



## PROTECTION OF CALCAREOUS TUFA SITES IN SOUTHERN POLAND

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**Abstract.** Calcareous tufa accumulated during the Late Glacial and Holocene reflect the changes of the environment. Numerous profiles of the mentioned deposits have been described from southern Poland. Profiles of calcareous tufa can be studied using various methods including conditions of sedimentation, geochronology, palaeotemperatures as well as plants and animals remains. Results of these analyses are the basis of the reconstruction of the palaeoenvironment, climatic changes and human impact. Selected localities of the mentioned deposits, representing the most complete sequences, should be promoted to the international geological heritage list.

**Key words:** calcareous tufa, geological heritage, Holocene, southern Poland.

**Abstrakt.** Martwice wapienne tworzące się w czasie późnego glacjału i holocenu odzwierciedlają zmiany środowiska. Liczne stanowiska tych osadów zostały opisane w południowej Polsce. Profile martwic wapiennych mogą być badane z użyciem różnorodnych metod obejmujących analizę procesów sedymentacji, paleotemperatur, aspekty geochronologiczne, a także badania szczątków roślinnych i zwierzęcych. Wyniki tych analiz stanowią podstawę dla rekonstrukcji paleośrodowiska, zmian klimatycznych oraz wpływu człowieka. Wybrane profile martwic wapiennych, reprezentujące najbardziej kompletne sekwencje, powinny zostać wpisane na międzynarodową listę dziedzictwa geologicznego.

**Słowa kluczowe:** martwice wapienne, dziedzictwo geologiczne, holocen, południowa Polska.

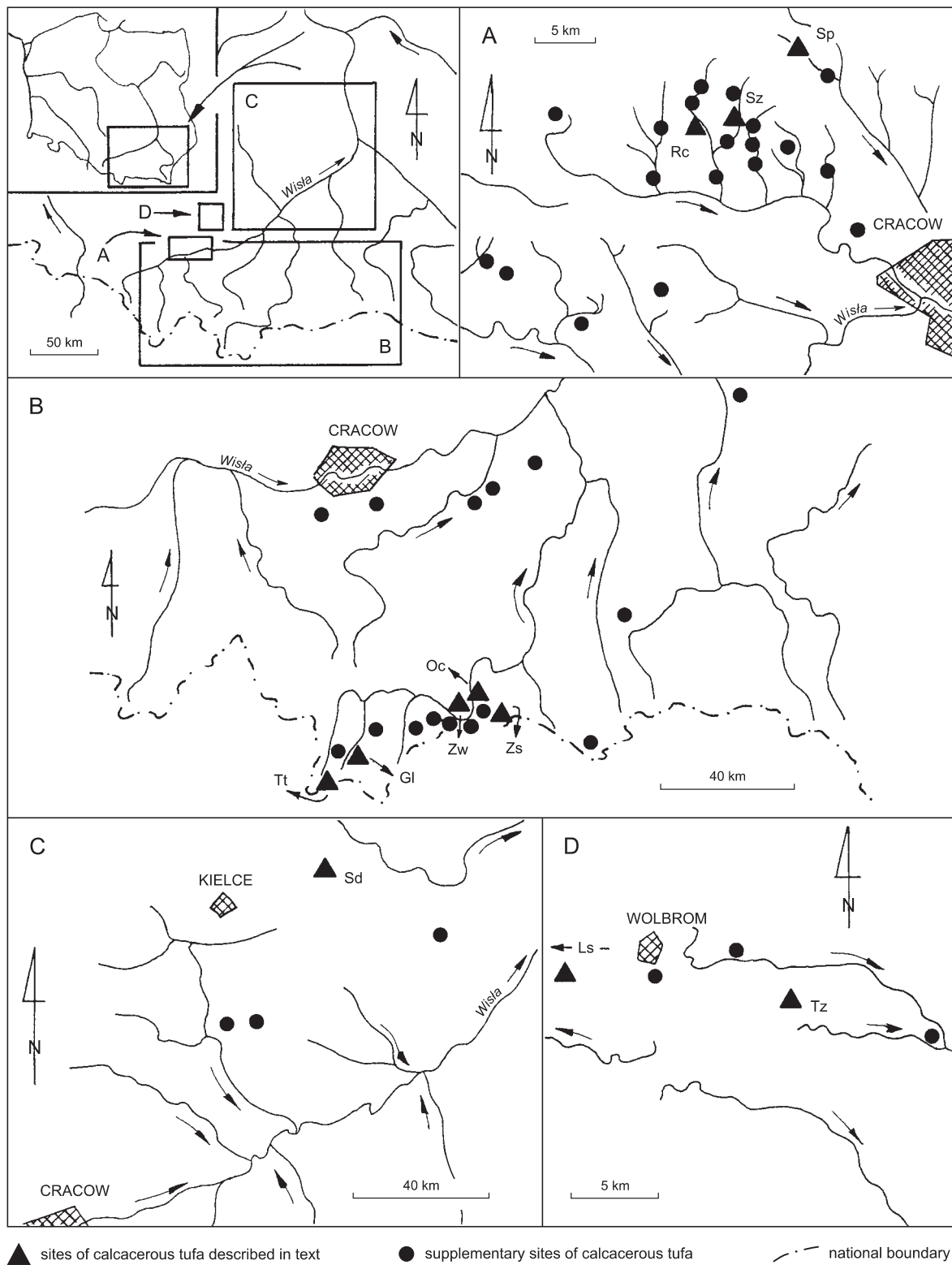
### INTRODUCTION

Late Quaternary calcareous tufa are commonly noted from Poland. Numerous localities of these deposits have been found in Polish Carpathians, Middle Polish Uplands and in the Holy Cross Mountains (Fig. 1). Few sites were described from Sudetes Mountains as well as from the Polish Lowland. The occurrences of calcareous tufa usually correspond with areas build of carbonate rocks. The important part of southern Poland is formed of Palaeozoic, Mesozoic or Tertiary limestones or other carbonate rocks. In the northern Poland, non-carbonate, postglacial sediments dominate. It is a main reason for the unequal distribution of sites of calcareous tufa. They are common in southern Poland and very rare in its northern part.

Calcareous tufa have been formed as a result of precipitating of carbonate calcium. This process is connected with changes of partial pressure or temperature of water and/or with the activity of organisms, especially algae. The mentioned sediments can be found in different geological positions. They

build terraces in relatively narrow stream valleys, forming crusts close to the springs, accumulated in the top parts of peat-bogs, at the base of rocky walls as well as encrusting rock fragments or plant remains, or only cementing pebbles and rock fragments. The lithology of freshwater limestones strongly corresponds to course of deposition. Two types of the mentioned sediments can be distinguished: travertines – cavernous and porous compact limestones and loose grainy tufa composed of detrital travertines, limestone sand and mud, pellets and other elements. Calcareous tufa occur usually as irregular bodies with a very complicated and differentiated internal structure. In several localities, these carbonate sediments contain rock detritus and can be intercalated by organic deposits, mainly peat or slope and fluvial sediments. The thickness of particular profiles vary from several centimetres up to 10 meters.

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**Fig. 1. Location of the selected sites of calcareous tufa in Poland**

Rc — Raclawka Stream Valley, Sz — Szklarka Stream Valley, Sp — Sąspówka Stream Valley; Gl — Gliczarów, Zw — Zawiasy, Oc — Ociemny Stream Valley, Zs — Skalski Stream Valley; Sd — Sieradowice; Ls — Laski, Tz — Trzebień Gorge

## CALCAREOUS TUFA IN SOUTHERN POLAND

Several hundred localities of calcareous tufa have been found in southern Poland until now. The most of them are small bodies of recently precipitating calcareous sediments. They are commonly noted from Pieniny Mountains and Flysh Carpathians. The mentioned profiles are usually composed of thin layers of travertines intercalated with fine or coarse grained tufa. From scientific point of view such sites are less interesting. In some regions in Flysh Carpathians, the occurrences of these deposits are strictly connected with springs following faults (Mastella, 1975; Gruszczyński, Mastella, 1986).

Several profiles of calcareous tufa have been accumulated during the whole Holocene and also sometimes during Allerød and Young Dryas Phase of Late Glacial. These localities reflect environmental changes in the course of last 10,000–12,000 years. Profiles representing similar period are very rare in Central Europe. They were described from Slovakia, Czech Republic (Ložek, 1964) and Germany (Zeissler, 1977), only.

Profiles of calcareous tufa have been studied using various methods including lithology, geochronology, palaeotemperatures as well as plant and animal remains. Lithological analysis made possible the reconstruction of the sedimentary environment. The age of mentioned sediments may be established with the radiocarbon method supplemented by analysis of stable isotopes (Pazdur, 1987). Rich and differentiated molluscs assemblages have been usually found in profiles of calcareous tufa. The fauna is composed of species living in different environments.

Five main ecological groups of molluscs may be distinguished (Ložek, 1964; S.W. Alexandrowicz, 1987): shadow-loving snails, open-country taxa typical of open and sunny habi-

tats, species of wide ecological tolerance (tolerant, mesophile), hygrophile snails inhabiting swamps and marshes, and water molluscs. The taxonomical composition and succession of molluscs communities are the evidence of the environmental changes in particular phases of Late Glacial and Holocene. During the Late Glacial molluscs assemblages were dominated by cold-tolerant snails preferring moist and open environments. At the beginning of the Holocene, a rapid warming of the climate was followed by the expansion of the forests. Shadow-loving species became the main component of the fauna.

The maximum expansion of the forests in southern Poland was connected with the Atlantic Phase of the Holocene (S.W. Alexandrowicz, 1983, 1987; W.P. Alexandrowicz, 1997). The development of agriculture and human activity during the Middle Holocene were the main factors of progressive deforestation. Molluscs assemblages connected with Subboreal and Subatlantic phases are strongly differentiated. In a woodless areas, mainly in the Upland zones, the fauna is dominated by open-country and mesophile species, while in narrow valleys and in the mountains shadow-loving snails still prevail (*op. cit.*). Other organic remains such as ostracods, imprints of trees leaves, stems of plants as well as bones and teeth of vertebrates also appear. Results of lithological, radiometric, floristic and faunistic investigations are the basis of the reconstruction of the palaeoenvironment, climatic changes and human impact. Selected localities of the mentioned deposits, representing the most complete sequences, should be promoted to the international geological heritage list as sites documented the youngest history of the Earth.

## CALCAREOUS TUFA IN PROTECTED AREAS

About fifty localities of Late Glacial and Holocene calcareous tufa have been reported from southern Poland (Fig. 1). Some of them are situated within protected areas: national parks, landscape parks or nature reserves. The other ones are protected as nature monuments or documentary sites of inanimate nature. However, a lot of profiles of the described deposits is still not protected. Several exposures of travertines and calcareous tufa occur within Tatra Mountains, Pieniny Mountains and Ojców National parks.

### Tatra Mountains National Park

A small cone of calcareous tufa have been found in the narrow part of the Kraków Gorge (Fig. 1B). It is formed of fine-grained deposits abounding in angular limestone debris. The mentioned deposits contain a rich fauna of land snails. Similar cones composed of limestone, of dolomitic debris and calcareous tufa were found in several other localities in

the Tatra Mountains. The succession of molluscs assemblages described from these localities indicates the climatic changes and oscillations of the timber line during the last 1000 years. According to the results of malacological analysis, three phases of warming, separated by two phases of colder climate, can be distinguished in this period (S.W. Alexandrowicz, 1988; W.P. Alexandrowicz, 2001a).

### Pieniny Mountains National Park

White coarse and fine grained calcareous tufa were found in Ociemny Stream Valley and Zawiasy, near Krościenko (Fig. 1B). A rich and differentiated molluscs communities with predominance of forest snails occur in these deposits. Both these sites represent Middle and Upper Holocene. Numerous localities of recently forming calcareous tufa have been noted from the whole area of the National Park.

### Ojców National Park

An interesting site of calcareous tufa is cropped out in the Sąspówka Stream Valley (Fig. 1A). The seven meters thick profile is composed of hard, porous travertines overlaid by loose calcareous tufa. Molluscs fauna from this section was described by S.W. Alexandrowicz (1983, 1997). Three types of communities may be distinguished. The first one is characterised by variable content of species belonging to the particular ecological groups. Water molluscs are the main component of the second type, while in the last one open-country molluscs prevail. The profile in Sąspówka Stream Valley represents whole Holocene.

Numerous profiles of calcareous tufa are protected in the nature reserves.

### Skalski Stream Valley (Zaskale-Bonarówka Nature Reserve)

The exposure is situated in the middle part of Zaskale Gorge, near Jaworki in Pieniny Mountains (Fig. 1B). Fine-grained calcareous tufa forming a relatively thin layer contain unusual rich fauna of molluscs composed of near eighty taxa of snails.

### Raławka Stream Valley Nature Reserve

Four travertine steps with ancient water basins filled with calcareous tufa have been distinguished in this valley (S.W. Alexandrowicz, 1983, 2000; Rutkowski, 1991) (Fig. 1A). The most interesting profile is situated about 1 km upstream of the village Dubie. The maximum thickness of the calcareous sediments is up to 9 m. The lithology of the main

outcrop was studied in detail by Szulc (1986), and the age of this deposits has been measured with the radiocarbon method (Pazdur, 1987). Analysis of stable isotopes carried out on samples from this profile (Pazdur *et al.*, 1988) are indicating climatic changes. According to the results of these analysis, the deposition of calcareous sediments started at the beginning of the Holocene and finished during the Middle Ages. The very rich molluscs fauna was described by S. W. Alexandrowicz (1983, 2000). The malacological sequence is composed of five assemblages (from the bottom upward):

- fauna dominated by cold tolerant water molluscs corresponding with the Preboreal Phase of the Holocene;
- mixed fauna with shadow-loving and tolerant taxa typical for the lower part of the Boreal Phase;
- fauna distinctly enriched in shadow-loving species, connected with the upper part of the Boreal Phase;
- rich and differentiated fauna with dominance of woodland species, represents the Atlantic and the lower part on the Subboreal phases;
- fauna with a relatively equal content of particular ecological groups, corresponds with Subboreal and Subatlantic phases.

The main outcrop of calcareous tufa in Raławka Stream Valley is one of the most representative site of such sediments in Poland. Supplementary localities were found in Eliaszkówka Nature Reserve and in Szklarka Stream Valley Nature Reserve as well as in Psary, Będkówka Stream Valley, Rudawa and Kobylany (S.W. Alexandrowicz, 1983, 1997) (Fig. 1A). All profiles mentioned above are situated inside landscape park.

Only a few localities of calcareous tufa are protected as nature monuments or documentary site of inanimate nature. A profile of travertine mound with small cave in Laski Village near Olkusz belongs to the first group (Fig. 1D). The mound is developed within a spring zone. Radiocarbon dating indicate the early and middle Holocene age of this travertines. Numerous shells of molluscs have been found in this profile (Gradziński *et al.*, 2001; Tyc, 2001).

## SELECTED UNPROTECTED PROFILES

Several profiles of calcareous tufa and travertines are not protected. Some of them seem to be very interesting and important.

### Trzebienice Gorge

Outcrops of calcareous tufa are located along the narrow part of small stream in Trzebienice near Wolbrom, about 30 km north of Cracow (Fig. 1D). Fine and coarse grained calcareous tufa build 7 m high terrace. The mentioned sediments were studied in detail using lithological and malacological analysis and dated by radiocarbon method (Pazdur, 1987). The deposition of calcareous tufa in Trzebienice started in Young Dryas and finished during historical times. Similar profiles were found nearby, in Rzeżuśnia and Sulistawice. The site Trze-

bienice should be protected as geological reserve, while the remaining ones as documentary sites of inanimate nature.

### Sieradowice

Late Glacial and Holocene calcareous tufa intercalated with organic mud were recognised in Sieradowice, in Holy Cross Mountains (Fig. 1C). Several samples from this site were dated with radiocarbon method. Lithological, malacological and stable isotopes analysis were carried out, too. The results of these investigations enabled the reconstruction of palaeoenvironment and history of sedimentation (S.W. Alexandrowicz *et al.*, 1987; Pazdur, 1987). The described site will be protected as documentary of inanimate nature.

### Gliczarów

Travertines intercalated with loose calcareous tufa and peat have been found in Gliczarów, north of Zakopane (Fig. 1B). Calcareous sediments occur as a layer about 2 m thick with very complicated internal structure. The sequence of molluscs

assemblages reflects the environmental changes during 12,000 years. Radiocarbon and stable isotopes analysis have been carried out, too. Similar sites of calcareous tufa in Podhale Basin occur in Groń, Ostrysz, Niedzica and Łapsze Niżne (Pazdur, 1987; W.P. Alexandrowicz, 1997, 2001b, 2003). These localities should and will be protected as documentary sites of inanimate nature.

## PROTECTION OF LATE GLACIAL AND HOLOCENE CALCAREOUS TUFA

Late Glacial and Holocene calcareous tufa and travertines are particularly interesting as documents of the youngest geological history of the region, changes of the environment and climate as well as the human impact. The mentioned sediments have been studied from different points of view. The results of these analysis can be useful in palaeogeographical reconstruction. The most important sites should be protected for science and education. Some sites described above are of regional or even international importance. They have to be protected as documentary sites of inanimate nature. Profiles of calcareous tufa in Raclawka Stream Valley, Szklarka Stream Valley, Trzebienice Gorge, Sieradowice and Gliczarów (Fig. 1) seem to be the most important and interesting ones. Such suggestion is supported by the following reasons:

- Several different lithological types of tufa and travertines as well as a lot of sedimentary structures may be observed.

- Calcareous tufa contain a rich and strongly differentiated molluscs assemblages characterising the environmental and climatic changes during the last 12,000 years. The location of particular sites in different geographical regions enable both local and regional reconstruction.
- A lot of samples have been dated with the radiocarbon method.
- Stable isotopes were analysed in several samples.
- Only a few sites of similar scientific value of calcareous tufa have been described in Central Europe till now.
- From those reasons pointed above sites should be promoted to the international list of geological heritage.

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