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Disk-driven migration of Jupiter: support from chondrite thermochronology

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Observations of the solar system and exoplanetary systems imply that migration of gas giant planets may be commonplace. Yet, the timescales of this process, which predict the underlying dynamical mechanisms, are not well constrained, even within the solar system. Two dynamical mechanisms are thought to have driven giant planet migration in the solar system: interaction with a gaseous protoplanetary disk [e.g. 1], and interaction with an outer planetesimal disk beyond the orbits of the giant planets [e.g. 2,3]. While the lifetime of gaseous protoplanetary disks are limited to the first ~10 Myr of stellar histories, dynamical models of outer planetesimal disks are capable of triggering giant planet orbital instability 100s of My into solar system history [2], overlapping the timescales of the hypothesized Late Heavy Bombardment at ~700 Myr, though more probable scenarios limit the timeframe of instability to the first 100 Myr of solar system history [3].

Since migrations drive dynamical instabilities, any large-scale planetary migration in the young solar system would have resulted in an epoch of dynamical scattering and enhanced bombardment in the inner solar system. To precisely constrain the timescales of giant planet migration and dynamical instability in the inner solar system's asteroid belt, we leverage thermochronologic cooling ages of asteroidal meteorites, which record the thermal imprint of such energetic impacts. We present a new database of ^{40}Ar-^{39}Ar cooling ages in chondrite meteorites and evaluate it with an asteroid-scale thermal code coupled to a Bayesian Markov chain Monte Carlo inversion. Simulations without bombardment histories fail to converge on the observed distribution of chondrite cooling ages. Simulations that include bombardment histories support a single bombardment event within the first 60 Myr of the solar system, refuting a solar system-scale Late Heavy Bombardment scenario. Model posteriors favor giant planet migration on timescales overlapping with or shortly following the lifetime of the protoplanetary disk.

[1] Kley, Nelson (2012), *Annu. Rev. Astron. Astrophys*. 5, 211-49. [2] Gomes et al. (2005), *Nature* 435, 466-9. [3] Ribiero de Sousa, et al. (2020), *Icarus* 339.