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Changes to the environment of intramontane basins in the light of malacological research of calcareous tufa: Podhale Basin (Carpathians, Southern Poland)

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ABSTRACT

The profiles of calcareous tufa occurring in the Podhale Basin (Carpathians, Southern Poland) were subject to a detailed malacological analysis. Studies were carried out in 15 sites. Five of them represent the period of the Late Glacial and Holocene, and the remainder is tufa deposited during historical times. On the basis of malacological analysis, 10 faunistic assemblages were defined. Each developed under specific environmental and climatic conditions. The observed sequences of molluscan assemblages in vertical profiles were the basis for paleoenvironmental reconstruction, determining the main phases of climatic changes and the human impact on the natural environment. The faunal sequence observed indicates a cold climate and the predominance of open habitats in the Late Glacial, with progressing warming and the increasing significance of shaded habitats in the Early and Middle Holocene, as well as anthropogenic pressure in modern times. The results of malacological analysis were complemented with determination of the age of deposits by radiocarbon dating and the results of palynological analyses conducted in the sites of peatbogs occurring in Podhale. The reconstruction indicates similarities and differences in the paleogeographic development of mountain and upland areas of Central Europe.

1. Introduction

Calcareous tufa is a deposit facilitating preservation of subfossil shells of molluscs. Molluscan assemblages occurring in the deposits are characterised by both regional conditions and local environmental features. Thus, they enable interpretation of trends of paleogeographic and climatic changes in the scale of geographic regions. They also give a unique and usually unattainable by other methods chance to reconstruct the local conditions in the direct vicinity of the deposits. The earliest descriptions of calcareous tufa in Poland come from the end of the XIXth and beginning of XXth century. Methodical research on malacological associations occurring in calcareous tufa was, however, undertaken only in the last 30 years. The calcareous tufa occurrence almost always is related to zones of outcrops of rocks rich in calcium carbonate, mainly limestones, marlstones, and calcareous sandstones. The Podhale Basin creates favourable conditions for sedimentation of these deposits. Thanks to the presence of calcareous sandstones of the Podhale flysch, and in the north-western part of the basin limestones belonging to the Pieniny Klippen Belt, over 100 occurrences of calcareous tufa in Podhale were located. The first group of these sites is contemporarily deposited hard and highly porous travertines, usually with very small thickness. They most frequently appear near sources and waterfalls. Many such profiles were located during cartographic research, and their presence is frequently correlated with the course of tectonic zones (Mastella, 1975; Mastella and Rybak-Ostrowska, 2012). From the malacological research point of view, they are of little interest, mainly due to the impossibility to separate shells of molluscs. Sometimes within such occurrences, loose tufa provides shell material. In the Podhale Basin, over a dozen such sites were described (Alexandrowicz, 1997a, 2004, 2010). However, only some of them contain molluscan assemblages useful for paleogeographic and paleoenvironmental interpretations. The second group of sites, much

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more interesting, is calcareous tufa representing longer periods of time, encompassing the whole Holocene and also the close of the Late Glacial. Five such profiles are located in the Podhale Basin (Alexandrowicz, 1997a, 2001a, 2003, 2004, 2013a; Alexandrowicz and Rybska, 2013). The objective of the paper is to present environmental changes of the Podhale Basin on the basis of diversity and sequences of molluscan assemblages occurring in Late Glacial and Holocene profiles of calcareous tufa as an example of paleogeographic evolution of intramontane basins.

2. Material and method

Fifteen sites of calcareous tufa located in the Podhale Basin were subjected to detailed malacological analysis (Fig. 1, Table 1). In total, 37 profiles of these deposits were developed, and 174 samples were the basis for the research. Samples were about 2.0 kg and included intervals of 10–20 cm depending on the deposit structure. Laboratory treatment of materials consisted of maceration and elutriation of rocks, and then selection of all complete shells of molluscs and determinable fragments. Determination of shell material was conducted based on keys and comparative collections. The number of species and specimens was determined in separate samples. Fragments of shells were converted into complete specimens in accordance with the scheme proposed by Alexandrowicz and Alexandrowicz (2011). In total, the analysed material consisted of 94 species of molluscs, represented by over 40 000 specimens and tens of thousands of undeterminable fragments (Table 1).

ecological structure was characterised on the basis of the malacological spectra of individuals (MSI) in accordance with the method described by Ložek (1964), and Alexandrowicz and Alexandrowicz (2011). The classification of molluscs into ecological groups (F – shade-loving species, O – species of open habitats, M – mesophilous species, H – hygrophilous species, and W – aquatic species) was based on the scheme for grouping molluscs from the viewpoint of their ecological requirements developed by Ložek (1964).

Thanks to very rich material, it was possible to separate and identify molluscan assemblages strictly referring to the features of the depositional environment. Separate assemblages were highlighted in accordance with the method described by Alexandrowicz (2004) and Alexandrowicz and Alexandrowicz (2011). The basic criteria were: the presence of taxa with strictly specified ecological requirements, and occurrences of taxa characteristic of climatic phases of the Late Glacial and Holocene. The sequences of assemblages in the profiles constituted the basis for the paleogeographic and paleoenvironmental reconstruction. The ecological characteristics of assemblages were illustrated on triangular diagrams, developed using a method described by Alexandrowicz and Alexandrowicz (2011). Individual projection points were combined into joint fields and named after the separated assemblages.

The age of calcareous tufa was established indirectly and directly. In the first case, the basis was the comparison of the malacocenoses features with other well-documented stratigraphic profiles of deposits with different genesis described from the Polish part of the Carpathians (e.g. Alexandrowicz and Alexandrowicz,

Table 1
Localities and malacofauna of calcareous tufa in Podhale Basin.

Locality	Deposits	Number of profiles	Number of samples	Total number of species	Total number of individuals	References
Os Ostrysz	Calcareous tufa	11	53	59	6340	Alexandrowicz, 1997a, 2001a
Gl Gliczarów	Calcareous tufa; peat; slope sediments	8	49	54	14,893	Urbański, 1932; Pazdur, 1987; Alexandrowicz, 1997a, 2003
Gr Groń	Calcareous tufa; slope sediments	1	17	43	4838	Alexandrowicz, 1997a, 2013a
Nd Niedzica	Calcareous tufa; slope sediments	1	16	55	4324	Alexandrowicz, 1997a; Alexandrowicz and Rybska, 2013
Łn Łapsze Niżne	Calcareous tufa; peat	6	25	42	10,619	Alexandrowicz, 1997a
St Stawiska	Calcareous tufa	1	2	38	997	Alexandrowicz, 1997a, 2010
Cg Czarna Góra	Calcareous tufa	1	1	18	206	Alexandrowicz, 2010
Łw Łapsze Wyżne	Calcareous tufa	1	1	16	125	Alexandrowicz, 1997a, 2010
Łs Łapszanka	Calcareous tufa	1	1	15	196	Alexandrowicz, 2010
Dz Dzianisz	Calcareous tufa	1	1	8	78	Alexandrowicz, 2010
Tr Trybsz	Calcareous tufa	1	1	3	111	Alexandrowicz, 2010
Kc Kacwin	Calcareous tufa	1	2	4	96	Alexandrowicz, 2010
Nv Niedzica Vilage	Calcareous tufa	1	2	23	141	Alexandrowicz, 1997a, 2010
Ma Majerz	Calcareous tufa	1	1	6	122	Alexandrowicz, 2010
Fa Falsztyn	Calcareous tufa	1	2	35	352	Alexandrowicz, 2010

Malacofauna occurring in particular locations were presented in the form of synthetic malacological diagrams. They include a general presentation of the lithology of sediments, characteristics of the ecological structure of assemblages in particular profiles, and – in the case of profiles spanning longer periods of time – in their particular parts, as well as the presentation of molluscan species being the most typical for locations and/or their parts. The

1995a,b; Alexandrowicz and Chmielowiec, 1991; Alexandrowicz, 1997a, 2004) and with the results of palynological research conducted on peatbogs located within the Podhale Basin (Obidowicz, 1990). The direct determination of the age of deposits was possible due to radiocarbon dating of 22 samples. The bases for dating were either shells of molluscs or remains of plants coming from the peat insertions occurring within some profiles. The