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BADENIAN PYROCLASTIC LEVEL FROM GACKI IN NIDA VALLEY,
CARPATHIAN FOREDEEP, POLAND

Abstract: The paper yields new data on mineralogy of the pyroclastic sediments (tuffite) outcropping in Gacki (Nida Valley), at the top of the marly clays (Ervilia Fm), around 4 metres below the crystalline gypsum. The tuffite, impregnated with considerable amounts of secondary gypsum, consists of clay matrix and crystaloclasts of quartz, feldspars, and altered biotite flakes. The heavy fraction contain ilmenite, apatite, prismatic crystals and rounded grains of zircon, as well as metamorphic minerals; garnet, epidote and staurolite. Mineralogical composition of the tuffite indicates diversified origin of its components and acid volcanism as a source of the pyroclastic material.

Keywords: pyroclastic rock, Gacki, Miocene, zircon.

GEOLOGICAL BACKGROUND

Miocene sediments of the Carpathian Foredeep in Poland cover a triangle-shaped area between the northern edge of the Flysch Carpathians and southern slopes of the Holy Cross Mts. Evolution of this basin, filled with various clastic, argillaceous, evaporitic and calcareous sediments, was closely related to the orogenic activity of the Carpathians, which determined depositional processes and facies distribution (Oszczypko 1996).

The Nida river valley is situated in the north-western, peripheral part of the Carpathian Foredeep. At the beginning of Middle Miocene (Badenian) this part of the basin consisted of a system of depressions (troughs or sub-basins), successively filled with sediments, and local shoals, stretching along the southern slopes of the Holy Cross Mts., between the Nida and Vistula rivers (Peryt et al. 1999). In this area the Badenian sequence begins with brackish facies followed by open marine, siliciclastic and lithotamnium-limestone facies (Baranów Beds and Skawina Formation) and a sandy or marly layer at the top (Ervilia Bed - Łuczowska 1967). Succeeding sulphate deposits (gypsum and anhydrite) are up to 60 m thick (Kubica 1992; Bąbel 1999).

The investigated pyroclastic sediments were encountered in the village Gacki near Pińczów, within the area of the Nida Valley Landscape Park (Fig. 1). Several-metre high escarpment on the north-eastern side of a small road between an abandoned gypsum quarry, actually filled with water, and the Lafarge Nida Gips plant presents a profile with hell-gray marls (Ervilia Fm) in its lower part and a few

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layers of coarse-crystalline gypsum at the top. The pyroclastic level, around 10 cm thick, occurs within marls, around 4 metres below the bottom of the gypsum series. It distinguishes from the surrounding marls by not uniform, gray-blueish colour with rusty patches of secondary iron hydroxides.

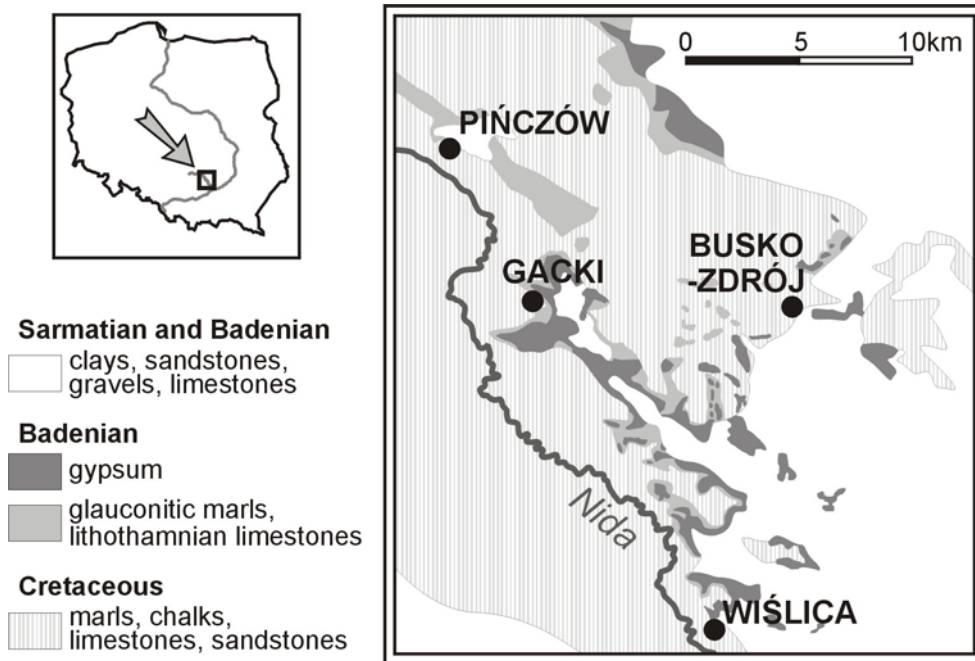


Fig. 1. Geological map of the Nida valley area, after Bąbel (1999), simplified.

METHODS

Thin sections of the pyroclastic rock (tuffite) and the adjacent marls, as well as grain mounts of the heavy fraction were examined in polarizing microscope Olympus BX-51. Pulverized rocks and the distinguished clay fraction were subjected to X-ray analysis. One polished sample and selected crystalloclasts of the pyroclastic rock were analysed in scanning electron microscope (SEM/EDS).

Heavy minerals were separated in tetrabromoethane ($C_2H_2Br_4$, $d=2.97 \text{ g}\cdot\text{cm}^{-3}$), from earlier distinguished coarser grains ($> 0.0625 \text{ mm}$), after removal of clay particles. X-ray analyses were made with the Philips X'Pert APD PW 3020 diffractometer in conditions as follows; CuK_{α} radiation, reflexion graphite monochromator, scanning step = 0.05° . X-ray patterns were recorded in the 2θ range of $3-73^{\circ}$ and diffraction peaks were interpreted with the XRAYAN computer program and the JCPDS standards.

Analyses SEM/EDS were carried out in FESEM Laboratory of the Institute of Geological Sciences, Jagiellonian University, with the microscope HITACHI S-4700, microanalysis system NORAN Vantage.

RESULTS

Microscope analysis revealed that the marls consist of very fine, pelitic clayey-calcite matrix with somewhat bigger (0.1-0.3 mm) detrital elements; angular quartz grains, calcite bioclasts, as well as sparse biotite flakes and black, opaque crystals. Minor components of secondary origin are green glauconite, dark brown, semi-opaque iron oxides, and automorphic gypsum crystals (up to 0.5 mm) filling voids and cracks. The tuffite is mostly composed of clay matrix and secondary gypsum crystals of various dimensions. Among crystalloclasts (angular or weakly rounded, up to 0.3-0.4 mm) quartz and feldspars are prevailing. Minor components are glass shards, rock fragments, thin flakes of biotite (up to 0.5 mm in length) and heavy minerals.

X-ray analysis of the marl sample pointed out quartz and calcite as the main phases, and smectite (15.1 Å) and mica (10.1 Å) as minor admixtures. In the case of the tuffite, the most intensive peaks were related to gypsum. Separation of pure clay fraction (below 2 µm) was hindered by coagulation of tiny particles, which formed relatively dense suspension just above coarser grains and crystals on the bottom. Diffraction pattern revealed that the main components of the suspended material were mixed-layered smectite, with the main peak at 15.6 Å, and gypsum.

Microscope investigations of the grain mounts allowed to recognise zircon, garnet, staurolite, biotite, and dark-brownish, almost opaque aggregates, presumably secondary iron hydroxides.

SEM/EDS analyses of the polished sample of the tuffite confirmed that the main crystalloclasts are feldspars, quartz and altered biotite. Among the separated crystals and grains there were distinguished zircon, apatite, ilmenite, garnet and epidote.

Table 1. EDS analyses of feldspars from Gacki tuff. Compounds in wt %, cation results based upon 24 Oxygen atoms.

Compounds	GACK 2-2	GACK 2-1	GACK 5-4	GACK 5-3	GACK 3-1
K ₂ O		0.48	0.33		7.98
Na ₂ O	4.07	6.83	5.74	10.35	2.44
CaO	11.93	6.42	8.87		
Al ₂ O ₃	28.08	23.98	25.61	19.22	13.39
SiO ₂	55.92	62.29	59.46	70.43	76.19
Total	100.00	100.00	100.00	100.00	100.00
Cations					
K		0.081	0.056		1.332
Na	1.062	1.758	1.487	2.606	0.618
Ca	1.722	0.914	1.271		0.914
Al	4.457	3.752	4.037	2.940	2.064
Si	7.531	8.270	7.951	9.144	9.965
Total	14.772	14.774	14.802	14.689	13.978

Feldspars are of different chemical composition, from alkali perthite (with quartz intergrowths) and almost pure albite to labradore (Table 1). Biotite is

Fe-rich with cationic ratio Mg^{2+}/Fe^{2+} around 1 : 3.3. Zircon is represented by euhedral, prismatic crystals (up to 0.4 mm in length) and less frequent, significantly smaller (< 0.1 mm), rounded grains. All analysed zircons proved to be pure, without detectable amounts of Hf, U or Th. Ilmenite, in form of euhedral or subhedral crystals, contained small admixtures of Mn, V and Mg. Garnets, observed only as fragments of broken crystals, were almandine-rich, with minor contents of Mg, Ca and Mn.

CONCLUSIONS

Patchy, gray-blueish and rusty colouration of the rock, its easy disintegration to loose grains, and high content of secondary gypsum indicate that the analysed tuffite is strongly altered. This may be also supported by relatively high content of clay matrix and low of volcanic glass. Two generations of zircon and minerals of metamorphic origin, like garnet, epidote, and staurolite point out various sources of terrigenous and pyroclastic material. Chemical composition of clay and feldspars, together with presence of biotite suggest that the pyroclastic material could be related to acid volcanism, like in the case of the Bochnia tuff (Parachoniak 1954, Dudek, Bukowski 2002).

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