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An integrated geodynamical spherical-shell model of mantle convection, continental growth, and preservation of geochemical heterogeneity

U. Walzer (1), R. Hendel (1) and J. Baumgardner (2)

(1) Universitaet, Inst. Geowiss., Burgweg 11, 07749 Jena, Germany, (2) Univ. Calif., Dept. Earth Planet. Sc., 307 McCone Hall, Berkeley, CA 94720-4767, USA

The focus is a common simulation of thermal whole-mantle convection, chemical mantle differentiation, continental growth, and preservation of geochemical heterogeneity in spite of enduring convection. The differentiation causes formation and growth of continents and, as a complement, the increase of the depleted MORB mantle (DMM). Here, we present a solution of this problem by an integrated theory that also includes the thermal solid-state convection in a 3-D compressible spherical-shell mantle. The conservation of mass, momentum, energy, angular momentum, and of four sums of the number of atoms of the pairs ^{238}U-^{206}Pb, ^{235}U-^{207}Pb, ^{232}Th-^{208}Pb, ^{40}K-^{40}Ar is guaranteed. The pressure- and temperature-dependent viscosity is supplemented by a viscoplastic yield stress, σ_y. No restrictions are supposed regarding number, size, form and distribution of continents. Only oceanic plateaus touching a continent have to be united with this continent. This mimics the accretion of terranes. The *results* are an episodic growth of the total continental mass and acceptable curves of the laterally averaged surface heat flow, *qob*, the Urey number, Ur, and the Rayleigh number, Ra. In spite of more than 4490 Ma of solid-state mantle convection, we obtain *separate*, although not simply connected geochemical mantle reservoirs. This is a step toward a reconciliation of the stirring problem. However, there are no unblended reservoirs. DMM strongly predominates immediately beneath the continents and the oceanic lithosphere. A further result is a marble-cake mantle. Earth-like continent distributions were found in a central area of a Ra-σ_y plot obtained by variation of parameters. There are also Ra-σ_y areas of small deviations of the calculated total continental size from the observed one, of acceptable values of Ur and of realistic qob. It is remarkable that the different acceptable Ra-σ_y areas have a common overlap area.