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Analyzing 3D-Structures of Syntectonic Magmatic Rocks: A new Approach Based on High Resolution Neutron Computed Tomography

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Syntectonic magmatic rocks, namely syntectonic granitoids, provide important information about large-scale crustal processes, such as formation of large-scale and deep-rooted faults and thrusts, and the compositional and structural re-organization of the continental crust in general. However, emplacement and crystallization of granitoid melts in regional stress fields, though very common processes, are not sufficiently understood. Magmatic structures are generally too coarse for thin-section analysis, too diffuse for precise conventional measurements, and often show irregular geometry which does not allow extrapolation from smaller to larger scales and, above all, from 2d to 3d. Neutron tomography offers, to date, the only sufficiently fast and precise method for 3d micrometer resolution of these magmatic structures on the required millimeter- to centimeter-scale. Such data sets form a strong basis for quantification of rock fabrics and, consequently, for comparison of natural, experimentally produced, and simulated fabrics, as well as a deeper understanding of fabric-forming processes.

First results of a comparative study are presented. A syntectonic tonalite from the fossil Hercynian lower crust of Calabria/Italy has been investigated. Because of good contrast of density, crystal structure, and composition between mafic (biotite, amphibole) and felsic (quartz, plagioclase) micrometer- to millimeter-sized phases, neutron tomography of 2 x 2 x 2 centimeter samples leads to 3d gray-shade patterns with clear contrasts and resolution on the 30-micrometer scale. In order to receive precise information about congruence between gray-shade patterns and crystal distribution patterns of various types of minerals, the measured samples are milled down in 50 micrometer steps and the resulting 400 2d patterns are digitized with high resolution and transferred into mineral distribution patterns. Subsequently, these patterns are stacked and geostatistically interpolated, resulting in a voxel array, which provides a versatile basis for further 3d analysis, in particular a comparison with neutron tomorgraphy images. In addition, thin sections are prepared from defined positions within the samples measured by neutron tomography. All relevant information (mineral composition, mineral phase distribution, internal crystal structures etc.) taken from the thin sections allow comparison with the results of neutron tomography at highest possible precision. First important information from these comparative investigations and the resulting interpretations of pattern-forming processes and rock history will be presented.