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MINERAL FORMING PROCESSES IN WEATHERING CRUSTS OF ACID MAGMATIC AND METAMORPHIC ROCKS OF LOWER SILESIA

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Abstract. Tertiary weathering crusts developed on acid crystalline rocks of Lower Silesia display zonal structure. Following zones can be distinguished: slightly altered primary rock, kaolinite-mica and kaolinite ones. These zones are the products of mineral forming processes of incongruent dissolution and transformation of structure proceeding according to the scheme: feldspar ⟶ kaolinite; feldspar ⟶ dioctahedral mica ⟶ kaolinite; biotite ⟶ kaolinite; biotite dioctahedral mica ⟶ kaolinite; muscovite ⟶ kaolinite. On the basis of mineral parageneses in individual zones it was possible to reconstruct the course of changes of physico-chemical conditions with increasing depth of weathering profile.

Recent weathering leads to the formation of weathered zones essentially montmorillonite-mica character with subordinate kaolinite content.

INTRODUCTION

During the Tertiary, thick kaolinite weathering crusts of essentially kaolinitic character have been formed. Actually these are 50—70 meters thick and occur in numerous parts of Strzegom—Sobótka granitoid massif, particularly in its eastern part. These crusts have been formed from bimicaceous or biotite granitoids. Similar crusts are also found to occur on gneisses e.g. on the Strzelin ones. Usually, Tertiary weathering crusts are overlain by younger deposits from few to several tenth meters thick and consisting of various gravels, sands, silts and clays. Locally these deposits include interlayers or lenses of brown coal.

Within the crusts in questions it is possible to observe some regularities in distribution of major constituents, first of all clay minerals. On the ground of this regularity it is possible to draw conclusions on the character of mineral forming processes which lead to the formation of these crusts.

The present author's considerations are based on the results of mineralogical examinations of weathering crusts developed on coarse grained biotite granite of Borów type (Roztoka), on biotite and bimicaceous Strzegom

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granitoids (Żarów, Bolesławice) as well as on coarse-grained biotite rich Rumburk granite exposed in brown coal mine of Turów. Finally the weathering crust of biotite Strzelin gneisses has been examined (Wyszonowice).

DISTRIBUTION OF MINERAL COMPONENTS WITHIN WEATHERING CRUSTS OF ACID CRYSTALLINE ROCKS OF LOWER SILESIA

Regularity of development and distribution of major mineral constituents in weathering crusts of crystalline rocks results from the character of mineral forming processes and are manifested as follows:

1. Differentiation of grain size and distribution of major mineral components among definite fractions, depending on the mechanism of origin and transformation of these minerals.

2. Vertical variability of mineral distribution within weathering profile (zonality) due to varying physico-chemical conditions with depth.

Quartz, kaolinite and mica minerals are the main constituents of weathering crusts developed on acid igneous and metamorphic rocks of Lower Silesia. Feldspars and (in the finest fraction) swelling clay minerals occur here in subordinate amounts. Contents of individual components vary within broad limits: quartz 20—60 per cent, kaolinite 20—70 per cent, micas 5—30 per cent. The content of feldspars amounts to several per cent and only close to unaltered rock their concentration increases up to several tenth per cent.

Distribution of major mineral components among various fractions is similar in all weathering crusts under examination and varies but slightly with depth (Fig. 1, 2).

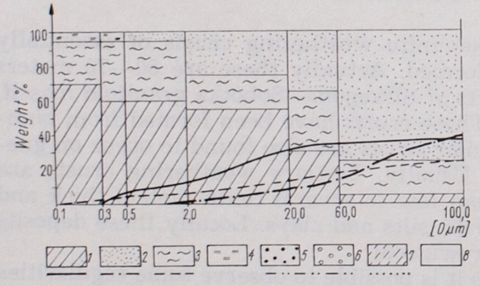


Fig. 1. Grain size distribution of the main minerals in the weathering crust on biotite granite (Bolesławice) — kaolinite — mica zone.
Explanation to Fig. 1—8
1 — kaolinite, 2 — quartz, 3 — micas, 4 — swelling minerals, 5 — K-feldspar, 6 — plagiocleses, 7 — montmorillonite, 8 — others

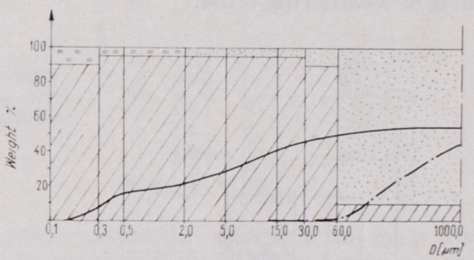
Quartz usually occurs as thick grains, above 30 μm in diameter. Only small amounts of this mineral are found in finer fraction 1—30 μm. Quartz is general a relict mineral left after primary rock.

Kaolinite occurs in all the fractions but distinctly concentrates in two of them: 30—2 μm and < 1 μm. In the former there occurs kaolinite Tc displaying moderate crystallinity whereas in the latter there prevails kaolinite D. This is generally authigenic kaolinite formed in weathering crust from feldspars and micas. This, originated from feldspars, is usually

fine grained whilst pseudomorphs after micas, usually developed as aggregates of kaolinite plates, are up to several milimeters in size.

Kaolinitic weathering crusts of Lower Silesia are comparatively rich in micas. There occur primary and secondary micas and their degradation products. Primary micas are represeted both by differently altered muscovite and biotite, preserved from the primary rock. Often these micas are kaolinizated in different degree. Grain size of primary micas varies from 20 to several milimeters. Secondary micas of sericite type have been formed from feldspars, like kaolinite, and concentrate in the fraction 2——20 μm together with fragments of flakes of primary micas disintegrated in the course of weathering process. In weathering crusts enriched in secondary micas we observe another range of concentration of this mineral — in the fraction < 1 μm. Micas occurring in this fraction contain some swelling layers in their structure and can be determined as illite.

Fig. 2. Grain size distribution of the main minerals in the weathering crust on biotite granite (Roztoka) — kaolinite zone
Explanations see Fig. 1



Potassium feldspar, as more resistant to weathering, occurs in coarser fraction, mostly > 30 μm, whereas plagioclases are preserved as grains < 30 μm in size. Feldspars show strong alteration consisting both sericitization and kaolinization.

Variability of mineral composition with depth is a typical feature of kaolinite weathering crusts in Lower Silesia. This variability is well observed in the cross-section of the crust developed on granite in Bolesławice (Fig. 3).

Several zones characterized by typical mineral parageneses can be distinguished on the base of distribution of minerals in weathering crusts under examination.

Zone of slightly altered primary rock (saprolite) occurs in lower parts of weathering crusts. It consists essentially of minerals of primary granitic or gneissic rock: quartz, partly altered potash feldspar, strongly altered plagioclases, muscovite and altered biotite. Numerous plagioclase and some potash feldspar grains have been completely kaolinized or sericitized in this zone. Sericite is also observed sometimes to form at the surface of the quartz grains (Phot. 2). Biotite exhibits strong alteration, manifested by the formation of iron and titanium oxides and its transformation into dioctahedral green or even colourless mica resembling muscovite. New minerals formed in this zone are: kaolinite and fine grained both colourless (sericitic) and green micas. Veinlets of secondary low-temperature quartz are locally observed.

The zone laying above the former one can be called *kaolinite-mica zone*. It consists mainly of relict quartz, kaolinite and micas. Feldspars occur in subordinate amounts (up to several per cent) whereby potash feldspar distinctly prevails over plagioclases. A characteristic feature of this zone is the increased content of minerals of the mica group. This enrichment is due to the origin of considerable amount of fine grained mica formed in the course of weathering of feldspars. Primary micas display kaolinization phenomena.

The above zone is overlain by a broad one which can be called the *kaolinite zone* due to abundance of this mineral in it. Kaolinite is accompanied in this zone mainly by quartz. Micas occur in minute amount and feldspar content is negligible. In upper part of kaolinite zone, the amount of kaolinite slightly decreases causing relative enrichment in quartz. This phenomenon is probably connected with washing out of kaolinite by descending atmospheric waters and its displacement towards the lower parts of weathering crust.

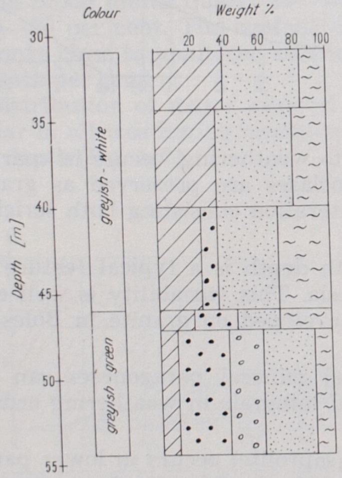


Fig. 3. Variability of main minerals content with depth in the weathering crust on biotite granite (Bolesławice)
Explanations see Fig. 1

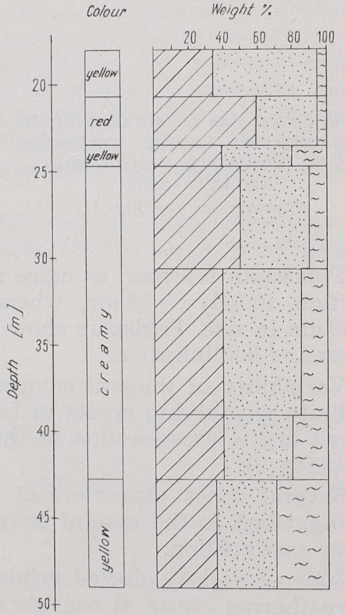


Fig. 4. Variability of main minerals content with depth in the weathering crust on biotite gneiss (Wyszonowice)
Explanations see Fig. 1

Sometimes in the upper part of weathering of crust, within kaolinite zone, there appears an additional mica-enriched horizon (Fig. 4).

The thickness of individual zones can be different and some of them can be but poorly developed, depending on local paleogeographic conditions and the type of primary rock. So e.g. weathering crust in Roztoka is distinctly low in micas (Fig. 5).

Apart from zonal distribution of major mineral components we also observe a zonality of iron distribution. Depending on the content and mineral form of this element, various parts of weathering crusts display different colouration (Fig. 3, 4, 5). This phenonomenon is particularly well developed in the weathering crusts on rocks abounding in biotite.

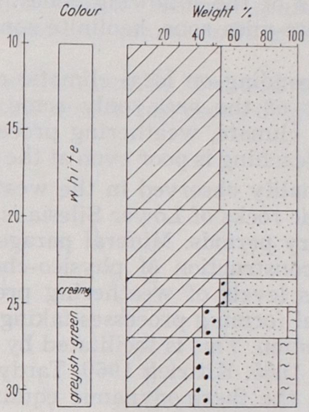


Fig. 5. Variability of main minerals content with depth in the weathering crust on biotite granite (Roztoka)
Explanations see Fig. 1

In Lower Silesian acid crystalline rocks this mineral is the main iron--bearing mineral. In this case, the zone of slightly altered primary rock and the kaolinite-mica one display grey-greenish colouration which is due to green micas. The latter minerals, products of weathering of biotite, contain both ferrous and ferric iron.. In the zone of slightly weathered rock, iron may also occur as siderite and even secondary magnetite. Slightly above, the crust is impoverished in iron and close to the top of kaolinite zone we sometimes observe yellow or red level, enriched in goethite and hematite. The latter is concordant with mica-enriched horizon, mentioned above. Further upwards, weathering crust is again impoverished in iron. Such distribution of various forms of iron is due to its migration and reprecipitation depending on vertical variability of pH and Eh (Segalen 1971). The problem of geochemistry of iron in weathering crusts of Lower Silesia is discussed in detail in a separate paper (Sikora 1972).

PHYSICO-CHEMICAL FACTORS DETERMINING THE ORIGIN OF MINERAL PARAGENESES IN WEATHERING CRUSTS

Zonality of weathering crusts has been examined and discussed by numerous authors (Petrov 1967, Millot 1970, Valeton 1972). This phenomenon has been explained by Ginzburg (1963), who was the first which show that mineral forming processes in weathering crusts are multi-stage in character. When weathering process develops, the lower border of weathering crust displaces downwards and clay minerals originated from the components of primary rock gradually pass into changed physico-chemical conditions (different pH, Eh, chemical composition of solutions saturating weathering crust). Consequently, these minerals are converted into another one or into aluminium and iron hydrated oxides.

Thickness of weathering crusts, their mineral composition and character of zones developed, depend on climatic conditions and the type of weathering rock. Complete weathering profile develops under conditions of tropical climate and good leaching. When developed on acid rocks it consists of the following zones: slightly changed primary rock, mica or kaolinite-mica zone, kaolinite zone and that of aluminium and iron hydroxides.

Depending on local climatic conditions, ground water level and topography of the area, only some zones can develope. Under moderately humid climate, weathering process can accomplish at kaolinite zone and when leaching is poor even at the mica one (Petrov 1967).

Zonality observed in the weathering crusts of acid igneous and metamorphic rocks of Lower Silesia is typical for a hot and humid climate with long dry periods. Mineral parageneses of individual zones can be a basis for reconstruction of physico-chemical character of the environment of various levels of weathering profile, determining in turn the course of mineral forming processes taking place during the formation of the crusts in question. This is facilitated by diagrams of minerals equilibria (Garrels, Christ 1965, Kittrick 1969, Tardy 1971) determinating the minerals stability at the thermodynamic equilibrium conditions. From thermodynamic viewpoint, a weathering crust represents an open system, exchanging its components with surroundings and their zones are gradually displacing downwards. However, the course of weathering processes is such that within a given zone definite physico-chemical conditions are stabilized and thus may be considered to represent as a quasi-stationary system being close to equilibrium conditions.

Stability diagram $K_2O—Na_2O—Al_2O_3—SiO_2—H_2O$ (Hess 1966) has been applied by the present authors. Its fragment corresponding to the conditions of continental weathering environment is presented in Figure 6.

Coexistence of feldspars, micas and kaolinite is characteristic for the zone of slightly altered primary rock. Formation of secondary micas along cleavage planes and on the surfaces of feldspar grains is observed here (sericitization, Phot. 1). Kaolinite forms from micas or directly from feldspars. It is thus concluded that average chemical composition of pore solutions in this zone corresponds approximately to the ternary point at the boundary of stability fields of feldspar, mica and kaolinite (Fig. 6). Local variations of composition of these pore solutions, caused by driect contact with surface of minerals of different composition and by the fact that their concentration is equalizated by slow diffusion process, change conditions of equilibrium as well as character of mineral forming processes. Thus, different secondary minerals can form from the same mineral, very close to each other (e.g. sericite or kaolinite from feldspar). In the vicinity of weathering feldspars, quartz displays chemical corrosion phenomena being subjected to surface sericitization (Phot. 2). Simultaneously in other places we observe local crystallization of low-temperature quartz grains. This process is due to supersaturation of solutions in silica in relation to quartz. Amorphous silica is evolved during weathering of feldspars. Its

solubility is much higher than that of quartz (100—140 and 7 ppm, respectively) and determines the concentration of dissolved silica in solutions (Siver 1957, Wey Siffert 1961).

Kaolinite-mica zone distinguishes by coexistence of kaolinite, quartz and micas. This paragenesis is possible in the environment the chemical composition of which corresponds to the line separating stability fields of mica and kaolinite on Hess's diagram (Fig. 6). Solubility of quartz essentially determines the concentration of silica. Relictic feldspar grains surrounded by thick layers of weathering products cannot influence more considerably the equilibrium conditions.

In kaolinite zone the concentration of K^+ ions is low and that of H^+ comparatively high. On the diagram this area is represented by stability field of kaolinite.

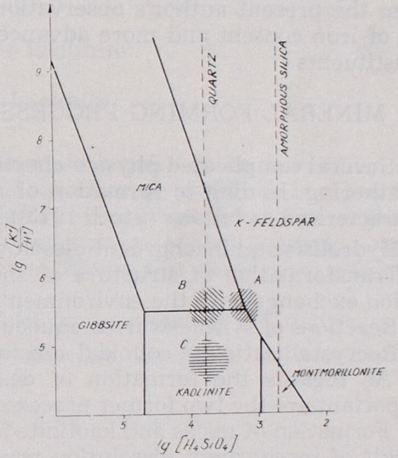


Fig. 6. Isoplethic section of the phase diagram for the system $K_2O—Na_2O—Al_2O_3—SiO_2—H_2O$, at $\lg \frac{[Na^+]}{[H^+]} = 4$ (Hess 1966)

Dashed lines mean solubility of the quartz and amorphuos silica in water. Hatched areas indicate supposed chemical composition of porous solution. *A* — in zone of slightly altered primary rock, *B* — in kaolinite-mica zone, *C* — in kaolinite zone

Kaolinite zone is situated in the upper part of weathering crust and during rainfall seasons it had to be intensively leached by comparatively acid atmospheric waters to decompose other minerals than kaolinite and quartz. Local occurrence of mica-enriched horizons within the kaolinite zone may be connected with concentration of alkalies above former horizons of ground waters. This local enrichment in alkalies took place during long dry periods and resulted from evaporation of pore solutions upraised by capillary forces.

Kaolinite-mica zone represents a more alkaline and more potassium-enriched environment. Most probably, it corresponds to poorly leached part of weathering crust, localized in the region of stagnant ground waters.

Because of considerable amount of feldspars in the zone of slightly altered primary rock, this environment is the most alkaline one (pH of suspensions of powdered granite is up to 9), (Grant 1969).

The distribution of iron compounds clearly indicates the variability of redox potential. Within slightly altered primary rock and overlying kaolinite-mica zones, Eh had to be low. Consequently, siderite and magnetite could form and a part of ferrous iron is preserved in biotite. Reducing environment was also preserved in lower parts of kaolinite zone resulting in dissolution of iron compounds and bleaching phenomena. A little upward, close to the ground water level, precipitation of goethite and hematite is observed connected with more oxidizing character of the environment.

No aluminium hydroxides have been found in the weathering crusts under examination. Large-scale development of kaolinite zone clearly indicates that there were no proper conditions for their origin or their zone was to thin to be preserved. Moreover, there are no evidences of resilification of aluminium hydroxides.

Weathering processes of Lower Silesian granites and gneisses were influenced by the presence of brown coals (Budkiewicz 1965). As follows from the present author's observations this is manifested by local decrease of iron content and more advanced decomposition of primary mineral constituents.

MINERAL FORMING PROCESSES IN WEATHERING CRUSTS

Several complicated physico-chemical processes take place during rocks weathering, leading to formation of new minerals. This processes can be characterized as follows (Stoch 1973):

1. Hydrolisis and incongruent dissolution of rock-forming silicate minerals.
2. Transformation of structure of sheet silicate minerals connected with ion exchange with the environment.
3. Reactions of synthesis from aqueous solutions.
4. Recrystallization of colloidal substances.

As regards the formation of described weathering crusts, the most important are the two former processes.

Formation of micas and kaolinite at the surface of feldspar grains is the result of incongruent dissolution process. In lower part of the profile we observe local dissolution of quartz and formation of sericite rims around its grains (Phot. 2). Sericitization of quartz has been reported already by Lapparent (1909). It can be explained by dissolution of SiO_2 in potassium and aluminium-bearing solutions according to the scheme:

$$\underset{\text{quartz}}{3SiO_2} + K^+ + 3Al^{3+} + 6H_2O = \underset{\text{sericite}}{KAl_2AlSi_3O_{10}(OH)_2} + 10(OH)^+$$

Formation of kaolinite rims around quartz grains leading to disintegration of quartz aggregates in the upper parts of weathering crust (Wyszonowice) can be explained by similar reaction. Development of rims around grains of primary minerals, consisting products of incongruent dissolution process, results in the formation of microzonality in distribution of minerals in weathering crust.

Transformation of mica structure is accompanied by exchange both layer and interlayer cations.

Dioctahedral micas are transformed into kaolinite directly or through intermediate vermiculite phase.

Biotite is altered directly into kaolinite. Moreover, gradual transformation of biotite into trioctahedral mica displaying lower magnesium and iron contents, then into ferrugineous dioctahedral mica and finally into dioctahedral mica of muscovite type was observed. The latter one is converted to kaolinite.

The above processes have been examined on micas displaying different degree of alteration, separated from weathering crust. The results of these investigations will be published later (Stoch, Sikora, in print).

In general, the main mineral forming processes taking place in the course of the Tertiary weathering of acid crystalline rocks in Lower Silesia, lead to the formation of kaolinite as the final product. Mechanism and course of these processes are different, depending on the type of primary minerals and physico-chemical conditions of the environment. These processes can be expressed by the following schemes:

feldspar ⟶ kaolinite
feldspar ⟶ dioctahedral mica ⟶ kaolinite
biotite ⟶ kaolinite
biotite ⟶ dioctahedral mica ⟶ kaolinite
muscovite ⟶ kaolinite

The sequence of weathering of primary minerals can be determined on the basis of decrease of their content in weathering profile. It is characterized e.g. by mean of so called Goldich's series which has to be slightly modified according to local physico-chemical and paleogeographic conditions. For weathering crusts of Lower Silesia this resistivity series of minerals is as follows:

$$\text{biotite} < \text{plagioclases} < \text{potash feldspars} < \text{muscovite} < \text{quartz}$$

Average sequence of mobility of chemical elements in weathering crusts under examination was as follows:

$$Mg > Ca > Na > K > Fe > Si > Al$$

A COMPARISON OF TERTIARY AND RECENT WEATHERING PROCESSES

In order to compare the trends of mineral forming processes that took place in Tertiary weathering crusts and proceed actually, soil profiles developed on granites in Strzegom and Borów have been examined. The latter profile is situated very close to the area of occurrence of a thick weathering crust in Roztoka.

Both the soil profiles show the same mineralogical character. Alteration stage of primary rock is comparatively low. Plagioclases are the most weathered minerals and thus their content diminishes upwards (Fig. 7). Clay minerals content in that soils is low. Among them soil montmorillonite prevails as well as secondary micas of illite and sericite type. Kaolinite of low degree of crystallinity occurs in subordinate amount. Clay minerals, including kaolinite, are finer than those occurring in Tertiary weathering crusts (Fig. 8). Soil montmorillonite containing much iron belongs to beidellite — montmorillonite series. Such montmorillonites occur in soils developed on others both acid and basic crystalline rocks of Lower Silesia, being characteristic product of their weathering.

Consequently recent weathering of Lower Silesian granites lead essentially to the formation of three-layer clay minerals (montmorillonite, illite), kaolinite beirg less abundant. Than forming weathering crusts can be callde montmorillonite-mica. Such weathering trend is due to several causes. The most important of them are different climatic conditions. Moreover, mineral forming processes proceed actually in a thin soil layer, whereas in thick Tertiary crusts, resembling chromatographic columns, free segregation of components could take place.

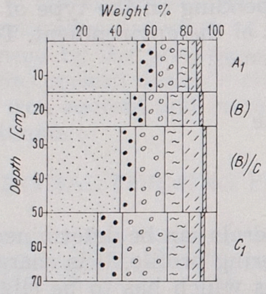


Fig. 7. Variability of main minerals content with depth in the soil on biotite granite (Borów)

Explanations see Fig. 1

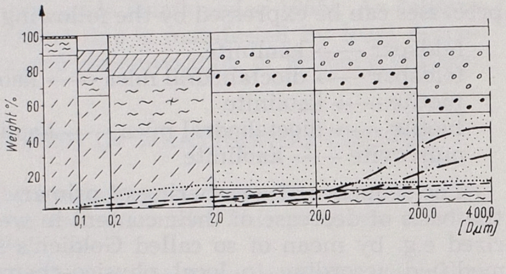


Fig. 8. Grain size distribution of the main minerals in the soil on biotite granite (Borów)

Explanations see Fig. 1

CONCLUSIONS

Mineral forming processes during a weathering of acid crystalline rocks (granitoids, gneisses) generally lead to the formation of kaolinite from primary minerals. This process proceeds directly or through an intermediate stage of three-layer lattice silicates. Both these processes develop simultaneously, depending on local variation of geochemical character of the environment.

The formation of kaolinite or three-layer silicates (micas, montmorillonite) from primary minerals depends on physico-chemical conditions regulated by climate and topography of the area and, locally, by the distance of a given zone from the primary rock surface.

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PROCESY MINERAŁOTWÓRCZE W POKRYWACH ZWIETRZELINOWYCH NA KWAŚNYCH SKAŁACH MAGMOWYCH I METAMORFICZNYCH DOLNEGO ŚLĄSKA

Streszczenie

Przedstawiono wyniki badań mineralogicznych trzeciorzędowych pokryw zwietrzelinowych uformowanych na gruboziarnistym granicie biotytowym typu Borowa (Roztoka), na biotytowych lub dwumikowych granitach strzegomskich (Żarów, Bolesławice), zwietrzeliny granitu rumburskiego odsłoniętej w kopalni węgla brunatnego Turów oraz zwietrzeliny biotytowego gnejsu strzelińskiego (Wyszonowice). Mają one charakter kaolinitowy. Stwierdzono prawidłowości w wykształceniu i rozmieszczeniu głównych składników mineralnych w tych pokrywach, wyrażające się: 1) zróżnicowaniem wielkości ziarn i rozdziałem pomiędzy określone klasy ziarnowe (frakcje) głównych składników mineralnych zwietrzeliny, co jest uzależnione od mechanizmu powstawania i przeobrażania tych minerałów (fig. 1, 2); 2) zmiennością pionową w rozmieszczeniu minerałów w profilu wietrzeniowym (strefowość), powodowaną zmieniającymi się z głębokością warunkami fizyko-chemicznymi (fig. 3, 4, 5).

W badanych pokrywach wydzielono następujące strefy, różniące się charakterem mineralogicznym: słabo zmienionej skały pierwotnej, kaolinitowo-mikową i kaolinitową. Na podstawie paragenez mineralnych typowych dla poszczególnych stref, określono jak zmieniają się z głębokością warunki fizykochemiczne w profilu wietrzeniowym. Wymienione strefy oraz rozkład zawartości żelaza w profilu wietrzeniowym wskazują, że badane pokrywy wietrzeniowe formowały się w klimacie gorącym i wilgotnym, z dłuższymi okresami suchymi, na obszarach o dość wysokim poziomie wód gruntowych i niezbyt intensywnym drenowaniu opadów atmosferycznych.

Głównymi procesami minerałotwórczymi w pokrywach zwietrzelinowych były: inkongruentne rozpuszczanie minerałów skałotwórczych i przeobrażania struktur warstwowych. W wyniku pierwszego procesu tworzył się kaolinit i serycyt ze skaleni, procesem przeobrażenia było przejście biotytu i muskowitu w kaolinit a niekiedy biotytu w mikę dioktaedryczną, typu muskowitu.

W zależności od warunków fizykochemicznych, regulowanych generalnie klimatem i topografią terenu, a lokalnie oddaleniem od skały niezmienionej, przeważa tworzenie się w czasie wietrzenia kaolinitu, lub krzemianów trójwarstwowych. Dlatego też wietrzenie trzeciorzędowe doprowadziło do utworzenia kaolinitowych pokryw zwietrzelinowych, natomiast wietrzenie współczesne, wskutek odmiennego klimatu, prowadzi do powstania utworów glebowych o charakterze montmorillonitowo-illitowym.

OBJAŚNIENIA FIGUR

Fig. 1. Zmienność zawartości głównych składników mineralnych z uziarnieniem w zwietrzelinie na granicie biotytowym (Bolesławice) — strefa kaolinitowo-mikowa
1 — kaolinit, *2* — kwarc, *3* — minerały pęczniejące, *5* — K-skaleń, *6* — plagioklazy, *7* — montmorillonit, *8* — minerały inne

Fig. 2. Zmienność zawartości głównych składników mineralnych z uziarnieniem w zwietrzelinie na granicie biotytowym (Roztoka) — strefa kaolinitowa

Fig. 3. Zmienność zawartości głównych składników mineralnych z głębokością w zwietrzelinie na granicie biotytowym (Bolesławice)

Fig. 4. Zmienność zawartości głównych składników mineralnych z głębokością w zwietrzelinie na gnejsie biotytowym (Wyszonowice)

Fig. 5. Zmienność zawartości głównych składników mineralnych z głębokością w zwietrzelinie na granicie biotytowym (Roztoka)

Fig. 6. Przekrój przez diagram równowag fazowych w układzie $K_2O—Na_2O—Al_2O_3—SiO_2—H_2O$ wzdłuż izoplety $\lg\frac{[Na^+]}{[H^+]} = 4$ (Hess 1966)
Liniami przerywanymi zaznaczono rozpuszczalność kwarcu i bezpostaciowej krzemionki w wodzie
Obszarami zakreskowanymi zaznaczono przypuszczalny skład chemiczny roztworów: *A* — w strefie zmienionej skały pierwotnej, *B* — w strefie kaolinitowo-mikowej, *C* — w strefie kaolinitowej

Fig. 7. Zmienność zawartości głównych składników mineralnych z głębokością w glebie na granicie biotytowym (Borów)

Fig. 8. Zmienność zawartości głównych składników mineralnych z uziarnieniem w glebie na granicie biotytowym (Borów) — poziom *(B)/C*
Objaśnienia zob. fig. 1

Ванда СИКОРА, Лешек СТОХ

ПРОЦЕССЫ МИНЕРАЛООБРАЗОВАНИЯ В КОРЕ ВЫВЕТРИВАНИЯ КИСЛЫХ МАГМАТИЧЕСКИХ И МЕТАМОРФИЧЕСКИХ ПОРОД НИЖНЕЙ СИЛЕЗИИ

Резюме

В работе представлены результаты минералогического исследования третичной коры выветривания, развитой на крупнокристаллическом биотитовом граните района Барув (Розтока), на биотитовых или двуслюдяных гранитах Стшегомского массива (Жарув, Болеславице), на румбурском граните (обнажения в буроугольном карьере Турув) и на биотитовых стшелинских гнейсах (Вышоновице). Продукты выветривания перечисленных пород отличаются каолинитовым характером. Определены закономерности в развитии и распредении основных минеральных компонентов коры выветривания, выраженные: а) дифференцированностью по величине зерен основных компонентов и их распределением по гранулометрическим классам (фракциям), что обусловлено процессами образования и изменения этих минералов (фог. 1, 2), б) особенностями распределения минералов в вертикальном профиле коры врветривания (зональность), обусловленными изменяющимися с глубиной физико-химическими условиями (фиг. 3, 4, 5).

Кора выветривания исследованных районов подразделяется на следующие зоны, характеризующиеся разным минеральным составом: зону слабо измененных материнских пород, каолинит-слюдяную и каолинитовую зоны. На основании парагенетических групп минералов, свойственных отдельным зонам, аннлизировались изменения физико-химических условий в разрезе коры выветривания. Зональность коры выветривания и распредение железа в ее разрезе показывают, что выветривание происходило в условиях жаркого, влажного климата, с продолжительными периодами, при довольно высоком залегании уровня грунтовых вод и в условиях слабой инфильтрации атмосферных вод.

Основные процессы минералообразования в коре выветривания состояли в инконгруэнтном растворении породообразующих минералов и переоборудовании слоистых структур. Первый процесс приводил к образованию каолинита и серицита за счет полевых шпатов, а в итоге преобразования структуры биотит и мусковит превращались в каолинит, а иногда биотит превращался в диоктаэдрическую слюду типа мусковита.

В зависимости от физико-химических условий, зависящих, главным образом, от климатической и топографической обстановки, а местами от расстояния до материнской неизмененной породы, преобладало выветривание с образованием каолинитов или же с образованием трехслойных силикатов. По этим причинам третичные процессы выветривания выражались в образовании каолинитовой коры выветривания, а современное выветривание, происходящее в иной климатической обстановке, способствует почвообразованию монтмориллонит-иллитового типа.

ОБЪСНЕНИЯ К ФИГУРАМ

Фиг. 1. Изменение содержания основных минеральных компонентов в зависимости от гранулометрического состава в коре выветривания биотитового гранита (Болеславице) — каолинит-слюдяная зона

1 — каолинит, *2* — кварц, *3* — слюда, *4* — разбухающие минералы, *5* — К-полевой шпат, *6* — плагиоклаз, *7* — монтмориллонит, *8* — другие минералы

Фиг. 2. Изменение содержания основных минеральных компонентов в зависимости от гранулометрического состава в коре выветривания биотитового гранита (Розтока) — каолинитовая зона

Фиг. 3. Изменение содержания основных минеральных компонентов с глубиной в коре выветривания биотитового гранита (Болеславице)

Фиг. 4. Изменение содержания основных минеральных компонентов с глубиной в коре выветривания биотитового гнейса (Вышоновице)

Фиг. 5. Изменение содержания основных минеральных компонентов с глубиной в коре выветривания биотитового гранита (Розтока)

Фиг. 6. Сечение через диаграмму фазовых равновесий в системе K_2O — Na_2O — Al_2O_3 — — SiO_2 — H_2O вдоль изоплеты $\lg\frac{[Na^+]}{[H^+]} = 4$ (Хесс 1966). Пунктирными линиями обозначена растворимость кварца и аморфного кремнезёма в воде. Заштрихованными полями показан предполагаемый химический состав растворов:

А — В зоне измененной материнской породы, В — в каолинит-слюдяной зоне, С — в каолинитовой зоне

Фиг. 7. Изменение содержания основных минеральных компонентов с глубиной в почве на биотитовом граните (Борув)

Фиг. 8. Изменение содержания основных минеральных компонентов в зависимости от гранулометрического состава в почве на биотитовом граните (Борув) — горизонт $(B)/C$

Объяснения как к фиг. 1.

PLATE I (PLANSZA I, ТАБЛИЦА I)

Phot. 1. Sericitization of orthoclase in slightly altered primary rock (Bolesławice). X 50, crossed nicols

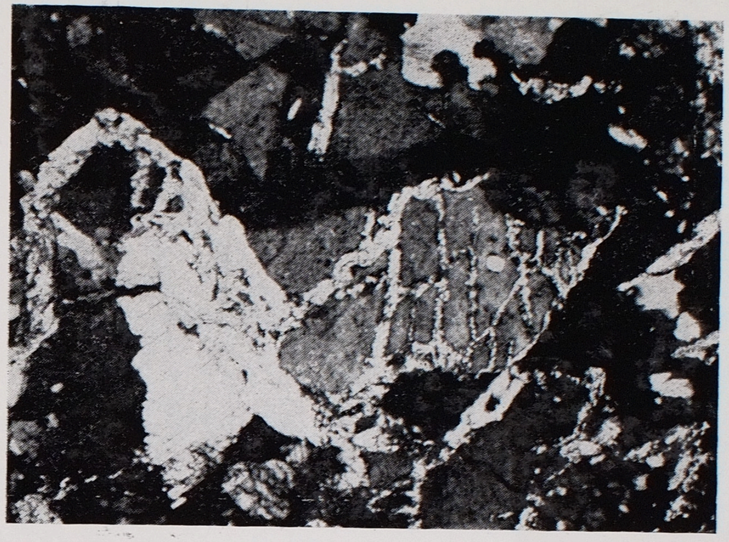
Serycytyzacja ortoklazu w strefie słabo zmienionej skały pierwotnej (Bolesławice). Pow. X 50, nikole X

Серицитизация ортоклаза в зоне слабо измененной материнской породы (Болеславице). Увел. X 50, николи скрещенные

Phot. 2. Sericite rims around of quartz grains. Bolesławice — slightly altered primary rock. Magn. X 140, crossed nicols

Obwódki serycytowe wokół ziarn kwarcu — Bolesławice, strefa słabo zmienionej skały pierwotnej. Pow. X 140, nikole X

Серицитовые каемки вокруг зерен кварца — зона слабо измененной материнской породы (Болеславице). Увел. X 140, николи скрещенные



Phot. 1

Phot. 2

Wanda SIKORA, Leszek STOCH — Mineral forming processes in weathering crusts of acid magmatic and metamarphic rocks of Lower Silesia