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Generation and flow of partially molten crust during orogenic collapse studied by *ELLIPSIS* dynamic modeling

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Partial melting of the continental crust is one of the most important processes during orogeny. The presence of a melt fraction influences rheology, and the pathways, scales, and rates of melt transport have profound implications for mass and heat redistribution, particularly during the collapse stage of orogens. Orogenic collapse occurs in two main modes. Fixed-boundary collapse involves redistribution of material internal to the system, and free-boundary collapse calls for extension of the system as a whole. The role of partial melting during these two types of collapse is investigated using the *ELLIPSIS* dynamic model that takes into account melting reactions and therefore simulates the generation of partial melt and its rheologic implications. In all models, the starting condition is a crustal section that represents the transition between a thick orogenic crust (approx. 65-75 km) that has thermally relaxed and the foreland region that has maintained a normal crustal thickness (approx. 40 km).

During fixed-boundary collapse, rapid thinning and horizontal flow of partially molten crust toward the foreland (channel flow) are accommodated by shortening and thickening of the foreland crust, with the propagation of a thrust wedge. Extension of the upper crust above the flowing partially molten crust is distributed. If this extension is forced to localize on a preexisting zone of weakness (a dipping fault), rapid upward flow of the partially molten crust simulates the formation of a metamorphic core complex. In the mode of free-boundary collapse, the thrust belt still develops as long as the divergent motion of the boundary remains below a certain rate. Beyond this rate, the thick crust thins uniformly, with flow of partially molten crust and boudinage of the overlying crust; no thrust belt develops. If extension is forced to localize, a wide metamorphic core complex is generated. A rolling-hinge detachment develops, with progressive upward flow and rapid cooling of partially molten crust in the footwall of the upper crust normal fault. This cooling material then pulls away from the normal fault and cools rapidly beneath an extremely attenuated upper crust, as more deep-seated rocks flow upward in the footwall of the normal fault to participate in another cycle of upward flow and cooling. These models suggest that, as a partial melt layer forms in the deep crust, it undergoes lateral flow, and also vertical flow, especially if extension of the upper crust is localized. This partial melt continues to form during decompression to shallow levels, as in a dome, and then crystallizes rapidly under an extremely attenuated upper crust. The $P-T$ and geochronologic output of the models compares favorably to the data collected from the Paleocene-Eocene metamorphic core complexes in the northern North American Cordillera.