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The 3D distribution of cordierite and biotite in hornfels from the Bugaboo contact aureole (British Columbia, Canada)

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The size, abundance, shape and spatial distribution of metamorphic minerals bears important information on the rates and mechanisms of fundamental processes that take place during metamorphic crystallization. X-ray computed tomography (XR-CT) has become the method of choice to study the three-dimensional (3D) disposition of minerals in rocks as it allows investigation of relatively large sample volumes at sufficiently high resolution required for statistically meaningful analyses, and as its non-destructive fashion permits further studies such as mineral chemical, isotopic or crystallographic analyses of select grains identified through XR-CT.

We present results obtained through the quantification of the 3D disposition of cordierite and biotite crystals in a hornfels from the contact aureole of the Bugaboo Batholith (British Columbia, Canada) using XR-CT and global as well as scale-dependent pattern statistics (Petley-Ragan et al., 2016). The results demonstrate a random distribution of cordierite and biotite crystal sizes for all scales across the entire rock volume studied indicative of interface-controlled prograde metamorphic reaction kinetics. We show that the common approach to approximate the shape of crystals as spherical underestimates the influence of the Strauss hard-core process on rock texture which may be misinterpreted to reflect ordering of crystal sizes by inhibition of nucleation and growth commonly associated with diffusion-controlled reaction kinetics. According to our findings, Strauss hard-core ordering develops at length scales equal to and less than the average major axis of the crystal population. This is significantly larger than what is obtained if a spherical crystal geometry would be assumed, and increases with deviation from sphericity. For the cordierite and biotite populations investigated in this research, Strauss hard-core ordering developed at length scales of up to $\sim$2.2 and 1.25 mm, respectively, which is almost 1 mm longer than the scales that would be obtained if a spherical geometry would have been assumed.

Our results highlight the importance of a critical assessment of the geometrical model assumptions commonly applied in the 3D analysis of crystal size distributions, and underline the need for a quantitative understanding of interface processes in order to appreciate their role in the kinetics of contact metamorphic reactions and rock texture formation.

References:
Petley-Ragan A, Gaidies F, Pattison DRM (2016) A statistical analysis of the distribution of cordierite and biotite in hornfels from the Bugaboo contact aureole: implications for the kinetics of porphyroblast crystallization. Journal of Metamorphic Geology 34:85-101