INVESTIGATION OF PORE SPACE IN THE GRANITIC ROCKS WITH FILLED JOINT USING X-RAY COMPUTED TOMOGRAPHY

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Summary: Generally the rock porosity and its spatial distribution play main role in the many geotechnical projects. Especially in the granitic rock, the pore space can be significantly influenced in the presence of the fulfilled joints. This joints can affect the migration parameters of the many different pollutant in the almost impermeable granitic rock. The μ-X-Ray CT and Mercury Intrusion Porosimetry were used for investigation of the porosity and its space distribution.

1. INTRODUCTION

One of the key issues in the design and operation of underground storage (e.g. nuclear spent fuel) is the protection of the environment, ie its safe isolation to prevent environmental contamination from the stored materials. The project "PAMIRe" of the Technology Agency of the Czech Republic (TACR) called "Transfer of granitic rock migration parameters from micro-scale to real scale in the rock massive" is dealing with the transport of pollutants in the rock mass.

The porosity and its spatial distribution are one of the most important properties of host rocks, which represent important natural barrier for the pollutants propagation in the environment. Especially in the granitic rock, the pore space can be significantly influenced in the presence of the fulfilled joints. These joints can affect the migration parameters of the many different pollutant in the almost impermeable granitic rock. The detailed knowledge of this phenomenon should enable simplifying the acquisition of relevant data for mathematical modelling of real migration processes and subsequently to help the design of underground facilities and significantly more reliable prediction of their impact on the environment in the long term. The PAMIRe main task of the Institute of Geonics is to visualize the distribution and nature of possible pore space in the selected type of rock material. In this case, crystalline rocks, mainly granitic material, are studied. This crystalline rock mass represents a major the potential locations for underground storages in the Czech Republic, especially for the radioactive waste repository.

2. EXPERIMENTAL METHOD

The contribution deals with the possibilities of mutual using Mercury Intrusion Porosimetry (MIP) and μ-X-ray Computed Tomography (XCT) on crystalline rock samples for analysis of the nature and 3D - distribution of pore space or other inhomogeneities. Variscan tonalites to granodiorites of the „Sázava suite“ (349 ± 12 Ma according to Holub et al. 1997 and 354 ± 4 Ma according to Janoušek et al. 2010 respectively) of the Central Bohemian Plutonic Complex taken from the Josef gallery in the Mokrsko-West gold deposit (about 50 km S from Prague) have been selected for this study. The rocks are mineralogically formed mainly by quartz and feldspars (plagioclase > potassium feldspar), dark minerals are represented by biotite (sometimes chloritised) and hornblende. Zircon is the most abundant accessory mineral.

MIP and XCT analysis were carried out on cylindrical samples prepared by high pressure water jet technology. The specimen volumes were approximately 800 mm^3 (specimen diameter - 10 mm). For porosity measurement, AUTOPORE 9500 porosimetry analyser was used. This device is able to operate with pressures which allowed for the detection of pores with diameters from 5.5 nm to 360 μm**.** The X-ray computed tomographic system X TH 250 ST from Nikon Metrology was employed. It is a fully automated system with a rotary scanning system equipped with a micro-focal X-ray source emitting a conical beam. The XCT system setting was subsequent: I) X-ray

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source operating voltage and power output - cc. 120 kV at 10 W; II) number of radiographic projections - 6283x4; III) radiographic image exposure time 2000 - 2800 ms; IV) flat panel detector with 4000 x 4000 Px's, 100 µm.Px^{-1}; V) cubic voxel resolution - cc. 3 µm. The tomographic data were analysed by reconstruction and analysis software from Nikon Metrology NV (CT for 3D and 2D), Volume Graphics (VGStudio MAX version 2.2 with additional modules for custom image analysis) and Simpleware (Scan-IP with additional modules).
The rock specimens was first scanned using the µ-X-ray CT to obtain the reference visualization and analysis of its inner structure. In the next sequence, the pore space of the tested body was analyzed using the mercury porosimetry. After loading in the mercury chamber, the same specimen was re-subjected to the µ-X-ray CT scan. The presence of mercury (which is of high density) in pores of granite caused significant changes in the distribution of attenuation fields in the analyzed sample. These changes enabled the visualization of the spatial distribution of pore space in the sample after the CT reconstruction.

3. RESULT

The presented results of the pore space analysis in the granite samples using the X-Ray CT and their initial comparison with the results MIP have comparable outcomes. The (see next Table).

Sample	MIP porosity (%)	CT porosity(%)
1A-2	2.48	1.94
2A-1	0.90	0,84
2A-2	1.02	1,20

The pore space is very well recognizable at rock specimens with filled joints. The figure 1(b) represents secondary open micro cracks with opening cc. 0.01 - 0.02 mm laying inside of the visualised joint. The figure 1(a) and 1(c) show the presence of the mercury in the connected (effective) pore space. The other pore space (outside of filled joints) is composed by the less-marked fissures. This fissures are associated with the grains of the biotite and amphibole probably due to its fissility. The X-Ray CT analysis represents a effective and modern alternative technique suitable for analysis of pore space nature in rock.

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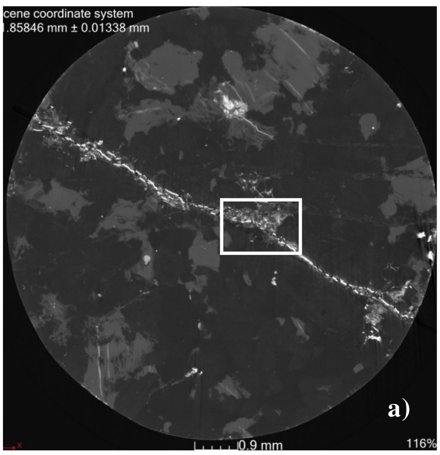
References

[1] Holub, F.V., Cocherie, A., Rossi, Ph. (1997): Radiometric dating of granitic rocks from the Central Bohemian Plutonic Complex (Czech Republic): constrains on the chronology of thermal and tectonic events along the Moldanubian-Barrandian boundary. Compt. Rendus. Geosci., 325: 19-26

[2] Janoušek, V., Wiegand, B.A., Žák, J. (2010): Dating the onset of Variscan crustal exhumation in the core of the Bohemian Massif: new U-Pb single zircon ages from the high-K calc-alkaline granodiorites of the Blatna suite, Central Bohemian Plutonic Complex. J. Geol. Soc. Lond., 167(2): 347-360.



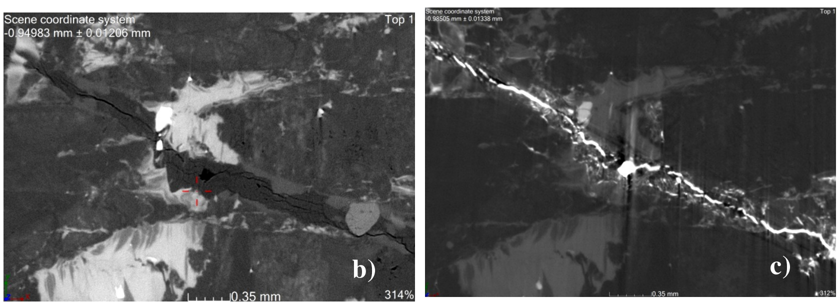


Figure 1: (a) The CT slice after MIP, (b) the detail of filled joint before MIP, (c) the detail of filled joint after MIP