# MINERALOGICAL CHARACTERISTICS OF WEATHERING CRUST ON THE POLISH FLYSCH CARPATHIAN SANDSTONES

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The outer zones of protected sandstone landforms such as tors, crags, pillars, mushrooms and others, occurring in the area of the Polish Carpathians are covered by weathering crust with characteristic lamination running parallel to the rock surface (ALEXANDROWICZ & PAWLIKOWSKI, 1982; ALEXANDROWICZ, 2008). In the Carpathian Foothill these sandstones occur within Silesia Unit represented by thick bedded sandstone formations such as Istebna Beds (Upper Cretaceous to Paleogene) and Ciężkowice Sandstone (Lower Eocene). The results of the presented study concern the characteristics of the mineral composition of the surface zones of these natural sandstone forms.

Based on the results of previous work, 31 crust samples of Istebna and Ciężkowice sandstones from six locations were collected. Optical microscopy (Olympus BX 51), X-ray diffractometry (DRON-3.0), scanning electron microscopy with energy dispersive spectrometry (FEI Quanta 200 FEG with EDAX), electron microprobe (Cameca SX-100), Mössbauer spectroscopy (Wissel 360 spectrometer), thermal analyses (Derivatograph C) and sequential chemical extraction (see RZEPA *et al.,* 2011 for details) were used for examine the crust samples.

The main components of the studied sandstones are quartz, rock fragments, feldspars, micas and accessory heavy minerals. The cement is of a mixed nature and formed by a matrix and ferruginous phases – iron oxides and hydroxides sometimes accompanied by carbonate minerals. Ferruginous phases occur in intergranular spaces, comprise pigment in clay minerals, fill fractures in detrital minerals and form single grains of various morphology. Mineralogy of secondary Fe-bearing phases (mostly goethite and hematite) is responsible for the variable colouration and cementation of the sandstones. Goethite is present in yellow and brown-coloured zones, whilst hematite is responsible for red and pink hues. The latter is probably not a direct product of weathering of primary minerals, but is a product of goethite transformation (RZEPA *et al.,* 2011).

The external surface of sandstone is usually covered by a very thin, hard, black crust with a sharp-edged fracture. An amorphous film, up to ten plus micrometres thick, is carbon-rich and contains Si, Al, Fe, P, Cl and K. Aggregates of opal-type silica and small rings with a fairly uniform diameter of several micrometres, probably of biological origin are apparent. Spherical particles of aluminosilicate glass, and iron oxides particles (chiefly hematite) were also found. Their composition and morphology indicate that they originated from industrial emissions (MARSZAŁEK, 2008). Secondary crystalline phases, chiefly gypsum, barite, alunite-jarosite and halite also appear within this layer. The majority of these (except halite) were locally found in the form of a thin, interrupted laminae in a distance from the surface.

The presence of sulfate minerals: gypsum, barite, and alunite-jarosite in sandstones often result from weathering processes accompanied with air pollutants. Sulfur may come from the atmosphere where it occurs commonly as $SO_2$ in various concentrations but it may also be released in the weathering process of sulphides present in the sandstones (KUBISZ, 1964; ALEXANDROWICZ & PAWLIKOWSKI, 1982). Formation of sulfate minerals results from the reaction between the products of decomposition of sulphides and products of weathering of feldspars, and also biotite, glauconite, muscovite, and calcite. Jarosite formation is a common process in all iron sulphide containing rocks, or the rocks subjected to impact of AMD-type waters (BINGHAM & NORDSTROM, 2000). Minerals from the jarosite group often constitute the last sulfate link in the cycle of iron migration within the weathering zone.

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