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Sands and calcite cement-bodies (the Baranów Beds) from Świniary, eastern margin of the Holy Cross Mts.

The paper presents the results of studies of sands with horizons of sandstones in the form of calcite cement-bodies from Świniary near Baranów Sandomierski. Besides a macroscopic description numerous laboratory tests such as SEM viewing, X-ray diffraction and trace elements content have been applied in these sediments. Morfology and microtexture of quartz grains enable determination of differences in the sedimentation environment of each part of the discussed sand deposits: from a marine basin with distinct influence of a shore zone, through a gradual change of physical-chemical conditions connected with deepening, followed by a decrease of shore zone grain content and increase of chemical features content. Chemical analyses of the cement and character of quartz grain surfaces from the calcite cement-bodies point to a complicated course of diagenetic processes connected with precipitation of calcite and barite and synchronous quartz dissolution and silica draining. The trace elements content of the cement points to non-marine source of cements. The age of diagenetic processes may be defined as Pliocene till present.

INTRODUCTION

The quartz sands from Świniary were described by K. Kowalewski (1929) in a paper on stratigraphy of the Krakowiec Clays. The author included sediments outcropping at Świniary to shallow marine Tertiary sediments of the Nida Trough. The age of the series was determined as Upper Tortonian, while the quartz sands were defined as sands with *Pecten scissus* included in the sub-*Ervilia* Beds. K. Kowalewski also noted the possibility of using the sands outcropping in the Vistula Valley slope in the glass industry. J. Czarnocki (1935) confirmed the stratigraphic position of the quartz sands from Świniary included them to the Baranów Beds, according to the definition of the Baranów Beds by V. Hilber (1882).

Further papers on the stratigraphic position and exploitation possibilities of the Świniary quartz sands appeared after the Second World War (K. Kowalewski, 1957; S. Pawłowski,

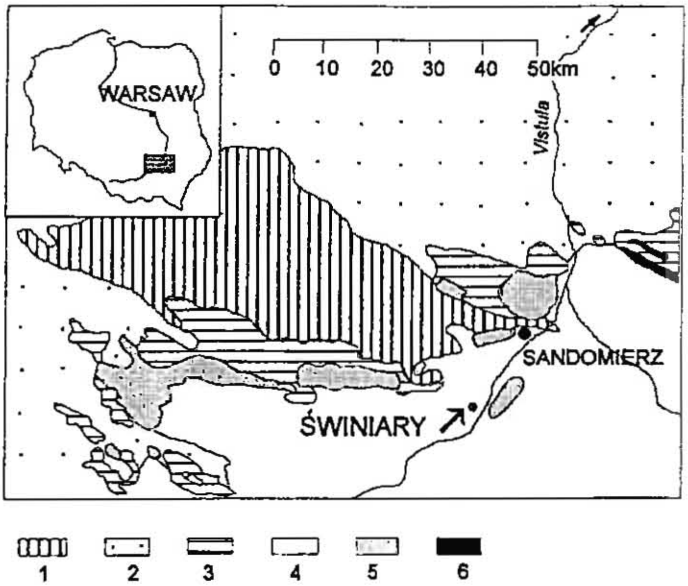

Fig. 1. Location of outcrop

1 — Palaeozoic; 2 — Mesozoic; Tertiary — Miocene: 3 — Badenian, 4–6 — Sarmatian: 4 — Krakowiec Clays, 5 — carbonate-detrital deposits, 6 — reef limestones

Lokalizacja odsłonięcia

1 — paleozoik; 2 — mezozoik; trzeciorzęd — miocen: 3 — baden, 4–6 — sarmat: 4 — iły krakowieckie, 5 — osady węglanowo-detrytyczne, 6 — wapienie rafowe

1956, 1957, 1965; M. Błaszak, 1965). In the years 1954 and 1962 the Geological Company from Cracow carried out a geological documentation of deposits from the Świniary sandpit.

Stratigraphic, palaeogeographic and palaeontologic problems were presented by A. Radwański (1973) in a paper concerning the development of the Miocene sea transgression onto the north-east and eastern slopes of the Holy Cross Mts. At present, according to the determinations of the VIII Congress of the Regional Commitee on Mediterranean Neogene Stratigraphy (S. Dyjor, A. Sadowska, 1986) the age of the Baranów Beds is defined as Lower Badenian. The latest papers (K. Pawłowska, 1985, 1994) confirm the stratigraphic position of the Baranów Beds.

The following paper presents the results of recent studies of sands including horizons of sandstones from Świniary based on methods not used previously by other researchers.

GEOLOGICAL SETTING

Deposits of sand facies, referred to as the Baranów Beds, are most clearly exposed in two regions of the southeastern margin of the Holy Cross Mts.: in the Opatówka Valley and in the vicinity of Sandomierz, in the area between Bogoria in the west, Nawodzice in the

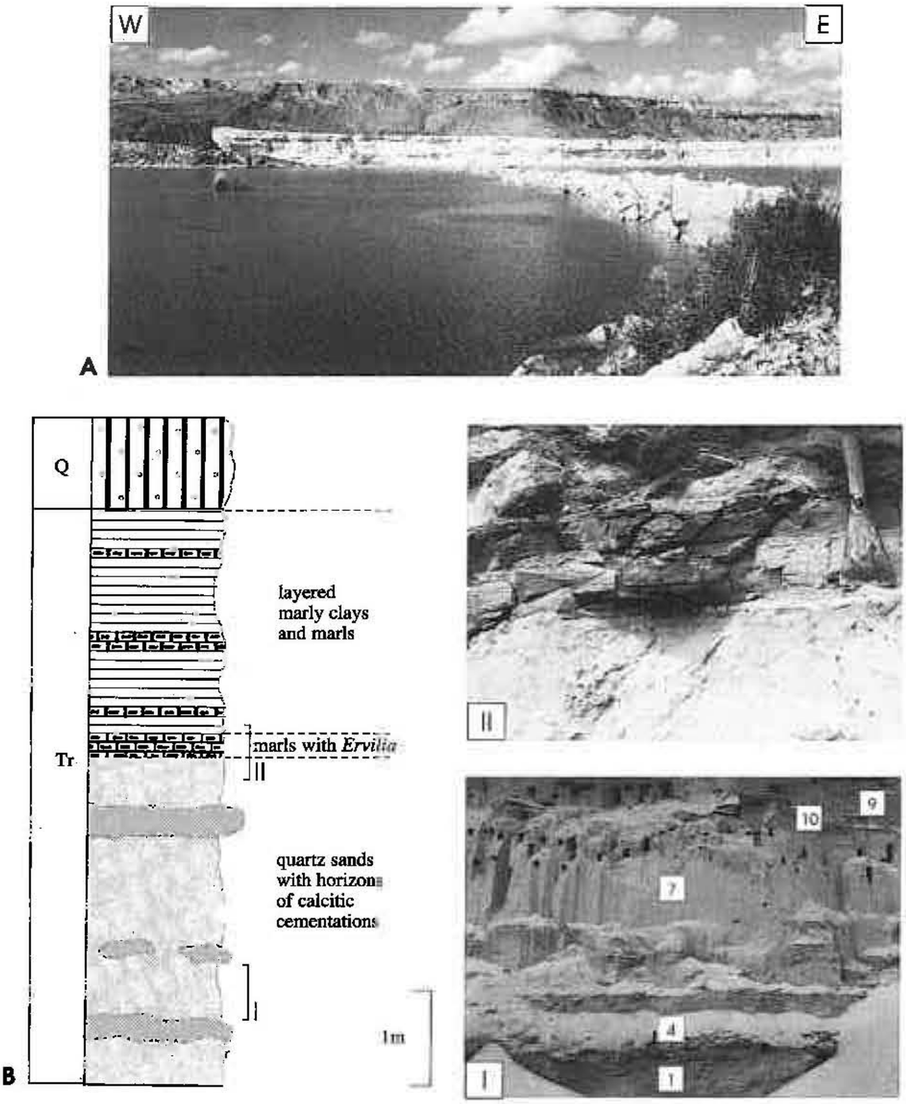

Fig. 2. A. General view of Świniary sandpit

B. Generalized lithological section: I — quartz sands with calcite cement-bodies horizons (1, 4, 7, 9, 10 — location of samples), II — top of quartz sands, passage through *Ervilia* marls into laminated clays and marls

Tr — Tertiary, Q — Quaternary

A. Widok ogólny odsłonięcia w Świniarach

B. Uproszczony profil litologiczny: I — piaski kwarcowe z poziomami cementacji wapnistych (1, 4, 7, 9, 10 — miejsca pobrania próbek), II — strop piasków kwarcowych, przejście poprzez warstwę margli z *Ervilia* do warstwowanych iłów i margli

Tr — trzeciorzęd, Q — czwartorzęd

east and Świniary in the south. The best, often previously described, sections of sand facies were found at Nawodzice, Rybnica and Świniary (K. Kowalewski, 1950; S. Pawłowski, 1957, 1965; M. Błaszak, 1965; W. Bałuk, A. Radwański, 1968; A. Radwański, 1973). At present the only well exposed section is the one at Świniary, about 4 km north of Baranów Sandomierski (Fig. 1).

In the lower part of the Miocene deposits in the vicinity of Świniary, limestones and marls with *Lithothamnia* occur. A quartz sand complex with frequent horizons of sandstones in the form of calcite cement-bodies occurs above them (thickness up to 20 m). The uppermost part of this complex, reaching from 3 to 4 m in thickness, is visible in the sandpit. Typically the quartz sand complex is structureless; sporadic bioturbation horizons and single burrows of *Ophiomorpha nodosa* Lundgren appear. In the eastern part of the outcrop units with tabular cross-lamination occur. The quartz sands contain sandstones in the form of calcite cement-bodies such as bed-form and cylinder-shaped cementations (Fig. 2A, BI), which most frequently occur in the western and central part of the sandpit. Whereas the eastern part of the outcrop lacks calcite cement-bodies. Sporadically poorly lithified spherical zones with a calcitic-ferruginous cement occur there. Sands and cementation horizons contain large amounts of oyster and pecten shells, numerous serpulids, bryozoan colonies and less frequent echinoids and asteroids. Oysters, serpulids and bryozoans often occur in agglomerates. Sporadic foraminifers can be also found (Pl.VI, Fig. 4). Shells as well as their fragments visible in the outcrop have been decalcified, as a result of which they are very soft. Skeletal elements are generally crushed; they often gather in distinct layers. This points to a high-energy environment, in which skeletal elements were crushed and redeposited. A 2 cm thick layer of cream-coloured marls with an abundance of crushed *Ervilia* shells (Fig. 2 BII) occurs directly above the sands. It corresponds to the *Ervilia*-Beds (K. Kowalewski, 1929, 1957; A. Radwański, 1973), a horizon which indicates facies changes taking place in the marginal parts of the Carpathian Foredeep. There is a sharp transition between the sands and this bed, preceded by a slightly larger admixture of pelitic fraction in the top part of the sands. In the present state of the outcrop it is difficult to investigate the layers continuity. Directly over the cream-coloured marls a 4–5 m thick complex of grey and brown layered marly clays and marls appears. These sediments are characterized by a large $CaCO_3$ and smectite content. The section is topped by a 2 m thick horizon of Quaternary tills.

METHODOLOGY

Besides a macroscopic description numerous laboratory tests have been used in analysing sands and calcite cement-bodies from Świniary. These methods can be grouped in three sections according to different techniques.

Grain size distribution. Sands as well as sandstones in the form of calcite cement-bodies have been put through granulometric analyses. Samples were taken from 4 vertical sections placed along the sandpit wall, coming to a total of 70 samples of sands and 32 samples of sandstones. 30 sand samples and 15 sandstone samples were examined in detail. Sand samples, after drying, were separated in a sieving column with the following meshes:

1.25, 0.8, 0.4, 0.315, 0.25, 0.16, 0.125, 0.09, and 0.063 mm. Sandstone samples collected from cementation horizons were etched in 5% HCl to remove calcite cement.

After washing in distilled water and drying they were separated in a similar sieving column as that used for the sand samples. Figure 3 shows grain size distribution and comparison of chosen statistical parameters (R. L. Folk, W. C. Ward, 1957).

Quartz sand grain surface microtextures. SEM viewing concerned quartz grains representing the 1.0–0.5 mm fraction from sand samples (samples 1, 7, 9) and the fractions obtained by etching sandstones (sample 10) from section I (Fig. 2BI) following the method presented by K. Rywocka-Kenig (1993). The whole fraction was etched in cold 0.1n HCl, and afterwards washed several times in distilled water and alcohol. $AgNO_3$ was used to check the presence of chlorides in the water. The next step was to choose 300 quartz grains at random singling out rounded, partly rounded and angular grain types with a polished or frosted surface. 16 quartz grains proportionally representing the mentioned quartz types as well as grain conglomerates, which did not get dissolved during HCl etching, were placed on a microscope stage. They were next coated with gold in the presence of a carbon electrode. Grains were viewed with the *Jeol JSM-840A* scanning microscope of the Polish Academy of Sciences with the possibility of making controlling qualitative analyses of the chemical content. A total of 70 photographs were taken, Plates I–VI show some of them. Microtexture characteristics classification of examined quartz grains was already presented in details by K. Rywocka-Kenig (1993) and is shown on Figure 6.

Cement mineralogy. Initially the mineralogy of calcite cements was determined by colouring thin sections following the B. D. Evamy method (1963) and using X-ray diffraction on powdered samples. The percentage content of $CaCO_3$ was determined through the Sheibler method (see E. Myślińska, 1992). A *Perkin Elmer* spectrometer type *400* was used to examine the trace element content from the HCl-etched cement (Mg, Fe, Mn, Ti, K, and Sr) (Tab.1). The sulphur content was determined on a scale, precipitating the examined elements with barium. The paraffin method (PN-88/B-04481) was used to check the degree of lithification in samples on the basis of bulk density changes (ρ).

RESULTS

SANDS

Quartz sand from the Baranów Beds is homogeneous in granulometric composition (Figs. 3–5), where the 0.125–0.25 mm fraction prevails, reaching up to 90% content. It can be defined as fine-grained sand, where mean grain size (M_ϕ) between 2.25–2.5 ϕ predominates, for sample 1 it reaches 2.43 ϕ, for sample 7 — 2.4 ϕ, for sample 9 — 2.2 ϕ. It is also characterized by very good sorting, which is confirmed by the invariability of sorting coefficient (σ_ϕ). Over 50% of the results are below 0.35 (R. L. Folk, W. C. Ward, 1957); for presented samples it comes up to: 0.3 for sample 1, 0.34 for sample 7 and 0.68 for sample 9. In the whole closely examined section from Świniary, grain-size distribution parameters (M_ϕ and σ_ϕ) do not change radically, apart from the topmost part of quartz sands with cementation horizons. Samples from this part of the sandpit (samples 9 and 10) have a slightly higher coarse fraction content (Figs. 3).

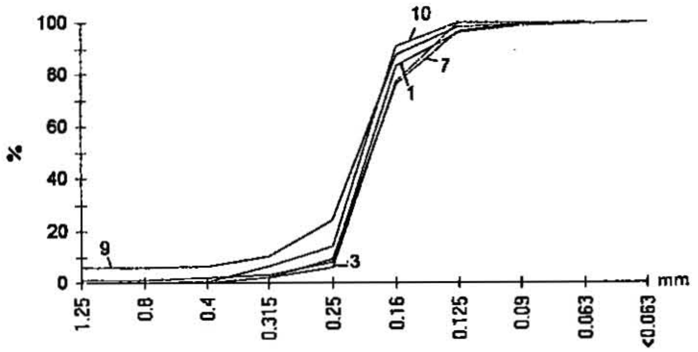

Fig. 3. Grain size distribution curves of quartz sands and quartz grains from horizons of calcite cement-bodies
1, 7, 9 — quartz sands samples; 3, 10 — samples from cement-bodies
Krzywe uziarnienia piasków kwarcowych oraz ziarn kwarcu z poziomów cementacji wapnistych
1, 7, 9 — próbki piasków kwarcowych; 3, 10 — próbki z cementacji

The mineral composition of sands from the outcrop is also uniform. Besides prevailing quartz, small amounts of heavy mineral grains are also present, as well as muscovite, feldspar and barite (Pl. IV, Fig. 5) (confirmed by SEM chemical analysis). Fraction over 0.25 mm comes to a maximum of 10% of the samples weight and is mainly composed of organic detritus, as well as calcitic and baritic agglomerates of quartz grains up to 1.5 mm in diameter (Pl. VI, Figs. 1, 1a, 2). Content of agglomerates as well as the fraction over 0.25 mm is higher in sample 9. X-ray analyses of fractions below 0.063 mm show that besides quartz only calcite is present, the content of which does not exceed 1% of the mass of the whole sample.

In the lower part of the outcrop, below the cementation horizon shown on Figure 2BI, prevailing quartz grains are angular, mainly transparent, less frequently translucent. They are mainly polished or some of them have a slightly frosting. Rounded quartz grains typical for marine environments are less frequent (Pl. I, Figs. 1, 2). SEM analysis displayed v-shaped subaqueous pits considered to be typical for a high-energy shore environment (Pl. I, Figs. 2a, 4). They were distinguished by D. H. Krinsley, J. C. Doornkamp (1973), and noted by E. Mycielska-Dowgiałło (1988) on grains from beaches in different parts of the world, as well as by K. Rywocka-Kenig (1993) on grains redeposited from beach environments. Occurrence of arch shaped incisions of different size and variable degree of development (Pl. I, Figs. 1a, 3) is strictly connected with the same grains and is shown on the diagram (Fig. 6, sample 1). These two features have a relatively strong correlation (K. Rywocka-Kenig, 1993). Similarly triangular forms are also well represented. They can be features of previous subaerial environments or are a feature of a shore environment. Generally, quartz grains from this sample are "clean", with a predomination of mechanical features, that is from transportation, while post-sediment features are less frequent. Polygenetic features are also scarce, i.e. granular disintegration, which is preserved in pits within the grain surface.

Many grains considered to have angular in the binocular microscope turned out to have slightly rounded corners after SEM viewing. Angular grains have a considerably lower

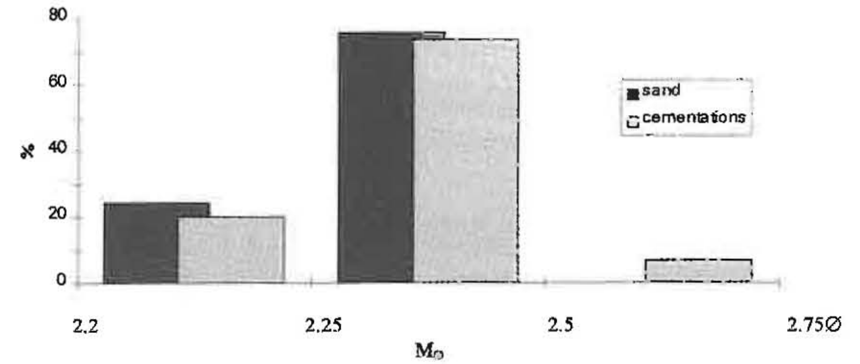

Fig. 4. Variation of mean grain size (M_ϕ) of quartz sands (30 samples) and quartz grains from horizons of calcite cement-bodies (15 samples)

Zmienność średniej wielkości ziarn (M_ϕ) piasków kwarcowych (30 próbek) oraz ziarn kwarcu z poziomów cementacji wapnistych (15 próbek)

variety stock of microtextural forms. On wide usually "clean" conchoidal fractures, features of secondary relief do not appear.

Quartz grains from examined sands are immature in the morphometric process, thus they characterize a short transport deposit. They come from intensely eroded areas, most probably from Cambrian sandstones of the Klimontów Range, which lies north of the Świniary area. At the same time, the influence of a nearby shore zone is marked, where grains with a relief typical for high-turbulence beach environments were formed. In general the environment of marine sedimentation had stable physical-chemical conditions, was warm, little aggressive to quartz grains, silica undersaturated (which is testified by a smooth grain surface) and lacking organic acids.

Entirely different conditions took place during the sedimentation of Miocene sands in the vicinity of Orłowo Cliff, where a strong froshing of quartz grains occurs (K. Kenig, 1995) and in the region of Bełchatów (J. Goździk, E. Mycielska-Dowgiałło, 1988).

In sample 7 from the central part of the sandpit (Fig. 2BI) from sands without cemented inclusions, binocular microscope viewing shows angular and partly rounded, transparent and translucent grains. They are usually polished, although an increase in comparison to sample 1 in frosted grains of variable size can be noted. Opalescent quartz grains, with cracks and inclusions, typical for Tertiary deposits are also present. Foraminifers such as *Nonionella* sp. (Pl. VI, Fig. 4) occur there, too (by J. Paruch-Kulczycka).

The most characteristic microtextural features are present on rounded and partly rounded grains (Pl. II, Figs. 1–3), at the same time the grain from micrograph 3 has fracture features, although with rounded corners. Grain from micrograph 2 magnified 200 x displays v-shaped subaqueous pits which point to processes taking place in a high-energy shore environment (Pl. II, Fig. 2a). The magnification of 1000 x allows observation of even more distinct fragments covered with sharply outlined v-shaped subaqueous pits (Pl. III, Figs. 2, 3). Apart from these forms rectilinear cracks and conchoidal fractures of a variable intensity are also frequent (Pl. III, Fig. 1). These features do not appear on freshly polished angular grains (Pl. II, Fig. 4) or on frosted angular grains (Pl. II, Fig. 5). The latter grain shows signs of

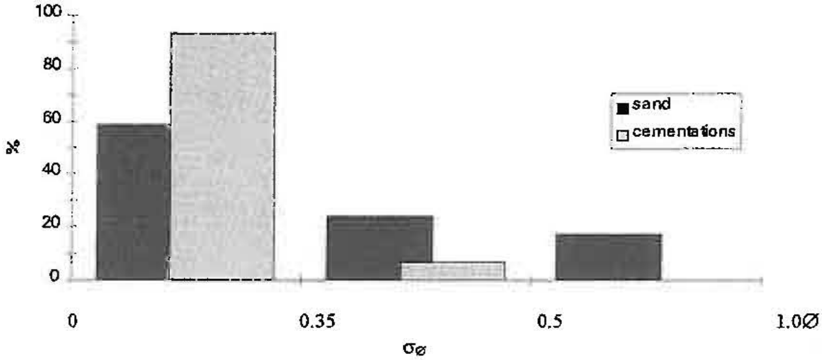

Fig. 5. Variation of sorting coefficient (σ_ϕ) of quartz sands (30 samples) and quartz grains from horizons of calcite cement-bodies (15 samples)

Zmienność współczynnika wysortowania (σ_ϕ) piasków kwarcowych (30 próbek) oraz ziarn kwarcu z poziomów cementacji wapnistych (15 próbek)

various chemical processes leading to formation of an aluminosilicate overgrowth, causing the frosting effect viewed under low magnifications (Pl. III, Fig. 4). Effects of grain dissolution are also visible on rounded grains (Pl. III, Figs. 5, 6). A general increase of chemical processes in sample 7 in comparison to sample 1 is shown on the diagram (Fig. 6).

In the binocular microscope, sample 9 from the fine-grained sand horizon with discontinuous cementation inclusions shows mainly angular and partly rounded grains, with a predominance of frosted over polished grains. Rounded polished grains also occur here. Most of the grains are translucent and milk quartzes, while transparent grains are in a minority.

The discussed sands have a considerably smaller number of rounded grains, with a smooth surface (Pl. IV, Fig. 1), with arch shaped incisions and less legible v-shaped subaqueous pits (Pl. IV, Fig. 1a). Partly-rounded grains are more frequent (Pl. IV, Fig. 2). Fractured grains are also present (Pl. IV, Fig. 3); both mentioned types have a slightly frosted surface. On angular grains, formed through large-scale conchoidal fractures signs of surface dissolution are also present (Pl. IV, Fig. 4). Grains with different grades of frosting, even rounded grains with a smooth surface, frequent signs of surface dissolution, precipitation and etching appear (Pl. V, Fig. 1). Notably smooth conchoidal fractures start to get covered with very fine precipitated silica (Pl. V, Fig. 2). Some etching forms are crystallographically oriented (Pl. V, Figs. 1, 4) or irregular (Pl. V, Fig. 3, 5, 6).

The increase of chemical features in sample 9 determined on the basic of SEM viewing is shown on the diagram (Fig. 6) and can be correlated with the increase of frosted grain content. It should be stressed that only SEM viewing allows a correct interpretation of frosting origin, conventional optical methods are not sufficient.

Table 1

Chemical analysis and the trace elements contain of cement from calcite cement-bodies horizons

Sample	Insoluble parts in HCl [% mass]	Ca [% mass]	$CaCO_3$ [% mass]	Mg [% mass]	Mn [ppm]	Ti [ppm]	Fe [ppm]	K [ppm]	S [ppm]	Sr [ppm]
3	53.84	16.48	41.16	0.10	25	10	135	140	912	–
4	53.10	20.20	50.44	0.17	225	13	545	200	460	46
20	83.52	6.60	16.48	0.05	45	66	130	110	750	–
49	79.71	8.12	20.29	0.08	28	46	221	100	775	–
63	60.20	16.80	41.95	0.22	30	26	400	136	70	61
73	65.07	14.50	36.21	0.24	37	13	205	111	80	45
106	62.84	15.50	38.70	0.20	200	17	270	130	140	42
214	58.04	17.50	43.70	0.13	470	12	250	120	410	25
215	76.50	9.80	24.47	0.12	61	12	70	92	70	30
218	63.40	15.20	37.95	0.30	16	29	330	145	220	57

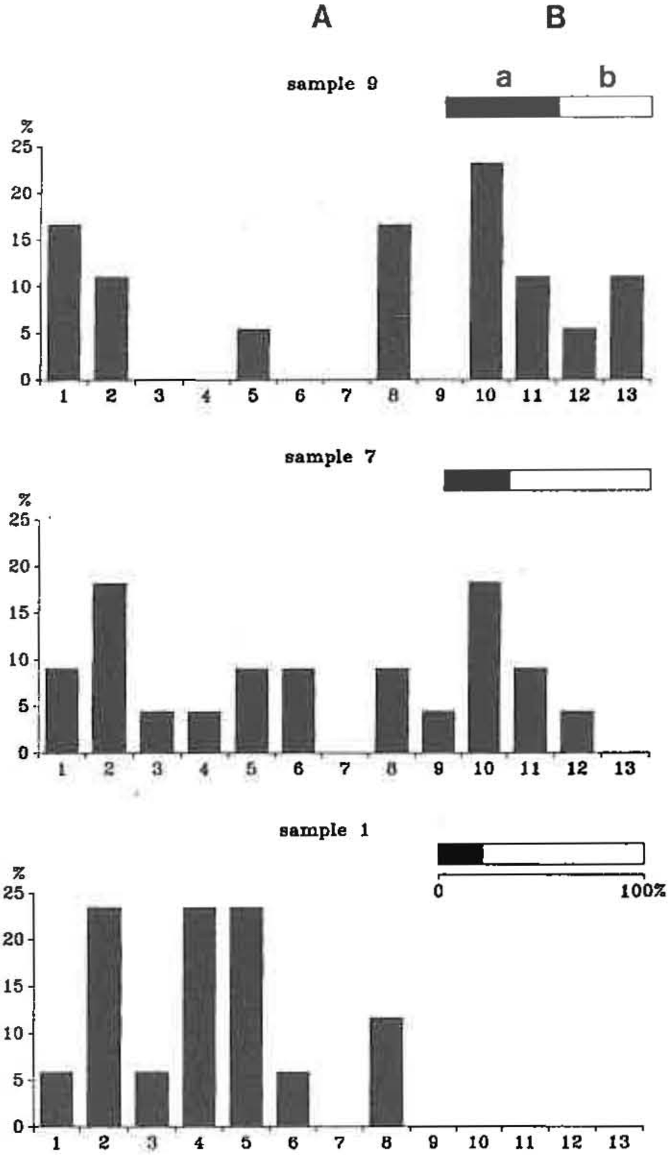

Fig. 6. A. Frequency of various microtextures of quartz grains

1 — conchoidal fractures, 2 — subaqueous v-shaped pits, 3 — abrasion v-shaped pits, 4 — triangular abrasive forms, 5 — arch shaped incisions, 6 — cracks, 7 — eolian pitting, 8 — granular disintegration, 9 — exfoliar disintegration, 10 — effects of silica dissolution, 11 — effects of silica precipitation, 12 — crystallographically oriented chemical etching, 13 — secondary minerals

B. Content of: a — frosted quartz grains, b — polished quartz grains

CALCITE CEMENT-BODIES

Sandstones occur within sands in the form of two calcite cement-bodies horizons (bed-form) in the west and central part of outcrop, reaching a maximum thickness of 0.7 m, and a variable number of horizons (2 to 7) of a thickness between 0.05 and 0.20 m restricted and laterally variable (Fig. 2). In the central part of the outcrop, rare cement-bodies in the form of lenses, diameter up to 0.3 m (cylinder-shaped form), occur. Horizons and flat lenses are typically found in a structureless, fine- and very fine-grained sediment-samples with mean grain size (M_{ϕ}) between 2.25 and 2.50 ϕ, and very good sorting — (σ_{ϕ}) between 0.23 and 0.42 (Figs. 3–5) — predominate. Organic remains within the calcite cement-bodies are rare and randomly distributed. They are mainly oyster and pecten shell fragments. The organic remains content is variable, from horizons lacking them, through rarely occurring foraminifers and fragments of algal thalli to lithified oyster-serpulid agglomerates.

Similiar cementation forms occur in the Opatówka Valley. They were described by G. Czapowski (1976) as a several forms of epigenetic carbonate cementations.

Apart from quartz, sporadic (below 1%) grains of heavy minerals, feldspars and micas compose the discussed sandstones. Quartz grains within cementations are angular or poorly rounded (Pl. VI, Figs. 2, 3). Microscope analysis shows lack of contact or single quartz grain contacts. In the discussed sandstones a low-magnesium cement predominates (Tab. 1). It occurs in the form of sparite. Within cementation horizons, apart from a calcite cement, barite and silica also occurs. Its occurrence was determined by microscope analysis of thin sections and SEM chemical analysis of conglomerates of quartz grains from sample 10 (Pl. VI, Figs. 2, 3). Its occurrence is restricted only to concentric zones up to 1 mm in diameter in which quartz grains are cemented with barite (Pl. VI, Figs. 1, 1a, 2, 3) or calcitic-siliceous cements.

The low content of magnesium and particularly strontium (Tab. 1) in the cement unequivocally points to fresh or mixed pore waters saturating the sediment during diagenesis. The process of quartz sandstones diagenesis, connected with the evolution of sparite cement with a synchronous quartz grain dissolution took place with variable intensity. Bulk density changes are supposed to express the lithification ratio within cementation horizons (J. Rutkowski, 1976). Infilling of pores by matrix causes decrease of porosity and increase of the rock's bulk density. Parts of cemented sands from Świniary are poorly lithified ($\rho <$ 1.8 g/cm^3), however cement-bodies with bulk density between 2.06 and 2.46 g/cm^3 predominate, representing strongly and very strongly lithified rocks. $CaCO_3$ content in calcitic quartz sandstones varies from 7 to 50%, with an average of 27.9% (Tab. 1). Part of the Ca^{2+} is bounded by phosphate ions, which is suggested by a 3% overestimate of the sum of dissoluble and insoluble parts obtained through chemical analyses (Tab. 1).

A. Częstość występowania ziarn z badaną cechą

1 — przełamy muszlowe, 2 — v-kształtne nacięcia podwodne, 3 — v-kształtne nacięcia aeralne, abrazyjne, 4 — trójkątne nacięcia abrazyjne, 5 — łukowate nacięcia, 6 — spękania, 7 — ospowata powierzchnia eoliczna, 8 — dezintegracja granularna, 9 — dezintegracja łuskowa, 10 — efekty rozpuszczania krzemionki, 11 — efekty wytrącania krzemionki, 12 — wytrawienia zgodne z kierunkiem krystalograficznym, 13 — minerały wtórne

B. Zawartość matowych (a) i błyszczących (b) ziarn kwarcu

SEM viewing of quartz grain surfaces from cementation horizons notes the predominance of chemical features connected with dissolution of quartz grain surfaces (Pl.VI, Fig. 3a). Rare, preserved mechanical forms are characteristic for beach zones (Pl. VI, Fig. 2). These forms appear on smooth grain surfaces. Mechanical forms typical for eolian transportation have not been observed (D. H. Krinsley, J. C. Doornkamp, 1973; K. Rywocka-Kenig, 1993).

The present state of the outcrop does not allow the observation of symmetric wave ripples described by A. Radwański (1973). They are a rare feature and conditions enabling their creation must have been of short duration, most probably only during storms. At present no macroscopic concentrations of native sulphur occur (M. Błaszak, 1965; S. Pawłowski, 1965; A. Radwański, 1973), and the S content in chemical analyses of cement is low, between 70 and 460 ppm (Tab. 1).

CONCLUSIONS

Accumulation of the discussed deposits took place in shallow water environments below wave base, which is testified by the lack of wash-outs, rare occurrence of wave ripples and cross lamination. The faunal assemblage, preservation type of skeletal elements also point to an environment sporadically influenced by redeposition of organic remains. The occurrence of single burrows of *Ophiomorpha nodosa* Lundgren restricts the basin depth to about 30 m (E. F. Dike, 1972). The application of SEM viewing allowed determination of the sequence of changes within the basin, which was a marginal zone of the Carpathian Foredeep. Mineral features, morphology and microtexture of quartz grains in SEM viewing enable determination of differences in sedimentation environment of each part of the discussed sand deposits from Świniary. Sand deposits from the accessible part of the sandpit, despite a monotonous granulometric content and a lack of a distinct variability of grain-size distribution parameters, show a change in type of sedimentation.

The number of polished grains decreases to the top part of the section, from 78% in the lower part, through 67.5% in the central part and up to 44.5% in the upper part in the horizon with discontinuous calcite cement-bodies. The variability of sedimentation in the discussed profile is as follows. The lower part (sample 1) represents a separate sedimentation unit, in which a notable influence of shore-beach environments took place, conditions are little aggressive to quartz grains with a small free silica content and considerably warm. This is testified by a predominance of original short transportation features, with a laterally increasing number of grains with shore environment features and a small number of chemical features. The upper part of the section, represented by sample 7, similarly points to a zone with influence of shore environments, where angular short transport quartz grains, without signs of distinct reworking, prevail. However the proportion of chemical features content increases, causing in general the chemical "destruction" of grain surfaces, testified by increase of frosted grains observed under the binocular microscope. This process intensifies consequently to the top with the continuing accumulation of sands, among which there are abundant cement-bodies. A slow change in the sedimentation environment can be presumed. The increase of polygenetic and chemical features of grain surfaces from sample 9 (Fig. 6) is testified by the increase of number of frosted grains. This is most probably connected with the warming of waters, deepening of the basin and/or the increase of free silica and organic acids in sea water.

Applying SEM viewing for testing grain surface features from Miocene sands of the Baranów Beds allowed determination of the sequence of environmental changes during their sedimentation originally these started from a marine basin with distinct influence of the shore zone, through a gradual change of physical-chemical conditions connected with deepening, followed by a decrease of shore-zone grain content. It can be stated that these analyses gave another confirmation of bathymetric changes within the marginal zone of the Carpathian Foredeep in the vicinity of Świniary, suggested earlier by A. Radwański (1973).

Preliminary recognition of diagenetic processes was possible through observations of thin sections and chemical analyses. Contacts between quartz grains, destruction of grain outline, frequently encircling of grains by singular calcite crystals visible with the binocular microscope point to a complicated course of diagenetic processes connected with precipitation of calcite and a synchronous quartz dissolution and silica draining. Chemical analyses of the cement point to non-marine source of cements.

Lithification of sediment connected with precipitation of low-magnesium calcite and barite as well as the geometrical forms of cementation occurrences are an effect of diagenetic processes, which can be connected with flow rate and source of porous waters (R. A. Berner, 1980; M. Wilkinson, M. D. Dampier, 1990), dissolution of detrital organic material (M. Wilkinson, 1991) and dissolution of quartz grain surfaces. The age of diagenetic processes may be defined as Pliocene to Holocene (G. Czapowski, 1976). Most probably it is connected with Pliocene warm climatic conditions and tectonic movements in the Holy Cross Mts. Some poorly lithified forms can develop recently. The solution of these problems requires further detailed studies and will be presented in the future.

Zakład Geologii Czwartorzędu
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Krystyna KENIG, Anna WYSOCKA

PIASKI I STREFY CEMENTACJI WĘGLANOWYCH WARSTW BARANOWSKICH ZE ŚWINIAR (WSCHODNIE OBRZEŻENIE GÓR ŚWIĘTOKRZYSKICH)

Streszczenie

Przedstawiono wyniki najnowszych badań litologiczno-sedymentologicznych piasków oraz zawartych w nich stref cementacji węglanowych, wykształconych w formie płaskur, soczew lub koncentrycznych, wapnistych piaskowców kwarcowych odsłaniających się w piaskowni w Świniarach.

Sposób zachowania elementów szkieletowych, charakter osadu oraz rodzaj występujących w nim warstwowań wskazują, że gromadzenie osadu odbywało się w strefie płytkowodnej poniżej podstawy falowania w morzu wczesnobadeńskim. Zastosowanie metody SEM pozwoliło wyróżnić sekwencję zmian zachodzących podczas sedymentacji osadów piaszczystych. Liczba błyszczących ziarn kwarcu o cechach środowiska morskiego maleje ku stropowi odsłonięcia, od 78.0% w części dolnej, 67,5% w części środkowej, do 44,5% w części górnej badanego profilu.

Utwory dolnej części profilu gromadziły się w basenie sedymentacyjnym, w którym zaznaczają się wpływy środowiska brzegowo-plażowego, w warunkach mało agresywnych dla ziarn kwarcu, z małą ilością wolnej krzemionki, dość ciepłym. Wyraża to przewaga ziarn o cechach krótkiego transportu pierwotnego, udział ziarn o cechach środowiska brzegowego oraz niewielka zawartość ziarn o cechach chemicznych.

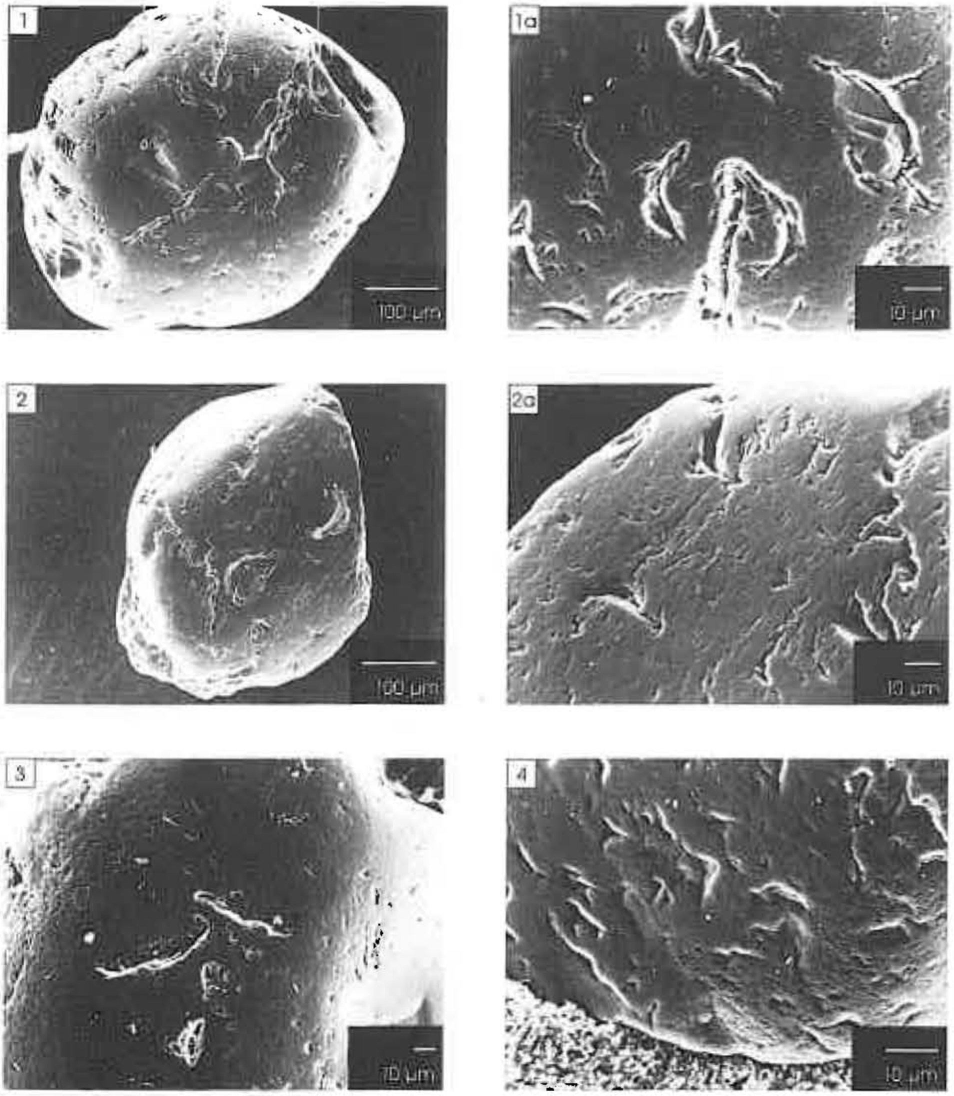
Środkowa część profilu tworzyła się nadal w basenie o cechach środowiska brzegowego. Oprócz ziarn o cechach tego środowiska, występują w znacznej ilości ziarna kanciaste (krótki transport) bez śladów wyraźnej obróbki. Zwiększa się jednocześnie udział ziarn o cechach chemicznych, będących efektem rozpuszczania powierzchni ziarn kwarcu oraz wytrącania glinokrzemianowej otoczki. Powoduje to ogólnie chemiczne zniszczenie powierzchni ziarn, o czym świadczy wzrost udziału ziarn matowych. Zjawisko to nasila się konsekwentnie ku stropowi, czyli wraz z postępującą akumulacją piasków, co wskazuje na powolną zmianę charakteru środowiska basenu sedymentacyjnego.

W górnej części profilu następuje dalszy wzrost liczby ziarn kwarcu o cechach poligenetycznych i chemicznych, co przejawia się zwiększeniem udziału ziarn matowych. Związane jest to prawdopodobnie z ociepleniem wód, pogłębieniem zbiornika i/lub wzrostem zawartości w wodach morskich wolnej krzemionki i kwasów organicznych.

Badaniom poddano również wapniste piaskowce kwarcowe, występujące w obrębie piasków w formie stref i poziomów cementacji wapnistych. Obserwacje szlifów oraz analizy chemiczne pozwoliły na wstępne rozpoznanie procesów diagenezy. Brak kontaktu lub kontakty punktowe między ziarnami kwarcu ze stref zlityfikowanych, zniszczenie pierwotnych zarysów ziarn, częste otaczanie poszczególnych ziarn pojedynczymi kryształami kalcytu, zmienny skład spoiwa — od wapnistego, poprzez krzemionkowo-wapniste, do sporadycznego spoiwa barytowego — oraz formy geometryczne stref cementacji wskazują na złożone procesy diagenetyczne, związane z wytrącaniem kalcytu oraz barytu przy jednoczesnym rozpuszczaniu kwarcu i odprowadzaniu krzemionki. Analizy chemiczne oraz zawartość pierwiastków śladowych w spoiwie wskazują jednoznacznie na inne niż morskie źródło cementów. Cementacja rozwijająca się w obrębie piasków kwarcowych odbywała się po zaniku zbiornika morskiego i wiązała się ze zmianami tempa przepływu wód porowych, rozpuszczaniem materiału detrytycznego o charakterze organicznym oraz rozpuszczaniem powierzchni ziarn kwarcu. Wszystkie formy cementacji obserwowane w odsłonięciu są epigenetyczne. Powstawały w wyniku procesów diagenetycznych zachodzących w osadzie od pliocenu po dzień dzisiejszy, przy czym w pliocenie przebiegały one najintensywniej ze względu na ciepły klimat oraz ruchy tektoniczne na obszarze Gór Świętokrzyskich.

PLATE I

Sample 1 (Próbka 1)
Fig. 1. Rounded grain, polished
Ziarno obtoczone, błyszczące
Fig. 1a. Arch shaped incisions, rather densely distributed on surface of grain from Fig. 1
Łukowate nacięcia, dość gęsto rozmieszczone na powierzchni ziarna z fig. 1
Fig. 2. Fractured rounded grain, polished
Przełamane ziarno obtoczone, błyszczące
Fig. 2a. Fragment of grain from Fig. 2, with large v-shaped pits and arch shaped incisions
Fragment powierzchni ziarna z fig. 2, z dużymi nacięciami v-kształtnymi i łukowatymi
Fig. 3. Rare, arch shaped incisions on smooth surface of rounded grain
Nieliczne, łukowate nacięcia na wygładzonej powierzchni ziarna obtoczonego
Fig. 4. Frequent, v-shaped pits, typical for high-turbulence shore environments
Liczne, v-kształtne nacięcia, typowe dla środowiska brzegowego o wysokiej energii



Krystyna KENIG, Anna WYSOCKA — Sands and calcite cement-bodies (the Baranów Beds) from Świniary, eastern margin of the Holy Cross Mts.

PLATE II

Sample 7 (Próbka 7)

Fig. 1. Rounded grain, smooth surface

Ziarno obtoczone o wygładzonej powierzchni

Fig. 2. Partly rounded grain, rather smooth surface

Ziarno częściowo obtoczone, o dość wygładzonej powierzchni

Fig. 2a. Fragment of grain from Fig. 2 with numerous, large v-shaped pits typical for high-turbulence shore environments

Fragment powierzchni ziarna z fig. 2 z licznymi, rozległymi, v-kształtnymi nacięciami, typowymi dla wysokoenergetycznego środowiska brzegowego

Fig. 3. Partly rounded grain, fractured but with smooth edges and corners, very smooth and polished

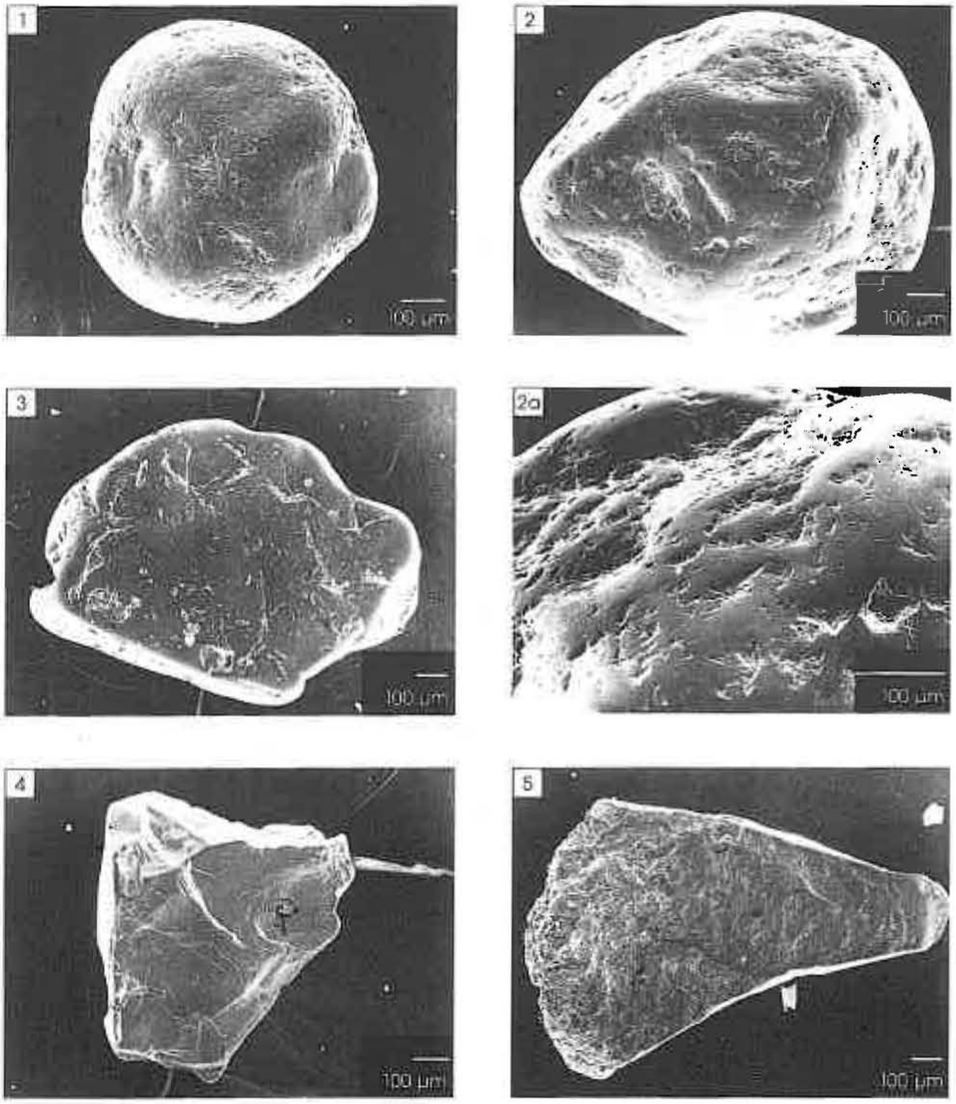
Ziarno częściowo obtoczone, przełamane, ale o złagodzonych krawędziach i narożach, o silnie wygładzonej i wybłyszczonej powierzchni

Fig. 4. Angular grain with fresh large-scale conchoidal fractures; in top right part of grain, albite inclusion in triangular pit

Ziarno kanciaste ze świeżymi wielkoskalowymi przełamami muszlowymi; w prawej, górnej części ziarna, w trójkątnym zagłębieniu wrostek albitu

Fig. 5. Angular grain with corners smoothed through dissolution processes (left part of grain)

Ziarno kanciaste o nieco złagodzonych narożach, np. w lewej części ziarna, przez procesy rozpuszczania



Krystyna KENIG, Anna WYSOCKA — Sands and calcite cement-bodies (the Baranów Beds) from Świniary, eastern margin of the Holy Cross Mts.

PLATE III

Sample 7 (Próbka 7)

Fig. 1. Fragment of grain surface (Pl. II, Fig. 3), with rectilinear cracks and small, arch shaped incisions
Fragment powierzchni ziarna (tabl. II, fig. 3); widoczne prostolinijne spękania i drobne, łukowate nacięcia

Fig. 2. Numerous v-shaped pits from high-turbulence shore environment on grain from Pl. II, Fig. 2
Liczne, v-kształtne nacięcia z wysokoenergetycznego środowiska brzegowego na ziarnie z tabl. II, fig. 2

Fig. 3. V-shaped pits of various intensity on rounded, polished grain
V-kształtne nacięcia różnej intensywności na ziarnie obtoczonym, błyszczącym

Fig. 4. Various forms of chemical dissolution of surface and precipitation of an aluminosilicate overgrowth on grain from Pl. II, Fig. 5
Różne formy chemicznego rozpuszczania powierzchni i wytrącania glinokrzemianowej otoczki na ziarnie z tabl. II, fig. 5

Fig. 5. Cavernous, irregular depressions created through dissolution of quartz surface on grain from Pl. II, Fig. 2
Kawernowate, nieregularne obniżenia powstałe na skutek procesów rozpuszczania powierzchni na ziarnie z tabl. II, fig. 2

Fig. 6. Singular dissolution pits on a considerably smooth surface of grain from Pl. II, Fig. 2
Pojedyncze dziurki z rozpuszczania na stosunkowo gładkiej powierzchni ziarna z tabl. II, fig. 2

PLATE III

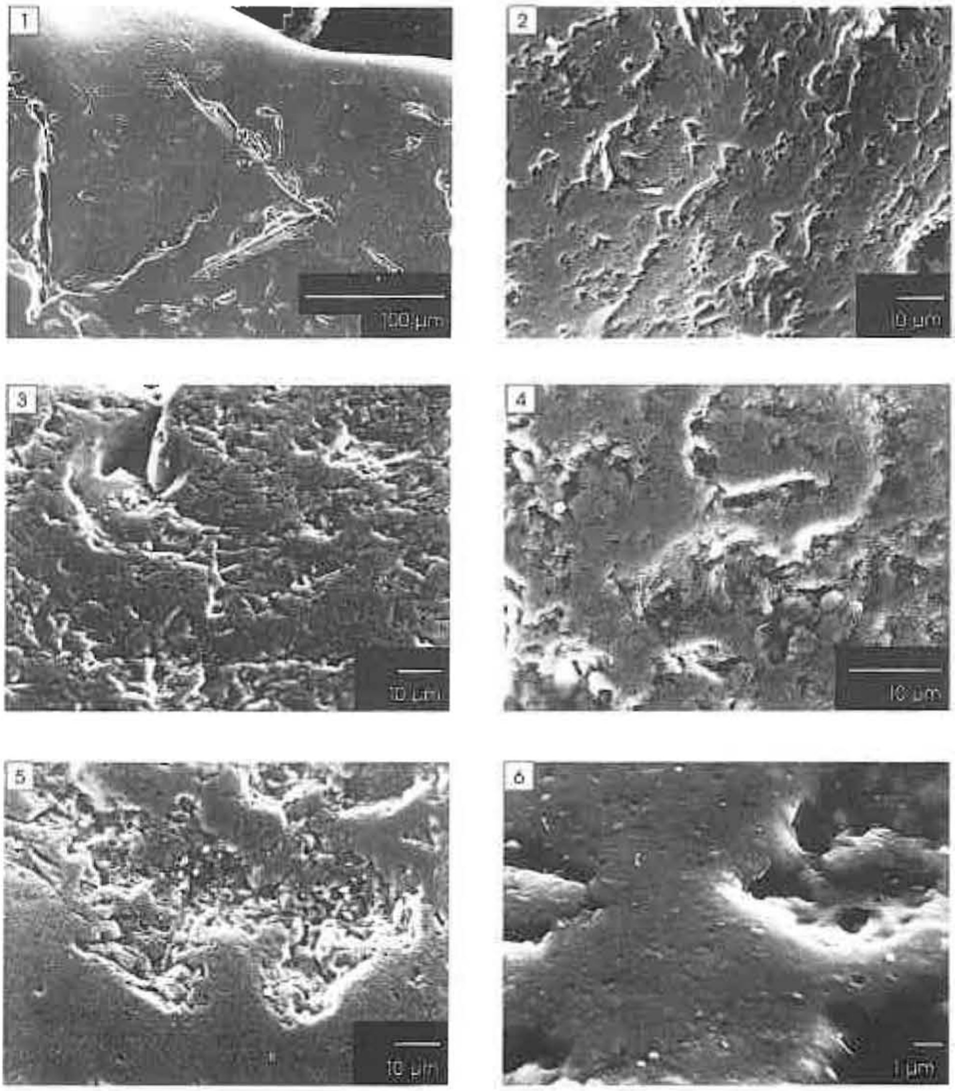


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PLATE IV

Sample 9 (Próbka 9)

Fig. 1. Rounded grain, very smooth surface, polished

Ziarno obtoczone, o silnie wygładzonej powierzchni, błyszczące

Fig. 1a. Arch-shaped incisions and rare v-shaped pits on grain from Fig. 1

Łukowate oraz nieliczne v-kształtne nacięcia na powierzchni ziarna z fig. 1

Fig. 2. Partly rounded grain, frosted

Ziarno częściowo obtoczone, matowe

Fig. 3. Rounded grain with large fracture

Ziarno obtoczone z rozległym wyłamaniem

Fig. 4. Sharp-edged grain with large surface of conchoidal fractures

Ziarno ostrokrawędziste o dużych powierzchniach świeżych przełamów muszlowych

Fig. 5. Sharp-edged barite grain with signs of cleavage

Ostrokrawędziste ziarno barytu ze śladami łupliwości

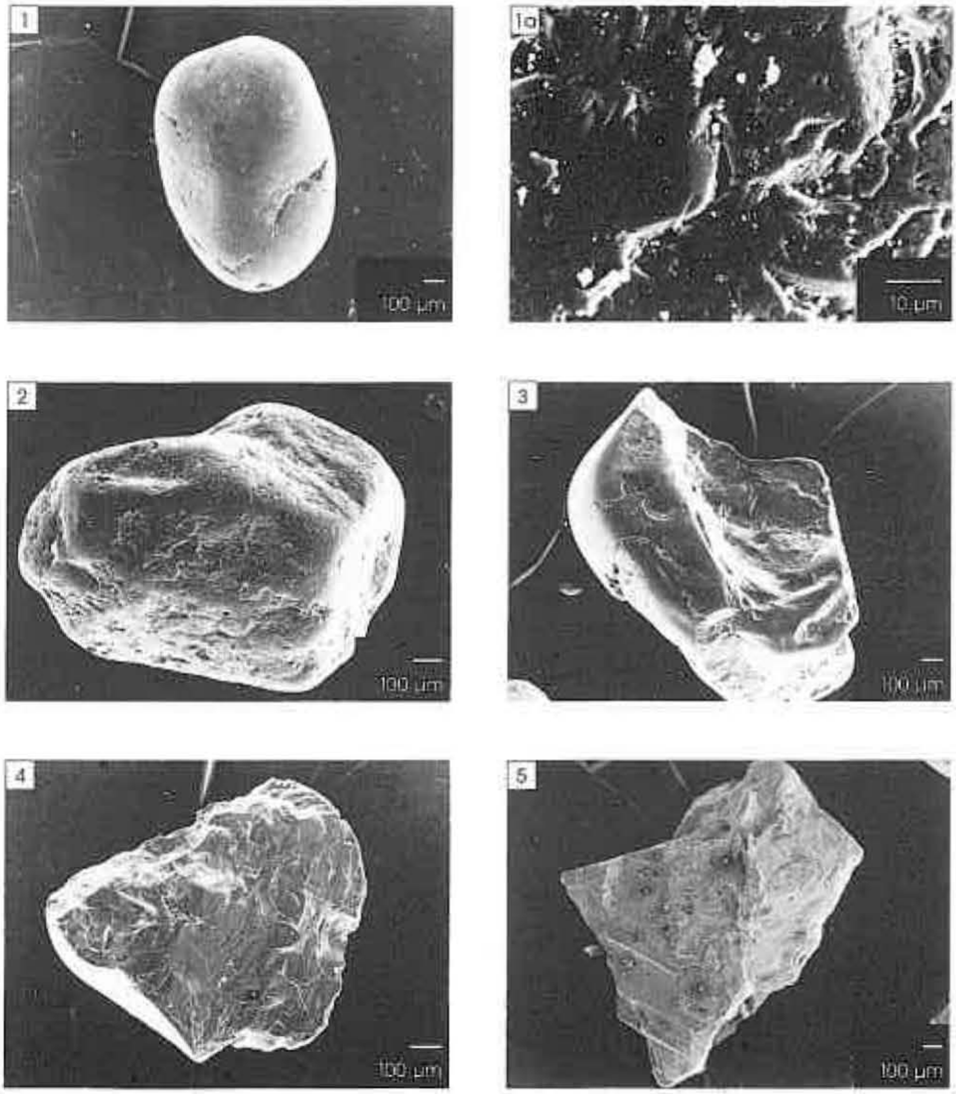

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PLATE V

Sample 9 (Próbka 9)

Fig. 1. Chemically destroyed dissolution-precipitation surface and triangular etching marks
Chemicznie zniszczona powierzchnia z rozpuszczania i wytrącania oraz trójkątne ślady wytrawiania

Fig. 2. Considerably smooth, ribbed conchoidal fracture with silica precipitation dust
Stosunkowo gładki, żeberkowany przełam muszlowy z drobnym pyłem krzemionkowym z wytrącania

Fig. 3. Fragment of smooth surface of conchoidal fracture with etched cavern
Fragment gładkiej powierzchni przełamu muszlowego z wytrawioną kawerną

Fig. 4. Chemically etched surface of upper part of grain from Pl. IV, Fig. 3; crystallographically oriented forms
Chemicznie wytrawiona powierzchnia górnej części ziarna z tabl. IV, fig. 3; formy ukierunkowane krystalograficznie

Fig. 5. Convex part of grain from Pl. IV, Fig. 2; numerous v-shaped pits, on edge, on surface strongly chemically affected
Część wypukła ziarna z tabl. IV, fig. 2; liczne nacięcia v-kształtne brzegowe na powierzchni silnie zniszczonej chemicznie

Fig. 6. Another fragment of the same grain; surface mainly modified by dissolution and silica precipitation
Inny fragment tego samego ziarna; powierzchnia w dużym stopniu zmodyfikowana rozpuszczaniem i wytrącaniem krzemionki

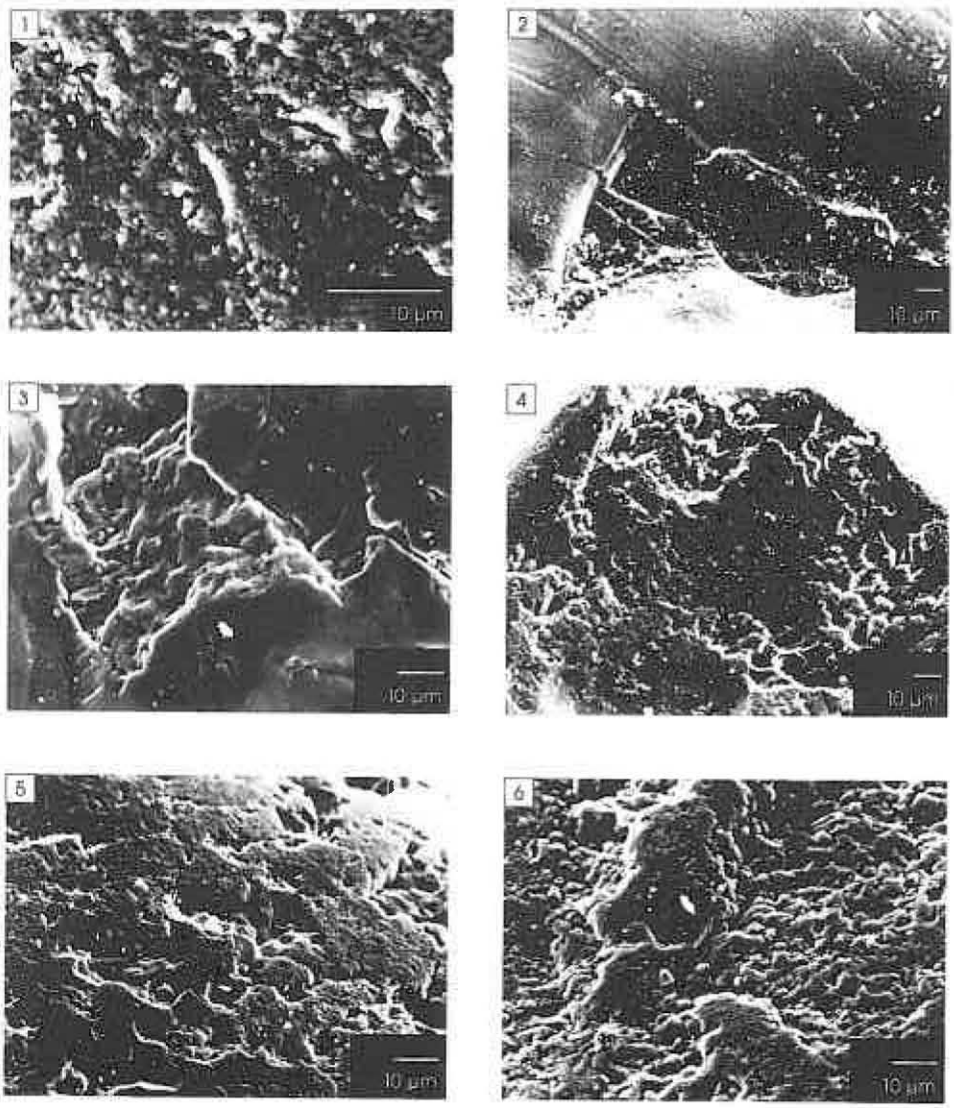

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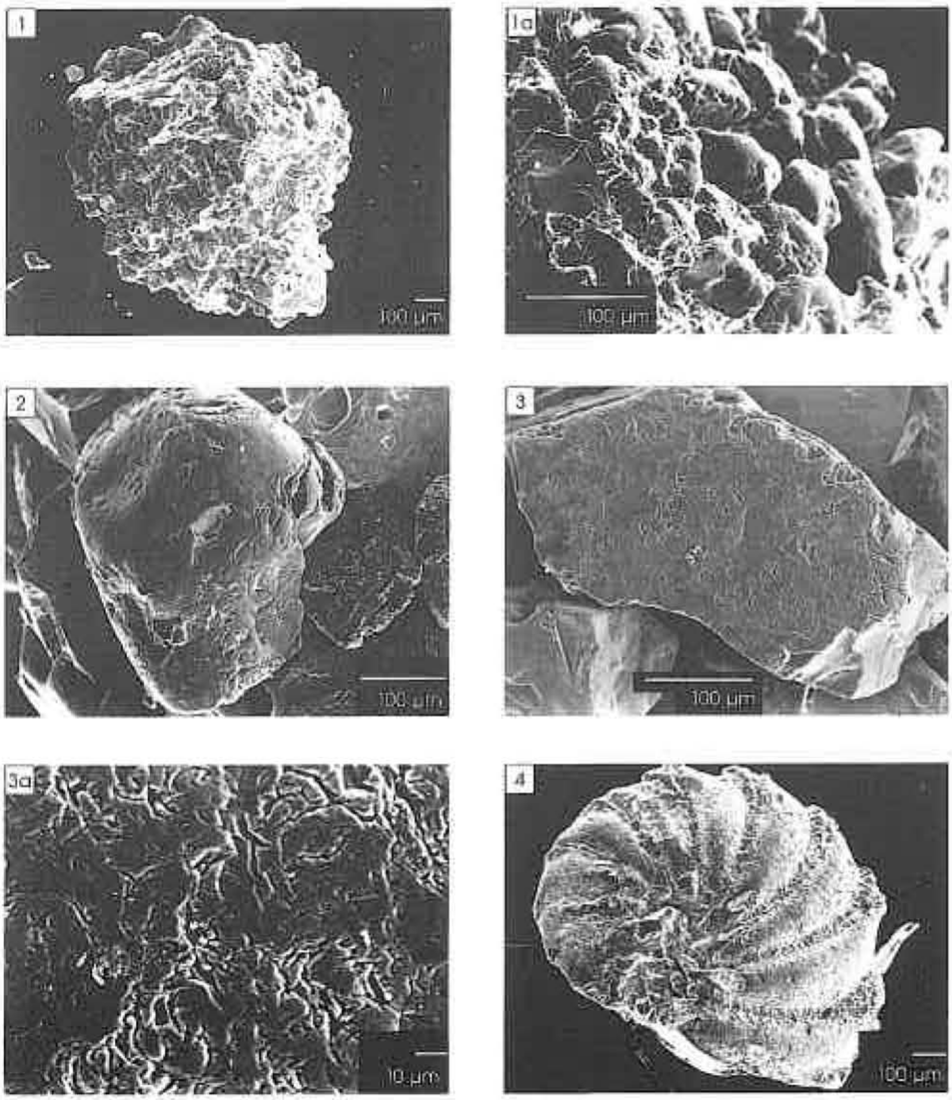
PLATE VI

Grain agglomerates (Zlepy ziarn)
Fig. 1. Barite agglomerate from sample 7
Zlep barytowy z próbki 7
Fig. 1a. Enlarged upper part of agglomerate, with quartz grains
Powiększona prawa, górna część zlepu, widoczne ziarna kwarcowe
Fig. 2. Partly rounded quartz grain from sample 10, from calcite cement-bodies with barite agglomerates
Częściowo obtoczone ziarno kwarcu z cementacji wapnistej zawierającej strefy o spoiwie barytowym (próbka 10)
Fig. 3. Angular quartz grain from sample 10
Kanciaste ziarno kwarcu z próbki 10
Fig. 3a. Strongly etched surface from Fig. 3
Silnie wytrawiona powierzchnia ziarna z fig. 3
Fig. 4. Moulde of the foraminifera *Nonionella* sp. from sample 7
Ośródka otwornicy *Nonionella* sp. z próbki 7



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