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Oxidised Material in Early Earth Accretion: Implications for the Ring Model

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The present-day Solar System consists of bodies with varying oxidation levels, from meteorites to planets, suggesting different oxidation pathways during formation. Studies of element partitioning between Earth's mantle and core [5] indicate that Earth initially accreted reduced material before later incorporating oxidised material. Recent work (Dale et al., in review) further supports that Earth must have formed from a mixture of both oxidised and reduced material to match the composition of the bulk silicate Earth (BSE).

In the ring model of terrestrial planet formation, Earth accretes from a narrow band of material [1], [2], [3], [4], [6]. This implies that all accreting material must originate within the ring. However, we show that planetary embryos rapidly accrete planetesimals from across the ring's width, incorporating both reduced and oxidised material. This results in early embryos becoming partially oxidised, creating a mismatch with the BSE due to the strong correlation between oxygen fugacity and siderophile element partitioning.

We demonstrate that reproducing the BSE requires the initial separation of reduced and oxidised reservoirs until the giant impact stage, where planetary differentiation is controlled by melting from embryo-embryo collisions. The late delivery of oxidised material towards the end of the disc's lifetime is thus essential for the success of the ring model and likely necessary in all dynamical models of terrestrial planet formation.

References:

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