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Fractal geometry-based fabric quantification in practice: deployment of automated analysis routines on magmatic flow patterns from the Squillace Tonalite (Calabria, Southern Italy)

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Magmatic processes such as magma emplacement and deformation-cooling histories leave visible traces in fabrics of magmatic rocks on all scales from μm to m. Together with the mostly diffuse and irregular nature of the patterns, this large scale range greatly impedes comprehensive analyses of the rock's fabrics.

While such fabric patterns have been analyzed using a number of conventional methods over the last two decades, the resulting interpretations are mostly related to geometric aspects of the analyzed patterns on a specific scale. Fractal geometry-based quantification approaches can help overcome this problem, as they can be applied on larger scale ranges and thereby help extracting additional information. Furthermore, they are specifically suitable to analyze the pattern's complexity as well as anisotropies and inhomogeneities that may occur within a pattern. One issue that has prevented a widespread application of these methods is the fact that - compared to methods that are based on conventional statistical approaches - the time and effort required for the deployment of fractal geometry-based quantification approaches is much higher. However, the better availability of computing power and the development of automated routines along with their successful application on complex magmatic patterns has largely resolved such reservations.

Still, the foundation of a meaningful analysis is laid in the initial preparation and processing of the analyzed patterns. To help avoid the influence of subjective decisions made along the way, we show an exemplary, rule-based work flow from pattern acquisition and image processing to deployment of automated quantification routines on a series of samples from geologically different locations within the Squillace Tonalite in the Serre (Calabria, Italy). All of the samples show evidence of flow, mingling and mixing processes of different intensity. These processes occurred during the injection and the shearing of the crystallizing melt-crystal mush. Based on two surfaces cut (1) parallel to the lineation and (2) normal to the foliation plane of each sample, we compare manually digitized binary phase images of mafic and felsic minerals to an automatic selection of appropriate thresholding boundaries and the results obtained with a polygon-based tracing algorithm. Subsequently, we analyze the patterns using, e.g., box-counting, map-counting and the modified Cantor dust method to provide quantitative measurements in terms of complexity, inhomogeneity and anisotropy and discuss the respective results as well as their geological context and significance.