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THE INVESTIGATION OF GEOARCHAEOLOGICAL LAYERS OF KRAKOW CITY, POLAND

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ABSTRACT. The aim of this paper is the short presentation of the results of mineralogical and chemical investigation of geoarchaeological layers examined at selected areas of Krakow. The information obtained by using mineralogical and chemical methods together with the results of the archaeological investigation enable the complete interpretation of the sequence of different phenomenon in the past. The old areas of the town, where archaeologist, as well as other specialists, conduct underground works, were selected for the investigation. These places are located at the centre of the town, i.e. at the Main Market Square of the City and at the Small Market.

Introduction

The geoarchaeological layers of towns are an important source of information that may be helpful at the reconstruction of various phenomenon. They are investigated mostly by archaeologists looking for interesting and spectacular artefacts (Zaitz, 1998; 2006a; 2006b; Zaitz, Zaitz, 2007). But these layers, their sedimentation, erosion and human activity, contain a lot of other, besides archaeological, information (Kluj et al., 2006; Sokołowski et al., 2006; Wardas et al., 2006a; 2006b; 2007; in press; Wardas, Such, in press). The information obtained by the use of mineralogical and chemical methods together with the results of the archaeological investigation enable the complete interpretation of the sequence of different phenomenon in the past.

The aim of this paper is the short presentation of the results of mineralogical and chemical investigation of geoarchaeological layers examined at selected areas of Krakow – the old capital of Poland. The old areas of the town, where archaeologist as well as other specialists conduct underground works, were selected for the investigation. These places are located at the centre of the town i.e. at the Main Market Square of the City and at the Small Market. The investigation confirms the importance of mineralogical and chemical methods used for the examination of geo-archaeological layers. These methods add a lot of interesting details to the archaeological interpretation of the function of the archaeological sites.

Methods

The samples were drayed, weight and mixed with water. Next, the material was sieved. The following fractions were obtained: <0.063 mm, 0.063-0.18 mm, 0.18-0.5 mm, 0.5-1,0 mm and >1.0 mm. The fraction <0.18 mm was tested chemically using the AAS method, while the fraction 0.18-0.5 mm was tested mineralogically. The samples designated for the mineralogical investigation were prepared as microscopic sections (fraction 0.1-0.5 mm). About 500 grains were counted under the polarizing light microscope using Eltinor automatic counter. The amount of both natural (mineral) components and components of anthropogenic origin was determined. The concentrations of metals, (samples extracted with concentrated nitric acid at 130°C, over a period of 2 hours) verified by repetitions and by an analysis of certified reference materials, were compared to the geochemical background of the regions of Poland.

Archaeological investigations

The Early Mediaeval settlements in Krakow are dominated by sandy-clay strata of relatively low pulpiness (up to 60-80 cm), which have accumulated material traces of various farming activity. There are bits of pugging; much more infrequently metal objects (from iron, bronze and copper), glass products and animal waste. Most often these layers contain sherds, splintered animal bones, crumbled charcoal and bones, horns, semi-precious stones etc. There are also organic and non-organic micro-traces of tree branches, stems and leaves of plants, seeds, fruits and pollen, or even slag affiliated with the waste remains of production of metal objects. Within the highest humus strata, the remains of levels that once functioned as roads, streets and squares hard-paved with pebbles or gravel stand out, just like the levels shaped by the interiors of buildings. Among these layers there are remains of

dirt floors, traces of wood floors, and in more representative sites, floors made of various stones, plaster, mortar, or fired clay.

In the Late Mediaeval period humus and sandy stratification were still formed, unlike the Early Mediaeval formations. But it started to be replaced by other stratification in the areas of the most concentrated farming activity. Apart from the humus formations with dominant sand and clay components, also a series of strata directly affiliated with farming and livestock appeared there. It reached a pulpiness of 300-400 cm, while its chief component was a large quantity of various plant materials (from leaves, branches and splinters, to seeds, pollen, fruits, remains of wooden constructions and everyday objects) and animal waste (animal dung and manure), as well as brick and stone rubble, charcoal, glass, metal, bone and stone objects, mortar and other refuse associated with the farming activities of the city and its residents. Among these humus and organic formations the cobbled surfaces of roads and streets appeared. In Krakow most often, they were made of calcium stone that laid on a sand base, flagstones (made of bricks and flagstones), clay threshing floors, wooden floors and grassy surfaces which were not paved. The Late Medieval development of the stone construction also display brick fragments and tiny calcium-bearing (or sand) stones and strata of wreckage. They were also very often accompanied by levelling embankments, whose task was to achieve a correct configuration of the terrain situated inside the constructions, on the streets, or in their nearby vicinity.

In modern times, after the XVII century – the organic strata such as that affiliated with livestock breeding within the walls of Mediaeval cities vanished to a large degree. Their place is occupied by compensatory layers and levelling embankments, levels with a soft surface (earth) or reinforced with stones (calcium stones), breakstone, gravel, rubble, as well as grounds made of bricks, flagstones and poured lime. The process of excessive collecting and accumulation of strata gradually comes to an end (Radwański, 1975; Zaitz, 1998; Zaitz, 2006; 2007; Zaitz, Zaitz, 2006a; 2006b; Firlet, Zaitz, 2007; Wardas et al., in press).

Mineralogical investigations

The amount of both natural (mineral) components and components of anthropogenic origin was determined. The following components of fraction 0.1-0.5 mm were determined as natural and anthropogenic. Naturally, easy for determination, components are represented by quartz (crushed) and clay minerals in form of aggregates. Fragments of burned clay, glass, organic matter, charcoal, bones etc., where determined as microartefacts of anthropogenic origin.

The Main Market Square. The mineralogical analyses of the fine fraction showed oscillation of the amount of determined components at tested profile. Grains of natural quartz are the dominating mineral while the accompanying microartefacts are represented mostly by unidentified organic compounds (Fig. 1). Traces of small fragments of bones, burned clay and charcoal are present together with these compounds.

Anthropogenic compounds are concentrated at two horizons - at depth of about 2.50-3.00 m and 4.65-5.15 m below the present surface of the Main Market (Fig. 2-3).

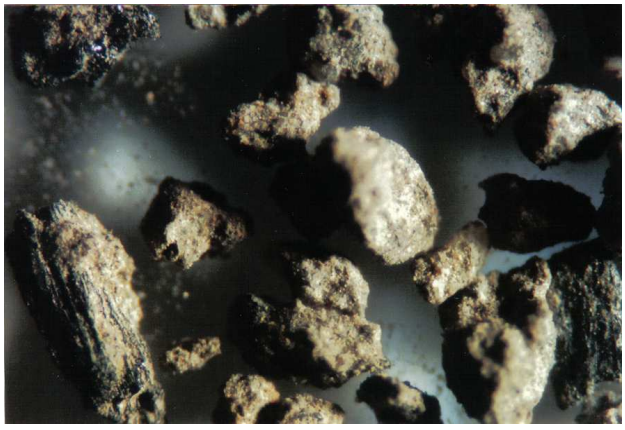

Fig. 1. Organic compounds present in the tested fraction; magnification x15

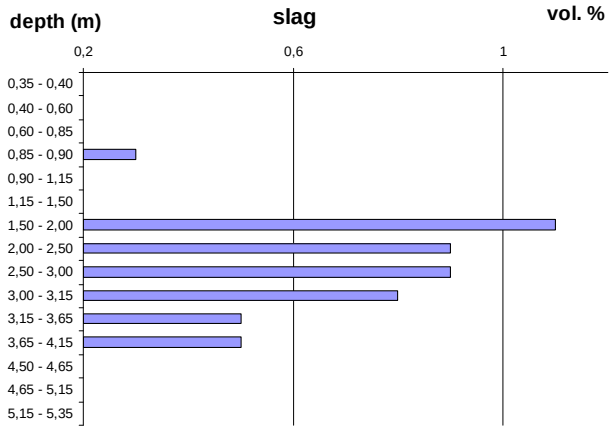

Fig. 2. Diagrams showing the amount of tested components at the examined profile of geoarchaeological layers at the Main Market Square of Krakow

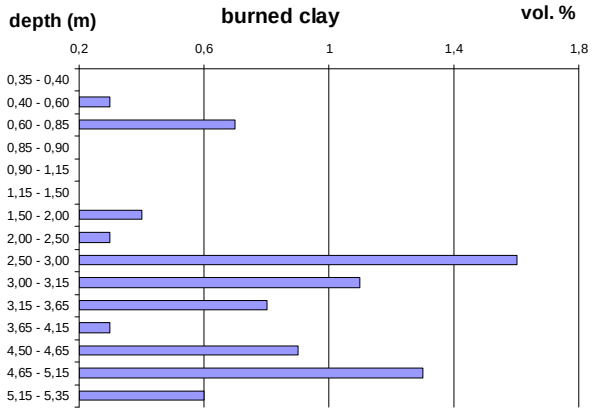

Fig. 3 Diagrams showing the amount of tested components at the examined profile of geoarchaeological layers at Main Market Square of Krakow

The mineralogical investigation helped to determine, among other components (Fig. 4), two types of quartz present at the tested profile. Together with main rounded grains of milky quartz one can observe sharp – crushed grains of pure quartz representing type of crushed rock crystal (Fig. 5). These sharp grains together with small fragments of glass of various colour (Fig. 6-7) confirm the presence of workshops making various products of glass what was unknown up to now in this part of town.

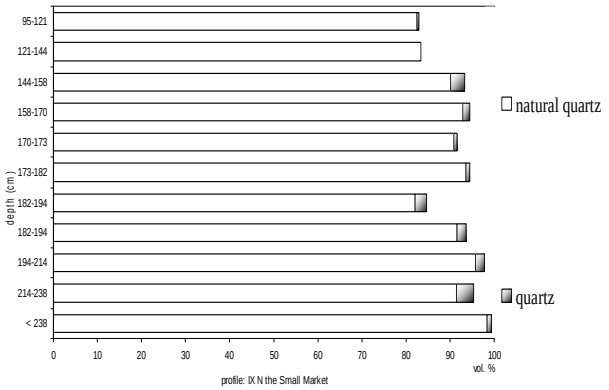

Fig. 4. Diagram showing oscillation of the content of counted components in sediments from the Small Market

Fig. 5. Sharp grains of crushed rock crystal; magnification x15

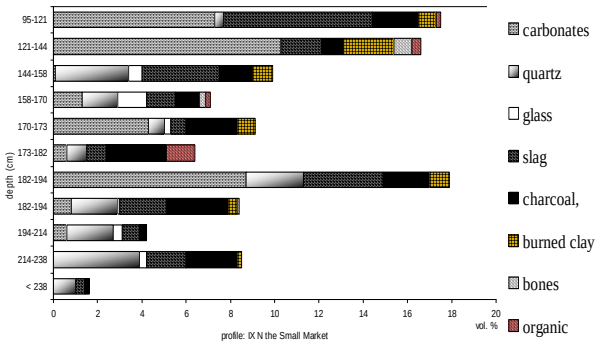

Fig. 6. Diagram showing oscillation of the content of counted components in sediments from the Small Market

Fig. 7. Small fragments of colour glass; magnification x15

Chemical investigations

The origin of concentration of heavy metals, interpreted as indicator for contamination of the usable surface in the discovered layer, i.e. in the specific historical period, requires very thorough analyses and correlation with historiography and archaeological research, including the chronology and the purpose of the examined structure. The accumulated earth layers may be considered as representative components of the environment and may be used to explain what was the historical composition of dust, water and wastewater, earth and soil, domestic waste and excrements, upon the examination of their solid and dissolved (or soluble) components. The chemical analyses of the samples document the presence of high concentration of Cu and Pb (Fig. 8). These concentrations are the result of Medieval metal workshops producing various metal products (Fig. 9; Table 1). The chemical analyses of the material showed low content of heavy metals (Fig. 10). This confirms relatively clean Medieval environment in this part of the town. The chemical analyses of the material showed low content of heavy metals (Fig. 10). This confirms relatively clean Medieval environment in this part of the town.

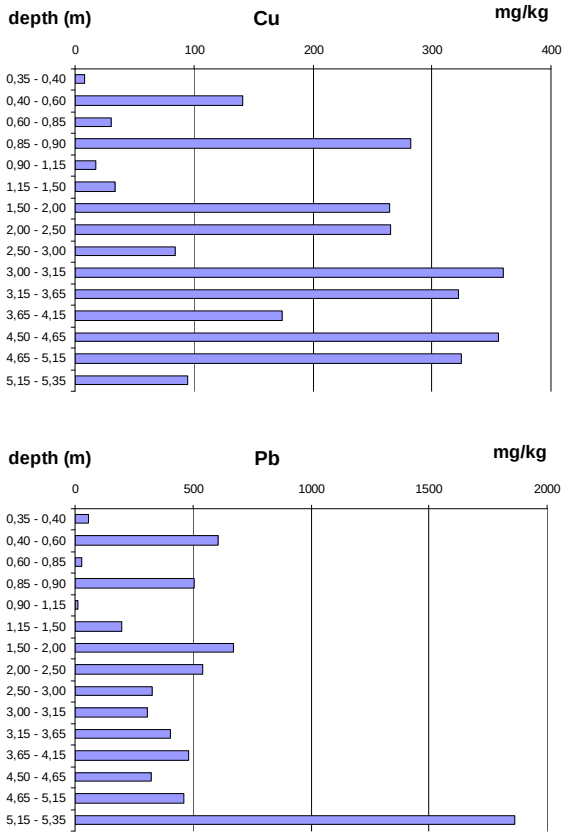

Fig. 8. The variability of Cu (above) and Pb (below) contents (mg/kg) in sediments fromt the Main Market Square of Krakow

Fig. 9. The variability of Pb content (mg/kg) in historical elements of drainage infrastructure

Table 1
The variability of Pb and Cu contents (mg/kg) in sediments from the Main Market Square of Krakow

Site sampling	Pb (mg/kg)	Cu (mg/kg)
Bracka Str.	521	313
	568	229
	762	271
	180	83
	610	195
Great Balance	17333	5655
Sukiennice Hall	595	306
	652	318
	569	229
	429	679
Main Market	201	54
Jana Str.	350	117
	243	70
Grodzka Str.	93	272
	-	313
Small Market	532	301
	283	330

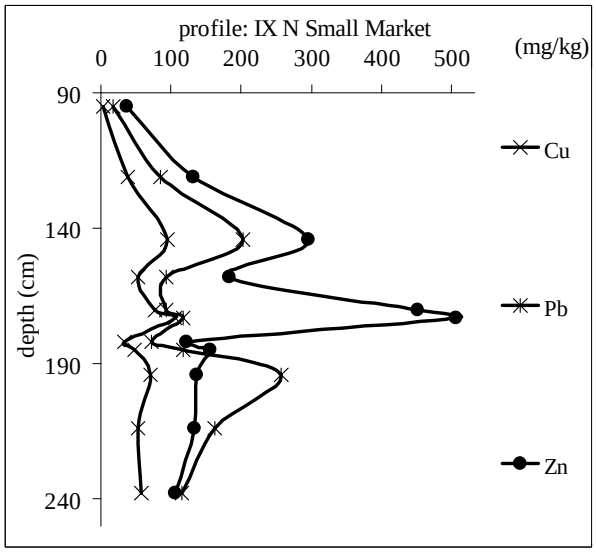

Fig. 10. Diagram showing oscillation of the amount of heavy metals at the profile from the Small Market

Results

The investigation helped to distinguish two main horizons rich in anthropogenic admixture of microartefacts. Moreover, chemical analyses confirmed strong pollution of the Medieval environment of this part of Kraków by heavy metals which was a great surprise, since so far the Medieval environment was thought to be completely pure (Fig. 11).

The large quantities of metals could have been accumulated at that place (just as they are today), and eventually removed with water and wastewater to other places even far from the source. Therefore, the contents of heavy metals in geoarchaeological layers may also be regarded as a geochronological indicator, most distinctively recorded in water sediments from the periods of increased anthropo-pressure.

The previous investigations of historical strata of grounds and sediments showed considerable variations and a strong Cu and Pb anomaly, exactly in the area mentioned above with

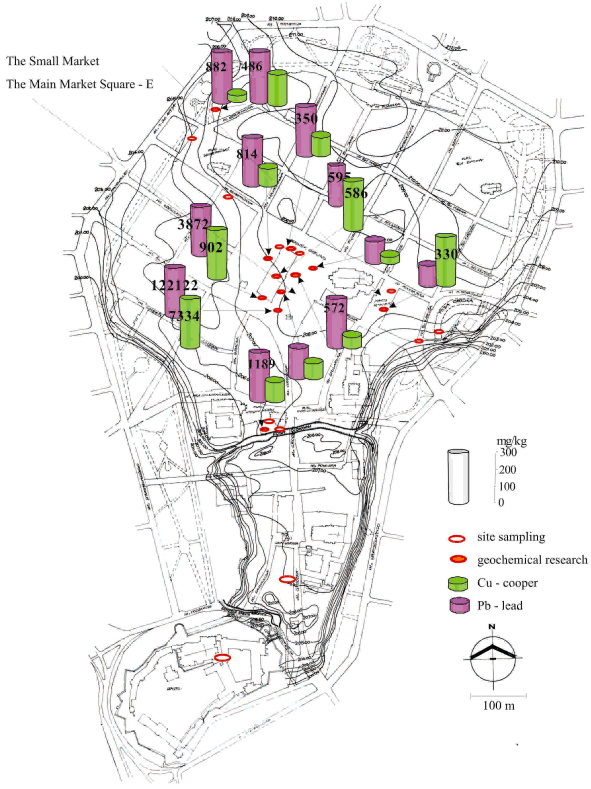

Fig. 11. Sampling sites and areas of geochemical research of historical layers: Kraków – Centre, morphological reconstruction in the Early Middle Ages, the level of the primary soil – undisturbed layer (according to Radwański, 1974; Wardas, Such, in press; Wardas et al., in press)

manufacture-trading objects (with historical manufacture centers, like the Small – and the Great Balance, as well). On the map of Kraków, limited to the area within the Planty Garden and the Wawel Hill, the diagrams of metal accumulation variability, and morphology of the town in those days are presented.

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