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# Sources and Properties of Natural Building Stone of Bratislava´s Historic Monuments

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The research deals with behavior and properties of the building stone of Bratislava´s monuments, (St. Martin´s Cathedral, Bratislava castle, old city gates, plague columns, etc.), as well as with characteristics of the stone from the source quarries in the vicinity. The monuments are mostly built from various types of weak Neogene detritic litoral sandstone, conglomerate and limestone (Vienna basin), which are subject of decay, mainly weathering and call for the urgent restoration. The main aim of the research is concentrated on the typology of the building stone weathering manifestation and search for the sources of the authentic or similar natural building material. There is no doubt, that very often used incompetent treatment like impregnation, hydrophobic cementation, improper cleaning, use of stiffening plastic coatings, etc. lead to significant changes in the appearance of monuments and to secondary damage (blistering, loss of grains, crystallization of salts, infiltrations, etc.), as well. Therefore the proper restoration method should be the substitution of the damaged stone parts with possibly authentic or very similar natural stone.

Our conclusions concerning the building stone provenance on the actual Austrian territory (sites Wolfsthal, Hundsheim, Leitha a.s.) and it´s use on Bratislava´s monuments were confirmed by several field, microscopic-petrographic and paleontologic studies. Besides it, a great difference (in comparison to microscopic methods like PFM, SEM, XRF a.o. used by Nijland et.al., 2003, Dubelaar et al., 2003, Larbi et al., 2003, etc.) made the decision to use laboratory geomechanical techniques and estimate physical and mechanical rock properties on cylindrical samples, both from monuments and quarries. With this in mind the stone durability and surface changes were assessed. The following characteristics were estimated: rock density, porosity, pore distribu-

tion, water absorption, uniaxial compressive strength (dry $\sigma_{cd}$, saturated $\sigma_{cw}$ and after freeze/thaw cycles samples $\sigma_{cf}$), calculated softening ($C_s = \sigma_{cw}/\sigma_{cd}$) and freezing coefficients ($C_f = \sigma_{cf}/\sigma_{cd}$) and the sample durability in the $Na_2SO_4$solution.

Further tests were carried out for the estimation of pore surface area using BET (60˚ and 110˚C), pore volume and distribution using Hg porosimetry, X-ray difraction and water sorption (SPS 11). Porosity, water sorption, strength characteristics, together with tests in Na2SO4 solution were regarded as suitable indicators of the stone durability. Tested samples were characterized by low strength typical for the group of weak rocks ($\sigma$cd $\approx$ 50 MPa), low durability according to Cs and Cf and relatively quick deterioration of samples in $Na_2SO_4$solution. Weathering changes of external building stone surface like color changes, flaking, scaling, loss of grains, gypsum growth, black crusts, etc. support these results.

All tests confirmed a similarity in behavior of rocks from monuments and historic quarries. Suitable substitutive building stone can be found in active quarries in St. Margarethen and Leitha Mts., or in abandoned quarries on Austrian territory. From investigated sites in Slovakia two promising sources were identified: abandoned quarry in Sokolovce (sandstone used for the restoration of the St. Martin´s Cathedral 50 years ago) and Chtelnica (Cretaceous fine-grained conglomerate).

The obtained data provide a comprehensive base for the interpretation of decay of the historic monuments and give useful hints for their successful conservation and reconstruction.