the Moon. Previous analyses of Apollo samples can provide physical and chemical constraints on lunar highland materials and pyroclastic glasses.

LROC Imaging: The key parameter to evaluate better the nature of erosion in lunar sinuous rilles via our models is an estimate of the range of lava flow thicknesses, which serve as a proxy for lava flow rates. These thicknesses can be estimated from images of lava flow outcrops exposed on the sides of the lunar sinuous rilles, such as that seen in Hadley Rille by Apollo 15 astronauts (Fig. 2).

Outlook: Topographic data derived from LROC NAC stereo pairs will have the potential to provide additional information on lava flow thicknesses in lunar sinuous rilles, as well as on the morphological structure of the rilles. This information will serve as key input data for our models of the lava erosion process, which will provide further constraints on the styles, duration, and extents of lunar mare volcanism.

Figure 1. Apollo 15 Metric camera image of the Aristarchus Plateau on the lunar nearside. For scale, crater Aristarchus at left is 40 km in diameter. The Aristarchus Plateau is about 200 km across, and is thought to be composed of crustal material uplifted, tilted, and fractured by the Imbrium impact event. At center right is Schröter’s Valley, a rille that is about 160 km long, up to 11 km wide and 1 km deep, and contains an inner sinuous rille. The plateau is cover by a pyroclastic deposit thought to be composed of Fe-rich glass spheres, visible in multispectral data. High-resolution LROC-NAC imaging at 50 cm/pixel could reveal outcrops in the walls of Schröter’s Valley, which can constrain our models of lava erosion and lava flow emplacement. Photo AS15-M-2610.

Figure 2. A telephoto lens view looking across Hadley Rille, photographed during the third Apollo 15 lunar surface extravehicular activity (EVA-3) at the Hadley-Apennine landing site on the lunar nearside. The blocky outcrop at the top of the west wall of the rille is about 1.9 kilometers from the camera. About one-half of the debris-covered wall is visible in the photograph. Smaller outcrops of lava flows could be exposed in other sinuous rilles and can be imaged by LROC-NAC (spatial resolution 0.5 m/pixel). Photo AS15-89-12157.