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Deciphering the coupling between tectonic and metamorphic processes in the Monte Rosa nappe (Western Alps)

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Our refined ability to estimate metamorphic conditions incurred by rocks has increased our understanding of the dynamic earth. Calculating pressure (P), temperature (T) and time (t) histories of these rocks is vital for reconstructing tectonic movements within subduction zones. However, large disparities in peak P within a structurally coherent tectonic unit poses difficulties when attempting to resolve a tectono-metamorphic history, if a depth dependant lithostatic P is assumed. However, what is clear is that pressure, or mean stress, in a rock cannot exactly be lithostatic during an orogeny due to differential stress, required to drive rock deformation or to balance lateral variations in gravitational potential energy. Deviations from lithostatic P is commonly termed tectonic pressure, and both its magnitude and impact on metamorphic reactions in disputed.

For the 'Queen of the Alps' (the Monte Rosa massif), estimates for the maximum P recorded during Alpine orogenesis remain enigmatic. Large disparities in published estimates for peak P exist, ranging between 1.2 and 2.7 GPa. Moreover, the highest P estimates (2.2 - 2.7 GPa) are for rocks that comprise only a small percentage (< 1%) of the total volume of the nappe (whiteschist bodies and eclogitic mafic boudins). We present newly discovered whiteschist lithologies that persistently exhibit higher P conditions (*c.* 2.2 GPa) compared to metagranitic and metapelitic lithologies (*c.* 1.4 - 1.6 GPa). Detailed mapping and structural analysis in these regions lack evidence for tectonic mixing. Therefore, we suggest that a ΔP 0.6 ± 0.2 GPa during peak Alpine metamorphism could potentially represent tectonic pressure. Furthermore, we outline possible mechanisms that facilitate ΔP, namely mechanically- and/or reaction-induced. We present data from numerical models that exhibit significant ΔP (*c.* 0.4 GPa) during a transient period of high differential stress prior to buckling and subsequent exhumation of viscous fold nappes, similar to exhumation mechanisms suggested for the Monte Rosa nappe. As well as this, we present new routines for calculating metamorphic facies distribution within numerical models of subduction zones that agree with natural distributions within orogens.

The maximum burial depth of the Monte Rosa unit was likely significantly less than 80 km (based on the lithostatic pressure assumption and minor volumes of whiteschist at *c.* 2.2 GPa). Rather, the maximum burial depth of the Monte Rosa unit was presumably equal to or less than *c.* 60 km,

estimated from pressures of 1.4 - 1.6 GPa recorded frequently in metagranite and metapelitic lithologies. In order to understanding, more completely, a rocks metamorphic history, consideration of the interplay between tectonic and metamorphic processes should not be overlooked.