Numerical tests on hypothetical primitive origins in a growing planet with core formation

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The presence of large-scale heterogeneity in the deep mantle has been proposed on the basis of the interpretation of strong seismic anomalies in the present Earth's mantle. We hypothesize that the origin is in the protoplanetary material that survived the late accretion stage of planetary formation. In order to examine this hypothesis, we performed the 3-D Stokes flow simulation under a self-gravitating field with a free-surface treatment. The numerical calculation starts with a Mars-sized protoplanet (PP) which may serve as the sources of primitive reservoir by assuming that it has the undifferentiated material or primitive mantle differentiated in an early oxidized state. From this Mars-sized initial embryo, the planet grows under continuous impacts which create local magma ponds which eliminate the chemical signature of PP. We found that generations of such melt ponds may not completely remove the PP material from the growing planet. We suggest that such remaining PP material may be the origin of the primitive reservoir in the deep mantle inferred from geochemical analyses. Our analysis may contribute to the understanding of the thermochemical structure of the early Earth.

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