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Magnitude of long-term non-lithostatic pressure variations in lithospheric processes: insight from thermo-mechanical subduction/collision models

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On the one hand, the principle of lithostatic pressure is habitually used in metamorphic geology to calculate paleo-depths of metamorphism from mineralogical pressure estimates given by geobarometry. On the other hand, it is obvious that this lithostatic (hydrostatic) pressure principle should only be valid for an ideal case of negligible deviatoric stresses during the long-term development of the entire tectono-metamorphic system - the situation, which newer comes to existence in natural lithospheric processes. The question is therefore not "Do non-lithostatic pressure variations exist?" but " What is the magnitude of long-term non-lithostatic pressure variations in various lithospheric processes, which can be recorded by mineral equilibria of respective metamorphic rocks?". The later question is, in particular, relevant for various types of high-pressure (HP) and ultrahigh-pressure (UHP) rocks, which are often produced in convergent plate boundary settings (e.g., Hacker and Gerya, 2013). This question, can, in particular, be answered with the use of thermo-mechanical models of subduction/collision processes employing realistic P-T-stress-dependent visco-elasto-brittle/plastic rheology of rocks. These models suggest that magnitudes of pressure deviations from lithostatic values can range >50% underpressure to >100% overpressure, mainly in the regions of bending of rheologically strong mantle lithosphere (Burg and Gerya, 2005; Li et al., 2010). In particular, strong undepresures along normal faults forming within outer rise regions of subducting plates can be responsible for downward water suction and deep hydration of oceanic slabs (Faccenda et al., 2009). Weaker HP and UHP rocks of subduction/collision channels are typically subjected to lesser non-lithostatic pressure variations with characteristic magnitudes ranging within 10-20% from the lithostatic values (Burg and Gerya, 2005; Li et al., 2010). The strength of subducted crustal rocks and the degree of confinement of the subduction/collision channel are the key factors controlling this magnitude (Burg and Gerya, 2005; Li et al., 2010). High-temperature (>700 C) UHP rocks formed by continental crust subduction typically demonstrate negligible non-lithostatic pressure variations at peak metamorphic conditions, although these variations can be larger at the prograde stage (Gerya et al., 2008; Li et al., 2010). However, the variability of tectonic mechanisms by which UHP rocks can form (e.g., Sizova et al., 2012; Hacker and Gerya, 2013) precludes generalization of this result for all types of UHP-complexes.

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