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Commentary

Effect of Buoyancy and Shear Forces on Orogenic Wedges

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DESCRIPTION

Shear and buoyancy forces have a major role in controlling the dynamics of developing collisional orogens. However, it is still difficult to determine the relative significance of these pressures, their temporal history, and how they affect the tectonic character of orogenic wedges. Here, we'll quantify the buoyancy and shear forces that were present throughout the collisional orogeny and look at how they affected the development of orogenic wedges and the exhumation of crustal rocks. A long-term (about 170 Myr) lithosphere deformation cycle that included subsequent hyperextension, cooling, convergence, subduction, and collision was simulated numerically in two dimensions using petrological-thermomechanical methods. A basin with exhumed continental mantle and asymmetric passive edges is created by hyperextension. Replace the top few kilometers of the extracted mantle with serpentinite prior to convergence to learn more about its function during subduction and collision.

Numerous researches have examined the mechanisms generating mountain growth in collisional environments. Collisional orogenic belts are an outstanding representation of plate tectonics. The wedge model is a well-liked geodynamic theory that explains how collisional orogens like the Western Alps, Pyrenees, and Himalayas originate. The initial mechanical models of so-called crucial wedges were used on accretionary wedges and took into account frictional deformation (stresses are governed by a particular yield criterion). Analog and numerical models have both been extensively used to study how these wedges arise. The kinematic boundary condition at the base of the crust, which involves a hard indenter or backstop and produces a kinematic singularity point at the base of the wedge, is what drives wedge models, which normally only take crustal deformation into account. The impact of surface processes on wedge formation as well as the production of viscous folds nappes during the evolution of fold and thrust belts have both been explored using these wedge models.

Crustal wedge models, also known as orogenic wedge models, have been used to describe whole collisional orogens. On the other hand, the geodynamic evolution of collisional orogens, like the Alps or the Himalayas, often entails the closure of oceanic domains and the subduction of rocks from the ocean and the continents prior to actual collision. Large areas of several of these orogens are also characterised by exhumed rocks with peak temperatures typically ranging from 500°C to 700°C. These rocks have high pressures (>1 GPa) and occasionally ultrahigh pressures (>2.7 GPa). Additionally, tomography of the Western Alps and the Pyrenees shows that the creation of orogenic wedges is influenced by the overlying lithospheric mantle, suggesting that these wedges are more like lithospheric wedges than just crustal wedges. The density disparity between the subducted crustal material and the surrounding mantle, the related creation and exhumation of (ultra) high-pressure rocks, and the aforementioned pre-collisional subduction may all have a substantial impact on the orogen processes. Particularly, the burial of crustal material under the pressure of subduction to depths greater than the isostatically balanced depth will result in (upward-directed) buoyant forces that work against the forces causing subduction and may even help exhume rocks.

From a mechanical perspective, the equilibrium of gravity forces (acting everywhere inside a representative rock volume) and shear forces regulates the lithosphere's comparatively slow tectonic deformation (no inertia) (or surface forces, acting on the surface of a representative rock volume). Shear forces are those that act perpendicular to or normal to the representative volume's surfaces and cause shear deformation, such as pure or simple shear, in the absence of volumetric deformation. Crustal wedge models frequently take gravity and shear forces into account. Gravitational forces affect frictional deformation by gravitationally adjusting topographic gradients and deepening confining pressure. Such models cannot forecast the deep subduction of continental crustal rocks because of the kinematic singularity point present in the majority of crustal wedge models. As a result, these models do not take into account (upward-directed) buoyancy forces caused by density variations between subducted crust and the overlying mantle. Here, we examine the impact of shear and buoyancy forces on orogenic wedge formation in a large-scale lithosphere (crust and mantle lithosphere) and upper mantle (asthenosphere and transition zone) framework, including subduction.

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