Beyond matching orbits and masses, terrestrial planet formation in the era of compositional constraints.

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We have entered a new era of terrestrial planet formation constraints. Since the dawn of modern terrestrial planet formation, one of the primary goals of the field has been to create simulated systems that match the orbits and masses of the terrestrial planets and the asteroids. Many different ideas have been advanced and detailed studies of the different growth regimes (runaway, oligarchic, giant impact) have occurred. The 'Grand Tack' scenario, which relies upon the inward-then-outward migration of Jupiter to carve the disk [1], was the first to accomplish this goal, and now other models are also approaching this objective including a steep surface density profile scenario that may be established by pebble accretion [2,3]. In order to continue to improve these scenarios, we must rely upon chemical constraints. Here, we focus on the abundances of highly siderophile elements (HSEs) and radiogenic systems such as Hf/W and U/Pb.

The HSEs are greatly depleted in Earth's mantle but occur in relative chondritic proportions. The best explanation of this observation requires that Earth accrete a 'late veneer,' which can only happen after core formation ceases and the Hadean matte occurs [4] – the Hadean matte is the exsolution and core segregation of FeS liquid during magma ocean cooling (see Rubie et al. this meeting for details). Furthermore, the radiogenic Hf/W and U/Pb systems constrain Earth's growth curve—mass as a function of time [5]. These requirements are strong constraints on any planet formation scenario and have repercussions such as the necessary magma ocean cooling timescales and the equilibration factor, which determines how much of an incoming projectile core undergoes metal-silicate equilibration with the mantle before segregation into the core.

[1] K. J. Walsh et al., (2011) *Nature*, 475, 7, 206–209. [2] H. F. Levison et al., (2015) presented at the Proceedings of the National Academy of Sciences, 112, 46, 14180–14185. [3] A. Izidoro et al., (2015) *MNRAS*, 453, 4, 3619–3634. [4] H. S. C. O'Neill, (1991) *Geochimica et Cosmochimica Acta*, 55, 4, 1159–1172. [5] J. F. Rudge et al., (2010) *Nature Geoscience*, 3, 6, 439–443.