Geophysical Research Abstracts
Vol. 17, EGU2015-11593, 2015
EGU General Assembly 2015
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Linking the dynamics and evolution of lower mantle heterogeneities with surface plate motion history

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Numerical studies of mantle convection have attempted to explain tomographic observations that reveal a lower mantle dominated by broad regional areas of lower-than-average shear-wave speeds beneath Africa and the Central Pacific. Termed LLSVPs ("large low shear velocity provinces"), the anomalous regions are often inferred to be thermochemical structures encircled by regions of higher-than-average shear-wave speeds associated with Mesozoic and Cenozoic subduction zones. Geochemical inferences of multiple chemical reservoirs at depth, strong seismic contrasts, an anti-correlation of shear-wave velocity to bulk sound velocity and increased density in the anomalous regions support a thermochemical origin for the LLSVPs. The origin and long-term evolution of the anomalous regions remains enigmatic. It has been proposed that the LLSVP beneath Africa was not present before 200 Ma (i.e. before and during most of the life-time of the supercontinent Pangea), prior to which time the lower mantle was dominated by a degree-1 convection pattern with a major upwelling centred close to the present-day Pacific LLSVP and subduction concentrated mainly in the antipodal hemisphere. The African LLSVP would thus have formed during the time-frame of the supercontinent Pangea as a result of return flow in the mantle due to circum-Pacific subduction. We present new results from a geodynamic-seismology study that investigates the hypothesis that the Pacific LLSVP is indeed much older than its antipodal counterpart by performing 3D numerical models of mantle convection integrated with a new plate tectonic history model. We improve upon previous studies by imposing kinematic surface velocity boundary conditions for a time interval that spans the amalgamation and subsequent break-up of Pangea and by allowing for a lateral heterogeneity difference between the African and the Pacific LLSVPs. Our results are distinct from those of previous studies in several important ways: our plate model explicitly includes (i) absolute longitudinal reconstructions and (ii) TPW correction, (iii) our model extends back to the mid-Paleozoic (410 Ma) and (iii) we include lateral compositional variations between the two antipodal LLSVPs.