MORPHOLOGY OF LAVA-CAPPED INVERTED VALLEYS NEAR ST. GEORGE, UTAH: ANALOGS FOR MARTIAN SINUOUS RIDGES R. M. E. Williams [1] and R. P. Irwin III[2], [1]Planetary Science Institute, 1700 E. Fort Lowell, Suite 106, Tucson, AZ 87519 (williams@psi.edu), [2]Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, 6th St. at Independence Ave SW, Washington DC 20013-7012, irwinr@si.edu

Introduction: Landscape inversion occurs when differential erosion preferentially removes less resistant materials leaving the more resistant material located in former topographic lows preserved as elevated terrain. A variety of fluvial landforms preserved in inverted relief have been recognized at a number of sites on Mars [e.g. 1-4]. A larger study is underway to examine a range of terrestrial inverted channels sites [e.g. 5-7] as analogs for martian sinuous ridges. The two research objectives of the overall investigation are: 1) to identify distinguishing morophological attributes of various indurating agents in inverted landforms, and 2) to evaluate the applicability of paleohydrologic models for inverted fluvial landforms. Here, we report on the morphological attributes of multiple lava-capped mesas near St. George, Utah that preserve portions of the ancestral Virgin River drainage in inverted relief.

Inverted lava-capped valleys near St. George, Utah. Cinder cones located on the flanks of the Pine Valley Mountains are the sources for multiple basalt lava flows that occurred over the past few million years and flowed into the ancestral Virgin River drainage network for distances up to 15 km. Cinder cones are very fragile features; most of the cinder cones in this area formed 20,000 years ago [8]. The lava-capped mesas are at different elevations and record a series of volcanic eruptions punctuating a period of uplift and erosion. For example, the Airport Mesa is a flow dated to 1.07 million years ago while the overlying West Black Ridge is 2.3 million years old (Figure 3) [9, 10]. Tectonic activity along the Hurricane Fault has largely been responsible for mesa relief of up to 300 m above the surrounding terrain [10].

Three general stages of formation are recognized in the development of the lava-capped valleys: 1) lava flows down existing valleys and blocks normal drainage creating lakes; 2) erosion along lava flow margins forms new valleys, leaving the lava flow as a sinuous ridge, and 3) further erosion creates isolated mesas and buttes [11]. Therefore, the oldest flows are topographically higher and discontinuous along course.

Mesa width varied non-systematically downstream, a reflection of a) variations in the original valley shape and/or b) areas of ponding of the lava flow behind topographic obstacles or valley constrictions. In contrast to the observed increase in channel width as a function of distance downstream and higher stream order observed in drainage networks, there was not a significant difference in mesa width between those sections located further upslope (e.g. former locations of lower order tributary channels) and those located proximal to the modern Virgin River (e.g. former location of the main trunk section). Original channel width (confirmed by outcrop exposure) is preserved in few locations corresponding to the narrowest sections of the mesa. Spurs along course that could represent former tributary junctions were rarely seen.

The ~10 m thick lava-capped mesas frequently exhibit columnar joints which act as planes of weakness where freeze-thaw cycles exploit to produce boulder-size clasts in a basal rubble pile. Stream gravels and sand are preserved in the ancient stream bed directly below the overlying basalt.

No lineations or other surface textures, such as those described by [7] for an older lava-capped inverted valley called the Stanislaus Table Mountain in northern California, were observed on the sparsely vegetated lava surface.

As expected, the preservation timescale of lava-capped channels is greater than cemented inverted channels; the later landforms have maximum surface re-exposure ages of a few hundred thousand years whereas lava-capped channels can persist for several million years [this work, 7].

Discussion: Lava-capped inverted valleys have distinct morphological differences from cemented inverted channels. Lava infilling of valleys results in partial preservation of the original drainage network with the flow typically proceeding down a tributary channel to the main trunk (e.g. Fig. 2); cemented channels have the potential to preserve a more representative planimetric section of the former fluvial network. Furthermore, lava flows fill the original fluvial channel and surrounding valley; thus preserved top width is often an overestimation of paleoflow width. Cemented inverted channels typically preserve the original channel width and, consequently, can exhibit more uniform width as a function of distance downstream [e.g. 6]. Additional observational criteria for distinguishing inverted channels in remotely sensed data include surface textures (e.g. flow lineations, scroll bars), profile attributes (e.g. columnar jointing, basal rubble piles, cross-bedding) and composition.

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Figure 1: (Top) Oblique aerial view of Washington Black Ridge, located between St. George and Washingon, Utah and its cinder cone source (arrow). The Pine Valley Mountains are in the background and the lava-capped mesa is cut by I-15 in the foreground. (Bottom) Oblique aerial view of cinder cone.

Figure 2: Satellite view of Washington Black Ridge. Cinder cone source is marked by white circle (see also fig. 1). Lava flowed to the south down the flank of the Pine Valley Mountain and turned southwest to enter the ancestral Virgin River; note modern course of Virgin River is near its former course and has a similar valley width to the mesa top width. The ancient channel width is preserved at a constriction along course, which coincides with the I-15 road cut. Upward reaches of flow have not experienced landscape inversion whereas the distal portion reaches ~80 m relief.

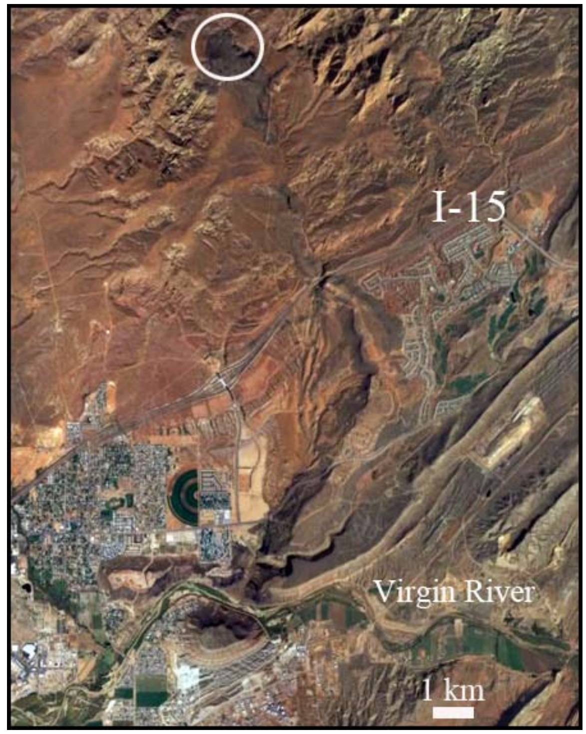

Figure 3: (Below) Oblique aerial view of the older Black Ridge Mesa (with 'D' on slope) that is at a higher elevation than the younger Airport Mesa in St. George, Utah.