Bercovici, David; **Schubert, Gerald**; **Glatzmaier, Gary A.**

Three-dimensional convection of an infinite-Prandtl-number compressible fluid in a basally heated spherical shell. (English) Zbl 0774.76076

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The authors investigate compressibility effects on three-dimensional thermal convection in a highly viscous fluid in a spherical shell, which is heated basally. The inner to outer radius ratio is about 0.55, which is characteristic of the Earth's whole mantle. Compressibility ranges from the Boussinesq approximation to that typical of the Earth's mantle and is implemented with the anelastic approximation and a hydrostatic adiabatic reference state whose bulk modulus is a linear function of pressure. Compressibility is significant when the superadiabatic temperature drop across the shell is an order of magnitude smaller than the adiabatic temperature, but has little effect on the special structure of the steady convection when the two temperature drops are comparable. For all non-Boussinesq cases convection cells at high temperature gradients break down into highly irregular patterns, penetrating into the upper shell and becoming strongly time dependent at Rayleigh numbers only ten times larger than the critical ones.

The authors present theory of compressible convection and the computational model, as well as a stability analysis and experimental results. Presentation is rigorous and results are displayed in excellent graphs and figures followed by an extensive bibliography. Effects of compressibility on mantle convection has profound geophysical implications, not so much in determining the mantle structure as in determining the temporal behavior of convection. Study of tectonic plates motion correlating to seismic phenomena are strong motivating factors for this investigation and should be expanded to include internal heating, a primary heat source for terrestrial mantles.

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MSC:

76R10	Free convection
76N10	Existence, uniqueness, and regularity theory for compressible fluids and gas dynamics
80A20	Heat and mass transfer, heat flow (MSC2010)
86A60	Geological problems
86A17	Global dynamics, earthquake problems (MSC2010)

Keywords:

Boussinesq approximation; Earth's mantle; anelastic approximation; hydrostatic adiabatic reference state; superadiabatic temperature drop; convection cells; irregular patterns; stability analysis; tectonic plates motion

Full Text: DOI

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