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Relative rates of metamorphic reactions during different stages of deformational events: insight from geological observations and P-T paths.

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The competition between changes in P-T-fluid activity parameters and rates (V) of metamorphic reactions (V_{MR}) is physicochemical basis of this problem. In terms of geology, the shear deformation on the one hand, and the reaction textures and chemical heterogeneity of minerals in their local equilibria on the other hand, are a strong source of data on the relative V_{MR} at different stages of a deformational event (D). In the general case V_D is always higher than the V_{MR} that are well recorded in the heterogeneity of minerals in metamorphic rocks. However, at different stages of a metamorphic process, as well as in different geological structures, the V_{MR}/V_D may vary within wide ranges. The highest V_{MR} and V_D are known from the cores of some impact craters, where both the V_D and the V_{MR} are immediately elevated after compact which is accompanied by metamorphic and structural transformations in the cores. For example, the core of the Vredefort impact crater is characterized by Achaean (3.1 Ga) granulites that contain enormous amounts of reaction textures *Grt+Qtz =>* *Crd+Opx*, that formed immediately behind of the impact wave (subisobaric heating), and during the subsequent exhumation of the crater core after impact. High V_{MR} are controlled by the formation of synchronous glass-rich granophiric pseudotahylites, a process that is well tested by numerical modeling (Melosh & Ivanov, 1999). The Phanerozoic UHT-UHP collisional complexes often preserve records of both the prograde and the retrograde reaction textures suggesting a high V_{MR} during the burial and exhumation stages of the collisional process. In contrast, the majority rocks from the Precambrian high-grade terrains commonly preserve no prograde reactions and

prograde chemical zoning demonstrating mainly retrograde *P-T paths* (Harley, 1989; Perchuk, 1989). In extremely rare cases relic prograde/peak microtextures or chemical zoning are preserved (e.g. Smit et al., 2001; Zeh et al., 2004). Therefore, in such cases the prograde V_{MR} (burial/peak stage) were higher than the retrograde V_{MR} (exhumation stage) because the prograde record was not entirely obliterated by the retrograde one. The most exciting results were obtained for polymetamorphic HT-HP complexes, which demonstrate strong control of V_{MR} by the fluid activity. This is clearly demonstrated by eclogite facies rocks that developed after mafic and ultramafic rocks formed under granulite facies conditions (Udovkina, 1971; Austrheim, 1990). This metamorphic transformation shows a critical influence of fluid activity on V_{MR} during the second deformational event (D2), dominated by shear deformation. An identical process is typical for “the D1 granulite – D2 granulite overprint” due to the penetration of a hot fluid along the shear zones. Normally the D2 rocks contain a lot of D1 relics within the newly formed HT granulite blastomilonitic matrix accompanied by the formation of reaction textures during sub-isobaric heating, similar to the impact $P-T$ path (Perchuk (2005). If the hot fluid activity along the shear zone is high enough, the DE1 rock can be completely transformed into the D2 rocks that only reflect the D2 isotopic Pb-Pb record (van Reenen et al., 2004). At lower shear-fluid activity this isotopic ratio varies over a wide range accompanied by systematic heterogeneity in the compositions of minerals in local equilibria (Boshoff et al., 2004). This suggests that $V_{D2}$is higher than V_{MR}. The paper demonstrates numerous examples from different granulite facies terrains around the word, showing that the low rates of metamorphic events dominate in comparison with deformational (geodynamic) events.

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