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Basalt Weathering Crust from Rutki near Niemodlin (Opole Voivodeship) – opportunities for its current utilization and remarks on its former use

Introduction

Basalts are igneous rocks utilized, among others, for the production of top-quality crushed stone. In Poland, Tertiary basalts occur in a belt extended from the St. Anna Hill near Strzelce Opolskie through the Lower Silesia to the Polish-German national border on the Nysa Łużycka River. If very fresh, the basalts reveal particularly favorable physico-mechanical properties, such as high compressive strength, high abrasion resistance, frost resistance, low water absorption capacity and related extremely high tightness, very low porosity and only a small difference between density and bulk density. However, under favorable physico-chemical conditions, basalts relatively easily undergo weathering processes, particularly chemical weathering, which results in the decomposition of major minerals,

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both femic (pyroxenes, olivines) and sialic (plagioclases). This is illustrated by the dissolution series of minerals developed by Goldich (1938) (Figure 1). His research was continued by numerous authors including Eggleton and Wang Qiming (1991). The weathering of basalts mainly produces clay minerals, the types of which depend mostly on the physico-chemical conditions controlling the given weathering environment. The relatively easy conversion of rock-forming minerals in basalts into the clay minerals, particularly those from the smectite group (Figure 2), is confirmed by the results of laboratory experiments reported by

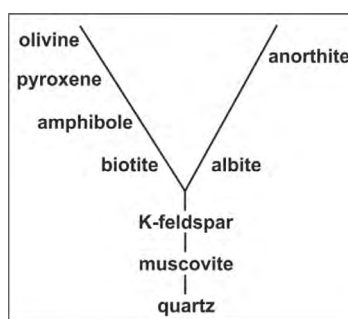


Fig. 1. Susceptibility of major rock-forming minerals of igneous rocks to chemical weathering (after Goldich 1938)

Rys. 1. Podatność głównych minerałów skałotwórczych skał magmowych na wietrzenie chemiczne

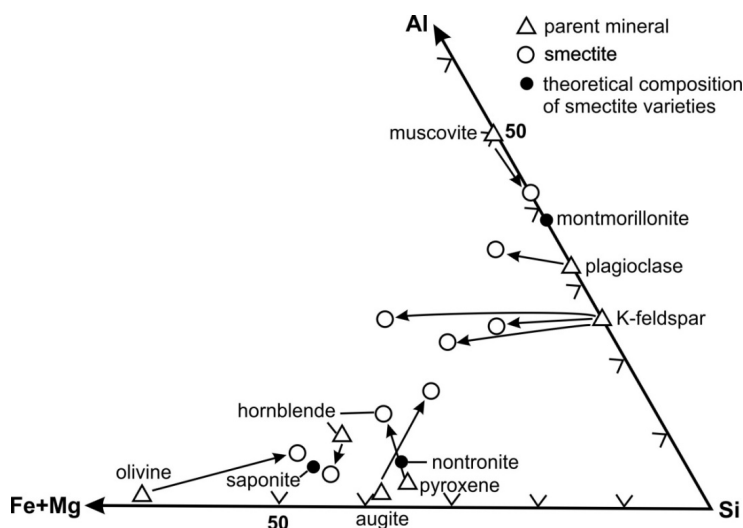


Fig. 2. Weathering pathways of major rock-forming minerals of igneous rocks (after Eggleton and Wang Qiming 1991)

Rys. 2. Kierunki wietrzenia głównych minerałów skałotwórczych skał magmowych

Kühnel and van der Gaast (1989) as well as by recent mineralogical and chemical studies on basalts from the Miraflores region in Panama conducted by Garcia-Romero and Suarez (2021). The latter results demonstrate that the quality of crushed stones produced from some basalt varieties quickly degrades under tropical climate conditions through the generation of smectite-group clay minerals. Such undesirable processes were observed in some crushed stone dumps after only a few months of storage. Obviously, aggregates showing such changes are unusable for concrete production, particularly for concretes used for the widening and deepening of the Panama Canal as well as for the construction of its additional locks in the years 2014–2016 (for details see Garcia-Romero and Suarez 2021).

1. Historical and recent applications of lower Silesian basalt weathering crusts

Centuries ago, the exploration of basalt weathering crusts in Silesia was much more adequate in the western part of the region than in its eastern part. This is particularly the case for the application of the crusts for medical purposes, especially for the preparation of medicines. Such application was initiated in 1568 by Johannes Montanus (1531–1604), a medic from Strzegom and later a doctor at the court of Emperor Rudolf II Habsburg. Montanus used the local basalt weathering crust rich in smectite-group minerals for the manufacturing of so-called *terra sigillata Strigoniensis*. Accumulations of that weathering crust were found at the top of three basalt hills towering over Strzegom town: the Szeroka Hill (German name *Breitenberg*), the Św. Jerzy Hill (German name *Georgenberg*) and the Krzyżowa Hill (German name *Kreuzberg*). The raw weathering crust was washed and then tablets were formed of around 1 inch (24 mm) in diameter and 0.5 inch thick. Each tablet was marked with a stamp identifying the producer. Due to the outstanding sorption properties of smectite, tablets were applied as a medicine, especially for stomach ailments, but were also used excessively and ineffectively for the treatment of many other diseases. However, the successful application of medicine invented by Montanus had been quickly noticed in many parts of Silesia (Figure 3) where accumulations of weathering clays that were mostly developed on basalts were discovered, and many competitive production centers of *terra sigillata* were established (Figure 4). An extended historical review of this interesting problem was recently published by Spielvogel and Pająk (2021). Also worthy of mention is the paper by Kowalski and Wiewióra (1974) focusing on the mineralogical aspect of the *terra sigillata*. The *terra sigillata* had become a popular remedy until the second half of the eighteenth century and then it completely disappeared. However, the healing clays were also known, although to much lesser extent, in the Opole region, which was formerly a part of Upper Silesia. The examples are red clays from Płużnica near Strzelce Opolskie and Krasiejów near Opole as well as white clays from Boroszów near Olesno (Spielvogel et al. 2021). Unfortunately, the available sources do not enable the identification of these clays as basalt weathering crusts. It must be emphasized that smectite-based pharmaceutical preparations



Fig. 3. Locations of Silesian medicinal clays *terra sigillata Silesiaca* (black triangles).
 Western Silesia: Strzegom (in German: *Striegau*), Legnica (*Liegnitz*), Złotoryja (*Goldberg*),
 Janowice Duże (*Groß Jänowitz*), Sichów (*Seichau*), Jawor (*Jauer*), Dzierżoniów (*Reichenbach*),
 Masłów (*Massel*) and Brachów (*Brechelwitz*).
 Eastern Silesia: Krasiejów (*Schönhorst*), Płużnica Wielka (*Groß Pluschnitz*) and Boroszów (*Boroschau*)
 (after Spielvogel et al. 2021, modified)

Rys. 3. Lokalizacja złóż (czarne trójkąty) skał ilastych wykorzystywanych do wytwarzania *terra sigillata Silesiaca*.
 Zachodnia część Śląska: Strzegom (nazwa niemiecka: *Striegau*), Legnica (*Liegnitz*),
 Złotoryja (*Goldberg*), Janowice Duże (*Groß Jänowitz*), Sichów (*Seichau*), Jawor (*Jauer*),
 Dzierżoniów (*Reichenbach*), Masłów (*Massel*), Brachów (*Brechelwitz*).
 Wschodnia część Śląska: Krasiejów (*Schönhorst*), Płużnica Wielka (*Groß Pluschnitz*), Boroszów (*Boroschau*)



Fig. 4. Tablets of *terra sigillata* with stamps of various production centers in Silesia
 after Volkmann 1720 fide Spielvogel and Pająk 2021

Rys. 4. Pastyłki *terra sigillata* ze znakami różnych wytwórni śląskich

are still used in modern medicine and are available in our pharmacies, such as the popular *Smecta* produced in France.

The recent mineralogical and geological studies on weathering processes of basalts from the western part of the Lower Silesia were initiated by Kozłowski and Parachoniak (1960) followed by numerous extended and detailed research projects completed in the second half of the twentieth century and summarized by Dyjor et al. (2008).

If the weathering zone of basalt extrusion is fully developed, three sub-zones can be distinguished (Dyjor et al. 2008):

- ◆ smectite (most common),
- ◆ smectite-kaolinite,
- ◆ kaolinite.

In some basalt weathering crusts, the smectite sub-zone is absent and the smectite-kaolinite sub-zone directly covers the slightly weathered basalt surface; in other cases, only the kaolinite sub-zone is present. In some cases, the latter may contain halloysite – a poorly ordered member of kaolinite group.

Together with mineralogical and geological studies, in the late nineteen-sixties, numerous applied research projects were run concerning the utilization of basalt weathering crusts for technological purposes, particularly at the Wrocław Technical University under the management of Prof. Marian Rutkowski (see summary in Rutkowski 2008). The results proved the usefulness of basalt weathering crusts for the production of many mineral sorbents such as bleaching earth and adsorbents used in many industries, especially in oil processing, petrochemistry and carbochemistry, pharmaceuticals, food processing, plastics production and environment protection.

Unfortunately, this extended research did not include the eastern part of Silesia, i.e. the Opole Region, where the vast, Central-European Volcanic Province of Tertiary age terminates. It embraces, inter alia, the St. Anna Hill basalts and the currently operating basalt quarries in Gracze, Ligota Tułowicka and Rutki. Fragmentary studies on tuffs from the Gracze deposit were reported by Kapuściński and Probierz (1999); the weathering crust currently assessed in the Rutki deposit is described below in Section 2.

2. Basalt weathering crust from the Rutki deposit

Basalts encountered in the vicinity of the St. Anna Hill, were identified as nephelinite, as was the case with the rocks forming the Rutki deposit (Wyszomirski et al. 2017). During the quarrying operations run in 2018, significant accumulations of weathering crust (about 20,000 m³) were encountered in the overburden covering the northwestern part of the quarry (Figure 5).

For this study, two samples of weathering crust: No. 1387 and No. 1388, about 1.5 kg each, were collected in 2018, and supplemented later with additional amounts for geochemical analyses.

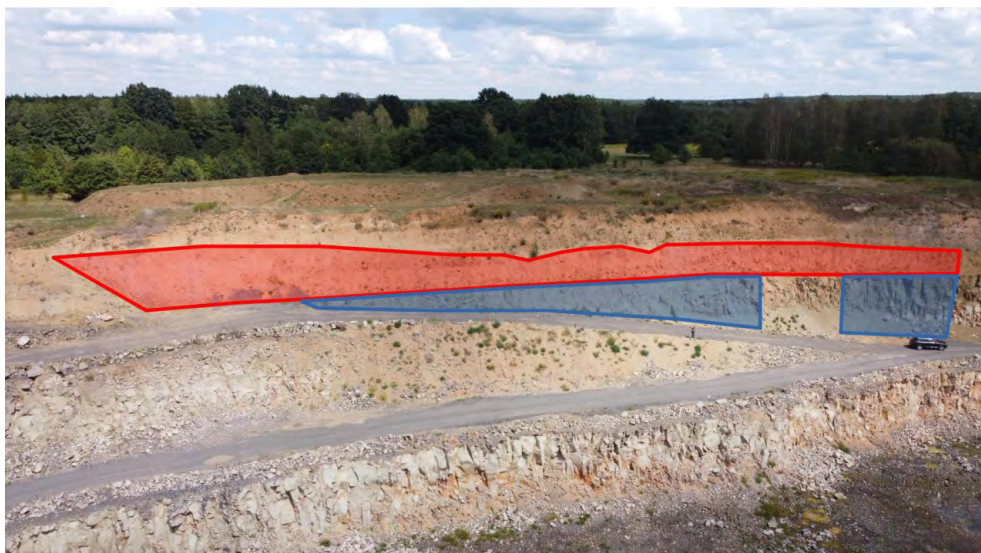


Fig. 5. View towards the north of the northwestern part of the Rutki Quarry with marked fragment of basalt weathering crust.

Red: stage of ordinates 170/164 (roof/floor) m a.s.l., blue: stage of ordinates 164/156 (roof/floor) m a.s.l.

Rys. 5. Widok w kierunku N części NW złoza Rutki z zaznaczonymi strefami występowania zwietrzliny bazaltowej: kolorem czerwonym w piętrze o rzędnych 170/164 m n.p.m. (strop/spąg) i kolorem niebieskim w piętrze o rzędnych 164/156 m n.p.m.

3. Methodology

From solid fragments of the crust, thin sections were prepared for microscopic observations. Other analyses were performed on powdered samples. The following observations and analyses were completed:

- ◆ microscopic observations of standard thin sections (0.02 mm thick) were conducted under transmitted light with the OLYMPUS BX 51 universal polarizing microscope connected with the DP12 digital camera for microphotographs,
- ◆ DSH X-ray powder diffraction patterns were recorded using the RIGAKU Smart-Lab X-ray diffractometer using the following working parameters: $\text{Cu}_{K\alpha}$ radiation, graphite monochromator, tube voltage 35 kV, tube current 30 mA, step $0.05^\circ 2\theta$, counting time 1 sec for 1 step. For the detailed identification of clay minerals, oriented samples were prepared under air dry conditions as well as samples saturated with ethylene glycol and calcinated at 560°C .
- ◆ Multi-element chemical analyses for major, minor and trace elements were performed at the ALS laboratory in Loughrea (Ireland). Powdered samples were converted into solution and analyzed with the ICP-AES method for major elements and for some

minor and trace elements. The remaining elements were analyzed with the ICP-MS method; a total of fifty-four elements were detected. Loss on ignition was determined with the “classic” weight method by measuring the mass difference of samples, first air-dried at 110°C and then calcinated at 1,000°C.

- ◆ Particle size was analyzed with the laser-diffraction-based Mastersizer 2000 device produced by the Malvern Instruments (USA), equipped with the Hydro-S instrument for the liquid dispersion of samples. This device can measure particle sizes from 20 nm to 2 mm. Sample preparation comprised the dispersion of analyzed substance in distilled water added to the Dispex ionic polyacrylic dispersant, which stabilized the suspension. The sample was then treated with ultrasound for three minutes. Particle size distribution was measured under room temperature. During the measurements, samples were intensively mechanically stirred. The following parameters were assumed: refractive index of analyzed samples – 1.56, refractive index of distilled water – 1.33 and absorption 0.01.
- ◆ Specific surface area was measured with the ASAP 2010 instrument produced by Micromeritics Inc. (USA). The BET multi-point method of physical adsorption of high-purity (99.999%) nitrogen was applied in accordance with the Polish Standard PN-ISO 9277:2000. Powdered samples were outgassed at 200°C for twenty-four hours under a pressure level of below 1.33 Pa. The measurements were performed with the discontinuous volumetric technique at the temperature of liquid nitrogen (77 K).
- ◆ The selected geotechnical parameters of optimum moisture content, maximum density of solid particles and filtration coefficient were determined. These parameters were measured with the standard methods in accordance with the Polish Standard PN-88/B-04481 (for optimum moisture content and maximum density of solid particles) and technical specification PKN-CEN ISO/TS 17892-11:2009 (for filtration coefficient). The filtration coefficient was measured with the Proctor apparatus after maximum compaction of samples with maximum moisture contents and applying the two consolidation load pressures of 25 and 100 kPa.

4. Results and discussion

4.1. Microscopic observations under transmitted light

Both studied samples represent compact although fragile clayey grayish-brown rock, although the color of sample No. 1387 appears to be somewhat darker. Both samples reveal a relic, porphyritic structure inherited after the volcanic parent rock, in which numerous, slightly rounded and distinctly darker phenocrysts, 0.1 to 3 mm in diameter, are scattered within the grayish-brown matrix.

Under the microscope, a fine-crystalline rock matrix hosts abundant, perfectly visible pseudomorphs, 0.1 to 3 mm in size, composed of secondary clay minerals and Fe-hydroxides completely replacing the subhedral olivine phenocrysts. The most common are brownish pseudomorphs (Figure 6) usually described as iddingsite, which in fact are mixtures of smectite and goethite. The inner parts of some larger pseudomorphs are sometimes filled with colorless clay minerals showing grayish interference colors that are typical of kaolinite (Figure 7). Such pseudomorphs are commonly surrounded by scattered, fine (0.02–0.03 mm across)

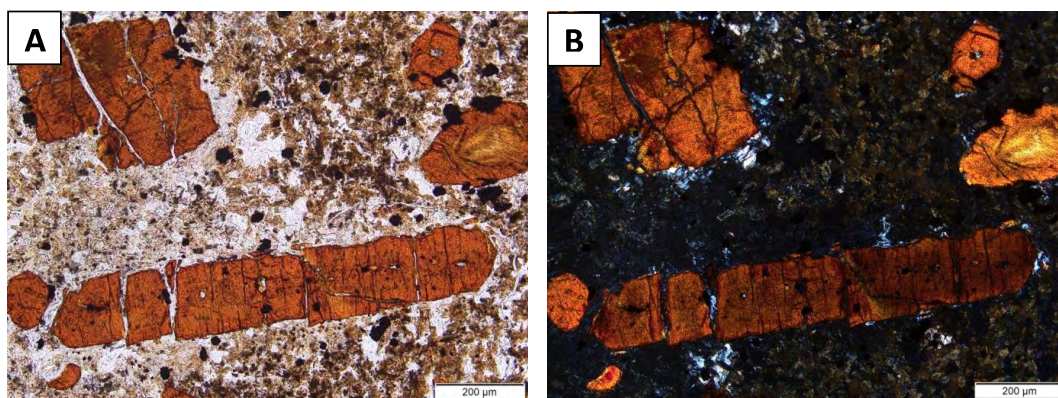


Fig. 6. Microphotographs of pseudomorphs after olivine composed of brownish iddingsite. Sample No. 1387, one polar (A) and crossed polars (B)

Rys. 6. Pseudomorfozy po oliwinie zbudowane z brunatnie zabarwionego iddingsytu. Próbką 1387, mikrofotografia, jeden polaryzator (A) i polaryzatory skrzyżowane (B)

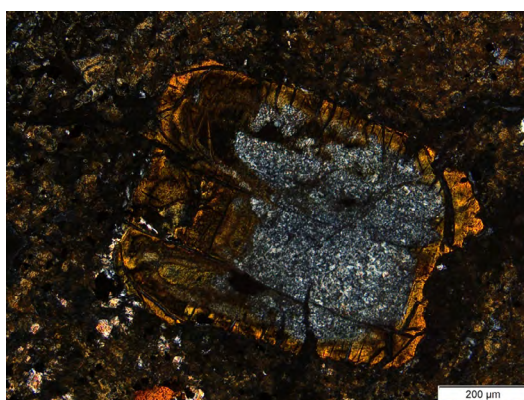


Fig. 7. Microphotograph of iddingsite pseudomorph after olivine with interior occupied by a mineral of gray interference colors. Sample No. 1388, crossed polar

Rys. 7. Pseudomorfoza iddingsytowa po oliwinie z wnętrzem wypełnionym minerałami ilastymi o szarych barwach interferencyjnych. Próbką 1388, mikrofotografia, polaryzatory skrzyżowane

lamellar aggregates of crystals having high interference colors (Figure 8). These are presumably secondary muscovite-type minerals produced by the weathering of nepheline. Matrix is composed of fine, darker, usually columnar aggregates, typically 0.005 mm, rarely larger (up to 0.3 mm) in size, presumably being the pseudomorphs after pyroxenes (Figure 9) accompanied by isometric crystals of opaque magnetite. Spaces between the pseudomorphs are filled with a clay mineral of low interference colors (Figure 9).

Very fine-crystalline clay minerals are difficult to identify under the microscope. Therefore, X-ray analyses were required. The results are presented in Chapter 4.2.

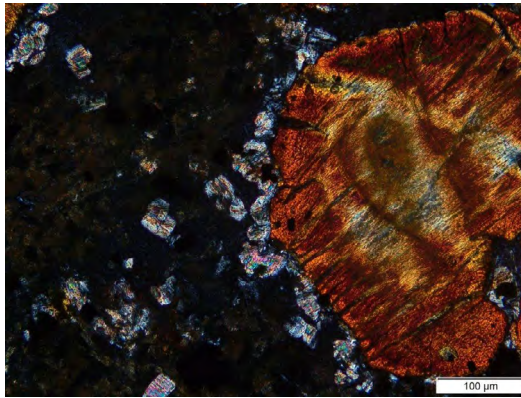


Fig. 8. Microphotographs of lamellar crystals showing high interference colors distributed around the pseudomorph after olivine. Sample No. 1387, crossed polars

Rys. 8. Agregaty blaszkowych kryształów o żywych barwach interferencyjnych w pobliżu pseudomorfozy po oliwinie. Próbką 1387, mikrofotografia, polaryzatory skrzyżowane

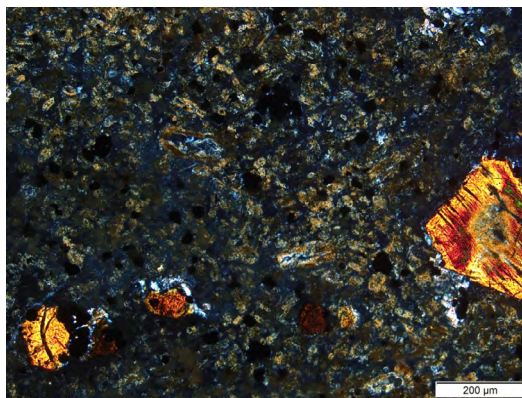


Fig. 9. Microphotograph of clay minerals pseudomorphs after columnar pyroxene phenocrysts accompanied by reddish-brown iddingsite pseudomorphs after olivine. Sample No. 1388, crossed polars

Rys. 9. Pseudomorfozy minerałów ilastych po słupkowych kryształach piroksenów oraz czerwono-brązowe pseudomorfozy iddingsytowe po oliwinie. Próbką 1388, mikrofotografia, polaryzatory skrzyżowane

Primary minerals: pyroxenes, olivines and nepheline together with the porphyritic structure suggest a volcanic source rock of nephelinite composition. This basalt variety composed both the Rutki deposit and the adjacent Ligota Tułowicka deposit (Wyszomirski et al. 2017). Moreover, it is known also from the nearby Gracze deposit and it builds the St. Anna Hill. It is thus concluded that the studied weathering crust was developed on nephelinite extrusion.

4.2. XRD analyses

The X-ray powder patterns revealed that the principal mineral components of both samples were clay minerals, particularly smectite accompanied by halloysite, kaolinite and micas (presumably muscovite and illite). Other identified minerals were magnetite and small amounts of goethite. In sample No. 1387, phosphate mineral (crandallite) was found (Figure 10). The presence of smectite was confirmed by the XRD patterns of oriented samples (Figure 11). The position of basal smectite reflection was shifted from 15.3 Å, typical of air-dry Ca-Mg smectite, to 17.4 Å, which is typical of an ethylene-glycol-saturated sample. After calcination at 560°C this reflection reached 10.0 Å whereas peak about 7.24 Å disappeared, which provided evidence for the presence of halloysite and kaolinite (Figure 11).

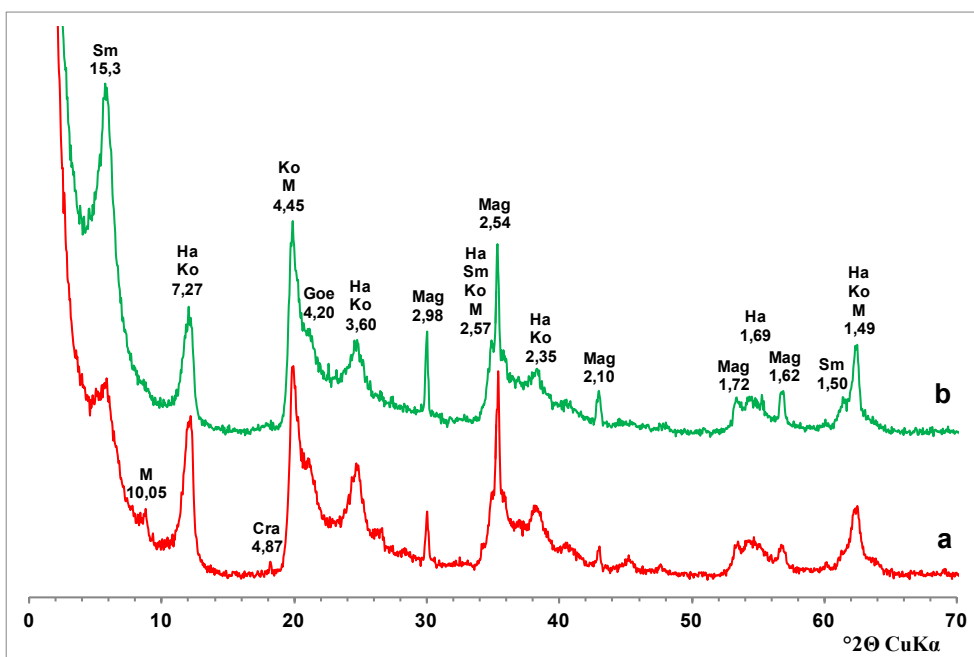


Fig. 10. XRD patterns of No. 1387 (a) and No. 1388 (b) samples
Cra – crandallite, Goe – goethite, Ha – halloysite, Ko – kaolinite, M – micas (muscovite, illite),
Mag – magnetite, Sm – smectite, d_{hkl} values given in Å

Rys. 10. Rentgenogramy próbek 1387 (a) i 1388 (b)

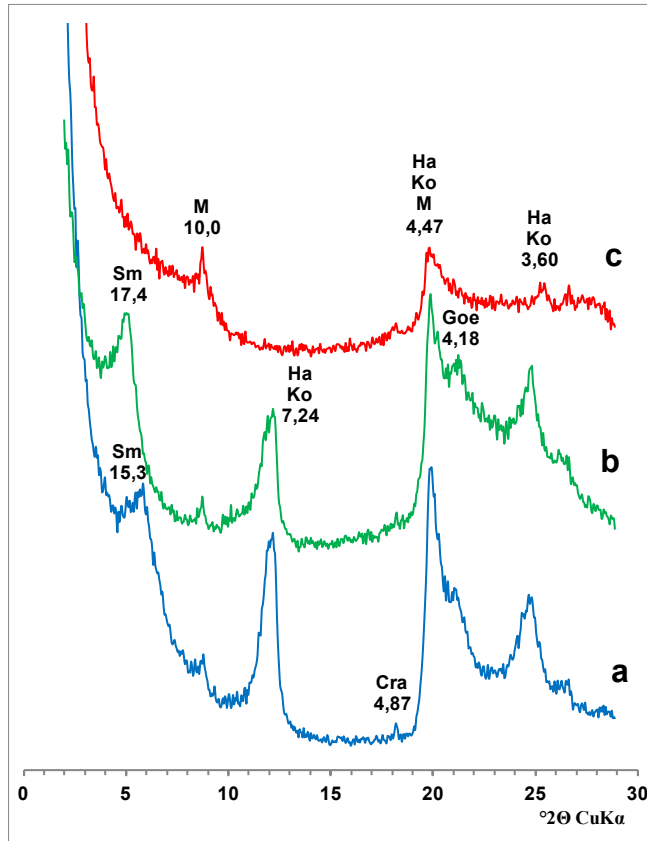


Fig. 11. XRD patterns of No. 1387 sample: a – air-dry, b – saturated with ethylene glycol, c – calcinated at 560°C
Cra – crandallite, Goe – goethite, Ha – halloysite, Ko – kaolinite, M – micas (muscovite, illite), Sm – smectite,
 d_{hkl} values given in Å

Rys. 11. Rentgenogramy próbki 1387

a – w stanie powietrznie suchym, b – po nasyceniu glikolem etylenowym, c – po wyprężeniu w 560°C

4.3. Chemical analysis of major, minor and trace elements

The chemical composition of the analyzed samples is listed in Tables 1 and 2. Apart from high SiO_2 content, the samples also contain about 20 wt.% of Al_2O_3 . Both components almost exclusively constitute clay minerals. Their presence is additionally confirmed by the high values of the loss on ignition, reaching up to 18 wt.%. The results of chemical analyses are consistent with both the microscopic observations and the X-ray patterns. Moreover, very high contents of Fe-oxides and Ti were encountered, which is typical of basalt weathering crusts. High contents of these colorants give a red color of basalt weathering crusts

Table 1. Major and minor components¹ (wt.%)

Tabela 1. Składniki główne i poboczne (% mas.)

Symbol	Detection limit	Content	
		Sample 1387	Sample 1388
SiO ₂	0.01	33.0	34.8
Al ₂ O ₃	0.01	20.8	18.95
Fe ₂ O ₃	0.01	21.3	19.90
MnO	0.01	0.21	0.17
MgO	0.01	1.40	1.84
CaO	0.01	0.66	0.97
BaO	0.01	0.09	0.11
Na ₂ O	0.01	0.04	0.08
K ₂ O	0.01	0.19	0.21
TiO ₂	0.01	4.29	4.10
P ₂ O ₅	0.01	0.38	0.35
Cr ₂ O ₃	0.002	0.113	0.105
Loss on ignition		17.85	17.80
Total		100.33	99.40

¹ Major elements are those which compose more than 1 wt.% of sample, minor elements constitute from 1 to 0.1 wt.% and trace elements compose below 0.01 wt% (≤ 100 ppm).

after firing. It seems very probable that the so-called “Silesian black pottery”, characterized by a red body which was produced in the neighboring Tułowice ceramic manufacture in the second half of the nineteenth century, was partly made of such weathering crust (Wyszomirski et al. 2021).

Among the trace elements, the important are e.g. Cr, Ni, Co and V, which are typical of mafic igneous rocks and their weathering crusts.

4.4. Results of particle size analysis

The results are presented as Gaussian distribution curves (Figure 12). For both analyzed samples, the curves are bimodal. Remarkable is the high amount of fraction of about 0.6 μm and finer, as revealed by peaks on the left side of the Figure 12 plot, whereas peaks visible on the right side correspond to fractions of about 6 μm (for sample No. 1387)

Table 2. Trace elements (ppm)

Tabela 2. Pierwiastki śladowe (ppm)

Symbol	Detection limit	Content		Symbol	Detection limit	Content	
		Sample 1387	Sample 1388			Sample 1387	Sample 1388
Ag	0.5	0.6	0.5	U	0.05	1.72	1.66
As	5	<5	<5	V	5	380	407
Cd	0.5	1.4	1.0	W	1	< 1	<1
Co	1	132	82	Y	0.1	15.9	14.5
Cr	10	820	750	Zn	2	248	218
Cs	0.01	6.97	9.80	Zr	2	367	347
Cu	1	173	60	REE:			
Ga	0.1	37.5	33.3	La	0.1	26.0	17.6
Hf	0.1	7.7	7.4	Ce	0.1	84.3	83.5
Li	10	30	30	Pr	0.02	5.52	5.28
Mo	1	4	2	Nd	0.1	20.8	22.6
Nb	0.1	130.0	123.0	Sm	0.03	4.53	5.52
Ni	1	544	419	Eu	0.02	1.70	1.98
Pb	2	12	9	Gd	0.05	4.65	5.48
Rb	0.2	53.4	50.2	Tb	0.01	0.75	0.78
Sc	1	37	33	Dy	0.05	4.20	4.22
Sn	1	3	3	Ho	0.01	0.76	0.72
Sr	0.1	109.0	134.5	Er	0.03	2.00	1.79
Ta	0.1	4.7	1.4	Tm	0.01	0.25	0.23
Th	0.05	9.80	9.21	Yb	0.03	1.48	1.39
Tl	10	<10	<10	Lu	0.01	0.21	0.19

and even over 20 μm (for sample No. 1388). With regard to the functional properties of the studied weathering crusts, particularly their waterproofing capabilities, the content of very fine fractions, i.e. about 0.6 μm and below, is crucial. Such particles, especially smectite aggregates, control the specific surface area, which is an important parameter in evaluation of sorption properties of given mineral raw material. This problem is discussed in Section 4.5.

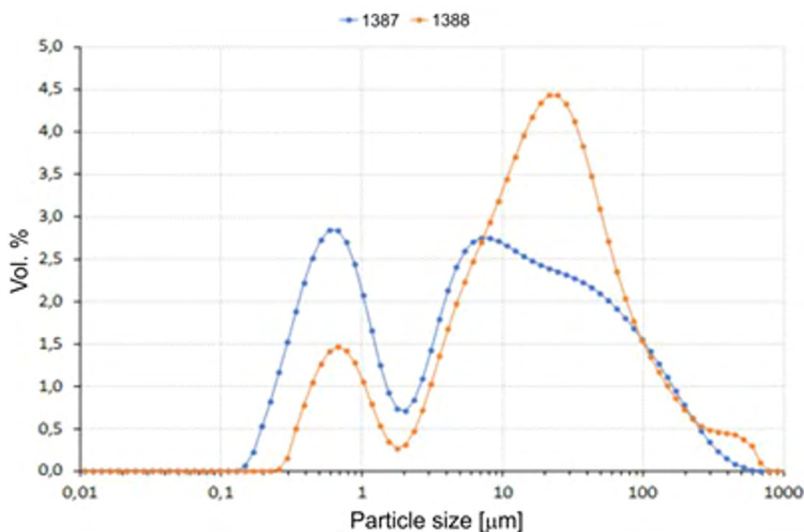


Fig. 12. Frequency distribution curves of basalt weathering crust from the Rutki Quarry

Rys. 12. Krzywe populacyjne zwietrzliny bazaltowej z Rutek

4.5. Determination of specific surface area

The specific surface area was determined with the multi-point nitrogen adsorption method within the relative pressure range p/p_0 from 0.05 to 0.20 (Figure 13).

Both of the analyzed samples show very high and similar values of specific surface area of about $100 \text{ m}^2/\text{g}$ (Table 3). It is an effect of mineral composition dominated by smectite and kaolinite with some admixture of halloysite. Comparison with archival data provided by Kłapyta and Żabiński (2008) for abandoned Miocene bentonite deposit in Chmielnik and Carboniferous bentonites from the Upper Silesian Coal Basin (Radzionków, Milowice) demonstrates a high value of specific surface area of basalt weathering crust from the Rutki Quarry. Therefore, its usability is concluded for the construction of artificial waterproofing

Table 3. Results of specific surface area determinations of basalt weathering crust from Rutki

Tabela 3. Wyniki oznaczenia wielkości powierzchni właściwej zwietrzliny bazaltowej z Rutek

Sample No.	Specific surface area (m^2/g)
1387	98.95 ± 0.15
1388	97.44 ± 0.20

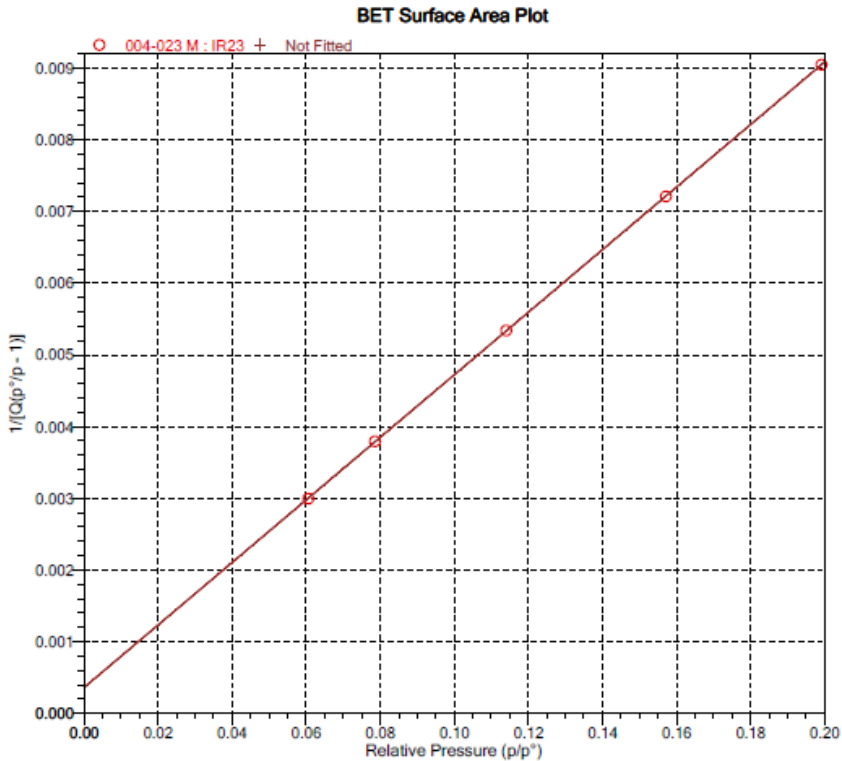


Fig. 13. Example of BET isotherm plot of nitrogen adsorption (sample No. 1387)

Rys. 13. Przykładowa izoterma adsorpcji azotu przedstawiona we współrzędnych BET (próbka 1387)

barriers. Unfortunately, many other possible applications (e.g. fine ceramic products) are limited by the grayish-brown color of the raw crust, which becomes even more intense after firing.

5. Recommendations for the potential utilization directions of basalt weathering crust from the Rutki Quarry

The basic geotechnical tests of studied weathering crust samples No. 1387 and No. 1388 included the measurements of optimum moisture content, maximum density of solid particles and filtration coefficient (Figarska-Warchoł and Kaczmarczyk 2023). The optimum moisture contents were similar in both samples, with levels of 36% and 33%, respectively. These values are consistent with those typical of standard bentonite raw-materials. An example of this is that raw bentonite from the Jelsovy Potok deposit in Slovakia, which is well-known on the Polish market, shows moisture contents of about 33%. The maximum density

of solid particles of studied samples reveals favorable low values: 1.32 g/cm^3 for No. 1387 and 1.38 g/cm^3 for No. 1388.

In the case of artificial waterproofing barriers, a particularly important property is the low permeability for fluids characterized by the filtration coefficient. This parameter represents the ability of water to percolate through porous rock and is a measure of its hydraulic conductivity. The rock resists the filtrating water due to a number of various controlling factors. According to, for example, Majer (2003), the boundary value of the filtration coefficient is about $k = 10^{-9} \text{ m/s}$. For mineral raw materials used as waterproof barriers, the filtration coefficient should be lower than this boundary value, as demonstrated by, for example, a nomograph applied for the evaluation of soil usability for the construction of mineral waterproof barriers (Wysokiński 2007). Both studied samples show favorable values of filtration coefficient of around 10^{-10} to 10^{-11} m/s . It is therefore concluded that the basalt weathering crust from the Rutki Quarry will be fully suitable for waterproofing purposes. This is the most common and simplest utilization direction for this raw material having such high sorption properties. Moreover, such utilization will contribute to the rational management of the weathering crust as an accompanying raw material, coexisting with basalt as a major product in the Rutki Quarry.

Conclusions

1. Basalt weathering crust from the Rutki Quarry developed on the nephelinite extrusion represents the smectite-kaolinite type with halloysite.
2. Interlayer spaces in smectite are occupied by bivalent cations (Ca^{2+} , Mg^{2+}), which is a most common feature of smectite raw materials.
3. A high content of clay minerals, particularly smectite accompanied by halloysite, results in a high value of specific surface area, reaching up to $100 \text{ m}^2/\text{g}$.
4. A high value of specific surface area together with favorable geotechnical parameters (optimum moisture content, maximum density of solid particles, filtration coefficient) support the utilization of weathering crust from the Rutki Quarry for waterproofing purposes in a raw state, without chemical activation.

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Standards and technical specifications:

PN-88/B-04481 – Construction grounds. Laboratory tests of ground samples (*Grunty budowlane. Badania próbek gruntów*) (in Polish).

PN-ISO 9277:2000 – Determination of the specific surface area of solids by gas adsorption using the BET method (*Oznaczanie powierzchni właściwej ciał stałych przez adsorpcję gazu metodą BET*) (in Polish).

PKN-CEN ISO/TS 17892-11:2009 – Geotechnical investigation and testing – Laboratory testing of grounds – Part 11: Determination of permeability at constant and changing hydraulic head (*Badania geotechniczne. Badania laboratoryjne gruntów. Część 11: Badanie filtracji przy stałym i zmiennym gradiencie hydraulicznym*) (in Polish).

BASALT WEATHERING CRUST FROM RUTKI NEAR NIEMODLIN (OPOLE VOIVODESHIP) – OPPORTUNITIES FOR ITS CURRENT UTILIZATION AND REMARKS ON ITS FORMER USE

Keywords

basalt weathering crust, smectite, specific surface, sorption, waterproofing

Abstract

In contrast to the western part of the Lower Silesia, information about the basalt-derived weathering crusts occurring in the Opole region is rather limited. However, in 2018, significant volumes of such regolith (about 20,000 m³) were discovered during development works in the NW part of the Rutki Quarry near Niemodlin. This weathering crust is rich in clay minerals and represents a smectite-kaolinite mixture with some halloysite, the latter being a poorly ordered member of the kaolinite group. The minerals of the smectite group contain in their interlayer spaces bivalent cations (calcium and magnesium), which is the most often case in the nature. The mineral composition of the regolith mass is supplemented by iron-containing phases, i.e. goethite and magnetite, and traces of phosphate mineral – crandallite.

A significant amount of clay minerals, particularly those belonging to the smectite group and halloysite, results in high value of the specific surface area (up to 100 m²/g) of the studied crust. Such favorable property of the crust makes it a promising sorptive raw material that can be applied, even in an unprocessed form, for waterproofing. It must be emphasized that the sorption properties of basalt weathering crusts were noticed some centuries ago in the western part of Lower Silesia, where medicine called terra sigillata was produced from them. Moreover, the crust from Rutki was also used in the XIXth century, in a ceramic manufacture located in nearby Tułowice, where the so-called “Silesian black porcelain” was produced.

**ZWIETRZELINA BAZALTOWA Z RUTEK K. NIEMODLINA (WOJ. OPOLSKIE) –
PERSPEKTYWY WSPÓŁCZESNEGO WYKORZYSTANIA I PRZEJAWY DAWNEGO UŻYTKOWANIA****Słowa kluczowe**

zwietrzelnina bazaltowa, smektyt, powierzchnia właściwa, sorpcja, hydroizolacja

Streszczenie

W przeciwieństwie do zachodniej części Dolnego Śląska, wzmianki o zwietrzelinach rozwiniętych na bazaltach trzeciorzędowych w okolicy Opola są nieliczne i sporadyczne. W 2018 r. zwietrzelnina tych skał została odsłonięta w większej ilości podczas prac górniczych prowadzonych w NW części kamieniołomu w Rutkach k. Niemodlina. Jej zasoby są znaczne i w odsłoniętym fragmencie szacowane na około 20 tys. m³. Zwietrzelnina ta reprezentuje typ smektytowo-kaolinitowy. Występuje w niej też słabo uporządkowany minerał grupy kaolinitu, tj. haloizyt. Minerale grupy smektytu zawierają kationy dwuwartościowe (wapń, magnez) w ich przestrzeniach międzypakietowych, co jest najczęstszym – obserwowanym w przyrodzie – przypadkiem. W zwietrzelinie występują też fazy żelaziste reprezentowane przez goethyt i magnetyt oraz – w śladowej ilości – minerał fosforanowy, tj. crandallit.

Znaczna zawartość minerałów ilastych w badanej zwietrzelinie – a zwłaszcza minerałów grupy smektytu i haloizytu – decyduje o dużej wartości jej powierzchni właściwej, dochodzącej do 100 m²/g. Stanowi to korzystną przesłankę do wykorzystania tej kopaliny jako materiału sorpcyjnego, który w stanie nieprzetworzonym może być stosowany w znacznych ilościach dla celów hydroizolacyjnych. Właściwości sorpcyjne zwietrzelin dostrzeżono już przed wieloma wiekami w zachodniej części Dolnego Śląska, wytwarzając z nich preparat leczniczy o nazwie *terra sigillata*. Zwietrzelnina bazaltowa z Rutek była natomiast stosowana w XIX wieku w manufakturze ceramicznej w pobliskich Tułowicach do wytwarzania tzw. czarnej porcelany śląskiej.

