Core formation and the Pb and Tl isotope evolution of the silicate Earth

R.G.A. BAKER[1,2], B.J. WOOD[3], M. REHKÄMPER[1], M. SCHÖNBÄCHLER[1,4] AND S.G. NIELSEN[5]

[1]IARC, Department of Earth Science and Engineering, Imperial College, London SW7 2AZ, UK
[2]The Natural History Museum, London SW7 5BD, UK
[3]GEMOC, Macquarie University, 2109 NSW, Australia
[4]SEAES, The University of Manchester, M13 9PL, UK
[5]Department of Earth Sciences, University of Oxford, Oxford OX1 4BH, UK

Recently published Hf-W data for lunar rocks [1] indicate that the Moon formed late, at least 50 Myr after the formation of the solar system. A protracted period of terrestrial accretion was previously also inferred from the Pb isotope composition of the Earth [2]. Further constraints on accretion processes are provided by the recently discovered extinct ^{205}Pb-^{205}Tl decay system ($t_{1/2} \approx 15$ Myr) [3]. Previous combined modeling of the U-Pb and Pb-Tl chronometers indicated that the Pb and Tl concentrations and isotope composition of the bulk silicate Earth (BSE) could be explained by assuming that a fast initial period of accretion was followed late sulphide segregation, which sequestered chalcophile Pb and Tl into the core [4].

Here we reexamine this conclusion in the light of the late Hf-W age of the Moon using new constraints that are provided by (i) high-pressure metal-silicate partitioning data for Pb and Tl that were obtained at temperatures and pressures of up to 2673 K and 24 GPa, and which indicate that Tl behaves increasingly siderophile at high pressure; and (ii) new Tl isotope analyses of chondrites, which provide revised estimates of the initial ^{205}Pb abundance and Tl isotope composition of the solar system.

The modeling shows that the Pb and Tl systematics of the BSE can be readiliy explained with the available partitioning data, even if the giant impact was associated with only incomplete equilibration of the impactor core with the BSE. Such disequilibrium during accretion is required to reconcile the young Hf-W age of the Moon with the 2 difference in the W isotope compositions of the BSE and chondrites [2]. Successful U-Pb-Tl models feature an Earth with $\mu \approx 0.7$-0.8 and may feature but do not require late-stage Pb-Tl segregation into the core with small amounts of sulphide. Late volatile loss of Pb and Tl is not indicated by the available constraints.

[1] Touboul *et al.* (2007) *Nature* **450**, 1206. [2] Halliday (2004) *Nature* **427**, 505. [3] Nielsen *et al.* (2006) *GCA* **70**, 2643. [4] Wood *et al.* (2008, in press) *EPSL.*