The argument for a young metallic core in Europa

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Abstract. While Europa is rightfully known for its potentially habitable subsurface ocean, rock and metal make up over 90% of the moon's mass. Gravity measurements from the NASA *Galileo* spacecraft yield bulk density and moment of inertia constraints that are typically taken to imply that Europa is differentiated into a metallic core, silicate mantle, and relatively thin hydrosphere[1]. A common but potentially unsubstantiated assumption is that Europa formed its metallic core shortly after accretion[2,3]. The timing of metal-silicate differentiation is highly dependent on when Europa formed (which is poorly constrained), core composition (which is an Fe-FeS alloy ranging from pure Fe to the eutectic[1]), and the time required to dehydrate Europa's initially hydrated silicates. Consequently, models that do not self-consistently model formation time, core composition, silicate dehydration reactions, and metallic core formation may result in inaccurate thermal histories. We show that metallic core formation in Europa was delayed or, in extreme cases, never occurred.

We investigate the effects of Europa's formation time, core composition, and hydrated silicates on the timing of metal-silicate differentiation. Our primary approach is to track the heat budget of Europa over time using the following equation,

$$Q_R = Q_L + Q_S + Q_O \ ,$$

where Q_R is radiogenic heat produced, Q_L is latent heat involved in silicate dehydration, Q_S is secular warming, and Q_O is heat transported from the rock/metal interior into the ocean.

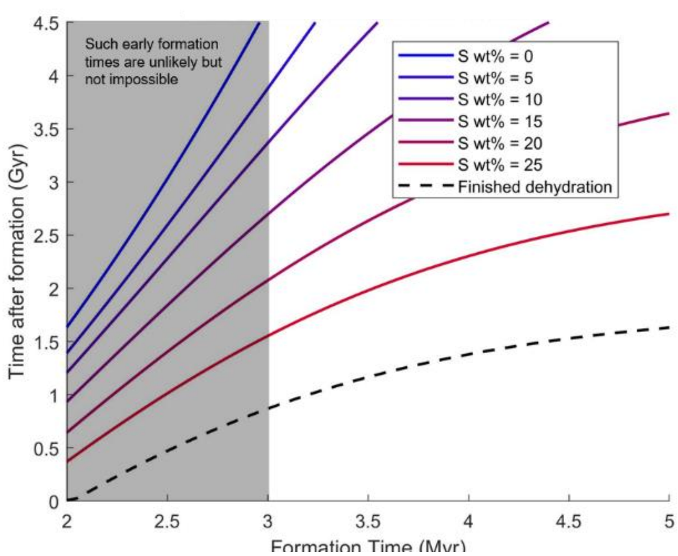

Figure 1) Time to initiate metallic core formation at Europa.

If Europa formed late, the moon would have scarce amounts of ^{26}Al since most of the isotope will have decayed during accretion, thus leading to a smaller Q_R produced only by long-lived isotopes (^{40}K, ^{235}U, ^{232}U, and ^{238}Th). We assume Europa formed its hydrosphere (ice shell and ocean) very shortly after accretion. Tidal heat is concentrated in the ice shell and ocean[4], so it should not significantly affect deep interior evolution. Figure 1 shows the lower limit to the time required for metallic core formation to begin after silicate dehydration, generated by assuming Q_O = 0 W always. Our in progress thermal evolution model will calculate Q_O and predict more dealyed core formation. Ultimately, the internal differentiation of Europa can be a protracted process.

[1]Anderson, et al. (1998) *Science, 281*, 2019—2022. [2]Travis, et al. (2012) *Icarus 218*, 1006—1019. [3]Běhounková, et al. (2020) *Geophys. Res. Lett.* 48 (3). [4]Sotin, et al. (2009) *Europa*, 85—117.