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SPATIAL ANALYSIS OF MICROSTUCTURES IN GRANITE – A CASE STUDY

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INTRODUCTION

Various characteristics of granite have been studied in the context of granite as a physical barrier. The vast majority of its hydraulic properties result from tectonics and fracturing. However, over long time scales, high pressure or gas storage also needs to be considered in order to accurately evaluate granite matrix porosity. Recently, pores and microstructures within the granite matrix have been studied extensively (Menendéz et al. 1999, Mori et al. 2003, Nováková et al. 2010). This poster presents a detailed approach to the description of granite matrix. The spatial data were provided by scanning electron microscope and its subsequent interpretation was undertaken within a GIS.

METHODOLOGY

A detailed ongoing project investigates the characteristics of granite matrix, in the various granites of the Bohemian Massif. Both archive and newly drilled borehole cores have been used to obtain fresh or lightly weathered samples. In order to visualise granite porosity, SEM has been used. In this paper, the applied methods will be outlined with specific reference to sample MEV2-70.

Sample MEV2-70 is derived from a depth of 70 m from the MEV2 borehole in the Lipnice Granite Massif. It is a coarse grained non-porphyric double mica granite. The main minerals are quartz, K- and Na-feldspars, biotite, and muscovite while apatite is also common. Zircon, monazite, and spinel may also be found.

Samples are cut and polished carefully, as require by the scanning electron microscope method. For each sample, a small area (~ 5 x 5 mm) is scanned using a Quanta 450 SEM at a magnification of x 500. To cover the whole area, 81 raster images are generated. These are stitched together, either manually or using Microsoft ICE (Fig. 1). Microcracks, pores, and grain boundaries are manually drawn as separate vector layers from the stitched image. Structures as small as 0.5 µm can be identified thanks to the high magnification and resolution of the image. The major microcracks are then highlighted. In addition, mineral grains are determined using EDAX (Fig. 2,3).

The layers are then imported into a GIS (Fig. 4,5,6). MapInfo and QuantumGIS are used simultaneously to undertake the spatial analyses. These determine the number of pores and microcracks in the different minerals, the surface area of the minerals, and the microcrack trend.

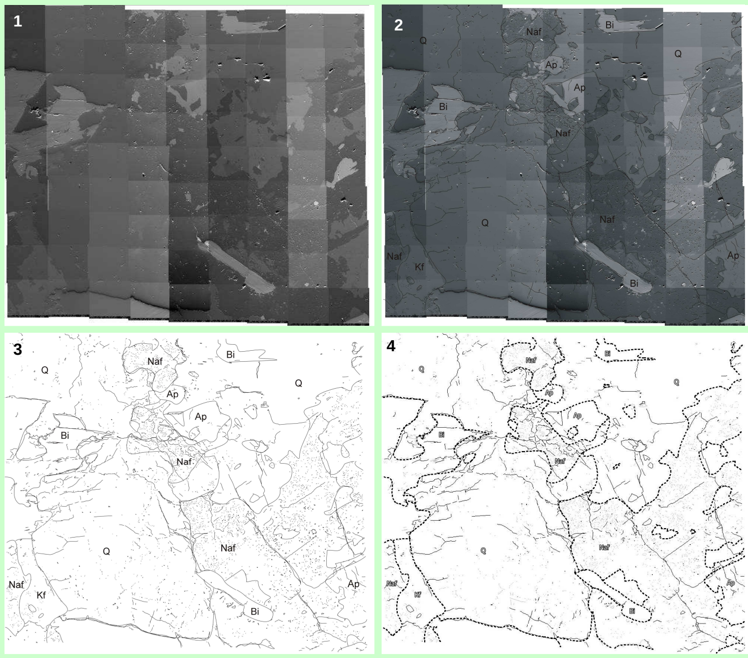

Fig. 1: a mosaic of SEM scans from sample MEV2-70; 2: a mosaic of SEM scans with drawn microcracs, minerals and pores; 3: draft of sample MEV2-70; 4: vector data and its interpretation; grain boundaries (dotted lines), microcracks (full lines), and pores (grey dots).

Minerals	Area		Microcracks			Pores		
	mm²	%	Count	%	per 1 mm²	Count	%	per 1 mm²
Na-feldspar (Naf)	9.43	29.2	256	31.8	27	3565	63.3	378
K-feldspar (Kf)	0.84	2.6	6	0.7	7	132	2.3	157
Biotite (Bi)	1.88	5.8	28	3.5	15	118	2.1	63
Apatite (Ap)	1.08	3.3	21	2.6	20	70	1.2	65
Quartz (Q)	16.08	49.7	256	31.8	16	1481	26.3	92
Other	3.02	9.3	21	2.6	7	270	4.8	90
Grain boundaries	-	-	216	26.8	-	-	-	-
Whole sample	32.33	100	805	100	25	5636	100	174

Tab. 1: The results of the spatial analyses for sample MEV2-70.

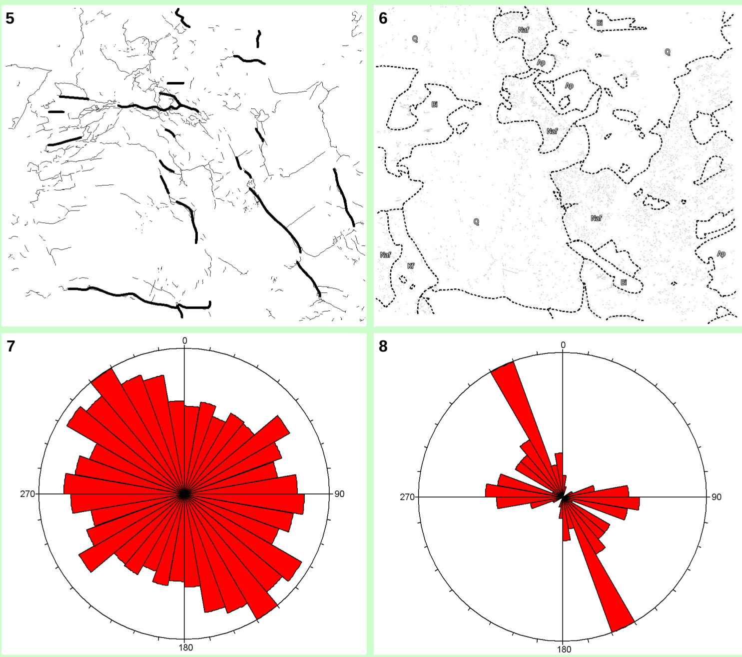

Fig. 5: vector data, microcracks (full lines) and major microcracks (bold lines); 6: vector data, grain boundaries (dotted lines), pores (grey dots); 7: rose diagram of microcrack trend; 8: rose diagram of major microcrack trend.

OUTCOMES

In the SEM images, it is possible to find all four matrix pore types defined by Mori et al. (2003). 'Pores' represent solution pores defined by Mori et al. (2003). Grain boundary pores and crack pores join to become microcracks (see Fig. 4). Sheet silicate pores were regularly observed but have not been depicted.

Moreover, the spatial analyses allow us to segregate pores and microcracks according to the various minerals. For example, the majority of pores occur in grains of Na-feldspar (Tab. 1) Taking the surface area of the mineral into account, the average amount of pores in Na-feldspar is double that of the whole sample average. A comparison between pore-rich Na-feldspar and pore-poor biotite or apatite is even more striking. A quarter of the observed microcracks are associated with grain boundaries. In general, the microcracks follow three main trends (Fig. 7) while the major microcracks follow just two (Fig. 8).

CONCLUSIONS

The SEM images provide a large amount of information. Transforming raster images into vector data before undertaking the necessary spatial analyses is time consuming. It is, however, essential for statistical processing of data, required within the framework of the outlined granite matrix porosity project. It is clear that the identification of minerals or areas that rich in pores or microcracks represents an important stage in the overall evaluation of granite matrix porosity and hydraulic conductivity.

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