Terrestrial Pb isotopes and a young age for the Moon

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The average Pb isotopic composition of Earth's mantle lies to the right of the Geochron implying that the U-Pb system evolved in at least two stages with an intervening U/Pb fractionation event [1]. We attribute this U/Pb fractionation to the loss of volatile Pb relative to refactory U in the aftermath of the giant Moon-forming impact. This model is supported by new Pb data demonstrating efficient planetesimal-scale volatile loss of Pb from the angrite parent body. The timing of this event (T_f) can be constrained if we adequetely define the starting and end points of the Pb isotopic evolution of Earth's mantle and the first stage $^{238}U/^{204}Pb$ ratio (μ_1-value). Of these three parameters, only the μ_1-value is not well constrained. We use our new estimate for the μ-value of Earth's precusor material, recent numerical models of planetary embryo accretion [2] and veneering [3], and the μ-value of Mars [4] to refine a model for the effective μ_1-value of Earth to be 0.9-1.8 at T_f. This range of μ_1-values infers an age for the Moon-forming impact between 4.426-4.417 Ga. It is important to note that a maximum age of 4.436 Ga is inferred for an extreme Solar μ_1-value of 0.2. Our preferred age range is ~100 Myr younger than current estimates for the age of the Moon but fully consistent with a recent age for lunar ferroan anorthosites [5] and the timing of Earth's first crust inferred from the terrestrial zircon record [6]. It requires that lunar samples >4.41 Ga [e.g. 7] are not primary crystallization ages as suggested by [8,9] and that CHUR models for bulk Earth Sm/Nd and Lu/Hf ratios are not accurate. Lastly, the estimated loss of ~98% of terrestrial Pb relative to the Solar System bulk composition by the end of the Moon-forming process implies that the current inventory of Earth's most volatile elements, including water, arrived during post-impact veneering by volatile-rich bodies.

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