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Editorial

Introduction to the Special Issue: Textures and Physical Properties of Rocks

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Crystallographic preferred orientations (textures) are one of the important fabric elements of rocks. Textures reveal information on the evolution of rock fabrics and on the mechanisms of fabric development. In addition, textures can control anisotropic physical rock properties to a large extent. However, texture analyses of rocks are difficult because of the low symmetry of most of the rock forming minerals and the generally polyphase composition of rocks. The resulting high demands of geologists to the methods of texture analysis are met by recent improvements of the techniques for texture determination, e.g. neutron diffraction to determine the global texture of large sample volumes and electron diffraction to measure complete single grain orientations. In the fields of quantitative texture analysis and numerical texture simulation materials scientists and mathematicians have refined their methods. These techniques and methods are now more accessible and easier to apply for users like geologists, who are mainly interested in the results and their application of all these new approaches and not in details of the analytical techniques themselves. At this stage and after the successful meeting and workshop on 'Textures of Geological Materials' at the University of Göttingen in January 1993 (Bunge et al., 1994), it became clear that geologists need their own forum to start new interdisciplinary discussions, to improve the cooperation between materials scientists and geologists, to develop new applications and joint projects for texture and physical property analyses of rocks and to involve scientists from related fields of research—always focusing on the special demands of geologically relevant materials and geological processes.

This was the motivation to initiate an international four-day conference on 'Textures and Physical Properties of Rocks' at the University of Göttingen in October 1999 (Leiss et al., 1999), accompanied by several workshops on current research topics. The number of participants (140 participants from 20 different countries) reflects the interest and the demand for such a forum. The aim of the conference was not only the presentation of new experimental methods, but also to demonstrate the application of texture analyses for a better understanding of the evolution of rock fabrics at all scales. Special attention was given to the close relationship between texture and anisotropic physical rock properties, and to the analyses of related materials like ice and biologically generated materials.

This special issue includes 25 papers, which comprise most topics of the conference. The first seven papers of section I focus on methodical aspects of texture and property analysis. The reliability of textures gained from different experimental techniques is discussed by *Ullemeyer, Braun, Dahms, Kruhl, Olesen and Siegesmund*. An example for advanced instrumentation at a neutron facility is given by *Jansen, Schäfer and Kirfel*. Mathematical aspects of texture data treatment are addressed by *Schaeben*, who proposes an alternative method for the quantitative texture analysis. Most papers in this section deal with 'volume-related textures', however, the contribution of *Bartozzi, Boyle and Prior* is related to single grain orientation measurements using electron backscatter diffraction (EBSD). An automated technique to identify grain boundaries in orientation contrast images is described. A new research field is introduced by two papers, which deal with neutron stress/strain determinations on geological samples, so far a unique enterprise in geosciences (*Pintschovius, Prem and Frischbutter; Frischbutter, Neov, Scheffzük, Vrana and Walther*). Both of the studies present first results from measurements on sandstones with different experimental settings and discuss the potential of stress/strain investigations in geosciences. The crucial problem of lattice stress calculation—determination of the stress-free lattice constants d_0—is discussed by *Wieder*, who summarizes the frequently used methods of d_0 determination.

Nine contributions of the second section focus on texture-forming mechanisms at the microscale. This is the most significant field for the application of the recently refined technique of EBSD. EBSD allows the analysis of single grain orientations and the analysis of the crystallographic relationship between neighbouring grains (misorientations). From these analyses, conclusions can be drawn on deformation mechanisms like intracrystalline slip, recrystallisation,

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solution precipitation and, as a new intention, on faulting (*Lloyd*). In three papers, this concept is applied to experimentally deformed polycrystals. *Trimby, Drury and Spiers* focus on recrystallisation processes in rocksalt, *Skrotzki, Oertel, Röseberg and Brokmeier* on the microstructure and texture formation in lead sulfide and *Mauler, Bystricky, Kunze and Mackwell* on the microstructural and textural development in clinopyroxene. The fourth study of this section is also based on deformation experiments, however *Heidelbach, Post and Tullis* used synchrotron source X-ray diffraction for local texture analysis of polycrystalline albite which was deformed by recrystallization-accommodated dislocation and precipitation creep. Three other papers report on EBSD studies of naturally deformed rocks. Orientation and misorientation characteristics are used by *Jiang, Prior and Tullis* to analyse mechanisms of granular flow in albite and by Neumann to analyse texture forming and recrystallisation mechanisms in quartz. So far, all the studies concentrate on ductile deformation processes. *Lloyd*, however, presents an application to brittle deformation processes by analysing the processes occuring during progressive quartz indentation into quartz. The next two contributions also present new ideas with an interesting future outlook. *Bons and den Brok* introduce a numerical model for the simulation of texture development by dissolution–precipitation creep. *Chateigner, Hedegaard and Wenk* investigate biologically controlled growth textures of aragonite in mollusc shells by X-ray diffraction and make the attempt to relate the textural features to the phylogenetic evolution. The latter is an example of succesful interdisciplinary cooperation.

The third section comprises five papers which focus on the quantitative influence of textures on the anisotropic physical properties of rocks. For this aim, the physical properties are experimentally determined and compared with those calculated from quantitative texture analyses. The difference between these quantities can be attributed to e.g. grain size effects, grain shape anisotropies, microcracks, polyphase compositions and heterogenous fabrics. *Leiss and Weis*s studied the influence of the anisotropic thermal dilatation on the weathering of different Carrara marble types. Measured and modeled anisotropic magnetic susceptibilities are the topic of the next two contributions. *Siemes, Schaeben, Rosière and Quade* show us Anisotropy of Magnetic Susceptibility (AMS) data for hematite in banded iron ores, *De Wall, Bestmann and Ullemeyer* present the first application to diamagnetic calcite from a carbonate shear zone. The paper of *Brosch, Schachner, Blümel, Fasching and Fritz* deals with the mechanical properties of a gneiss which is used as a building stone.

In the contributions of the fourth section, textures, physical properties and microstructures are applied as indicators for geological processes of regional significance. In order to learn more about the kinematics of a calcite marble shear zone on Thassos Island in Greece, *Bestmann, Kunze and Matthew*s characterize the microstructures and textures of the shear zone in detail. Fabric studies of different Carrara marbles by *Molli, Conti, Giorgetti, Meccheri and Oesterling* give new insights into the deformation and thermal history of the Alpi Apuane in Italy. The textural development of quartz is used by *Unzog and Kurz* in order to understand the kinematics of a transpressional collision zone in the Panafrican Orogen in Egypt. In contrast to these three classical applications of textures to deformation histories, the next two papers demonstrate the application of anisotropic physical properties, namely magnetic fabrics, for analysing the emplacement mechanisms of plutons. *Becker, Siegesmund and Jelsma* investigate the Chinamora batholith in Zimbabwe and *Steenken, Siegesmund and Heinrichs* characterize the Rieserferner pluton in the Eastern Alps.

The assembled papers demonstrate that the highly developed techniques and methods supply a new quality of textural data. In this volume, the high potential of these new data is mainly demonstrated on the texture forming mechanisms at the microscale – particularly pushed by recent developments of the EBSD technique. A fresh impetus is given to the quantitative correlation of textures and physical anisotropies by the volume-related neutron diffraction technique. Numerous contributions can be expected in the near future, e.g. in characterizing building stones and in the evaluation of residual stresses in the Earth's crust. In the future, the routine application of texture and/or physical property analyses for the understanding of the development of geological structures at all scales is expected to be another prospering field. However, the interaction between the texture forming mechanisms within crystals at the microscale and the structure forming mechanisms e.g. of contintents or the Earth's mantle on a large scale has to be considered appropriately.

This Special Issue will, hopefully, help to establish modern concepts of texture and property analyses in structural geology and to intensify interdisciplinary research. In order to keep discussion alive, a webpage www.RockTextures.de has been implemented recently. All contributions to the web page are welcome.

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