THE FATE OF ICY SLABS ON EUROPA: IMPLICATIONS FOR DETECTING ACTIVE CONVERGENT MARGINS IN OCEAN WORLD ICE SHELLS.  S. M. Howell1 (samuel.m.howell@jpl.nasa.gov) and R. T. Pappalardo1, 1Jet Propulsion Laboratory, California Institute of Technology

Introduction: The outer ice shell of Europa has experienced significant tectonic modification in its outer ice shell over its ~60 Myr visible history. While the most prevalent tectonics are observed to be extensional in nature [1,2], Voyager and Galileo spacecraft images of Europa show little evidence of corresponding convergent tectonics. Understanding if and where tectonic transport and recycling of surface material occurs has fundamental implications for Europa habitability because such processes may allow oxidants produced at the surface to reach a reducing seafloor [3,4].

Kattenhorn and Prockter [5] reconstructed a 134,000 km² region of Europa, and found evidence for the removal of ~20,000 km² of surface material. That study proposed that subduction-like “subsumption” may allow old lithosphere slabs to be reincorporated into the ice shell and recycled.

In this study, we use pseudo two-dimensional models of an icy slab intruding into the ice shell interior [6,7] to predict slab temperature, density, porosity, and composition over time. As a slab subsumes, we predict the isostatic topography and topographic slope, as well as the time and distance scales over which the slab is reincorporated into the interior of the ice shell.

Models: We investigate a range of initial slab and lithosphere thicknesses, spanning 10-50% of the assumed ice shell thickness (25 km). For each slab thickness, we investigate the effect of an initial porosity (up to 20%) that evolves through time with changing temperature, pressure, and viscosity. We also look at the effect of a slab containing up to 15% densifying salts.

For each combination of parameters, we run models at two convergence rates. The faster rate (40 km/Myr) is consistent with terrestrial subduction [5,7], while the slower rate (4 km/Myr) may be more plausible from a force-balance perspective in ocean world ice shells [7].

Results: For increasing slab thickness, the predicted isostatic topography increases. This occurs because thicker slabs take longer to thermally equilibrate with their surroundings, retaining their thermal structure, and thus density structure longer. Similarly, faster convergence rates result in greater topography because the faster moving slab reaches a greater depth before losing its density structure.

Limited topographic relief (<100 m) is produced by the thermal anomaly of the subsumed ice, with predicted topographic slopes of <1°. Significant porosity or salt content within the slab may allow for 100s m topographic relief and slopes of up to ~5°.

Conclusions and Perspectives: Slabs thrust into the ice shell interior will quickly reach thermal equilibrium. As these slabs equilibrate, they subsume, losing their density and mechanical contrasts with their surroundings. We predict very little isostatic topography associated with subsumption, even if the predicted density anomalies persisted indefinitely through time. Elastic flexure at active subsumption zones may contribute to the dynamic topography, though low interior viscosities, thin elastic layers, and potentially low driving strain rates would limit any elastic behavior.

Future robotic exploration of Europa, including NASA’s planned Europa Clipper mission, may have difficulty detecting topographic variations of ~100 m over distances of 10s km. Therefore, geologic mapping and reconstruction of convergent margins may continue to offer the best mechanism for detecting regions of subsumption. A possible additional method of detecting active convergent margins is radar investigation of potential compositional variations associated with active or fossil geological processes [8].