Onset of giant planet migration ca. 4.49 Ga

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The asteroid belt, and by extension the terrestrial planets, experienced variably intense bombardment from late accretion. The sources and tempo for late accretion are poorly known; robust U-Pb and Pb-Pb geochronometers in HED and other asteroidal meteorites record formation of crust beginning at ca. 4.563 Ga, but impact-induced resetting of the relatively high closure-temperature U-Pb system no later than ca. 4.45 Ga. Younger ages confined to relatively low closure-temperature $^{40-39}$Ar geochronology describe an age continuum from ca. 4.48 Ga and thereafter that extends in a long tail of accretion to about 3.0 Ga, with occasional resetting events as recently as 250 Ma. As constrained by U-Pb zircon geochronology, the inception of such a dynamical cooling profile time must pre-date the last time Earth (ca. 4.40 Ga), Moon (ca. 4.42 Ga) and Mars (ca. 4.43 Ga) experienced wholesale crustal melting by heavy bombardment. Here, we track late accretion by coupling dynamical models of giant planet migration using asteroidal meteorite ages compiled from radiogenic systems with variable sensitivity to age-resetting by impacts. Analysis shows that if giant planet migration commenced at ca. 4.51 to 4.49 Ga – approximately coincident with the Moon-forming event – it resulted in an intense ~30 Myr influx of comets to the inner solar system capable of continually resetting ages of planetary crusts until ca. 4.45 Ga. This also comports with estimates from extrapolation of planetary values to primordial Pb and Nd isotopic compositions, which yield separation times for terrestrial silicate reservoirs at about 4.48 Ga. Concurrent bombardment by leftover planetesimals continued to effect the inner solar system as a smooth (monotonic) decline in impactor flux. We describe the dynamical basis of this late accretion scenario and its thermal consequences to the crusts of inner solar system planets. Our analysis is also used to assess the likelihood that a persistent biosphere could be established on Earth and Mars as early as 130 Myr after solar system formation.