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Dynamic Pressure Variations in the Lower Crust Caused by Localized Fluid-Induced Weakening

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When continents collide, the Earth's crust experiences structural and metamorphic transformations that control the geodynamic evolution of the orogen. Metamorphism of dry, lower crust requires fluid supply and produce mechanically weaker rocks. Metamorphism is often localized in shear-zones, which provide the available fluid pathways. Several field-based studies show that shear zone development is preceded by brittle faults, frequently portraying evidence for seismic slip rates and introduction of externally derived fluids. However, despite the extensive documentation of lower crustal metamorphism and associated deformation features, a unifying model coupling deformation to fluid migration and metamorphic reactions does not exist. Here, we present a visco-elasto-plastic model where the most pertinent features observed in transformed lower crust emerge from basic mechanical principles during the deformation of a coherent rock volume with associated fluid introduction. Characteristic features include a strikingly dynamic and heterogeneous pressure distribution in the reacting and deforming rock volumes. Lower crustal pressure variations may reach 1 GPa at any given depth. This will have first order effects on the pattern of fluid migration in the lower crust, and may also explain the apparent discrepancies between the relevant tectonic settings and petrologically-inferred burial depths. An additional petrological consequence of the positive pressure variations is the generation of fluid-undersaturated high-pressure assemblages. For common bulk-rock compositions that are observed in the Bergen Arcs (Norway), and for finite amounts of fluid, phase equilibria modelling results suggest that the quasi-isothermal pressurization will lead to the formation of H_2O-undersaturated metamorphic rocks. These results highlight the importance of coupling between metamorphic reaction progress and deformation at high-grade conditions.

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References:

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