HELENE: THE FACE THAT LAUNCHED A THOUSAND SLIPS. J. M. Moore[1], O. M. Umurhan[1], A. D. Howard[2], and P. M. Schenk[3], [1]NASA Ames Research Center, MS 245-3, Moffett Field, CA 94035 (jeff.moore@nasa.gov, orkan.umurhan@gmail.com), [2]Dept. of Environmental Sci., University of Virginia, Charlottesville, VA 22903 (ah6p@virginia.edu), [3]Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston, TX 77058 (schenk@lpi.usra.edu).

Introduction & Observations: Helene (Fig. 1) is a small satellite (~17.6 km mean radius) that is a Lagrangian L4 Trojan co-orbital of Dione. It has been imaged in several passes by Cassini with a maximum resolution of 42 m/pixel in which the leading hemisphere is best imaged. This hemisphere features an unusual morphology consisting of broad depressions (modified large craters) and a generally smooth surface patterned with streaks and grooves. The streaks appear to be oriented down-gradient, as are the grooves. This pattern suggests intensive mass-wasting as a dominant process on the leading hemisphere [1, 2]. Kilometer-scale impact craters are very sparse on the leading hemisphere other than the degraded km-scale basins defining the overall satellite shape, and many small craters have a diffuse appearance suggesting ongoing mass wasting. Thus mass wasting must dominate surface-modifying processes at present. In fact, the mass wasting appears to have been sufficient in magnitude to narrow the divides between adjacent basins to narrow septa, similar, but in lower relief, to the honeycomb pattern of Hyperion. The prominent groves occur primarily near topographic divides and appear have cut into a broad, slightly lower albedo surface largely conforming to the present topography but elevated a few meters above the smooth surfaces undergoing mass wasting flow. Low ridges and albedo markings on the surface suggest surface flow of materials traveling up to several kilometers. Diffusive mass wasting produces smooth surfaces - such a pattern characterizes most of the low-lying surfaces. The grooves, however, imply that the transport process is advective at those locations where they occur, that is, erosion tends to concentrate along linear pathways separated by divides. In fact, in many places grooves have a fairly regular spacing of 125-160 m, defining a characteristic erosional scale. We also note in views of other facets of Helene that several craters, seem to have rims and even floors at relatively high elevations (Fig. 2). These crater “floors” appear almost perched, as if they were the cap rock of small mesas.

Several questions are prompted by the unusual morphology of Helene: 1) what is the nature of the surface materials?; 2) are the transport processes gradual or catastrophic motion from one or a few events?; 3) what mechanisms drive mass wasting and groove development?; 4) have the formative processes been active in the recent past?; and 5) is the surface accreting or eroding?

Discussion: The smooth character of the leading edge hemisphere of Helene and the dominance of mass wasting suggest that the surface is composed of fine grained debris, probably dominated by dust-size to small gravel particles. The Lagrangian points of saturnian satellites are locations where planetesimals might have accreted to form co-orbital satellites such as Helene [3] and they may capture ejecta from their master moon (Dione) [4]. The models of *Dobrovolskis et al.* [4] and *Izidoro et al.* [3] suggest that Helene is a site of net accretion, but we find no extant explanation for the dominance of fine grain sizes for the surface (and probable subsurface) composition of Helene and the other Lagrangian satellites.

Observation of the mass wasting tracks on Helene suggests the presence of well-defined streams of debris with low bordering levees that may be depositional features or remnants of the dissected higher surface. Some flows in grazing illumination appear to have a convex cross-section. This mass-flow morphology might be consistent with the occurrence of large-scale flow events, but which might have occurred through rapid emplacement or slow glacier-like creep. On the other hand, small craters appear to have been “softened” by creep-like processes, indicating ongoing mass wasting [1, 2].

Processes that might account for observed mass wasting on Helene include micrometeorite impacts, ground shaking from large impacts (presumably on the trailing hemisphere), electrostatic levitation, and bulk flow due to internal regolith deformation. The continuing modification of small craters suggests one or a few single large impacts are not a sufficient explanation for the mass wasting features.

From our preliminary analysis we have developed a historical working scenario. Following the assembly of the satellite there was the formation of the large craters (maybe concomitant with accretion). Next we speculate that there could have been hardening of material in some crater floors and rims during impact (impact sintering?) allowing them to stand in relief during a period of loss of a considerable volume of material including eradication of small craters and raising some craters to positive relief (the “mesas”). Subsequently there has been the deposition of a thick surficial layer (dust?, E-ring fallout?, coarser impact-generated debris?), which has become slightly cohesive. This surficial layer is itself undergoing mass wasting producing the streaks and grooves. Within this material can be seen a few small craters, some of which appear slightly diffused.

Among the several issues raised by this scenario are whether the mass-wasting events are gradual, a one-time catastrophe, or episodic, uncorrelated events involving one or a few mass flow tracks at a time? Our next step is applying a landform evolution model we have successfully used on Callisto and Hyperion [5,6] in conjunction with a high resolution stereo-image derived topographic model. By quantitatively characterizing landforms from the DEMs, and comparing them with simulation modeling we will evaluate whether mass wasting is driven by shallow surface processes such as creep by micrometeorites, or whether it is degraded by deeper mass-flows occurring either rapidly (hours or a few days) or slowly by deep-seated creeping flows. Using the simulation modeling we will examine what type of flow mechanism and material properties are capable of producing the strongly modified surface of Helene. The initial results of this work are being reported at this conference [7].

References: [1] Thomas, P.C., *et al.* (2013) *Icarus 226,* 999-1019. [2] Hirata, N. and Miyamoto, H. (2012) *Icarus 220,* 106-113. [3] Izidoro, A., *et al.* (2010) *Mo. Notices Royal Astro. Soci., 405,* 2132-2140. [4] Dobrovolskis, A.R., *et al.* (2010) *Icarus 210*, 436-445. [5] Howard, A.D. and Moore, J.M. (2008) *GRL 35*, L03203. [6] Howard, A.D., *et al.* (2012) *Icarus 220*, 268-276. [7] Umurhan, O.M., *et al.* (2014) LPS, XLV, this conference.

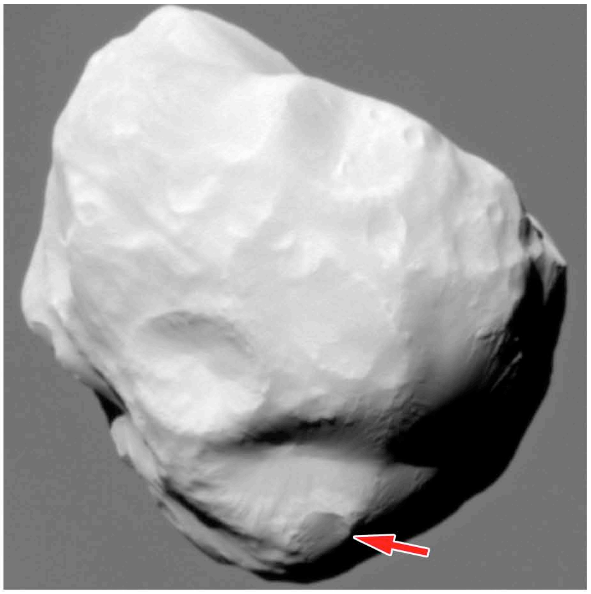

Fig. 2. The Anti-Saturnian side of Helene exhibiting an example of a crater floor at relatively high elevation. These crater "floors" appear almost perched, as if they were the cap rock of small mesas. we speculate that there could have been hardening of material in some crater floors and rims during impact (impact sintering?) allowing them to stand in relief during a period of loss of a considerable volume of material including eradication of small craters and raising some craters to positive relief (the "mesas"). (*Cassini* ISS image N1646319549.118. Orignal resolution 113 m/pixel, N is to the upper right)

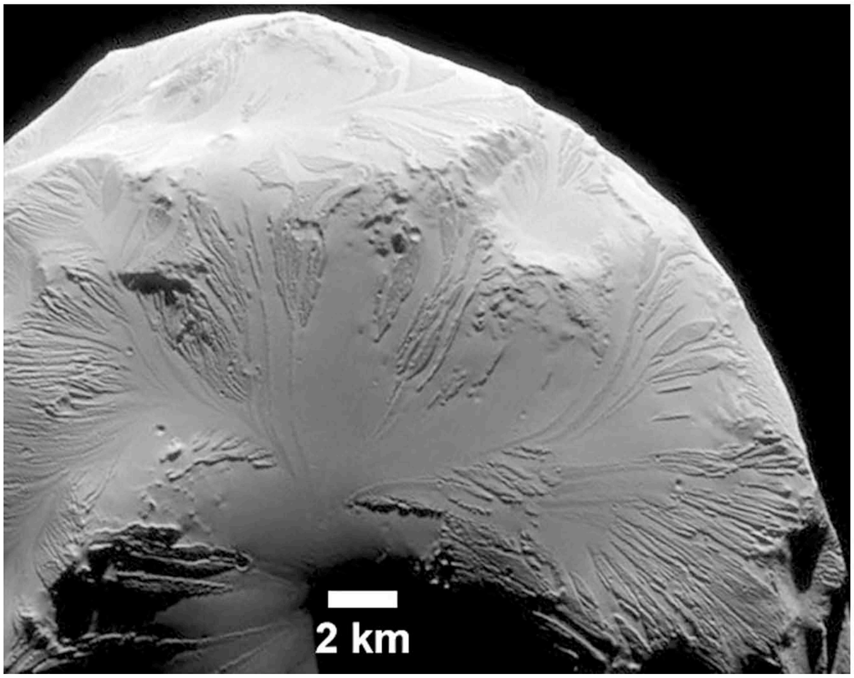

Fig 1. Leading side of the saturnian satellite Helene. This landscape features an unusual morphology consisting of broad depressions (modified large craters) and a generally smooth surface patterned with streaks and grooves. The streaks appear to be oriented down-gradient, as are the grooves. This pattern suggests intensive mass-wasting as a dominant process. Several questions are prompted by the unusual morphology of Helene: 1) what is the nature of the surface materials of Helene?; 2) are the transport processes gradual or catastrophic motion from one or a few events?; 3) what mechanisms drive mass wasting and groove development?; 4) have the formative processes been active in the recent past?; and 5) is the surface accreting or eroding? (*Cassini* ISS image N1687119756.13. Orignal resolution 42 m/pixel, N is to the left)