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P-T-t-z conditions in continental subduction settings , rheological and surface controls on the collision style

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We use thermo-dynamically coupled thermo-mechanical numerical models that account for brittle-elastic-ductile rheology, surface processes and continuous metamorphic phase changes to study continental subduction and the related P-T-t-z conditions in various subduction settings. The model traces P-T-t-z paths that can be interpreted in terms of collision/exhumation mechanism. The experiments suggest that continental subduction is a necessary context for UHP exhumation although it is short-lived in most cases (slow or fast convergence settings). Stable subduction occurs in case of strong lithospheres with competent mantle part (T_Moho<550°C), at high initial convergence rates (>1.5-5 cm/yr). Depending on lower-crustal rheology (strong or weak), either the entire (upper and lower) crust or only the lower crust can be involved in subduction. In case of weak metamorphic rheologies, phase changes leading to material softening significantly improve chances for stable subduction. Exhumation of UHP-HP rocks to the surface is favoured if the crustal rheological profile has internal ductile decolement levels (between the upper and lower or intermediate crust and the lower crust and mantle lithosphere). Pure shear collision is dominant when T_Moho>550°C or convergence rates are lower than 1.5-3 cm/yr (subduction number, S > 0.5). The maximal amount of subduction is achieved for surface erosion rates such that tectonic uplift rates are fine-balanced by denudation rates. In case of fast collision scenario (convergence > 5 cm/y, stiff lower plate), the optimal balance is achieved for k ∼3000-4000 m2/yr. In case of fast convergence settings, continental subduction may continue for tens of Myr allowing for subduction of 600 – 800 km of continental "slab", and both surface and deep mantle evolution are strongly affected by surface processes. We suggest that most orogenic belts could have started their formation from continental subduction, yet, in case of slow convergence (<2-3 cm/yr) or weak lithosphere the subduction channel locks up after few Myr, and is relayed by a different deformation mode such as pure shear collision (e.g. , the Alps). In that case (slow convergence), surface processes have a minor impact on deep exhumation processes and largely control near surface stages of exhumation. In fast convergence settings, formation of high large plateaux instead of rather narrow mountain ranges is conditioned by the degree of locking of the subduction channel, erosion rates on the plateau side and the rheological structure of both the upper and lower plate.