



Andrzej GAŚIEWICZ

## Gypsum-ghost limestones and selenitic gypsum relation of the Osiek – Baranów Sandomierski sulphur deposit

The most spectacular feature of the Polish native sulphur deposits is postselenitic gypsum fabric forming gypsum-ghost facies (composed of empty spaces or so-called calcite or calcite-sulphur pseudomorphs after selenite gypsum). These rocks are often used as the cardinal argument for the bioepigenesis of Polish native sulphur ores. A comparative study of regional characteristics of both gypsum-ghost facies and selenite gypsum deposits as well as their particular subfacies clearly indicates that these facies significantly differ in: (1) both horizontal and vertical distribution patterns, (2) thicknesses, (3) frequency in vertical sections, and (4) percentage of the Chemical Series sections. This indicates that features of the gypsum-ghost facies are distinctly inconsistent with the features of coarse-crystalline gypsum beds. Therefore, gypsum-ghost limestones cannot be correlated or accepted as an analog of the selenite gypsum lithotypes as has been commonly assumed so far.

### INTRODUCTION

According to the bioepigenetic model of Polish native sulphur formation the alteration of primary solid rocks (sulphates) into mineralized or barren carbonates is reflected by various structural and textural features of the ore deposits inherited after gypsum deposits.

In this light, crystalline or selenite gypsum complexes seem to be very important because they exhibit salient features which may be easily traced in the postsulphate rocks (so-called calcite or calcite-sulphur pseudomorphs after selenite gypsum). Limestones with abundant postselenitic gypsum structures are commonly found in all Polish native sulphur deposits as well as in associated barren limestones.

Although, workers have invoked various gypsum lithotypes which have been altered, a comparative petrographic study revealed that the features of selenitic gypsum facies and gypsum-ghost limestones (as the claimed facies equivalents) cannot be simply correlated one to the other — petrologic features of these two facies are too different to be interpreted as being analogous (A. Gašiewicz, 1994). However, for the purpose of this work (to evaluate

the model independently, based upon a regional comparison of original gypsum facies preserved in the postgypsum limestones and those proper to selenite gypsum) it has been assumed that petrographic differences between these two facies are insignificant and thus the facies are conventionally treated here as analogous deposits. This work compares a regional distribution of both gypsum-ghost limestones and selenitic gypsum facies associated with the Osiek – Baranów Sandomierski deposit (Fig. 1).

## MATERIAL AND METHODS

Core material examination of 68 boreholes from the Osiek – Baranów Sandomierski deposit and from surrounding areas (located in the northern part of the Carpathian Foredeep) as well as numerous field studies in the open-pit mine at Machów and the Holy Cross Mts. area were carried out. Among boreholes studied, the gypsum-ghost facies has been identified in 49 boreholes. In addition, some data collected in the geological documentation of the Osiek – Baranów Sandomierski deposit (J. Kowalik *et al.*, 1979, 1980) were used in this work.

## STRATIGRAPHIC AND LITHOLOGIC FRAMEWORK

### STRATIGRAPHY

Cainozoic deposits of the Carpathian Foredeep are represented by Karpatian, Badenian and Sarmatian stages which rest unconformably on Palaeozoic and/or Mesozoic strata. Stratigraphic and lithologic framework of the Carpathian Foredeep is described in detail by K. Pawłowska (1962, 1965), S. Pawłowski (1970), S. Pawłowski *et al.* (1965, 1979, 1985), see also summaries by K. Pawłowska (1994) and P. Karnkowski (1994).

### CARBONATE SERIES

So-called secondary (sulphur-bearing or barren) limestones have been developed and preserved in some places (mainly in the marginal part of the Carpathian Foredeep basin) within the evaporite (sulphate) unit (Fig. 1). The carbonate complex is generally of lower thickness (maximally about 45 m thick) compared to the sulphate series which may slightly exceed 60 m in thickness (J. Kowalik *et al.*, 1979).

Native sulphur formation is composed of various lithologies among which limestone is the main one and contain subordinate content of marls or marly claystones and sulphates. They have been described in a general way by K. Pawłowska (1962), S. Pawłowski (1970), S. Pawłowski *et al.* (1979, 1985), M. Nieć (1982). In general, this series is predominated mainly by barren and mineralized limestones. The boundary between both sulphur-bearing and barren limestones is irregular and embayed and the transition itself may be sharp or gradual and is usually expressed by a sudden or gradual decrease of content and size of both sulphur aggregates and gypsum moulds. According to most workers and based on sedimen-



Fig. 1. Location of native sulphur ores in the Carpathian Foredeep

1 — sulphur deposits, 2 — sulphates, 3 — sulphate free areas, 4 — northern extent of the Miocene (after B. Kubica, K. Pawłowska, 1984); arrow indicates Osiek – Baranów Sandomierski deposit

Lokalizacja złóż siarki rodzimej w przedkarpacim

1 — złoża siarki rodzimej, 2 — siarczany, 3 — obszary pozbawione siarczanów, 4 — północny zasięg utworów miocenu (według B. Kubicy, K. Pawłowskiej, 1984); strzałką zaznaczono złożo Osiek – Baranów Sandomierski

tological study (A. Gąsiewicz, 1994), both mineralized and barren limestones seem to be petrographically very similar and macroscopically distinct differences appear as the presence or lack of native sulphur. That study shows that these two lithologies display very similar original structures, but small differences are marked, for instance, by less frequent and smaller postgypsum relics found in the barren limestones. These structural differences may reflect normal variability of characteristics, while the presence or lack of native sulphur may be connected with other, late ore-forming processes (like secondary remobilization of sulphur) postulated by J. Czermiński (1968) and M. Nieć (1982, 1986). Thus, for the purpose of this work, these differences appear as rather insignificant and therefore are ignored.

The sulphur-bearing rocks are not uniform and based upon form and distribution of sulphur aggregates, porosity, bedding, etc. it is possible to distinguish distinct textural varieties in the ore series (M. Nieć, 1969, 1982, 1992). Although the textural varieties occur in complex relationships, the most distinctive feature of the series is a mimicry of original gypsum structures presented by R. Krajewski (1962), K. Pawłowska (1962), S. Pawłowski, (1968, 1970), M. Nieć (1982, 1992), S. Pawłowski *et al.* (1965, 1979, 1985), M. Pawlikowski (1982). As is evident from a sedimentological view (A. Gąsiewicz, 1994), original selenitic gypsum precursors form specific interbeds characterized by their own sedimentary and mineralogical textures.

Carbonate sulphur-bearing formations contain smaller “islands” or “blocks” or lenses of gypsum deposits commonly interpreted as “unreplaced” relics. These deposits form a kind of transitional zone composed of carbonate-gypsum intercalations. The boundary between limestones and sulphate series is irregular and embayed.

## SULPHATE SEQUENCE

Sulphate deposits form a laterally extensive unit in the Carpathian Foredeep and are composed of different lithofacies (e.g., S. Pawłowski *et al.*, 1965, 1985; M. Pawlikowski, 1982; M. Bąbel, 1986, 1987; A. Kasprzyk, 1989; B. Kubica, 1992; all with references therein). In the marginal part of the foredeep, gypsum deposits distinctly predominate lithological composition of the evaporite unit.

Generally, the series starts (for detailed illustrations of vertical succession of gypsum lithofacies see also A. Kasprzyk, 1994a in a case study) with distinct, vertically oriented and twinned giant gypsum intergrowths forming crystals up to a few metres in height. This series is overlain by an alternation of bedded selenites and stromatolitic gypsum layers which in turn are covered by so-called skeletal and sabre-like gypsum deposits with characteristically bent crystals. This complex, sometimes with marly-clayey admixture and thinner laminated gypsum intercalations, commonly exhibits chaotic and tight overgrowth of successive gypsum crystal generations. These beds are followed by series consisting of massive, bedded, finely crystalline and laminated gypsum complexes with thin selenitic clusters or layers. Synsedimentary clastic gypsum deposits are developed in the upper part of the sequence.

In general, the lower part of the gypsum sequence of the Carpathian Foredeep is dominated by exceptionally coarse (giant) or very coarse selenites while the upper part is dominated by massive, bedded and laminated crystalline or brecciated gypsum strata.

## GYPSUM-GHOST LIMESTONES

### GENERAL FEATURES

Generally, gypsum-ghost (sulphur-bearing or barren) limestones are characterized (see A. Gąsiewicz, 1994) by the presence of abundant and distinct relics of calcium sulphate precursors. Based upon detailed macroscopic and microscopic investigations of the gypsum-ghost limestones of the Polish native sulphur deposits, it is possible to distinguish (1) fine gypsum-ghost subfacies and (2) coarse gypsum-ghost subfacies (described in detail by A. Gąsiewicz, 1994).

### DISTRIBUTION

Gypsum-ghost interbeds occur in both sulphur-bearing or barren limestones as distinct carbonate lithotypes of the sulphur formation. The distribution of sulphur-bearing and barren carbonates is not uniform (Fig. 2A), small local occurrences are also found beyond the main carbonate area. The change from gypsum sequence to carbonate series is highly irregular in both horizontal and vertical directions. This transitional area, which forms a laterally discontinuous zone, is composed of irregular bodies of gypsum series intercalated by carbonate beds. Characteristically, the sulphur deposit generally occurs in the northern marginal part of the carbonate area, while southward a large area of barren limestones occurs. Thus, the deposit is mainly associated with the transitional zone.

Generally, gypsum-ghost limestones are found occurring mainly in the lower, rarely in the middle, and often in the upper part of the ore series. The gypsum-ghost limestones do not form laterally continuous horizons; they occur in various parts of the carbonate sequence and were found in 75% of investigated boreholes. These rocks occur mainly in exclusively carbonate sections (about 61% of analysed boreholes with the facies recorded) and relatively rarely were found in carbonate series intercalated by sulphate deposits. Gypsum-ghost bodies commonly form isolated, lense-like bodies or relatively more stratiform and thinner beds, which only sometimes are laterally more continuous (commonly up to a few tens of metres in length, as has been observed many times in the Machów open-pit mine). Laterally more extensive gypsum-ghost rocks occur in the lower part of the carbonate section, which, however, become more and more occasional and horizontally discontinuous up section. In the upper part of the carbonate section they commonly intercalate generally massive, bedded, grey and micrite or microsparitic carbonates. The interval of intercalation, like three-dimensional distribution, is highly variable.

The gypsum-ghost facies irregularly occurs in an entirely carbonate area, including the transitional carbonate-gypsum zone. The number of gypsum-ghost interbeds, which usually intercalate other carbonate or sulphate lithotypes, changes from 1 to 6 beds. Generally, the regional distribution of these intercalations is highly irregular and all the available analyses made on the core material are too scarce to be conclusive. However, most of the carbonate area (about 76% of investigated boreholes) contains only 1–2 gypsum-ghost interbeds. In addition, the data collected here seem to suggest that the ore body contains a higher frequency of gypsum-ghost interbeds compared to the barren area: only about 59% of analysed boreholes from the ore area and as much as 80% of the boreholes from the barren area contain only 1–2 gypsum-ghost interbeds. Thus, it seems highly probable that the higher frequency of gypsum-ghost facies is connected with the ore area and not with the central part of the carbonate area. This relation is not reflected by the distribution of total thickness of the gypsum-ghost facies. As may be seen from tabulated data in Fig. 2B, generally thicker gypsum-ghost interbeds seem to occur in the barren area. Additionally, as is evident from geological sections (Fig. 3), the quantitative ratio of gypsum-ghost to other carbonate lithologies is extremely variable as well. In addition, the gypsum-ghost interbeds are laterally discontinuous, forming lense-like layers or complexes which cannot be correlated one to other, even between very closely located boreholes.

Vertical carbonate sections do not exhibit any arrangement of the gypsum-ghost facies that would suggest the preservation of cyclic development. Instead, the gypsum-ghost facies distribution throughout the Chemical Series is occasional with a general trend to more abundant occurrence in the lower part of the section.

In view of the fact that the sulphate series is distinctly differently developed in the lower part than in the upper part, for the purpose of this work one may justify the conventional division of carbonate series into lower and upper series. In such a division of the carbonate section, the gypsum-ghost limestones are more frequent in the lower part of the series (about 62% of gypsum-ghost interbeds). With regard to the occurrence of particular gypsum-ghost subfacies there are visible differences as well. Fine and coarse gypsum-ghost subfacies only sporadically co-occur (one recognized example), forming beds of a mixed type. However, these subfacies usually define separate layers or complexes. The core material examinations have established that the fine gypsum-ghost subfacies is more common (about 80% of

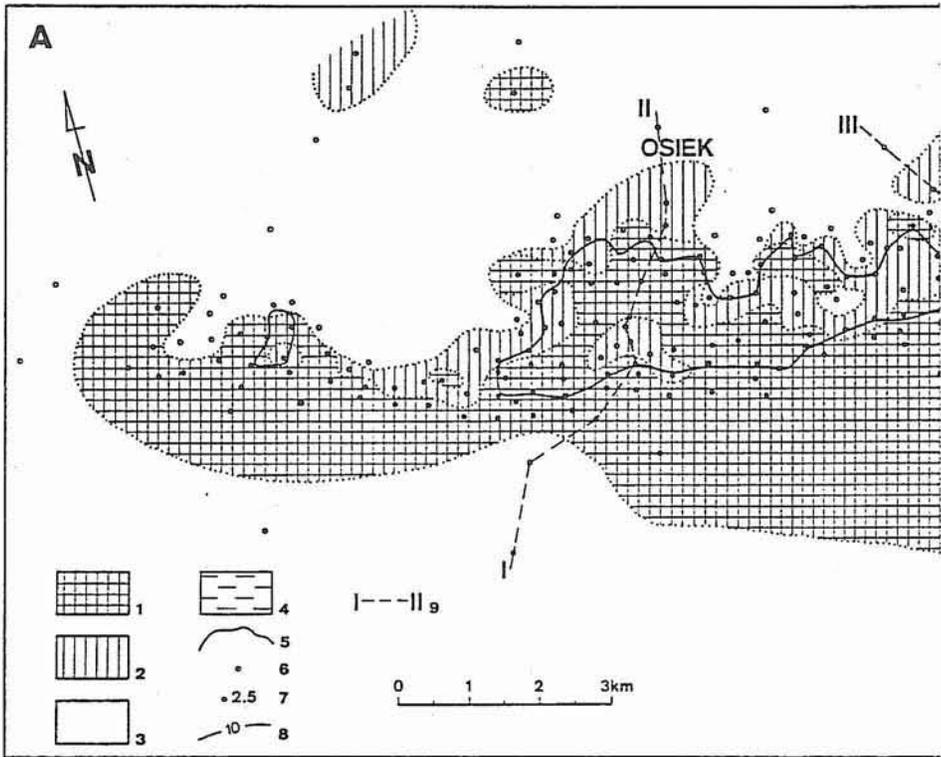
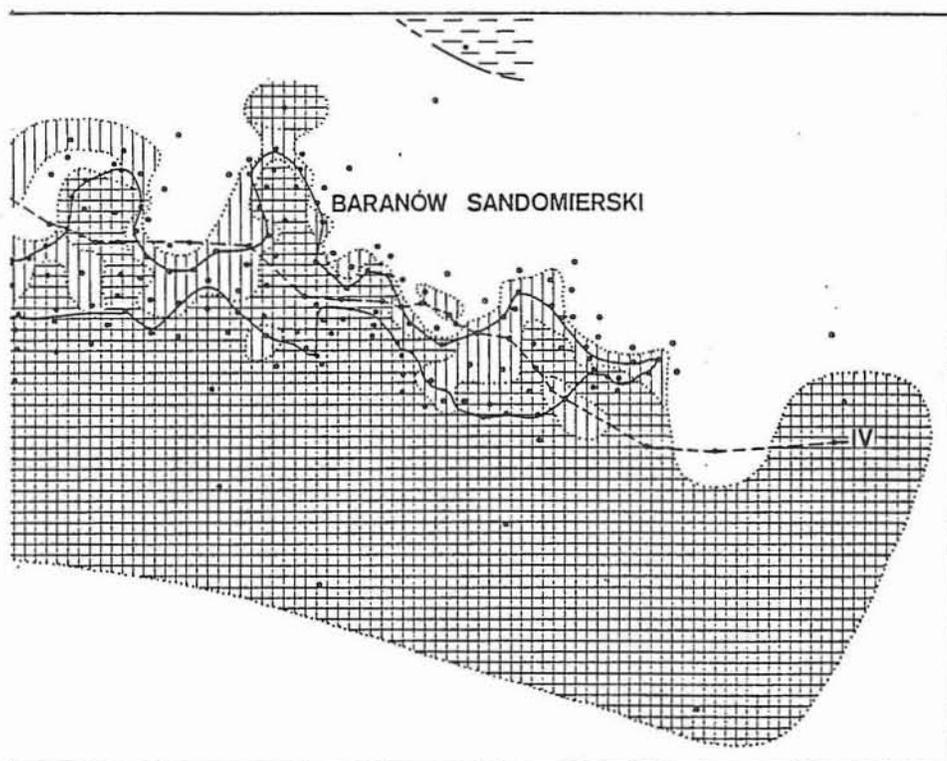


Fig. 2A. Lithologic differentiation associated with the Osiek - Baranów Sandomierski deposit — distribution of carbonate, carbonate-sulphate and sulphate complexes

1 — carbonates, 2 — carbonates intercalated by gypsum, 3 — gypsum, 4 — area devoid of Chemical Series deposits, 5 — ore body area, 6 — borehole, 7 — borehole with cumulative thickness of gypsum-ghost limestones, 8 — isoline of cumulative thickness of selenite gypsum, 9 — geological sections

boreholes studied) than the coarse one (about 56% of boreholes studied). The gathered data indicate also that the vertical sections of the Chemical Series may be predominated by one type of gypsum-ghost facies (about 65% of investigated boreholes). Among the sections containing only one type of gypsum-ghost subfacies, the fine gypsum-ghost interbeds distinctly prevail (about 41% of investigated boreholes) over the characteristic coarse gypsum-ghost subfacies (which occurs in about 24% of investigated boreholes). In the sections where the both subfacies co-occur, the fine gypsum-ghost facies occurs higher (all investigated boreholes and exploited walls in the open-pit mine sections) in stratigraphic position than the coarse one, which preferentially occurs in the lower parts of the sections. The upper part of the carbonate section is predominated by the fine gypsum-ghost subfacies (about 54% of all gypsum-ghost interbeds), while the lower one by the coarse gypsum-ghost subfacies (about 46% of all gypsum-ghost complexes).



Zróżnicowanie litologiczne w otoczeniu złoża siarki Osiek – Baranów Sandomierski — występowanie utworów węglanowych, węglanowo-siarczanowych i siarczanowych

1 — węglany, 2 — węglany przewarstwiane gipsami, 3 — gipsy, 4 — obszar pozbawiony utworów serii chemicznej, 5 — obszar złoża, 6 — otwór wiertniczy, 7 — otwór wiertniczy z podaną łączną miąższością wapieni poselenitowych, 8 — izolinia łącznej miąższości gipsów selenitowych, 9 — linie przekrojów geologicznych

#### THICKNESS

The gypsum-ghost facies form more or less laterally elongated, flat, lense-like carbonate bodies, commonly up to a few metres thick. The thickness of the gypsum-ghost facies varies in the vertical section. In general, the gypsum-ghost facies forms relatively thicker interbeds developed in the lower part of the carbonate series which, in turn, become thinner upwards. In boreholes with more than two gypsum-ghost interbeds, there is a general tendency for the facies thickness to decrease toward the top of the series: about 61% of thicker beds occur in the lower part of the carbonate series, about 32% in the middle part, and about 7% in the upper part.

The collected data indicate that most (about 84%) gypsum-ghost beds occur in a range of thickness from 0.1 to 3.0 m. With regard to the particular subfacies, about 73% of the fine gypsum-ghost interbeds and about 64% of the coarse ones occur in the thickness range of 0.3–3.0 m. Tabulation of total thicknesses of the gypsum-ghost facies as well as its particular subfacies indicates similar results, for beds from 0 to 4 m thick, about 74% of

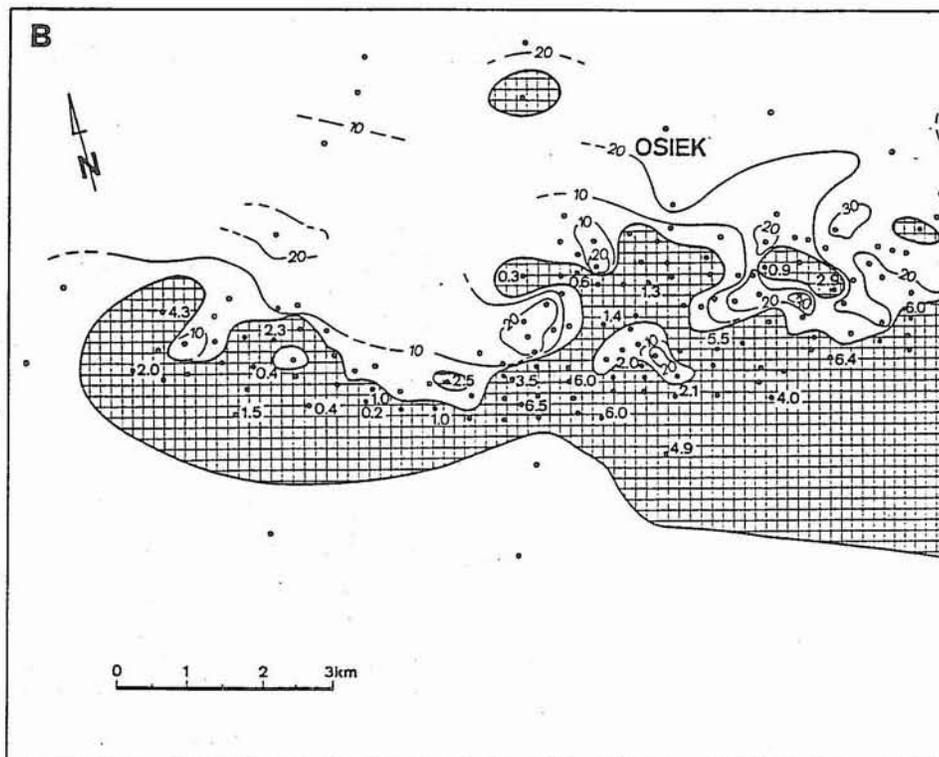
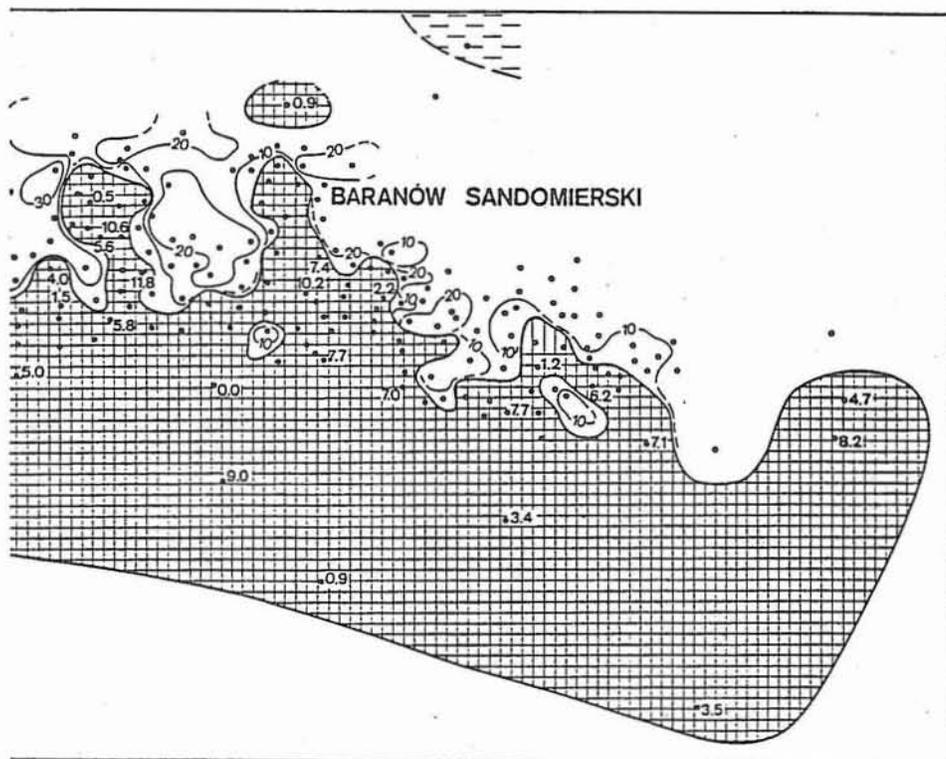


Fig. 2B. Lithologic differentiation associated with the Osiek - Baranów Sandomierski deposit — cumulative thickness (in metres) of both selenitic gypsum deposits (isolines) and gypsum-ghost facies (points) Explanations see Fig. 2A

analysed boreholes contain the fine variety of gypsum-ghost facies, 70% contain the coarse subfacies (Fig. 4A), while 60% contain general gypsum-ghost limestone (Fig. 4B).

#### PERCENTAGE

Gypsum-ghost facies comprise varying content of the Chemical Series (measured by the percentage of the facies in total thickness of the Chemical Series found in analysed boreholes). Generally, for the content from 0 to 40% of the sections, about 90% of investigated boreholes contain the fine gypsum-ghost subfacies (Fig. 5A) and about 93% contain the coarse subfacies, and about 85% contain the general facies (Fig. 5B).



Zróźnicowanie litologiczne w otoczeniu złoża siarki Osiek – Baranów Sandomierski — łączna miąższość (w metrach) gipsów selenitowych (izolinie) i wapieni poselenitowych (punkty)  
 Objaśnienia jak na fig. 2A

## CHARACTERISTICS OF SELENITIC GYPSUM FACIES

### GENERAL FEATURES

A spectacular feature of the gypsum sequence is the presence of selenitic (i.e., composed of macroscopically visible gypsum crystals) complexes and layers allowing distinction of crystalline or selenitic and other gypsum lithotypes. Based upon variation in texture and structure (particularly on the size, arrangements of gypsum crystals and sedimentary structures) the selenitic gypsum may be further subdivided into a few varieties (e.g., A. Kasprzyk, 1989, 1994a). The selenitic gypsum strata may form separate thicker complexes or form a few relatively thinner beds which intercalate other gypsum lithotypes. For the aim of this work, the selenitic gypsum complexes are divided into two distinct categories: (1) giant or very coarse, glassy and massive, so-called *szklica* selenites, which commonly occur at the base of the gypsum sequence and are characterized by both irregular thickness (usually up to several metres) and occurrence, and (2) crystalline or coarse to fine (including

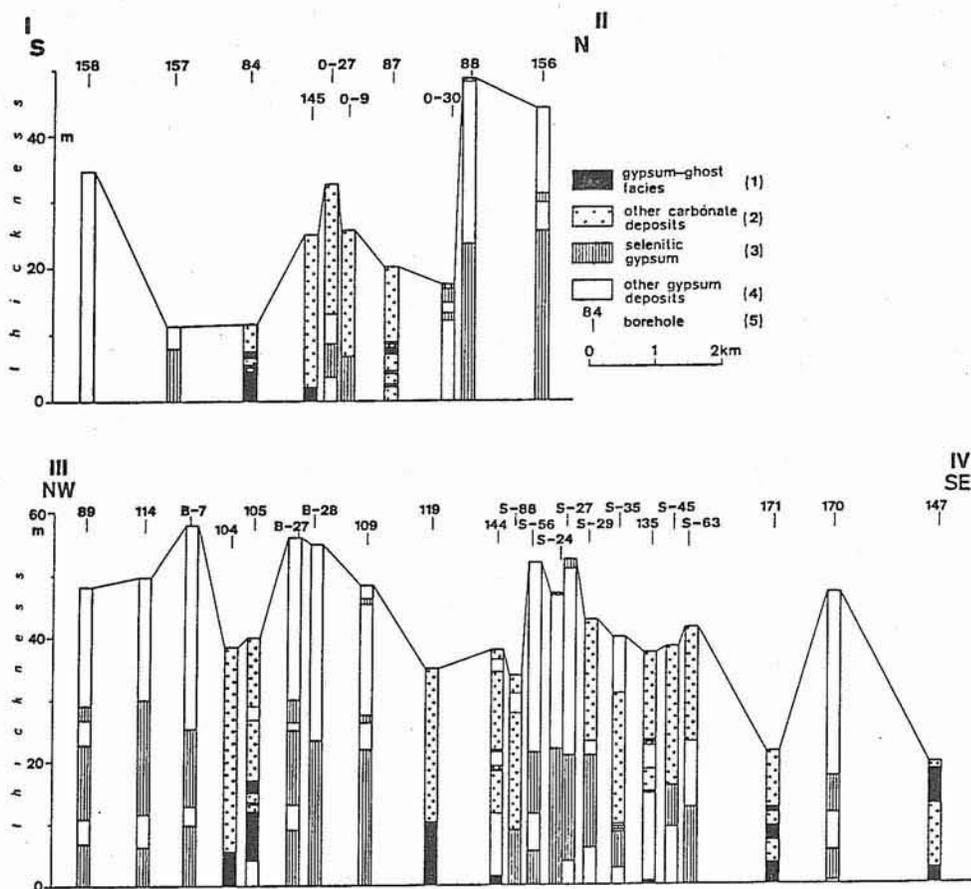


Fig. 3. Geological sections of the Chemical Series associated with Osiek – Baranów Sandomierski ore sulphur body (I–II and III–IV)

Profile geologiczne serii chemicznej w rejonie złoża siarki rodzimej Osiek – Baranów Sandomierski (wzdłuż linii I–II i III–IV)

1 — facje poselenitowe, 2 — inne utwory węglanowe, 3 — gipsy selenitowe, 4 — inne utwory gipsowe, 5 — otwór wiertniczy

centimetre up to 30 m in length gypsum crystals) selenitic gypsum, which are more bedded and, in turn, include other selenitic sublithotypes (e.g., well described sabre-like, skeletal and bedded selenitic gypsum). In general, crystalline gypsum complexes are much thicker and highly variable in thickness (up to a few tens of metres thick) compared to the former variety. These coarse to fine selenite gypsum complexes are often intercalated or separated from other gypsum lithotypes by other thinner or thicker gypsum lithofacies and generally are more frequent in the middle part of the gypsum series.

## DISTRIBUTION

Generally, selenitic gypsum deposits are numerous in the lower part of the sulphate sequence (Fig. 3), rarely occur in the middle one and usually thinly intercalate with other gypsum lithotypes in the upper one. As evident from the data presented by S. Pawłowski *et al.* (1985), B. Kubica (1992) and A. Kasprzyk (1994b) as well as the data tabulated here, the selenitic gypsum facies forms much more laterally continuous beds compared to the gypsum-ghost facies and also may be identified in most analysed boreholes containing sulphates (Fig. 2).

Selenitic gypsum forms more distinct stratiform, relatively thick complexes and laterally more extensive facies in the lower part of the sulphate section. They usually become more horizontally discontinuous forming flat, thicker or thinner lense-like bodies upward. These rocks occur in exclusively sulphate sections as well as in the zone where sulphate deposits interfinger with carbonate beds (Figs. 2A, 3). The number of selenitic gypsum beds is various in vertical sections and changes from place to place.

Sulphate series is conventionally divided into two lithotypes: (1) giant or very coarse selenite and (2) coarse to fine selenite gypsum forming characteristic complexes. The giant or very coarse selenite is more frequent in the lower part of the section while the latter lithotype is more abundant in the middle and upper part. Vertical sections of the sulphate series may contain only one type of selenitic gypsum facies (43% of investigated boreholes) with a slightly higher frequency of the coarse to fine selenitic gypsum (about 24% of analysed boreholes) than the giant or very coarse selenitic gypsum beds (about 19% of boreholes studied). In general, the coarse to fine selenitic gypsum is more common (about 78% of all analysed boreholes) compared to the giant or very coarse selenitic gypsum (about 46% of analysed boreholes). Moreover, observations have established that the gypsum sections are distinctly predominated (57% of tabulated boreholes) by the occurrence of both subtypes of selenitic gypsum facies. As has been stated earlier, in the sections where both subfacies occur, the giant and very coarse selenites preferentially occur in the lower part of the sequence.

The sulphate sequence of the Carpathian Foredeep exhibits distinct cyclic development described several times for the evaporitic sequence development of the Carpathian Foredeep (A. Kasprzyk, 1994b with references therein).

## THICKNESS

In general, the selenitic gypsum deposits form relatively laterally elongated bodies characterized by more or less regular thickness, commonly relatively thick. Distinctly more differentiated in thickness are the coarse to fine selenitic gypsum complexes. With regard to the particular selenitic gypsum subfacies, about 85% of the coarse to fine selenitic gypsum complexes occur in the thickness range of 0–14 m and about 81% of the giant or very coarse ones occur in the thickness range of 0–10 m. Thus, this clearly indicates that the giant or very coarse selenitic gypsum has generally lower and relatively stable thickness in the area studied. The tabulated data (Fig. 4) of the total thicknesses of the selenitic gypsum complexes and its particular varieties indicate similar results. With regard to the coarse to fine variety, about 69% of analysed boreholes occur in the thickness range of 6–10 m; with regard to

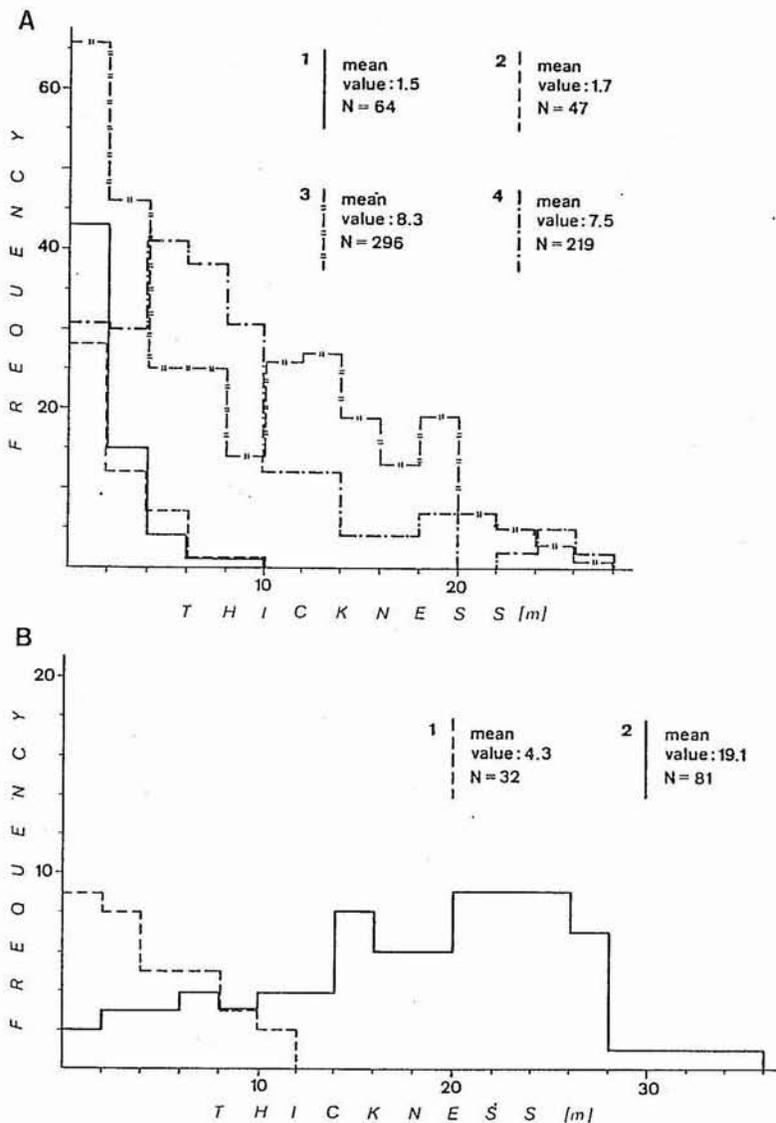


Fig. 4. Histograms of frequency of total thicknesses of gypsum-ghost limestones and selenite gypsum in core material studied

A — subfacies: 1 — fine gypsum-ghost limestones, 2 — coarse gypsum-ghost limestones, 3 — coarse to fine selenite gypsum, 4 — giant and very coarse selenite gypsum; B — facies: 1 — gypsum-ghost limestones, 2 — selenite gypsum; N — number of analysed lithological complexes (A) and number of analysed boreholes (B)

Histogramy częstości występowania całkowitej miąższości wapieni poselenitowych i gipsów selenitowych w rdzeniach wiertniczych

A — subfacje: 1 — wapień z drobnymi strukturami poselenitowymi, 2 — wapień z dużymi strukturami poselenitowymi, 3 — grubo- i drobnokrystaliczne gipsy selenitowe, 4 — gigant- i bardzo grubokrystaliczne gipsy selenitowe; B — facje: 1 — wapień poselenitowe, 2 — gipsy selenitowe; N — liczba analizowanych kompleksów litologicznych (A) i liczba analizowanych otworów wiertniczych (B)

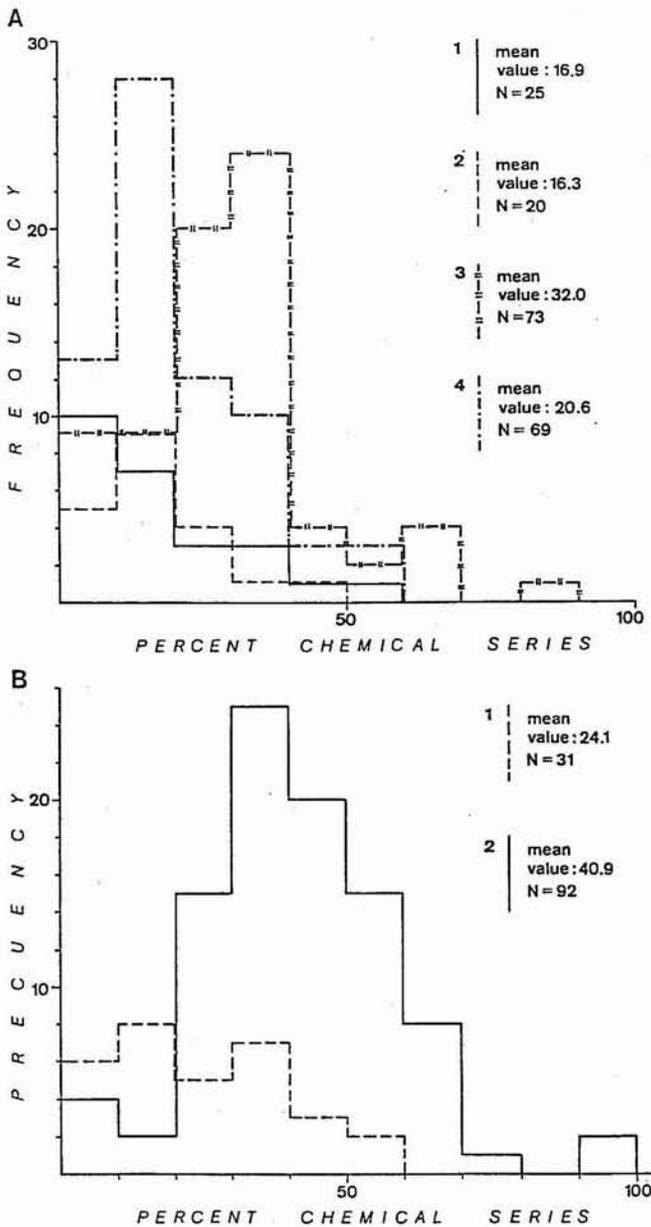


Fig. 5. Histograms of percentage of gypsum-ghost limestones and selenitic gypsum in Chemical Series  
 N — number of analysed boreholes; other explanations as in Fig. 4

Histogramy udziału procentowego wapieni poselenitowych i gipsów selenitowych w serii chemicznej  
 N — liczba analizowanych otworów wiertniczych; pozostałe objaśnienia jak na fig. 4

the giant or very coarse variety, about 65% of analysed boreholes occur in the thickness range of 2–10 m (Fig. 4A); while with regard to the general selenite gypsum facies, about 77% of analysed boreholes occur in the thickness range of 10–28 m (Fig. 4B).

#### PERCENTAGE

The percentage of the selenite gypsum facies varies in vertical sections of the Chemical Series. Generally, in about 55% of analysed boreholes the coarse to fine selenite gypsum comprises 20–40% of the sulphate sequence, and in about 91% of analysed boreholes the giant to very coarse selenite comprises 0–40% of the series (Fig. 5A). With regard to general selenite gypsum facies, about 80% of analysed boreholes comprise 20–60% of the section (Fig. 5B).

### COMPARISON OF GYPSUM-GHOST LIMESTONES AND SELENITIC GYPSUM DEPOSITS

To explain the possible role of palaeogeography during the alteration of the sulphate sequence into native sulphur deposits, the present author attempted to compare both gypsum-ghost limestones and selenite gypsum deposits. This approach is based upon an evaluation of regional distribution of gypsum-ghost facies as a possible analog of selenite gypsum. Although from the petrographic analysis it is evident that there is no strict analog between the gypsum-ghost limestones and adequate sulphate beds and the similarities are only occasional, to facilitate the consideration by means regional characteristics, these general facies as well as their particular subfacies are roughly treated here as analogous. For this purpose, it has been assumed here that the coarse gypsum-ghost subfacies corresponds to the giant or very coarse selenite gypsum and the fine gypsum-ghost subfacies to the coarse and fine selenite gypsum. Comparison of regional features of the both gypsum-ghost limestones and selenite gypsum deposits exhibits only general similarity; distinct and numerous quantitative differences occur not only between these main facies but also between their subfacies.

#### DISTRIBUTION

The prevailing occurrence of the coarse gypsum-ghost facies in the lower part of the carbonate sequence generally correlates with the giant or very coarse selenite gypsum of the sulphate sequence, and the general position of the fine gypsum-ghost facies (mainly in the upper part of the carbonate series) resembles the stratigraphic position of the coarse to fine selenite gypsum facies. However, it should be emphasized that irrespective of these very general similarities that, first, the carbonate series commonly is distinctly thinner than the sulphate series and, second, the thickness of the gypsum-ghost interbeds is also significantly lower compared to the selenite gypsum interbeds. All these facts make the correlation completely worthless in most instances (comp. Fig. 3). Distinct differences are connected with the occurrence of the both gypsum-ghost and selenite gypsum facies. The first visible difference is in that the gypsum-ghost facies seems to be less common (75% of

boreholes studied) compared to selenite gypsum deposits found almost everywhere in the sulphate sequence surrounding the Osiek – Baranów Sandomierski deposit (Fig. 2). As is clear from Figure 2, the selenitic gypsum facies occurs in both the exclusively sulphate area and in the transitional zone (where sulphate deposits are intercalated by carbonate beds). Detailed observation of the core material and exposed sections as well as the data collected in this work accordingly show that in this zone the gypsum facies occur with no discernible differences, i.e., without noticeable differences in the occurrence, number and thickness of the concerning facies (as well as in their preservation). In addition, the selenitic gypsum facies form laterally more continuous beds with continuity far exceeding that of the gypsum-ghost facies. The gypsum-ghost subfacies occurs in various parts of the carbonate sequence in a manner generally less regular than that found for the selenite gypsum facies in the sulphate sequence.

There also occur distinct differences with regard to the frequency of both facies as well as their particular subfacies. (The calculations were made for 48 boreholes with the gypsum-ghost facies recorded and for 157 boreholes with the selenite gypsum facies). In general, much more of the carbonate area is occupied by one type of the gypsum-ghost subfacies (found in about 65% of investigated boreholes) compared to the areas with one type of selenite gypsum subfacies (found in about 43% of investigated boreholes). However, a completely different picture is demonstrated by comparison of geological profiles characterized by the presence of both gypsum-ghost and selenite gypsum subfacies. The gypsum-ghost subfacies occurs only in about 35% of analysed boreholes, while the selenite gypsum facies in about 57% of analysed boreholes.

Some similarity seems to occur with regard to the percentage of the fine gypsum-ghost subfacies and the coarse to fine selenite gypsum subfacies in the Chemical Series; they comprise 80 and 78% of analysed boreholes respectively. In contrast to this, a slight difference occurs with regard to the percentage of the coarse gypsum-ghost subfacies and the giant to very coarse selenite gypsum subfacies in the Chemical Series; they comprise 56 and 64% of analysed boreholes respectively. The differences between the gypsum-ghost facies and the selenite gypsum facies are better seen by means of ratios of the percentage of particular carbonate and selenite gypsum subfacies in the Chemical Series. The thickness ratio of the fine to the coarse gypsum-ghost subfacies equals 1.43, while the ratio of the coarse and fine selenite gypsum to the giant and very coarse selenite gypsum equals 1.22.

In vertical section, the gypsum-ghost facies distribution throughout the Chemical Series is occasional with a general trend to a higher frequency in the lower part of the section. Vertical arrangement of the gypsum-ghost facies in carbonate sections (in contrary to the role played by the selenite gypsum facies in sulphate sequences) do not exhibit any pattern that would suggest the preservation of original (gypsum) cyclic development. Note however, the cyclic development of carbonate series could not be preserved either due to obliteration by diagenetic processes or cannot be recognized within the carbonate sections based upon only these facies. Moreover, the distinctly discontinuous nature of the gypsum-ghost facies may additionally obscure the recognition of a cyclic pattern.

## THICKNESS

Thickness of the both gypsum-ghost facies and selenite gypsum deposits vary in vertical section; the former becomes thinner upwards while the thickness of the latter is highly irregular throughout the sequence. While the gypsum-ghost facies forms relatively thicker interbeds in the lower part of the carbonate series (predominated by the coarse gypsum-ghost subfacies), the selenite gypsum is generally much thicker in the upper part of the sulphate sequence (predominated by the coarse to fine selenite gypsum complexes). In general gypsum-ghost limestones commonly are up to a few metres thick, while selenite gypsum is characterized by more or less regular thickness and distinctly thicker (commonly up to several metres) complexes: most (about 84% of analysed boreholes) of gypsum-ghost beds occur in the thickness range of 0.1–3.0 m, while most (about 66%) of the selenite gypsum complexes occur in the thickness range of 0–8 m.

The differences are also marked with regard to the thickness of the particular gypsum-ghost and selenite gypsum subfacies. The gypsum-ghost subfacies are characterized by distinctly lower thickness (about 73% of the fine gypsum-ghost interbeds and about 64% of the coarse ones occur in the thickness range of 0.3–3.0 m) compared to the selenite gypsum subfacies (about 85% of the coarse to fine selenite gypsum complexes occur in the thickness range of 0–14 m and about 81% of the giant and very coarse ones occur in the thickness range of 0–10 m). Similar results are provided by a comparison of tabulated data (Fig. 4) on the total thicknesses of these two main facies and their subfacies. With regard to the gypsum-ghost limestones in the thickness range of 0–4 m, as much as 60% of boreholes (with the facies recorded) contain the general facies, about 74% contain the fine subfacies and 70% contain the coarse subfacies. With regard to the selenite gypsum deposits about 77% of boreholes (with the general selenite facies) comprise a thickness range from 10 to 28 m, the coarse to fine selenite subfacies with the thickness range of 6–10 m comprise about 69% of boreholes, and the giant and very coarse subfacies with the thickness range of 2–10 m comprise about 65% of boreholes. The differences in the thickness of both facies may also be indicated by coefficient of variation ( $\eta$ ) calculated according to the formula:

$$\eta = (\sigma/\bar{X})100\%$$

where:  $\sigma$  — standard deviation ;  $\bar{X}$  — arithmetic mean.

Coefficients of variation in thickness in general differ between the considered subfacies and the main facies. As is visible from Table 1, coefficients of variation in the thickness are distinctly higher in both gypsum-ghost subfacies than in the selenite gypsum ones. As is evident from the tabulated data, significant thickness differences with regard to both general as well as particular subfacies occur in the area analysed.

## PERCENTAGE

The percentage of the both gypsum-ghost and selenite gypsum facies and their subfacies varies (Fig. 5) in vertical section of the Chemical Series. In general, the first facies comprise 0–40% of the section (about 85% of investigated boreholes), while the second one 20–60% of the section (about 80% of investigated boreholes), thus marking a significant difference

in the percentage of the section. With regard to the percentage of the particular subfacies in the Chemical Series, the gypsum-ghost subfacies shows a very similar pattern, while the selenite gypsum subfacies a very different one. About 90% of investigated boreholes with the fine gypsum-ghost subfacies recorded and about 93% with the coarse one comprise 0–40% of the unit. In 55% of analysed boreholes, coarse to fine selenite gypsum comprises 20–40% of the Chemical Series; whereas the giant to very coarse selenite subfacies comprises 0–40% of the series in 91% of analysed boreholes.

Although coefficients of variation in the percentage of the both selenite gypsum subfacies and the coarse gypsum-ghost subfacies are generally similar, they are distinctly different with regard to the both considered facies (Tab. 2).

From these results is clear that the coarse gypsum-ghost and giant to very coarse selenite gypsum subfacies comprise very similar percentages, while distinct differences occur in both fine gypsum-ghost and coarse to fine selenite gypsum subfacies.

## DISCUSSION

Based on postgypsum relics in the limestones, the gypsum-ghost facies have commonly been assumed as an equivalent of the selenitic gypsum facies, which is commonly found in the areas surrounding sulphur ore bodies (e.g., K. Pawłowska, 1962; S. Pawłowski, 1968, 1970; S. Pawłowski *et al.*, 1965, 1979, 1985; M. Nieć, 1992, T. Osmólski, 1972; M. Pawlikowski, 1982; B. Kubica, 1992, 1994). Thus, the structural and textural features of the postsulphate (epigenetic) rocks enabled workers to associate the gypsum-ghost limestones with the primary selenite gypsum deposits. However, this identification is — according to the present author — based upon very general similarities of the gypsum-ghost facies and the selenite gypsum rather than upon a detailed comparison or correlation with appropriate selenite facies having similar or the same features. In particular, as one might expect, this common assumption is based mainly upon: (1) generally similar stratigraphic position of mineralized or barren gypsum-ghost limestones and the selenite gypsum sequences (because both lithotypes are more frequent in the lower part of the Chemical Series), and (2) the findings that macroscopic features of the coarse gypsum-ghost limestones (especially those found at the base of the carbonate series) resemble the characteristics of some selenitic gypsum beds developed in the lower part of the sulphate sequence. Moreover, the authors commonly have not specified (or have not agreed) what types of original selenite gypsum facies were preserved in the carbonate series (see discussion in A. Gąsiewicz, 1994). In addition, the epigenetic model of the solid sulphate alteration into mineralized or barren limestones does not explain other questions like why one particular gypsum-ghost subfacies is recorded in the sequence, while the other one is not, or why various gypsum lithotypes may be found in the transitional zone (where sulphates inter-finger with epigenetic carbonates, the variability of gypsum lithotypes does not differ from surrounding sulphate areas and does not indicate favouring of any particular facies).

Detailed examinations of both sulphur-bearing or barren gypsum-ghost and selenitic gypsum facies as well as their subfacies, show distinct differences in both textural and structural development (A. Gąsiewicz, 1994). This conclusion is also supported in the course of this study by the use of detailed comparisons of three-dimensional distribution and regional

Table 1

## Comparative thicknesses of gypsum-ghost and selenite gypsum facies and subfacies

Lithology		Parametre				
		min. [m]	max. [m]	arithmetical mean [m]	number of observations N	coefficient of variation $\eta$ [%]
Subfacies	fine gypsum-ghost	0.1	8.2	1.5	64	109
	coarse gypsum-ghost	0.1	5.6	1.7	47	96
	coarse to fine selenite gypsum	0.2	26.1	8.3	296	80
	giant and very coarse selenite gypsum	0.2	27.1	7.5	219	75
Facies	gypsum-ghost	0.4	11.8	4.3	32	73
	selenite gypsum	0.7	34.0	19.1	81	41

All data included in the Table refer to exclusively carbonate (gypsum-ghost limestones) or sulphate (selenite gypsum) sections and subfacies are referred to particular beds, while facies to the total facies thickness found in the boreholes

characteristics as the general gypsum-ghost beds and selenite gypsum bodies as well as their subfacies. In general, the most striking features of the investigated gypsum-ghost facies, in comparison to the selenite gypsum deposits, are their relative rarity and monotony, and both lesser extent and thickness.

The preferential occurrence of both coarse gypsum-ghost facies in the lower part of the carbonate sequence (correlative with a stratigraphic position of the giant or very coarse gypsum deposits of the sulphate sequence) and the fine gypsum-ghost facies in the upper part of the series (correlative with the coarse to fine selenite gypsum facies) represents only a general and rough correlation. Indeed, detailed comparisons of these two main facies as well as their particular subfacies (with regard to their local correlation, thickness, distribution and frequency) indicate that there is no detailed correlation not only between these two main facies but also (as one would expect the more) with regard to the two particular gypsum-ghost and selenite gypsum subfacies. A lack of any correlation between gypsum-ghost facies was convincingly demonstrated by a dense and uniform distribution (250 x 250 m) of boreholes at Piaseczno mine (S. Dźwigała, 1965). Therefore, both gypsum-ghost and selenitic gypsum facies cannot be taken as lateral equivalents. In addition, in the heterogeneous transitional zone (where sulphates intercalate carbonates and form intrastratal layers, beds, irregular or lense-like sulphate intergrowths or buttes of gypsum deposits): (1) there is no preferential occurrence or preservation with regard to these two facies and, (2) these facies continue from the host lithologies or occur independently with no discernible differences. As may be inferred from the data tabulated here, with regard to these main

Table 2

## Comparative percentages of gypsum-ghost and selenite gypsum facies and subfacies

Lithology		Parametre				
		min. [%]	max. [%]	arithmetic mean [%]	number of observations N	coefficient of variation $\eta$ [%]
Subfacies	fine gypsum-ghost	1.2	54.9	16.9	25	85
	coarse gypsum-ghost	0.7	46.3	16.3	20	60
	coarse to fine selenite gypsum	1.5	100.0	32.0	73	59
	giant and very coarse selenite gypsum	0.4	59.8	20.6	69	62
Facies	gypsum-ghost	1.2	54.9	24.1	31	61
	selenite gypsum	1.5	100.0	41.4	92	40

All data on subfacies and facies included in the Table refer to exclusively carbonate (gypsum-ghost limestones) or sulphate (selenite gypsum) sections

facies, the area of gypsum-ghost limestones is distinctly more monotonous — predominated (65% of analysed boreholes) by one type of subfacies — compared to the selenite area which is predominated (57% of analysed boreholes) by occurrence of both selenite gypsum subfacies. This incompatibility of both gypsum-ghost and selenite gypsum facies is also well expressed by distinctly different thickness ratios between particular subfacies (1.43 and 1.22 respectively). This again indicates that both carbonate and gypsum areas differ significantly in the content of original gypsum facies and at the same time confirms the facies differentiation of the carbonate area and thus also some heterogeneity of these two lithologically different areas.

As it may be noticed from the analysis carried out above relatively stable thickness is connected with both gypsum-ghost subfacies and with the giant to very coarse selenite gypsum. Although, the thickness of gypsum-ghost facies and selenite gypsum deposits vary in vertical section and as far as the former becomes slightly thinner upwards; the latter is highly irregular in thickness throughout a whole sequence with distinctly thicker complexes developed in the upper part of the series (predominated by the coarse to fine selenite gypsum). However, the thickness of the gypsum-ghost facies is incomparably lower than that of the selenite gypsum (best illustrated by differences in the mean thicknesses which are equal to 4.3 and 16.6 m respectively). The same refers also to their particular subfacies (Fig. 4). Such significant differences in both facies and subfacies thicknesses clearly indicate that at the facies level of analysis, the gypsum-ghost limestones cannot simply be believed as an analog of the selenite gypsum lithotypes. In addition, they clearly illustrate

the incompatibility of these two lithologies. This remains true even if we take into account about 30% loss of sulphate thickness predicted by the model of epigenetic alteration (e.g., K. Pawłowska, 1962; R. Krajewski, 1962; S. Pawłowski, 1970; S. Pawłowski *et al.*, 1979, 1985; M. Nieć, 1982, 1992; B. Kubica, 1992).

Another difference between the gypsum-ghost and selenite gypsum facies as well as between their subfacies is connected with their percentage in vertical sections of the Chemical Series. The first facies usually comprises significantly less (0–40%) than the second (20–60%) (Fig. 5B). This difference is best seen by comparison of the mean percentage values of these facies, which are equal to 23.4 and 40.4% respectively. In addition, a similar pattern may be observed with regard to their subfacies (Fig. 5A). Only the coarse gypsum-ghost and the giant to very coarse selenite gypsum subfacies comprise a very similar percentage of the section. From the percentage data of both these main facies in the Chemical Series, as well as their subfacies summarized here, there is no doubt that, in general, the considered facies cannot be correlated one to the other. However, there are some similarities reflected by (1) the percentages of the coarse gypsum-ghost and the giant to very coarse selenite gypsum subfacies in the Chemical Series sections and, (2) coefficients of variation of the percentage with regard to both selenite gypsum and coarse gypsum-ghost subfacies (Tab. 2). These two coincidences are (if not accidental) possibly more pronounced and reflect the nature of diagenetic processes responsible for the transformation of sulphate series. This question arises mainly from the fact that, as is conveniently assumed by the epigenetic theory (not only with regard to Polish bioepigenetic sulphur deposits), a full alteration of sulphate deposits into (generally) postsulphate carbonates may or may not preserve the original structures and textures. In this light, obliteration of the primary gypsum depositional structures during the course of the alteration appears as an additional and important factor of sulphur deposit origin and needs further geological study. This, however, cannot be reliably answered without a reconstruction of original diagenetic signatures preserved in the altered limestones.

It is interesting to note that the calculated mean percentage value (40.4%) of selenite gypsum facies in the Chemical Series of the Osiek – Baranów Sandomierski deposit and its vicinity (including also the data from the transitional zone) is almost equal to the mean percentage value (40.7%) that may be calculated from the data tabulated by B. Kubica (1992) for selenite gypsum deposits (comprising crystalline gypsum deposits of the following facies: A, C and F) of four more extended regions of the northern Carpathian Foredeep. This additionally evidences that, first, the calculations for the Osiek – Baranów Sandomierski deposit are correct and, second, indicates that there is no significant or direct influence of the transitional zone on general sulphate facies composition (as one might expect based on preferential alteration induced by epigenetic processes and implied by many workers). This in turn again reflects the nature of the diagenetic processes responsible for the alteration of sulphate deposits.

## SUMMARY

Both sulphur-bearing and barren limestones exhibit distinct features of original gypsum precursors defined as gypsum-ghost facies. Inheritance of original gypsum crystal shape

and thus a general analogy with gypsum deposits is undoubted. This was the reason why gypsum-ghost limestones commonly found in bioepigenetic carbonates were roughly identified as an analog of selenite gypsum deposits.

However, detailed regional comparison of both gypsum-ghost (sulphur-bearing or barren) limestones and selenite gypsum deposits as well as their particular subfacies (which include the fine and coarse gypsum-ghost subfacies, and the coarse to fine and giant or very coarse selenite gypsum respectively) revealed that these facies significantly differ in their: (1) horizontal and vertical distribution patterns, (2) thicknesses and coefficients of variation, (3) frequency of interbeds in vertical section, and (4) percentages of the facies in the Chemical Series sections and their coefficients of variation.

The comparative study of both these distinct carbonate and selenite facies indicates that features of the gypsum-ghost facies are distinctly inconsistent with the features of coarse crystalline gypsum beds and therefore they cannot be correlated. The data obtained in this work led the author to conclude that the gypsum-ghost limestones are not an analog of the selenite gypsum lithotypes as has been commonly believed so far. The study indicates also that there was no simple nor preferential conversion of selenite gypsum beds into porous gypsum-ghost facies and thus also implicates more complex conditions responsible for formation of the Polish native sulphur deposits than it has been assumed so far.

**Acknowledgements.** Thanks are due to G. Czapowski for critical comments on the earlier version of the manuscript and T. Dobroszycka for technical aid.

Zakład Geologii Surowców Mineralnych  
Państwowego Instytutu Geologicznego  
Warszawa, ul. Rakowiecka 4

Received: 12.07.1994

#### REFERENCES

- BABEL M. (1986) — Growth of crystals and sedimentary structures in the sabre-like gypsum (Miocene, southern Poland). *Prz. Geol.*, **34**, p. 204–208, no. 4.
- BABEL M. (1987) — Giant gypsum intergrowths from the Middle Miocene evaporites of southern Poland. *Acta Geol. Pol.*, **37**, p. 1–20, no. 1–2.
- CZERMIŃSKI J. (1968) — Epigenetic processes within Tortonian sulphur-bearing series. 23rd Intern. Geol. Congress, Czechoslovakia, Proc. Sect. **8**, p. 121–127. Praha.
- DŹWIGAŁA S. (1965) — Native sulphur deposit at Tarnobrzeg against the geological background of the adjacent area (in Polish with English summary). *Prz. Geol.*, **13**, p. 257–259, no. 6.
- GASIEWICZ A. (1994) — Gypsum-ghost limestones facies of the Polish sulphur deposits: an analog of selenitic gypsum facies? *Geol. Quart.*, **38**, p. 415–448, no. 3.
- KARNKOWSKI P. (1994) — Miocene deposits of the Carpathian Foredeep (according to results of oil and gas prospecting). *Geol. Quart.*, **38**, p. 377–394, no. 3.
- KASPRZYK A. (1989) — Lithology of the Miocene sulfate deposits in the Staszów region (in Polish with English summary). *Kwart. Geol.*, **33**, p. 241–268, no. 2.
- KASPRZYK A. (1994a) — Distribution of strontium in the Badenian (Middle Miocene) gypsum deposits of the Nida area, southern Poland. *Geol. Quart.*, **38**, p. 497–512, no. 3.
- KASPRZYK A. (1994b) — Cyclicity of sedimentation of the Badenian evaporate deposits in the Carpathian Foredeep (southern Poland) (in Polish with English summary). *Prz. Geol.*, **42**, p. 349–356, no. 5.

- KOWALIK J., PISKORZ S., ŚMIECH S., PISKORZ A. (1979) — Dokumentacja geologiczna w kat. C<sub>1</sub> złoża siarki rodzimej „Osiek”. Kombinat Geologiczny „Południe” w Katowicach. Zakład Projektów i Dokumentacji Geologicznych, Oddział w Kielcach.
- KOWALIK J., PISKORZ S., ŚMIECH S., PISKORZ A. (1980) — Dokumentacja geologiczna w kat. C<sub>1</sub> złoża siarki rodzimej „Baranów Sandomierski – Skopanie”. Kombinat Geologiczny „Południe” w Katowicach. Zakład Projektów i Dokumentacji Geologicznych, Oddział w Kielcach.
- KRAJEWSKI R. (1962) — O budowie i powstaniu złoża siarki w Piasecznie. *Wszechświat* (1931), p. 85–91, no. 4.
- KUBICA B. (1992) — Lithofacial development of the Badenian chemical sediments in the northern part of the Carpathian Foredeep (in Polish with English summary). *Pr. Państw. Inst. Geol.*, **133**.
- KUBICA B. (1994) — Metasomatism of Badenian sulphates of the Carpathian Foredeep and its palaeogeographic conditions. *Geol. Quart.*, **38**, p. 395–414, no. 3.
- KUBICA B., PAWŁOWSKA K. (1984) — Złoża siarki rodzimej oraz perspektywy ich poszukiwań w miocenie zapadliska przedkarpackiego. *Mater. Sympozjum nt. Górnictwo surowców chemicznych. Zbiorniki podziemne i środowisko naturalne*, p. 581–595, Kraków.
- NIEĆ M. (1969) — Types of sulphur ore structures and their influence on the behaviour of ore during its smelting processes. *Tech. Poszuk. Geol.*, **8**, p. 34–38.
- NIEĆ M. (1982) — Genetic problems of biochemogenic native sulphur deposits on example of Mishraq deposit, Iraq (in Polish with English summary). *Zesz. Nauk. AGH*, **858**, *Geologia*, no. 28.
- NIEĆ M. (1986) — Sulfur deposits transforming processes (in Polish with English summary). *Prz. Geol.*, **34**, p. 366–374, no. 7.
- NIEĆ M. (1992) — Native sulfur deposits in Poland. In: *Native sulfur developments in geology and exploration* (eds. G. R. Wessel, B. H. Wimberly), p. 23–50. Littleton, Colorado.
- OSMÓLSKI T. (1972) — The influence of the geological structure of the marginal parts of the Działoszyce Trough on the metasomatosis of gypsum (in Polish with English summary). *Biul. Inst. Geol.*, **260**, p. 65–188.
- PAWLIKOWSKI M. (1982) — Mineralogical and petrographical study of alteration products of the Miocene gypsum rocks in the Wyrzyska sulphur deposit (in Polish with English summary). *Pr. Miner. Komis. Nauk Miner. PAN*, Kraków, **72**.
- PAWŁOWSKA K. (1962) — On gypsum, native sulphur and post-gypsum rocks from the Miocene of the Holy Cross Mts. (Poland) (in Polish with English summary). In: *Księga Pamiątkowa ku czci Profesora Jana Samsonowicza*, p. 69–82. Wyd. Geol.-PAN. Kom. Geol. Warszawa.
- PAWŁOWSKA K. (1965) — Syntetyczny opis litostratygraficzny osadów miocenu na obszarze między Chmielnikiem i Tarnobrzegiem. *Przew. 38 Zjazdu Pol. Tow. Geol.*, Tarnobrzeg, p. 21–39.
- PAWŁOWSKA K. (1994) — Miocene and its basement in sulphur-bearing areas of marginal part of the Carpathian Foredeep — a summary. *Geol. Quart.*, **38**, p. 365–376, no. 3.
- PAWŁOWSKI S. (1968) — Geology of sulphur deposits in Poland. 23rd Intern. Geol. Congress, Czechoslovakia, *Proc. Sect.*, **8**, p. 249–267. Praha.
- PAWŁOWSKI S. (1970) — Geologia złóż siarki w Polsce. In: *Geologia i surowce mineralne Polski*. *Biul. Inst. Geol.*, **251**, p. 614–635.
- PAWŁOWSKI S., PAWŁOWSKA K., KUBICA B. (1965) — Sulphur mine at Piaseczno (in Polish with English summary). *Prz. Geol.*, **13**, p. 252–257, no. 6.
- PAWŁOWSKI S., PAWŁOWSKA K., KUBICA B. (1979) — Geology and genesis of the Polish sulphur deposits. *Econ. Geol.*, **74**, p. 475–483, no. 2.
- PAWŁOWSKI S., PAWŁOWSKA K., KUBICA B. (1985) — Geology of the Tarnobrzeg native sulphur deposit (in Polish with English summary). *Pr. Inst. Geol.*, **144**.

Andrzej GAŚIEWICZ

**ZWIĄZEK WAPIENI „POSELENITOWYCH” Z GIPSAMI SELENITOWYMI  
NA PRZYKŁADZIE ZŁOŻA SIARKI OSIEK – BARANÓW SANDOMIERSKI**

**Streszczenie**

W artykule porównano cechy regionalne charakterystycznych wapieni siarkonośnych zawierających relikty po kryształach gipsów selenitowych, tzw. „wapieni poselenitowych” (obejmujących zarówno wapienie zmineralizowane, jak i płonne) oraz gipsów selenitowych. W obrębie tych facji można wyróżnić subfacje: wapienie z drobnymi strukturami poselenitowymi i wapienie z dużymi strukturami poselenitowymi oraz grubo- i drobno-kryształiczne gipsy selenitowe oraz giganto- i bardzo grubokryształiczne gipsy selenitowe.

W dotychczasowych pracach poświęconych genezie wapieni siarkonośnych wapienie poselenitowe stanowią jeden z głównych argumentów na rzecz hipotezy bioepigenetycznej transformacji (metasomatozy) utworów siarczanowych w wapienie posiarczanowe, siarkonośne i płonne. W tym ujęciu wymienione wapienie są w sposób ogólny utożsamiane z facjami gipsów selenitowych, jednakże dotychczas brak dokładnych porównań między tymi utworami. Ma to istotne implikacje genetyczne i stanowiło cel niniejszej pracy.

Na podstawie danych zebranych w trakcie badań terenowych, a także danych z dokumentacji geologicznych obejmujących złożę siarki rodzimej Osiek – Baranów Sandomierski i jego okolice, porównano nie tylko ogólne facje wapieni poselenitowych i gipsów selenitowych, ale także wyróżnionych w ich obrębie subfacji, przyjmując założenie, że są one odpowiednikami litofacjalnymi. Dokładne porównanie cech regionalnych wymienionych utworów pokazuje, że facje te (jak i ich subfacje) różnią się zasadniczo: (1) schematami rozmieszczenia poziomego i pionowego, (2) miąższością, (3) częstością występowania w profilu pionowym i (4) udziałem procentowym tych facji w profilach serii chemicznej. Różnice te są tak znaczne, że pozwalają stwierdzić, że wapienie poselenitowe nie mogą być uważane bezpośrednio za analog gipsów selenitowych, jak to dotychczas przyjmowano. Wyniki badań implikują także, że w trakcie bioepigenetycznej konwersji siarczanów w wapienie pogipsowe była bardziej złożona niż zakładano, co zwraca uwagę na nierozpoznaną jak dotychczas naturę procesów diagenetycznych.