INVESTIGATING THE EFFECTS OF SHALLOW LIQUID WATER ON CRATER FORMATION. J. P. Kay1, A. R. Rhoden2, and A. M. Stickle3, 1 Lunar and Planetary Institute, USRA, Houston TX 77058, 2Southwest Research Institute, 1050 Walnut St., Boulder, CO 80304, 3Johns Hopkins University Applied Physics Laboratory, 11100 Johns Hopkins Rd., Laurel, MD, 20723. (kay@lpi.usra.edu)

Introduction: Craters can provide insight into the mechanical structure of a planetary body through their morphologies, while crater modification over time (e.g., relaxation) can help constrain the thermal evolution and age of the body. However, much is unknown about how crater formation and modification differ on icy, ocean worlds versus rocky ones. Recent work has shown that including an ocean under an ice shell can affect the depth of the crater, which suggests that there may be a mechanism by which oceans can be identified from observed crater morphologies [3].

Europa, an ocean-bearing moon of Jupiter, may also have pockets of liquid water within its ice shell. Liquid water has been implicated in the formation of large-scale (100s of km in diameter) chaos features as well as small-scale (<10 km) chaos, pits, and uplifts. Some models implicate liquid water pockets within the upper few km of the ice shell. We explore the effects of shallow water pockets (i.e., sills) on the morphologies of impact craters, using the shock physics code iSALE.

The goals of our work are to better understand crater formation on non-homogenous icy surfaces and to identify morphological characteristics that are diagnostic of liquid water (or slushy ice) layers within an ice shell.

Methods: There are many factors that control the shape of an impact crater on a body, including: gravity, material properties of the crust and the impactor, impactor energy, and the subsurface structure. Larger and faster impactors will excavate larger volumes of subsurface material, which would change the size/shape of the resultant crater. The thickness of the ice shell has been widely debated with estimates that range from 2km – 30km [3]. Previously, impact modeling has been used to estimate the thickness of the ice shell based on the resultant crater morphology [5]. They found that the ice shell must be greater than four kilometers thick.

To investigate the influence of shallow subsurface structure, specifically layer viscosity and depth, on the formation of craters on Europa, we performed several simulations of the impact using the iSALE hydrocode (version iSALE-dellen) [6-8]. As part of this study, we are not aiming to reproduce any specific crater on Europa, but rather look at the generic Europa-like body.

Here, we examine a variety of end-member cases with a low viscosity layer (i.e., slushy ice) or a layer with no viscosity (representing liquid) at different depths from the surface: 1 and 5 km. We used a 1.25 km projectile made of water ice moving at 15 km/s. In our preliminary simulations, the model resolution is 250 m per grid cell, which is likely to under resolve the damage caused by the impactors. To keep the initial analysis simple, a small impactor size was chosen to ensure that craters remain in the “simple crater” category. Subsequent investigations will explore more complicated crater morphologies.

Results and discussion: Figure 1 shows a sample result for one simulations: a 1.25 km projectile impacting into ice with a 1-km deep low-viscosity layer. Temperature and pressure fields are shown 255 sec after the impact. Though all have similar crater sizes, there are some differences in target temperature and crater morphology observed when a low-viscosity layer is near the surface. The depth of the low-viscosity layer also affects the volume of fall back material that remains in the crater, but will be proportional to the size of the impactor. Larger impactors will probe deeper into the crust than smaller projectiles, which increases the influence of a potential low viscosity layer at depth. A larger projectile would likely be influenced by a deeper layer, however. This will be examined in follow-on simulations.

With our current model resolution and impactor size/velocity, there does not appear to be any change in the d/D ratio beyond the presence of fall back material. This is something we will explore in future simulations.


Figure 1: One sample model results. A shallow (1km) low viscosity layer.