1. **Introduction:**

The initial stages of planetary formation occur in a protoplanetary disk dominated by an atmosphere of hydrogen and helium. Terrestrial planetary formation can be described by aggregation of grains to form planetesimals. Next, planetesimals accrete to create embryos up to 0.5 the mass of the Earth (ME), and lastly large impacts occur accreting planets to their current sizes. (Olson and Sharp, 2019). Within this period of accretion, it is likely that the nebular atmosphere (H-He) can ingas into the terrestrial interior (Hayashi et al., 1979; Hayashi, 1981; Hayashi et al., 1985). A major component of the nebular atmosphere is helium, which contains two isotopes: 3He and 4He. The radiogenic isotope, 4He, is continually replenished by alpha decay of Uranium (U) and Thorium (Th), while 3He is the primordial isotope and cannot be replenished (Olson and Sharp, 2019, 2022). Helium is the lightest noble gas with an atmospheric concentration of 5 ppm, and a 3He/4He ratio of 1.39 x 10-6­ (denoted as RA) used to compare samples against the atmospheric standard (Oliver et al., 1984, Farley and Neroda, 1998). Despite there being no new sources of 3He, it is still fluxing out of Earth’s interior, most prominently at mid-ocean ridges (Clarke et al., 1969).

The continued presence of 3He enables helium to act as a proxy for the extent of degassing for interior reservoirs. Degassing will remove both 3He and 4He equally from a reservoir, but only 4He will grow back, and therefore high 3He/4He ratios are indicative of materials that have lost little gas (O’Nions and Oxburgh, 1983). Indeed, Earth’s mantle contains a high 3He/4He reservoir that is commonly interpreted to reflect undegassed or little degassed domains. High 3He/4He ratios are mostly commonly observed associated with hotspot volcanism, and hotspots are often interpreted to sample the mantle near the core-mantle boundary, leading to the speculation that core-mantle boundary contains primordial materials (O’Nions and Oxburgh, 1983).

A major observation in high 3He/4He values is correlated with a radiogenic tungsten (W) isotope in Ocean Island Basalts (OIBs). The 182Hf-182W (Hafnium-182 and Tungsten-182) system has a half-life of 9 million years and is sensitive to core formation due to W being moderately siderophile (iron-loving) and Hf lithophile (silicate-loving) (Lee and Halliday, 1995). Hafnium-182 is now extinct, therefore 182W can be used to determine primordial components since no more can be produced. Retrieved mantle samples from Galapagos-Juan Fernandez-Heard and Hawaii-Samoa show a negative correlation in 3He/4He and (Mundl-Peitermeier et al., 2020). Through mass balance, assuming that the Earth silicate average and the Earth bulk chondritic value , the core (1,000,000 deviation from the 182W/180W from standard Earth) values may be as low as -220 which would also see a high 3He/4He, possibly up to ~80 RA assuming mass balance (Mundl-Peitermeier et al., 2020). Erupted basalts from Baffin Island dating to 61 Myr have a high 3He/4He close to ~50 RA, suggesting that OIBs may sample a reservoir with high 3He/4He (Stuart et al., 2003). A possible reason for high 3He in OIBs is the assumption that they are rooted at the core mantle boundary, therefore core or the lower mantle may be a reservoir of primordial helium.

Any Helium 3 reservoir would have had to be formed during the early stages of planetary formation. Independent measurements of Neon derived from the solar nebula has been found in high 3He/4He. While not well constrained the solar nebular blanketing effect dissipates rapidly, between 1-10 million years of planetary formation (Mamajek, 2009). Additionally, under the Kyoto model a growing planet will form at high temperatures and pressures which has repercussions for the stability of major silicate components (Hayashi et al., 1979; Hayashi, 1981; Hayashi et al., 1985). Within this framework, we investigate noble gas transport into a growing planet blanketed by a gas-rich atmosphere made of H2-He. We propose that during the early stages of core formation, helium may have dissolved into the Earth leading to a large reservoir at the core. Additionally, we see increased temperature and pressures suggesting that large melts and vaporization of magmatic components like SiO2 and FeO would melt leading to increase in free oxygen. Therefore, we hope to answer, “Is the core can be the ultimate reservoir for helium?” and “What was the oxidation state of the Earth during planetary formation?”.