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Using Volcanic Geochemistry and Seismic Tomography to Refine Global Models of Mantle Temperature and Plate Thickness

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The thermochemical structure of lithospheric and asthenospheric mantle exert primary controls on surface topography and volcanic activity. Volcanic rock compositions and mantle seismic velocities provide indirect observations of this structure. Here, we compile and analyze a global database of the distribution and composition of Neogene-Quaternary intraplate volcanic rocks. By integrating this database with seismic tomographic models, we show that intraplate volcanism is concentrated in regions characterized by slow upper mantle shear-wave velocities and by thin lithosphere (i.e. < 100 km). We observe a negative correlation between shear-wave velocities at depths of 125-175 km and melt fractions inferred from volcanic rock compositions. Furthermore, mantle temperature and lithospheric thickness estimates obtained by geochemical modeling broadly agree with values determined from tomographic models that have been converted into temperature. Intraplate volcanism often occurs in regions where uplifted (but undeformed) marine sedimentary rocks are exposed. Regional elevation of these rocks can be generated by a combination of hotter asthenosphere and lithospheric thinning. Therefore, the distribution and composition of intraplate volcanic rocks through geologic time will help to probe past mantle conditions and surface processes.