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A two-phase flow model for the water-rock differentiation of Ceres.

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The early Solar system produced a variety of objects with different properties. Among the small bodies, objects that contain notable amounts of water ice are of particular interest. Water-rock separation on such worlds is probable and has been confirmed in some cases. Assuming accretion of ice and dust, the rheology is dominated by one of the components, depending on their fractions. Two differentiation regimes arise: (a) Upon melting of an icy matrix, the dust grains settle via Stokes flow; (b) Upon melting of ice in a rocky matrix, water ascends by Darcy flow. For (a), a fast differentiation is expected. For (b), melting of ice creates a melt porosity in the matrix, enabling percolation of water if the matrix deforms to squeeze the water out. Temperatures of up to 700 K are needed for this latter process. Thus, water will first remain in suspension until the matrix deforms and then percolate. To study the processes described above, we couple accretion and water-rock separation of an icy object in an adaptive-grid two-phase flow model. The model is applicable to Ceres, icy satellites, and Kuiper belt objects, and is suited to assess the thermal metamorphism of the interior and the present-day internal structures.

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