LEVERAGING TERRESTRIAL MARINE ICE CORES TO CONSTRAIN THE COMPOSITION OF ICE ON EUROPA.

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Introduction: The origin of non-ice materials identified on Europa's surface, although debated, is either exogenic or endogenic. Exogenic fluxes have been constrained [1], but endogenic fluxes have been largely neglected despite implications for habitability.

The endogenic flux of material to Europa's ice shell is governed by the fractionation of chemical species present in the source water as it freezes [2-3]. Historically, these factors have been obtained empirically through laboratory experiments and field observations. The degree of fractionation is highly dependent on the type of ice formed as well as the rate of formation, governed by the temperature gradient.

Accreted Ices: Europan ice is expected to be predominantly of accreted origin, as opposed to meteoric. Accreted ices fundamentally form either through congelation growth or frazil accumulation. Congelation growth occurs when heat is lost through conduction to the overlying ice. Frazil forms in supercooled water through nucleation of individual ice crystals in the water column. Congelation growth is characteristic of sea ice and facilitates the interstitial incorporation of brine, enhancing the bulk salinity. Marine ice and platelet ice are both hypothesized to form by frazil accumulation beneath existing ice layers. Platelet ice forms below sea ice, whereas marine ice forms below ice shelves. Marine ice is thought to be distinct from platelet ice based on its total thickness (which can exceed that of platelet ice by an order of magnitude), lower temperature gradient, and reduced rate of formation. Deviatoric buoyancy stresses imparted by accumulating frazil crystals have been hypothesized to promote consolidation of marine ice. This formation mechanism is considered to contribute to the relative purity and elevated degree of fractionation of marine ice.

Implications for Europan Ices: Europan ice may be composed of both sea ice and marine ice analogs. Where conduction through the ice shell promotes thickening, sea ice may be a more appropriate analog, although additional consideration must be given to the temperature gradient. At low temperature gradients, fractionation will be elevated relative to terrestrial sea ice. Ice accreted in regions where the ice shell is relatively thinner, either due to kinetic processes or increased basal heat flux, could be more analogous to marine ice. Marine ice could play an important role in supporting the compositional diapirism hypothesized to form chaos terrain [4-6]. Moreover, diapirs could serve as a vehicle to transport accreted oceanic material towards the surface of the ice shell.

Marine Ice Cores: Here, we summarize published marine ice core data to constrain the composition of hypothesized marine ice on Europa. Sites considered are shown in Fig. 1. Samples of marine ice from "green" icebergs are also included. Properties such as salinity, anion and cation concentration, and grain size are presented. Properties are evaluated in the context of the source water where possible to obtain an estimate for fractionation factor. The presence of biogenic material in accreted ice is noted where observed. General trends in marine ice properties between samples are identified and their implications for Europa are discussed. Sites are evaluated as potential analogs for the ice-ocean interface at Europa.

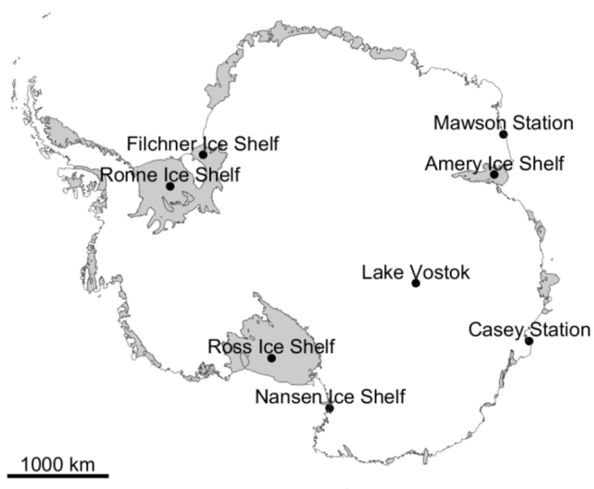

Figure 1. Published marine ice cores [3,7-13].

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