POROSITY AND SALT CONTENT DETERMINE IF SUBDUCTION CAN OCCUR IN EUROPA'S ICE SHELL. A. C. Pascuzzo[1], B. C. Johnson[1], R. Y. Sheppard[1], E. A. Fisher[1], S. E. Wiggins[1] [1]Brown Univeriesty, Dept. of Earth, Environmental, and Planetary Science, Providence, RI 02912 (Alyssa_Pascuzzo@Brown.edu).

Introduction: Motivated by recent evidence for subduction in Europa's ice shell [1–3], we explore the geophysical feasibility of this process. Understanding the feasibility of subduction informs whether it is, or was previously, a primary process in transporting surface materials to Europa's subsurface. Subduction in Europa's ice shell would enhance the rate at which surface material could be delivered to its subsurface ocean, possibly improving Europa's astrobiological potential [4,5]. We construct a simple model to track the evolution of porosity and temperature within a slab that is forced to subduct, and probe the effects that various initial salt contents have on ice slab buoyancy.

Method: We use a one-dimensional finite difference model to track the evolution of temperature and porosity within a slab as it subducts through a reference ice shell (ρ=920 kg/m^3, [6]), consisting of a conductive lid and an underlying warm convective layer (Fig. 1) [7]. Our simulations track the evolution of an individual parcel or slice of the slab. Tracking the parcel's density anomaly (or the density of the parcel relative to that of the reference shell) as a function of time is crucial to understanding how the evolution of temperature and porosity affect the buoyancy of the slab. When the parcel's average density anomaly is positive, it is non-buoyant and we argue that subduction is feasible. When the parcel's average density anomaly is negative, it is buoyant and subduction is unlikely. At each time step, the depth of each cell is evolved assuming a constant slab velocity and a subduction geometry (Fig. 1). At each time step, the

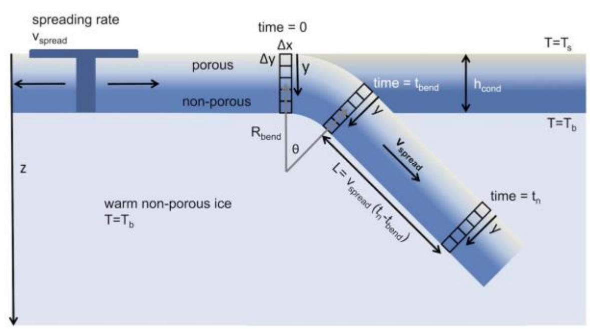

Fig. 1. Geometry of a simple one-dimensional model of a subducting slab. The modeled parcel of material is shown at three times, time=0, t_{bend}, and t_n. T_s=100 K and T_b=260 K. Note the schematic only shows 5 cells while our actual model has 200 cells. Additionally, for a time step Δt=1 yr and spreading rate v_{spread}=40 mm/yr, the cells have a horizontal extent $\Delta x \approx v_{spread}\Delta t$=2.8 cm while for h_{cond}=6 km the vertical dimension $\Delta y = h_{cond}/n_{cell}$=30 m, where n_{cell} is the number of cells. Dark blue material at the top left represents the dilational spreading bands. The schematic shows a slab bent through the dip angle θ = 45° along a radius $R_{bend} \approx 2\ h_{cond}$ in a time $t_{bend} = R_{bend}\theta / v_{spread}$. After time t_{bend}, slab continues to subduct at a constant dip angle and constant rate, v_{spread}.

depth of each cell is evolved assuming a constant slab velocity and a subduction geometry, which in turn changes the top temperature boundary condition and increases overburden pressure (Fig. 1). At each time step, temperature is evolved using Fourier's law of heat conduction, and porosity is evolved by tracking removal of pore space by viscous flow.

Although the salt content at the surface and at depth is unconstrained, first order estimates for its effect on slab buoyancy are required to test subduction and material transport feasibility. We calculate the density difference due to salt content of each cell using the following equation, $\Delta\rho = -\alpha\rho_{ice}\Delta T - \rho_{ice}\Delta\phi + \Delta f_{salt}(\rho_{salt} - \rho_{ice})$, where ΔT, $\Delta\phi$, and Δf_{salt} are the difference in temperature, porosity, and salt content, respectively, between the cell of interest and material in the reference ice shell at the same depth as the cell of interest. We assume a salt density of 1444 kg/m^3 appropriate for natron, a potentially dominant component of surface salts based on spectral unmixing analyses of [8]. This assumption produces conservative estimates for density anomalies produced by a given difference in salt content.

Results and Conclusions: We find that porosity and salt content play dominant roles in determining whether the slab is non-buoyant and subduction in Europa's ice shell is possible. Even after a thermal anomaly is erased, most models in which subduction is feasible retain a density anomaly associated with salt content. Unless salts can drain away from the slab on a time scale of ~1 Myr, this material will continue to descend. Generally, we find that initially low porosities and high salt contents within the conductive lid are more conducive to subduction. If salt contents are laterally homogenous, and Europa has a reasonable surface porosity of ϕ_0=0.1, the conductive portion of Europa's shell must have salt contents exceeding ~22% for subduction to occur. If salt contents are laterally heterogeneous, with salt contents varying by a few percent, subduction may occur for a surface porosity of ϕ_0=0.1 and overall salt contents of ~5%. Thus, we argue that under plausible conditions, subduction in Europa's ice shell is possible.

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