Small-scale mass movements on Europa, Callisto & Ganymede. R. Parekh[1], R. Pappalardo[1], J.E.C. Scully[1], M. E. Cameron[1]. [1]Jet Propulsion Laboratory/California Institute of Technology (rutu.a.parekh@jpl.nasa.gov)

Introduction: In early 1990s, the Solid-State Imager (SSI) camera onboard the Galileo spacecraft acquired the images of the icy Galilean satellites of Jupiter (Europa, Ganymede, Callisto) and revealed multiple lines of evidence related to surface degradation processes [1,2,3]. All three satellites have undergone widespread endogenic and exogenic geological processes [1,2,3]. In this study, we focus on analysis of mass movements, which is highly resolution dependent and generally observed under 30 m/pixel resolution [4]. However, most imaging data acquired from the Galileo mission has lower resolution [5]. Despite this, limited previous studies related to mass movement morphologies and dynamics were conducted on Europa, Ganymede, and Callisto [1,2]. During mass movement the surface material follows the slope, travelling downward under the influence of local gravity (e.g., [6]) effecting the overall surface topography. The analysis of mass movement features indicates surface processes which directly influence the evolution of a planetary object. Therefore, in this study, we review and report our preliminary analyses of landforms potentially associated with mass movement on each icy Galilean satellite.

Europa: Among all three icy satellites studied in this work, Europa's surface is the most complex due to large-scale ridges, bands, and chaotic terrains; and is also the youngest [2,7]. Hence, the majority of Europan geological research has been focused on tectonism and other processes related to these bands, ridges, and chaos terrains [7,8,9]. Nevertheless, small-scale mass movements have been identified on Europa are found on the steep slopes of ridges, bands [1,4], and rarely on the rims of the impact craters.

We observed that mass movement deposits accumulate at the lowest slope of the flank from where the mass was detached, creating tongue like bulges at the front of the deposit (Fig. 1a, red arrows). The upper surfaces of the flanks possibly expose rugged subsurface bedrock. In the current example (Fig. 1a), we do not observe any evidence related to debris disintegration, such as boulders (at a given resolution). However, prior studies discussed blocky debris at the bottom of ridges [1] which raise the possibility of the further disintegration and production of regolith material at a local scale.

Callisto: The most commonly observed mass movements on Callisto are lobate (flow-like) features [1,11], which usually produce alcoves and fan-like structures due to lateral spreading (Fig. 1b). Typically, this type of mass movement is noted on icy planetary bodies such as Ceres, Mars [12,13] where the effective friction coefficient between individual particles of detached mass is lost completely [6] and moving fragments collide with each other producing a striated morphology (Fig. 1b). At the resting position, the deposits show thin sheet-like spreading morphologies (Fig 1b). Commonly, flow-like movements are intermixed with impact ejecta [14] concealing the original topography of the neighboring regions (Fig. 1b). Based on our preliminary observations, we interpret that mass movements on Callisto are of relatively larger scale than those observed on Europa and Ganymede, which is potentially related to higher momentum due to lower friction.

Ganymede: Significant slide movements are observed on the slopes of some fresh impact craters on Ganymede. In the example of Fig.1c, slide features include distorted crater rims, and brightness variations from the upper to intermediate part of the slope (Fig. 1c, highlighted in red dotted line). The darker material at the floor of the crater appears mottled, which is probably due to piles of detached mass at the base of the slope. In this example, the mass seems to be detached from the crater rim, covering the crater floor (~ 1.3 km^2 area) and exposing the surface of failure at the NE crater rim. We also observe V-shaped spur/gully features at the upper rim of the crater, which are possibly reminiscent of volatile-induced landslides identified on other planetary objects such as Vesta, Ceres, and Mars [12,15, 16]. In the case of Fig. 1c, the slide mass dropped ~ 0.4 km height from the rim and continued travel in the direction of crater floor until the surface became flat enough to restrict further spread.

Summary: The presence of various types of mass movement processes and associated features have modified the surfaces of Europa, Callisto and Ganymede at a regional scale. Small-scale mass movements have given rise to albedo dichotomies on Europa; relatively large-scale lobate features on Callisto have decreased overall surface slopes; and collapse of sliding masses on Ganymede have modified the rims of impact craters. Additionally, detached material has produced thin regolith in the form of debris on the surfaces of Europa, Callisto and Ganymede. Next, with the help of numerical modeling, we aim to enhance our understating related to the surface regolith dynamics of all three Galilean satellite.

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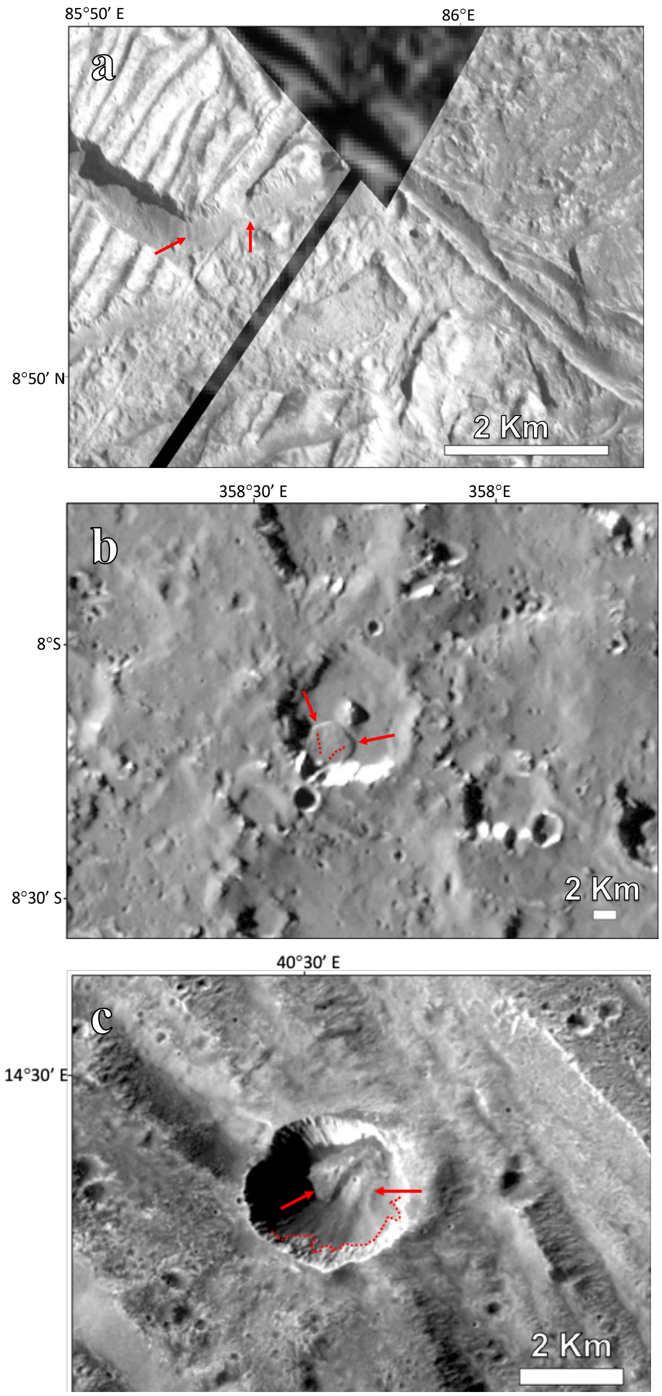

Fig. 1(a) Galileo observation 12ESCHAOS_01 (9 m/pixel): Located within Conamara Chaos, the small-scale mass movements are observed on the slopes of the plates in chaos terrain (highlighted in red arrows). The image is one of the highest resolution available on Europa. (b) C9CSCRATER01 (155 m/pixel): Intracrater debris, interpreted as a mass avalanche (red arrows) on Callisto. The subdued topography of the neighboring region is probably due to spreading of impact ejecta of surrounding craters. The red dotted lines delineate striations. (c) 28BRTDRK02 (21 m/pixel): Located aside Harrpagia Sulcus, there is clear evidence of a sliding mass (red arrows) that altered most of the crater (~3.9 km in dia.) floor on the surface of Ganymede.