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An alternative model of low pressure terrestrial core formation

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The current, widely accepted, model of core segregation is that it was a protracted process in which aliquots of metallic core equilibrated with overlying silicate at the base of a magma ocean which deepened as the Earth grew. To explain the current abundances of siderophile (lit. '*iron-loving'*) elements in Earth's mantle, this model proposes that the proto-Earth began as a highly reduced body, with little iron oxide (FeO) in its silicate mantle, and became progressively more oxidised (and FeO rich) as the magma ocean deepened to greater than 800 km in depth. Geochemical support for the depth of the magma ocean arrives, principally, from the observation that the abundances of Ni and Co in the mantle are too high to be explained by low-pressure equilibration of liquid metals and silicates. In its simplest form the "deep magma ocean" model relies on the assumption of continuous equilibration of infalling metal with some or all the silicate mantle and final pressures of 40-50 GPa are based on this assumption. However, at the point in planet formation when the chemical evidence demands a high degree of equilibration between metal and silicate, the dynamical simulations of accretion suggest that this is least likely to occur. Furthermore, incomplete equilibration of core metal and mantle silicate appears to best fit the Earth's tungsten isotopic anomalies generated from the decay of lithophile ^{182}Hf to siderophile ^{182}W. The physical models of accretion are therefore in conflict; they either downplay equilibrium and the experimentally derived metal-silicate elemental partitioning data, or, in the deep magma ocean model, regard these data as rigid constraints. To reconcile these observations, we propose an alternative, low—pressure, model of core formation in which the Earth inherits its mantle composition from reduced (~80%) and oxidised (~20%) differentiated precursors in which olivine was stable together with melt and segregating metal. Importantly, the Terrestrial mantle's transition element abundance may be satisfied if core segregation occurs in the oxidised bodies at modest (~8GPa) pressures, equivalent to bodies around 11% Mars mass, with metal equilibrating with both silicate liquid and olivine.