

Summary

The aim of this research was to determine the nature and effects of rock weathering processes that affected sandstones used in selected monuments of Wrocław, compared to equivalent sandstones from selected quarries in Cretaceous formations of the North- and Intra-Sudetic Basins. Six historic buildings (churches, museums a market hall and a bridge) located in the city centre as well as six quarries, situated within the likely regions of origin of the building stones used in the selected monuments, were studied.

The research especially focused on determining and assessing differences of weathered sandstone surfaces exposed to environmental factors in near-natural conditions (sandstones from the quarries) compared to those in an anthropogenic setting (sandstones from the monuments). An additional objective of the research, in cooperation with biologists, was the determination of the main lichen and moss species living on the analysed rocks and an attempt to assess their role in weathering processes. The study of rock materials was carried out by means of methods and equipment used in petrography and mineralogy, such as: the polarising microscopy, the environmental scanning electron microscopy, the electron microprobe, the X-ray diffraction and other instrumental methods of determining chemical composition of rocks.

Approximately 130 rock samples were analysed. A detailed petrographic analysis of the sandstones provided the basic data for further discussion on deterioration. Sandstones occurring in the monuments of Wrocław and in the quarries show a great similarity mineral composition and textures. The main framework component in all samples is quartz, with average contents of approximately 98%. Cement is represented by microcrystalline silica and clay minerals (mainly kaolinite). The rocks studied show also significant textural similarities in terms of grain size, sorting and related parameters.

The analysis of sandstone surface reaction zones showed considerable differences between samples taken in the quarries and those from the centre of the Wrocław agglomeration. The external surfaces of sandstones sampled in the quarries are mostly characterised by a strong granular disintegration with related flushing and redistribution of the comminuted material and its accumulation on the surface of the samples. On the other hand, the surfaces of the sandstones from the monuments and other buildings at Wrocław are additionally covered with a discontinuous, thin but compact crust which was probably formed as the result of reaction of rock components with environmental

components (water with dissolved compounds) and then accumulation of reaction products together with environment-derived particles. The main component of the crust is an amorphous / microcrystalline with varied elements' composition (predominantly Si, Al, Ca, Fe, S, P). Within this mass and on its surface, there are abundant particles of spherical shape (spherules), showing a variable chemical composition (mainly aluminosilicate glass and iron oxides). There are several secondary substances occurring on the surface of the crust, such as: calcium sulphate, barium sulphate, sodium chloride and calcium phosphate. Secondary substances of this type and spherules are very rarely observed on the surfaces of sandstones from the quarries.

Clear differences were also visible in the geochemical analysis aimed at comparing the heavy metal contents of the altered surface zones and the interior of sandstone samples. The near-surface zones (especially of the samples taken from the historic monuments) are particularly enriched in Pb, Zn, As and Cu and also in Ba, Co, Cs, Nb, Rb, Sr, U, V, Zr, Y.

All the differences in structure and composition of the surface altered zones on sandstones from the historic monuments and from the quarries are the results of different air pollutant concentrations found within the area of urban agglomeration, and that one distant from the anthropogenic impact. A similar relation is also observed in results of the biological analysis. The species diversity of mosses and lichens occurring on the quarry walls was much richer (48 species of lichens, 3 species of mosses) compared to the architecture objects at Wrocław (36 species of lichens, 1 species of moss). One could notice also differences in the form of specimens of the same species depending on the place of occurrence. The mosses from quarries have much more developed colonies compared to those from the city buildings. It was similar in the case of lichens. The lichen thalli from the quarries were bigger and more numerous than the equivalent species found in Wrocław.

The results obtained show that despite a general similarity, the differences in structure and composition of reaction zones of sandstones from the two analysed site groups are significant. The main factor that determined the different course of weathering processes was the greater concentration of pollutants (anthropogenic gases and dust) in the urban air.