QUANTIFICATION OF SYNMAGMATIC FLOW STRUCTURES: a tool for Rock Quality Evaluation

Martin Schwindinger (1), Mark Peternell (1), Benedito C. Rodrigues (2), Jorge Pamplona (3)

1. Tektonophysik, Johannes-Gutenberg University Mainz, 55099 Mainz, Germany, mschwindinger@web.de; 2. CGUP, Porto University, 4169-007 Porto, Portugal; 3. CIG-R /DCT, Minho University, 4710-057 Braga, Portugal

Introduction

Methods based on fractal geometry offer the possibility to quantify complex rock patterns, which provide information about the pattern forming processes [Kruhl. 2013]. Mineral distribution patterns of Variscan post-tectonic granites from NE Portugal (Vila Pouca de Aguiar Pluton) were analysed with the MORFA and Map-Counting method [Peternell, 2011]. The result of the analysis provides information about pattern inhomogeneity and anisotropy, i.e. magmatic flux directions and mineral equilibrium processes in the crystallizing magma chamber. Additionally, the used methods may also provide important information for the rock industry, because they allow a fast and automatically evaluation of rock quality.

Sampling and Processing

The investigated rock is a very homogenous, medium grained biotite-granite. Two granite phases of different economic quality were distinguishable inside the outcrop and are separated by sharp contacts: A homogenous, equal grained granite phase and a large grained phase rich in cumulated feldspar, schlieren structures and small mafic enclaves. No magmatic foliation or lineation is visible in the rock.

For the analysis of rock patterns, high resolution field photographs were taken from six rock surfaces (4.75 -19 m²) and three perpendicular cuts within a quarry. The field photographs were converted to binary images of mineral distribution patterns and analysed with MORFA and Map-Counting. In case of MORFA, 4838 – 20037 single measurements were performed for each rock surface, in case of the higher resolved Map-Counting, 129717 - 533976.

Structural Results

Statistical evaluation of the general very weak pattern anisotropy (Fig.1) results in a mean bulk orientation vector that varies in strength, dependent on the orientation of the analysed surface. Therefore, it is possible to determine an extreme weak subhorizontal magmatic foliation (012/15 NW) and a subhorizontal lineation (010/15 NW), which are in good coincidence with earlier anisotropy magnetic susceptibility (AMS) results of Sant'Ovaia & Noronha [2005].

With MORFA, also the variation of the lineation can be determined, indicating magmatic flow partitioning scale-dependent into different domains. High variation is observable in the decimetre scale and bulk orientations reveal two perpendicular domains at the scale of several meter.

Throughout homogenous results of the Map-Counting analysis with mean D_b-values of 1.55 equilibrium conditions for mineral crystallization during emplacement of the pluton are indicated. Locally, the feldspar cumulated phase show wider D_b-ranges caused by processes such as magma mixing and extraction.

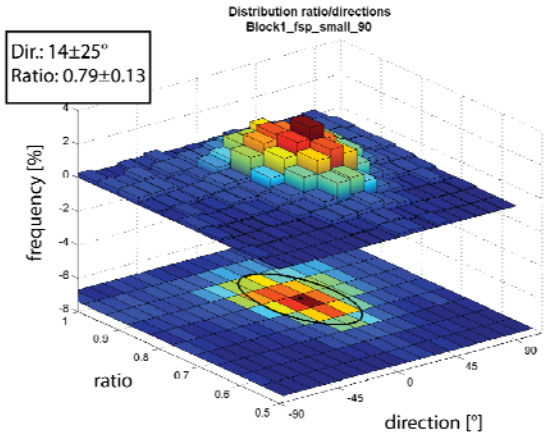

Figure 1: Determination of the bulk orientation vector of a surface by plotting anisotropy intensity and direction into bivariate histograms. The mean and standard deviation are evaluated by a Gaussian fit.

Rock Quality Evaluation

Quarries active in the mining of ornamental rock have to evaluate the quality of their products. In general, stones with very homogeneous patterns are of higher value for the stone industry. As a natural material, formed by the interaction of various geological processes, granite is not homogeneous over large scales. Schlieren, mafic enclaves, variation in grain size or the cumulative phase in the studied quarry mark heterogeneities which are

undesirable and lower the market value of the rock [Taboada et al., 1999]. During application of the methods these features can visualized by contrasting Db-values (Fig.2).

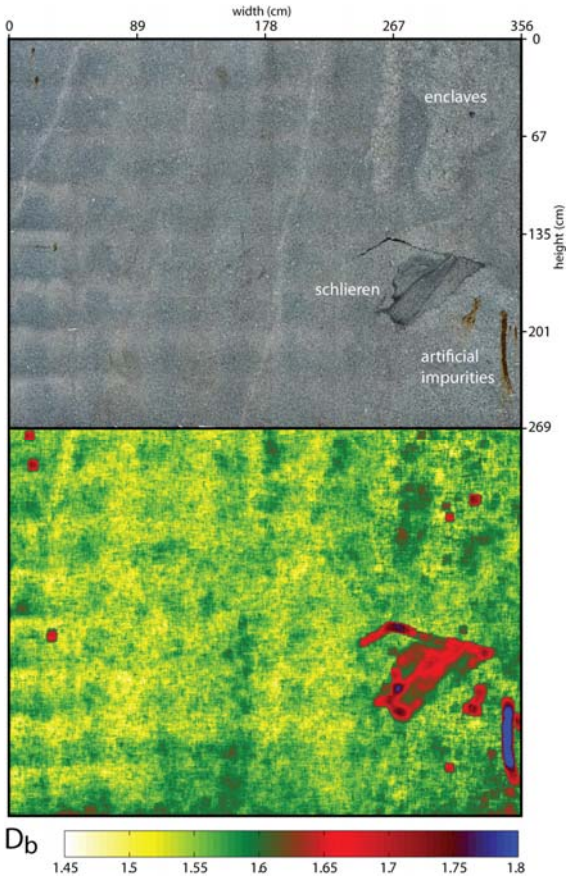

Figure 2: Analysis of a granite surface with Map-Counting. Inhomogeneities, as an impairment of quality, strike out by higher D_b-values.

As far as homogeneity is an essential criterion for economic quality of the rock, the method may be used to determine quarry internal homogeneity distribution and to build up a classification scheme that discriminates various degrees of homogeneity. In this way, the former objectively rock homogeneity can be quantified with absolute numbers and certificated if wanted. As the economic market prefers homogeneous granites, companies owning this high quality rock can stand out against other by a certification. Low quality rock would consequently get no certificate and has to be sold at lower prices. With time customers may prefer certificated granite and a demand is created.

This classification is also advantageous for the end-user, because it offers him a possibility to compare offers and to understand prices. Problems may arise from quarries with less homogeneous rocks, which do no benefit from the classification. But homogeneity is more an aesthetic criterion and relies on natural processes and it is doubtful if the classification should only be based on this single parameter.

Additionally, quantification and knowledge of inhomogeneity and anisotropy distributions in a quarry can provide important information for a mining engineer in directing the mining operations. Based on images taken from superficial rock surfaces it is possible to quickly determine anisotropy directions from mineral distributions, which form preferred directions in the mining.

Acknowledgements

This work is supported by the owners of the Irmãos Queiroz Quarry in Pedras Salgadas, who allowed me to work inside the quarry and provided hospitality during my three week stay.

References

Kruhl, J. Struct. Geol., 46:2-21, 2013.
Peternell et al, J. Struct. Geol., 33:609-623, 2011.
Sant'Ovaia et al, Cad. Lab. Xeol. Laxe, 30:75-86, 2005.
Taboada et al, Eng. Geol., 53:1-11, 1999.