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The effect of plate dynamics on the convective mixing of chemical heterogeneities in the earth's mantle

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Geochemical studies indicate that the Earth's mantle is characterized by numerous small and large-scale heterogeneities. Numerical simulations of mantle convection are frequently used to study the mixing behavior of the mantle, with the aim of obtaining a better understanding of the origin, and the spatial and temporal evolution of such geochemical heterogeneities. Here we present the results of numerical mixing experiments that employ a three-dimensional convection model that displays self-consistent plate dynamics. Plate tectonic processes are observed to have a first-order effect on the mixing properties of the mantle. In the absence of plate movements, chemical heterogeneities are efficiently isolated within convection cells that are internally well mixed. The movement of the plates, however, is observed to enhance mixing across cell boundaries in the direction of spreading. Our numerical experiments also indicate that passive chemical heterogeneities can persist in the mantle for several complete plate tectonic cycles, equivalent to a timescale of approximately 1 - 2 Ga.