Mantle Structure and Dynamics at the Cordillera-Craton Transition in Western Canada

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Abstract:

The boundary between the Canadian Cordillera and North American Craton plays a key role in shaping the surface topography and tectonics of western Canada. A range of observations, including surface heat flow, seismic tomography and electrical resistivity, show that there is a dramatic contrast in thermal structure between the Cordillera and Craton. The Cordillera is characterized by hot, thin lithosphere (50-70 km thick) and the Craton lithosphere is much cooler and thicker (200-300 km). In southwest Canada, the transition in lithosphere thickness occurs over a lateral distance of 50-100 km, approximately below the Rocky Mountain Trench. We use two-dimensional numerical models to explore mantle dynamics in this region. The first set of models examines the longevity of the Cordillera-Craton lithosphere step. Such a step is inherently unstable and prone to deformation by both internal gravitational instabilities and shearing by the surrounding mantle. The observed gradient in lithosphere thickness can persist for 50 Myr or longer only if the lowermost Craton lithosphere is both dry and chemically depleted. The second set of models examine the origin of the thin Cordillera lithosphere, motivated by seismic studies that propose that this is the result of recent gravitational thinning through delamination. Models start with a thick Cordillera lithosphere, and delamination initiates if there is a pre-existing weak zone in the lithosphere. This leads to Cordillera-wide thinning in 5-10 Myr, which is accompanied by an increase in surface heat flow and elevation and a change in crustal stresses. Both delamination and ongoing mantle convection at the Cordillera-Craton step may (partially) explain basaltic magmatism found in the Cordillera interior.


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