Crystal distribution patterns and their anisotropy behaviour in igneous rocks: towards an automated quantification, first results *Vortrag*

Mark Peternell[1] Jörn H. Kruhl[1]

Introduction

Since approximately two decades fractal geometry offers tools for the quantification of rock fabrics, and new methods are currently under development to investigate the inhomogeneity of crystal distributions, grain- and phase-boundary patterns as well as their anisotropy behaviour (Kruhl et al. 2004). These methods are now adapted for automated processing and suitable to quantify the inhomogeneity and anisotropy of rock fabrics from macro to microscale. Applications for quantifying inhomogeneity are mainly based on the box-counting and map-counting (Peternell 2002) methods, for anisotropy behaviour mainly based on modified Cantor-dust methods and provide fractal dimensions, fractal-dimension isolines and azimuthal anisotropies of fractal dimension (AAD, Volland & Kruhl, 2004). For instance, the results provide information about the local variations of fabric patterns and their prefer orientation behaviour at macro and microscale.

Measurements

Inhomogeneity

Different types of granites from the Tuolumne Batholith (Sierra Nevada, USA), the Piquiri Syenite Massif (Neoproterozoic basement of southern Brazil) and a fine-grained granite from central China (plates sold by a do-it-yourself store, Munich) have been investigated. Based on digital photographs of flat non-polished, polished and stained surfaces of fine-grained granites, the distributions of phase-boundary patterns for biotite, quartz, plagioclase and K-feldspar have been quantified by the box-counting method (Fig. 1). All distributions and patterns

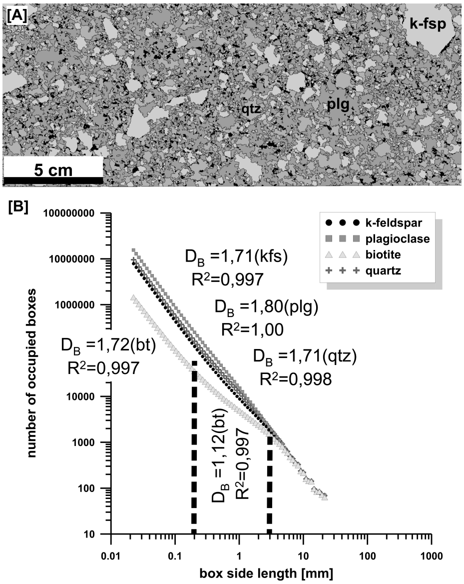

Figure 1: [A] Image of quartz (qtz), plagioclase (plg), K-feldspar (fsp) and bt (black) phases based on data from a stained plate of a fine-grained granite from Central China (plates sold by a do-it-yourself store, Munich). [B] Results of box counting on [A] - the linear relation between the number of occupied boxes and the box-side length plotted in a double-logarithm diagram for all phases shows that the pattern for each face is self similar. The box dimension (D_B — defined as the slope of the line) for all different patterns is app. the same, except for biotite (marked by the dashed lines).

[1] Tectonics and Material Fabrics Section, Technische Universität München, D-80290 München, Germany

are self-similar, and their fractal box-dimensions range from 1.71 to 1.80 for all phases and for all different surfaces of the samples, but they are significantly different within the box-size interval of approx. 0.2 mm to 2 mm for biotite. This indicates the influence of at least two pattern-forming processes during crystallization:

1. equilibrium crystallization conditions for all minerals, and
2. biotite distribution controlled by feldspar, as biotite crystals may have either grown in the remaining spaces or rotated during feldspar growth.

A comparison of manually (highest precision) and automatically digitized crystal distribution and grain-boundary patterns shows no significant differences in fractal-dimension values, and indicates the possibility of fully automated data processing. Box-counting measurements of crystal distribution for hornblende/pyroxene- and feldspar-phases on differently-oriented cuts of a foliated syenite show significantly different box-dimensions for mafic and felsic minerals. This may result either from feldspar having controlled the crystallization and/or orientation of the mafic minerals, or from the influence of early-formed pyroxene cumulates now disrupted and found as schlieren. Otherwise the cut orientation has no influence on the results of the measurements, indicating that the box-counting method is not useful for analyzing anisotropic behaviour of rock patterns.

Anisotropy

Because of the impracticalness of the box-counting method for analyzing the anisotropic rock pattern behaviour of the syenite, the hornblende/pyroxene and feldspar phases on the differently-oriented cuts are analyzed with a new automated process based on the work of Volland & Kruhl (2004). First results should show different orientation behaviour of;

1. the mineral phases in relation to the differently-oriented cuts and
2. different anisotropic behaviour between the hornblende/pyroxene and the feldspar phases.

The results from the differently-oriented cuts could be potentially useful as a step towards the analyses of 3D anisotropic material as well as the interpretation of the 2D cut effect of such material. Different anisotropic behaviour of different mineral phases in the syenite possibly indicate complex geometrical as well as chemical phase-to-phase interactions caused by either different pattern forming processes, for each phase, during the crystallization of the rock or by different crystallization time during the same process.

Results

The application of box-counting, a classical fractal geometry method for analyzing inhomogeneity distributions indicates:

1. Stained, polished and even non-polished granite surfaces yield the same information about the rock pattern distribution and, therefore, about the pattern-forming processes of different phases like quartz, feldspars, and opaque phases even if the precision for digitizing the outlines of the different

phases is not the same in different surfaces. Such record forms the basis of automated fractal geometry procedures and, consequently, of detailed pattern analysis of larger areas.

2. Pattern differences between different minerals may be detected, even if they are not apparent, and quantified, as a necessary basis for the further investigation of pattern-forming processes.

3. Box-counting seems not to be adequate for analyzing the anisotropic behaviour of rock patterns. Thus an automated process based on the Cantor dust method was applied on anistropic mineral-phases patterns. The results show different orientation behaviour of this pattern due to differently oriented rock cuts and mineral phases, potentially indicating

4. complex mineral-phases growth interactions, influenced by one or several pattern forming processes at the same time or at different times, during the crystallisation of the syenite.

5. Combining fractal and non-fractal data, i.e., chemical and/or mineralogical properties of rocks, may provide even more useful data sets.

References

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