How to solve numerically solid convection at high Rayleigh numbers with solid/liquid boundaries during magma ocean crystallization

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In the early stage of the formation of terrestrial planets partial or even complete melting of the mantle can occur, leading to the emergence of magma oceans. Depending on how the crystallization proceed in the magma ocean, solid mantle forms upwards and/or downwards. At the solid-liquid phase boundaries, depending on the ratio of the phase change to viscous deformation timescales, matter can cross the boundaries (permeable boundaries) via melting/freezing. Weakly non-linear stability analysis have shown that the permeable boundary affects the dynamics of the solid mantle, reducing the critical Rayleigh numbers under which convection occurs, leading to very efficient heat transfer and mantle cooling. Mantle temperature profiles obtained with permeable boundaries, and close to the critical Rayleigh number, show a thermal boundary layer (tbl) between the up- and down-welling and the phase change limit of a thickness which decreases as $1/Pe$, Pe being the dimensionless vertical velocity at the boundary (Peclet number).A thin tbl requires high resolutions and long time calculation to be resolved numerically, even for an isoviscous fluid and under Boussinesq approximation. To overcome this issue we employ a Robin temperature boundary conditions which applies to the interior side of the tbl and allows to not treat the steep temperature gradient. The energy balance is accounted for by the inclusion of an advective term across the boundary. For comparison with fully resolved solutions, the total thickness of the convective layer needs to be corrected to add the non-resolved boundary layer in calculation employing the Robin boundary conditions. This new boundary condition allows us to investigate a large range of Rayleigh numbers for solid convection with a phase change at either or both horizontal boundaries.