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Correlation of sulphate deposits of the Carpathian Foredeep at the boundary of Poland and Ukraine

Badenian (Middle Miocene) sulphate deposits comprise different lithofacies of primary gypsum, anhydrite and secondary gypsum. Facies and sedimentary studies indicate the gypsum deposits were submitted to burial alteration to anhydrite in several stages of diagenesis. Preservation of primary lithologic features allows the correlation of gypsum and anhydrite sections over a large area of the northeastern Carpathian Foredeep. The facies variety reflects distinct sedimentary conditions in the peripheral part of the evaporite basin. They comprise subaqueous (relatively deep- and shallow-water) as well as subaerial settings.

INTRODUCTION

Studies on the Badenian evaporite formation of Poland and Ukraine have continued for more than one hundred years (see reviews by S. Kwiatkowski, 1972; A. Garlicki, 1979; A. W. Pobierieżski, 1991; B. Kubica, 1992), resulting in recognition of facies and their distribution in the Carpathian Foredeep. Hitherto, the sulphate deposits in both countries were studied separately and any comparison of facies and sequences had not been made.

The author's long lasting studies on Miocene sulphates of Poland (e.g., A. Kasprzyk, 1989, 1991, 1993*a*, *b*, *c*; T. M. Peryt, A. Kasprzyk, 1992*a*, *b*, and references therein), and results of recent research in Western Ukraine allow presentation of correlation of sulphate sections of the northeastern Carpathian Foredeep, which is the aim of this paper. Several boreholes with sulphate deposits (gypsum and anhydrite) at depths between 21.6 and 435.5 m, located in the areas of Lubaczów (SE Poland) and Drogobycz (W Ukraine) (Fig. 1), have been chosen to focus upon this topic.

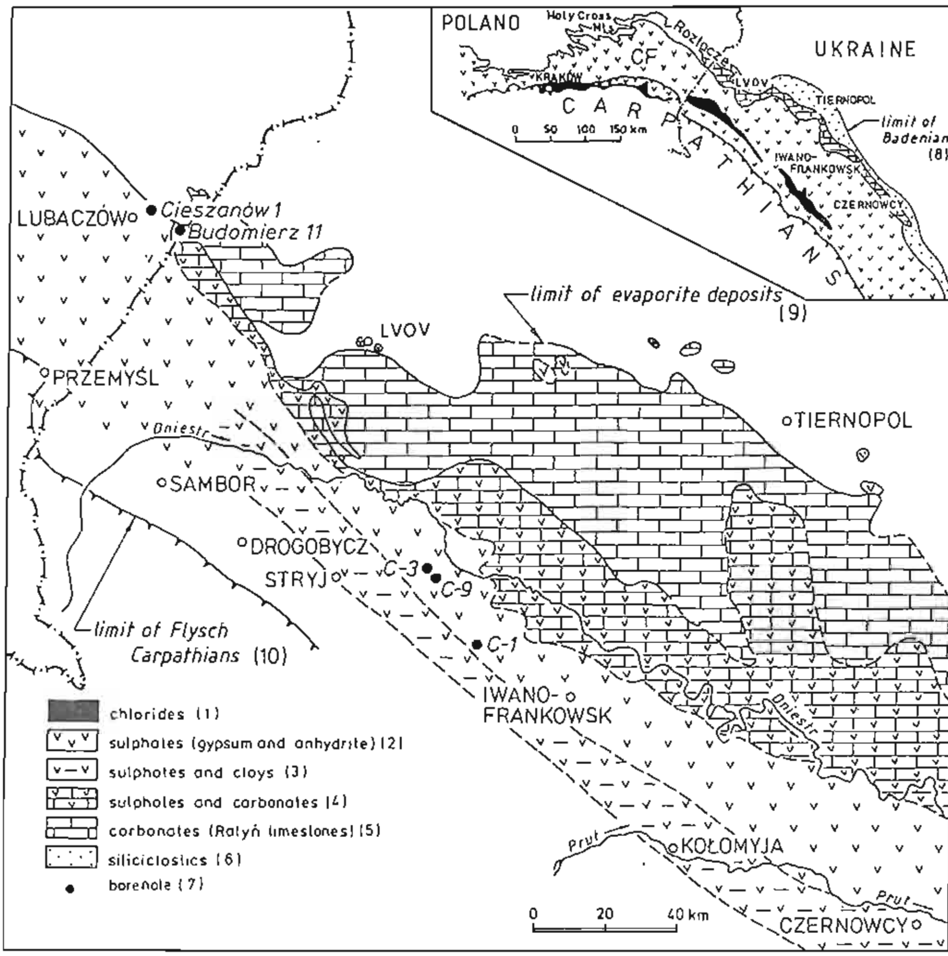


Fig. 1. Distribution and facies of evaporite deposits in the Carpathian Foredeep (CF) (after L. N. Kudrin, 1955; A. Garlicki, 1979; I. W. Wenglinski *et al.*, 1982)

Zasięg i facje utworów ewaporatowych w zapadlisku przedkarpackim (CF) (według L. N. Kudrina, 1955; A. Garlickiego, 1979; I. W. Wenglinskiego i in., 1982)

1 — utwory chlorkowe; 2 — utwory siarczanowe (gipsy i anhydryty); 3 — utwory siarczanowe i ilaste; 4 — utwory siarczanowe i węglanowe; 5 — utwory węglanowe (wapienie ratyńskie); 6 — utwory klastyczne; 7 — otwór wiertniczy; 8 — zasięg badenu; 9 — zasięg utworów ewaporatowych; 10 — zasięg Karpat fliszowych

GEOLOGICAL SETTING

During the Badenian (Middle Miocene), the Carpathian Foredeep was a place of widespread evaporite sedimentation resulting from the restriction of the northernmost part of the Central Paratethys (Fig. 1). The facies succession and lateral distribution of evaporites are an expression of different sedimentary environments including the basin margin, the shelf and the basin. On the shelf, developed on the southern peripheral zone of old platforms of the Carpathian foreland, deposition took place in a system of widespread shallow-water lagoons (S. Kwiatkowski, 1972; I. W. Wenglinski *et al.*, 1982; A. Kasprzyk, 1991; B. Kubica, 1992). Resulting evaporites are 60 m thick and comprise sulphate deposits (gypsum and anhydrite) intercalated and (or) laterally equivalent to carbonate and siliciclastic marginal facies. These deposits are the lateral equivalent to basinal sulphate laminites and halite deposits of deeper environments (A. Garlicki, 1979). In the northern peripheral part of the Carpathian Foredeep, the sulphates are preserved as gypsum that is replaced by anhydrite and associated secondary gypsum in a southward direction.

The studied boreholes are located in the northeastern peripheral part of the Carpathian Foredeep (Fig. 1). In this area, the sulphates overlie siliciclastic and organogenic carbonate deposits (Lower Badenian), and are covered by a thick marly-clay complex of Late Badenian and Sarmatian age.

A salinity crisis was the result of climatic changes and geodynamic processes influencing the Carpathians and its foreland during the Miocene. Consequently, sedimentation of evaporites occupied a large area of about 40,000 km^2 in the Carpathian Foredeep. The regional tectonic framework of the area is characterized by a dominant NW–SE fault system linked to Carpathians overthrusting. The bottom structural surface of sulphates is cut by fault dislocations with amplitudes of one hundred through hundreds of metres (B. Kubica, 1992).

LITHOSTRATIGRAPHY OF GYPSUM DEPOSITS

Gypsum deposits of the northern peripheral part of the Carpathian Foredeep of Poland comprise different lithofacies which form a constant, laterally extensive sequence of eighteen lithostratigraphic units, from *a* to *r* (A. Wala, 1980; A. Kasprzyk, 1991) — Fig. 2. It begins with giant gypsum intergrowths, called *szklica* gypsum, as unit *a* (M. Bąbel, 1987; B. Kubica, 1992; A. Kasprzyk, 1993*a*). Overlying bedded gypsum (units *b* to *e*) comprises an alternation of selenite horizons (*grass-like* or *cavoli sensu* G. Richter-Bernburg, 1973) and alabastrine or stromatolitic gypsum layers (A. Kasprzyk, 1993*c*). It is followed by a thick-bedded selenitic complex composed of *skeletal* and *sabre-like* gypsum (units *f–i*) with elongated prismatic crystals oriented chaotically or, in the upper part, uniformly. Bedding is expressed in intercalations of laminated gypsum, several centimetres thick. Overlying deposits are laminated and stromatolitic gypsum (units *i, l, m*), separated by clayey-carbonate-gypsum laminites, pelites or clastic gypsum facies (units *k* and *l*). The upper section (units *n–r*, Fig. 2) is composed of laminated and clastic gypsum: gypsorudites and gypsarenites with sedimentary structures typical of mass flow, slump, and density flow deposits (T. M. Peryt, A. Kasprzyk, 1992*a*). Locally, clastic gypsum facies are intercalated with biolaminites and nodular gypsum (units *o* and *r*). The complete gypsum sequence terminates with gypsiferous microbial-peloidal carbonates (T. M. Peryt, A. Kasprzyk, 1992*b*), followed by gypsum laminated marly claystones and marls.

Due to synsedimentary exposure and erosion, the gypsum sequence is incomplete over the large area along the present limit of the gypsum deposits, and terminates with units *n* or *o* (A. Kasprzyk, 1993*a*). Units *a–r* have their equivalents in sulphate sections where gypsum

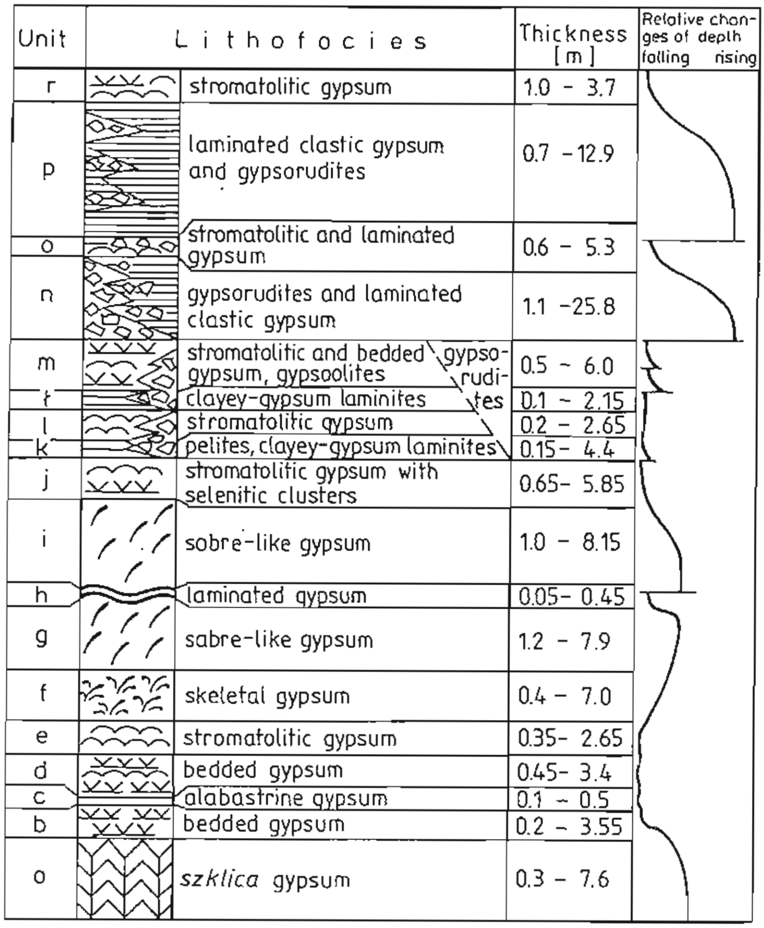


Fig. 2. Lithostratigraphy of the gypsum deposits in the northern Carpathian Foredeep of Poland (after A. Kasprzyk, 1993*a*)
Explanations of lithofacies as in Fig. 3
Litostratygrafia gipsów w północnej części zapadliska przedkarpackiego Polski (według A. Kasprzyk, 1993*a*)
Objaśnienia litofacji jak na fig. 3

was partly or completely replaced by anhydrite and secondary gypsum during burial diagenesis (B. Kubica, 1992; A. Kasprzyk, 1993*b*).

DESCRIPTION OF FACIES AND SEQUENCES

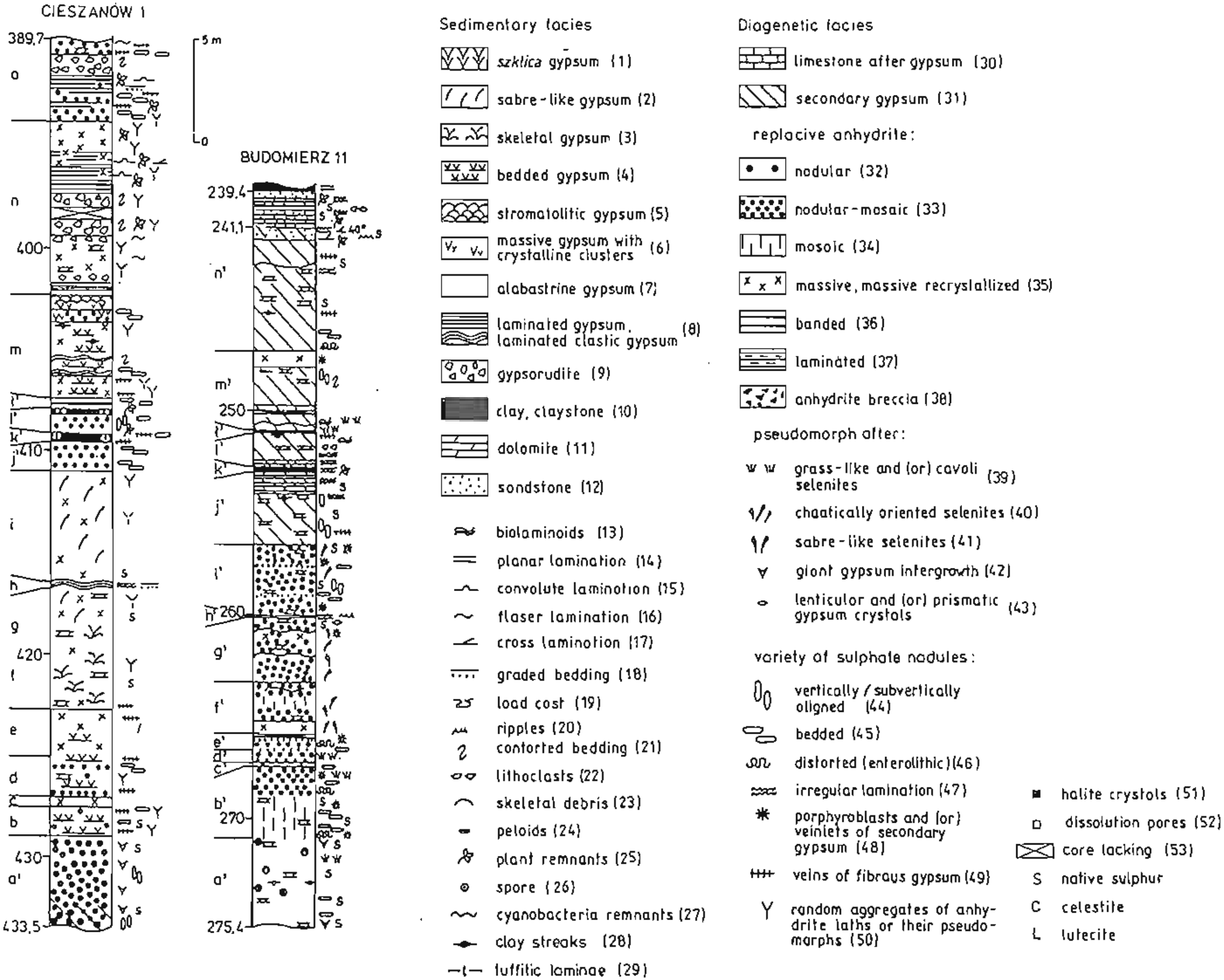
Macroscopically, the sulphates in studied cores show a distinct variation in lithofacies that consist of primary gypsum, anhydrite and secondary gypsum. The facies variety and succession of layers from *a* to *n* may have been distinguished as equivalent to the gypsum section of the northern Carpathian Foredeep of Poland. Appropriate lithostratigraphic units in altered sections are labelled *a'* through *n'*. For description of lithofacies, the terminology suggested by S. Kwiatkowski (1972), B. Kubica (1992) and A. Kasprzyk (1993*a*) for gypsum, and by W. R. Maiklem *et al.* (1969) for anhydrites, was applied. The classification of microstructures of F. Orti Cabo (1977), and F. Orti Cabo, L. Rosell Ortiz (1982) was used for anhydrite and secondary gypsum.

LUBACZÓW AREA

In borehole Cieszanów 1 (Fig. 3), the primary gypsum is partly replaced by anhydrite and secondary gypsum, which is expressed in nodules, irregular bodies and chaotic-prismatic aggregates of anhydrite laths throughout the gypsum section. Based on crystalline and sedimentary structures preserved, it is possible to distinguish a vertical set of several lithostratigraphic units (Fig. 3).

In the lower nodular-mosaic layer (unit *a'*), nodules are up to 15 cm in diameter and vertically or subvertically aligned. These are separated by stringers and anastomosing seams of clayey-bituminous material. Some of them seem to be pseudomorphs after blocky crystalline aggregates (giant gypsum intergrowths). The nodular-mosaic layer is followed by bedded gypsum with *grass-like* selenites and alabastrine intercalations (units *b–e*), partly replaced by massive and nodular-mosaic anhydrite and associated secondary gypsum (Fig. 3). Overlying selenitic lithofacies including *skeletal* and *sabre-like* gypsum varieties with minor intercalations of laminated gypsum (units *f–i*, Fig. 3) only occasionally show effects of partial replacement. Selenite crystals occur aggregated within a gypsum-dolomite background. Units *j'–l'* are nodular-mosaic and banded anhydrite with carbonate-clay impurities and interbeds. Overlying alternation of selenitic and laminated or stromatolitic gypsum facies forms unit *m*. It is followed by a thick complex of laminated gypsarenites intercalated with gypsum-carbonate breccias — units *n* and *o* (Fig. 3). These deposits are strongly affected by replacement into anhydrite with a dominant nodular-mosaic fabric at the top (unit *o*).

In borehole Budomierz 11, located 10 km south-east of borehole Cieszanów 1 (Fig. 1), the primary gypsum facies are completely alterated. There, a 4.4 m thick layer (unit *a'*) of secondary gypsum and relict anhydrite nodules occurs in the lower part of the section (Fig. 3). Composite sulphate nodules within gypsum-carbonate matrix show porphyroblastic vein fabric along the boundaries resembling assemblages of pseudomorphs after giant gypsum intergrowths and selenite horizons. Units *b'–e'* are composed of a sequence of mosaic and nodular-mosaic anhydrite with diffuse clayey-carbonate laminae. Locally, sulphate nodules and nodular layers exhibit pseudomorphs after *grass-like* and *cavoli* selenites; layers deformed enterolithically are common. In the overlying nodular-mosaic anhydrite (units *f'–i'*), pseudomorphic fabric after *skeletal* and *sabre-like* selenites is spectacular. Pseudomorphs are defined by rims of coarse-crystalline anhydrite outlined by a bitumen-stained zone. A layer, several centimetres thick, of alternating carbonate-anhydrite laminae with ripples forms unit *h'*. The facies association of units *j'–m'* are alabastrine secondary gypsum, sulphur-bearing limestone and sandy claystone with coalified plant debris, all of which show irregular lamination. The upper section (unit *n'*) is composed of nodular and irregularly laminated porphyroblastic secondary gypsum. The transition to overlying marly sandstones



CIESZANÓW 1
BUDOMIERZ 11
5 m
0
389,7
400
410
420
430
433,5
239,4
241,1
250
260
270
275,4
Sedimentary facies
szklica gypsum (1)
sabre-like gypsum (2)
skeletal gypsum (3)
bedded gypsum (4)
stromatolitic gypsum (5)
massive gypsum with crystalline clusters (6)
alabastrine gypsum (7)
laminated gypsum, laminated clastic gypsum (8)
gypsorudite (9)
clay, claystone (10)
dolomite (11)
sandstone (12)
biolaminoids (13)
planar lamination (14)
convolute lamination (15)
flaser lamination (16)
cross lamination (17)
graded bedding (18)
load cast (19)
ripples (20)
contorted bedding (21)
lithoclasts (22)
skeletal debris (23)
peloids (24)
plant remnants (25)
spore (26)
cyanobacteria remnants (27)
clay streaks (28)
tuffitic laminae (29)
Diagenetic facies
limestone after gypsum (30)
secondary gypsum (31)
replacive anhydrite:
nodular (32)
nodular-mosaic (33)
mosaic (34)
massive, massive recrystallized (35)
banded (36)
laminated (37)
anhydrite breccia (38)
pseudomorph after:
grass-like and (or) cavoli selenites (39)
chaotically oriented selenites (40)
sabre-like selenites (41)
giant gypsum intergrowth (42)
lenticular and (or) prismatic gypsum crystals (43)
variety of sulphate nodules:
vertically / subvertically aligned (44)
bedded (45)
distorted (enterolithic) (46)
irregular lamination (47)
porphyroblasts and (or) veinlets of secondary gypsum (48)
veins of fibrous gypsum (49)
random aggregates of anhydrite laths or their pseudomorphs (50)
halite crystals (51)
dissolution pores (52)
core lacking (53)
S native sulphur
C celestite
L lutecite

and sandy limestones with concentration of sulphur is gradual. Characteristic sedimentary structures include cross-lamination, ripples, flaser and irregular lamination, and brecciated layers.

DROGOBYCZ AREA

The only sulphates identified in cores of this area were anhydrite and secondary gypsum. Relics of, and pseudomorphs after, crystalline and sedimentary structures indicate the former gypsum underwent transformation into anhydrite during diagenesis. These pseudomorphic fabrics allow a comparison of sulphate sections of Western Ukraine to well studied gypsum sequences of the northern Carpathian Foredeep of Poland, and differentiation of several equivalent units, labelled *a'* through *n'* (Fig. 4).

Unit *a'* in studied cores (Fig. 4) is composed of mosaic anhydrite that locally is partly or completely alterated into porphyroblastic secondary gypsum. Distinct sulphate nodules are several centimetres in diameter and vertically aligned or deformed. These are interpreted as being pseudomorphs after giant gypsum intergrowths. Overlying bedded nodular-mosaic anhydrite and associated secondary gypsum (units *b'–e'*) exhibit irregular horizontal lamination. This is expressed in an alternation of centimetre-thick nodular layers and thinner, dolomitic or clay-organic laminae. Pseudomorphs after *grass-like* and *cavoli* selenites are noticeable within nodular layers. Perfectly preserved pseudomorphs after chaotically oriented and sabre-like selenite crystals are an impressive feature of overlying nodular-mosaic and massive anhydrite of units *f'–i'*. Locally (borehole C-9), irregular laminae of halite crystals and (or) their moulds alternate with sulphate layers. Other sedimentary and diagenetic structures include: diffuse bedding of the host sediment, irregular and flaser lamination, pseudomorphs after selenite horizons and isolated gypsum crystals. The host sediment is a gypsiferous microbial-peloidal dolomicrite. A variety of horizontally laminated anhydrite and secondary gypsum is characteristic of units *j'–m'*. Anhydrite laminae are nodular and locally distorted. In borehole C-3, there is a layer, 0.5

Fig. 3. Sections of sulphate deposits in boreholes Cieszanów 1 and Budomierz 11, situated in Lubaczów area
Profile utworów siarczanowych w otworach wiertniczych Cieszanów 1 i Budomierz 11, zlokalizowanych w rejonie Lubaczowa

F a c j e s e d y m e n t a c y j n e : 1 — gipsy szklicowe, 2 — gipsy szablaste, 3 — gipsy szkieletowe, 4 — gipsy warstwowane z poziomami selenitów, 5 — gipsy stromatolitowe, 6 — gipsy zbite z agregatami krystalicznymi, 7 — gipsy alabastrowe, 8 — gipsy laminowane, gipsy klastyczne laminowane, 9 — gipsorudyty, 10 — iły, iłowce, 11 — dolomity, 12 — piaskowce, 13 — biolaminoidy; l a m i n a c j a : 14 — pozioma, 15 — konwolutna, 16 — smużysta, 17 — przekątna; 18 — uziarnienie frakcjonalne; 19 — struktury z obciążania; 20 — riplemarki; 21 — warstwowanie zaburzone; 22 — litoklasty; 23 — szczątki fauny; 24 — peloidy; 25 — szczątki roślin; 26 — spory; 27 — szczątki sinic, 28 — smugi ilaste, 29 — laminy tufitowe; f a c j e d i a g e n e t y c z n e : 30 — wapienie pogipsowe, 31 — gipsy wtórne; a n h y d r y t y : 32 — gruzłowe, 33 — gruzłowo-mozaikowe, 34 — mozaikowe, 35 — masywne, masywne przekrystalizowane, 36 — pasmowane, 37 — laminowane, 38 — brekcje anhydrytowe; p s e u d o m o r f o z y p o : 39 — selenitach typu murawy i (lub) *cavoli*, 40 — kryształach selenitowych zorientowanych chaotycznie, 41 — kryształach selenitowych szablastych, 42 — wielkich zrostach krystalicznych, 43 — soczewkowych i (lub) pryzmatycznych kryształach gipsu; g r u z ł y s i a r c z a n o w e : 44 — pionowo i (lub) skośnie wydłużone, 45 — poziomo wydłużone, 46 — enterolitycznie zdeformowane; 47 — laminacja nieregularna; 48 — porfiroblasty i (lub) pseudożyły gipsu wtórnego; 49 — żyły gipsu włóknistego; 50 — chaotyczne agregaty pryzmatycznych kryształów anhydrytu lub ich pseudomorfozy; 51 — kryształy halitu; 52 — pory z rozpuszczania; 53 — brak rdzenia; S — siarka rodzima; C — celestyn; L — lutecyt

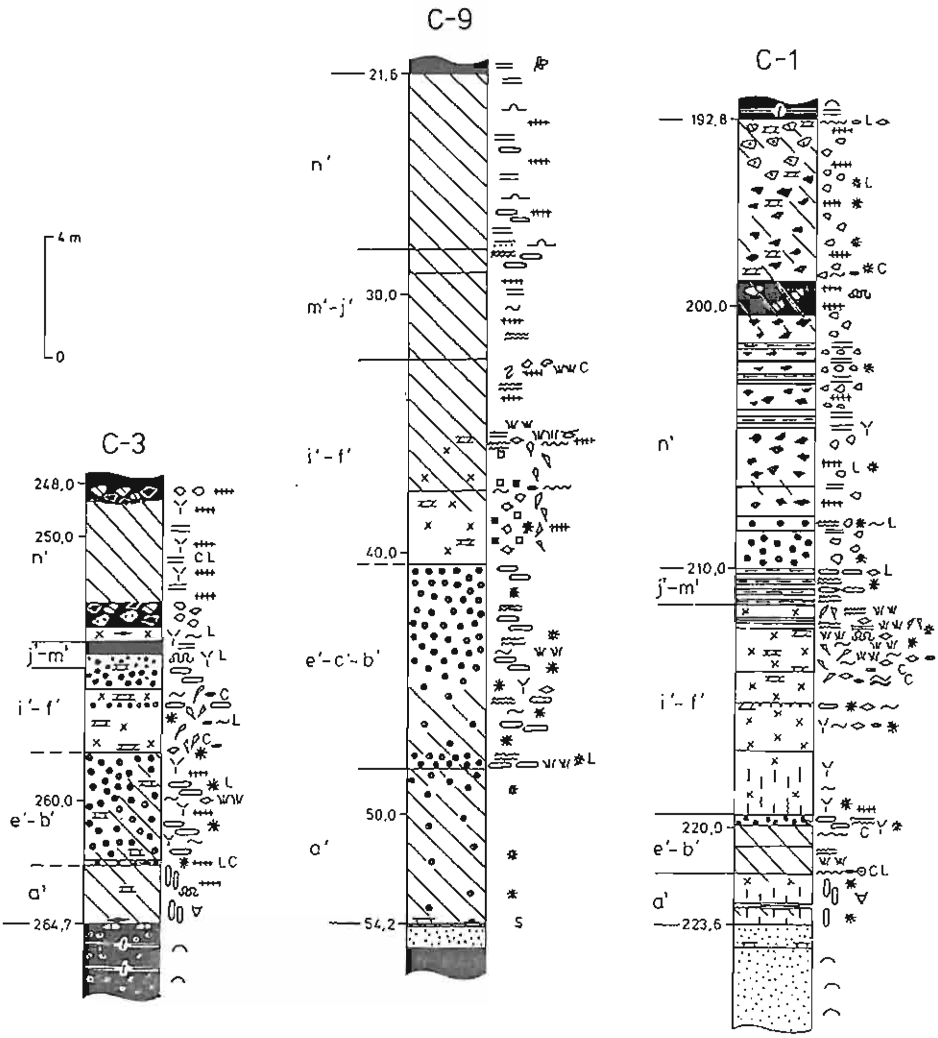


Fig. 4. Sections of sulphate deposits in selected boreholes of the Drogobycz area
For explanations see Fig. 3
Profile utworów siarczanowych w wybranych otworach wiertniczych w rejonie Drohobycza
Objaśnienia na fig. 3

m thick, of laminated siltstone in the upper part. Unit *n'* is composed of sulphate breccias and laminites with common structures: horizontal, flaser and convolute lamination, grading, and contorted and brecciated layers, all of which are characteristic of redeposited clastic deposits. Lamination is expressed in an alternation of sulphate and clayey-carbonate laminae. In the south-east borehole C-1, breccias are composed of deformed anhydrite nodules and argillaceous lithoclasts. Within the pelitic-carbonate matrix, peloids, cyanobacterial filaments, and pseudomorphs after broken gypsum crystals and grains are oriented parallel around the great sulphate lithoclasts. Intercalations of laminated anhydrite are common. Toward the north-west, breccias disappear and pass laterally into laminated facies presently composed of secondary gypsum (boreholes C-3 and C-9) (Fig. 4).

Overlying clayey-carbonate deposits with coalified plant and skeletal debris belong to the Upper Badenian.

LITHOFACIES INTERPRETATION

All lithological observation to date suggest the gypsum was an original sedimentary product that underwent transformation into anhydrite. This proccss was most likely initiated in the lower part of the gypsum section where selenitic facies dominate, as shown in borehole Cieszanów 1 (Fig. 3). The primary lithofacies sequence of units *a–m* (Figs. 2, 3) indicates deposition in shallow-water lagoonal settings subject to episodic subaerial exposure (c.f. A. Kasprzyk, 1993*b*). It is assumed that a sea-level drop initiated the gypsum to anhydrite transformation in early diagenesis. Consequently, replacive anhydrite nodules and nodular aggregates formed (Fig. 3). This may have been favoured by increased brine salinity and (or) temperature (see P. Sonnenfeld, 1984; S. Hovorka, 1992; A. Kasprzyk, *in press*). Primary fabrics of the rocks were obliterated by nodule formation during early diagenesis. The upper gypsum section (unit *n*) formed in relatively deep and less concentrated waters, due to redeposition of clastic gypsum sediment from the margin to the deeper parts of the basin. The rapid sea-level drop terminated formation of sulphates. The marginal zone was emerged and subject to intense denudation. Locally, microbial carbonates formed in extremely shallow hypersaline ponds while siliciclastic deposition dominated the other areas of the coastal plain, as is suggested from the facies association at the top of the Budomierz 11 borehole (Fig. 3).

In partly alterated gypsum deposits (Fig. 3), irregular patches and random aggregates of replacive anhydrite laths are scattered throughout the section while anhydrite nodules occur in layers below or within the extremely shallow-water and (or) subaerial facies evidencing the episodic exposure of the area. Occurrence of pseudomorphs after giant gypsum intergrowths in the lower section, allows us to interpret the basal nodular mosaic facies of anhydrite and secondary gypsum (unit *a'*) as an equivalent of *szklica* gypsum. The replacive anhydrite distribution throughout the seetion indicates differentiated intensity of gypsum to anhydrite transformation. This was perhaps dependent on primary features sueh as crystalline fabrics, structures, and impurities (c.f. P. Sonnenfeld, 1984). Considering the facies and petrographic data, another explanation for the above observations is that anhydritization was perhaps a multistage process, as well earlier suggested by B. Kubica (1992) and A. Kasprzyk (*in press*). Because transformation was not completed, the primary gypsum fabrics have been perfectly recognized.

In completely alterated sections (Figs. 3, 4), the only sulphates are anhydrite and secondary gypsum. Fortunately, the well-documented sedimentologic setting and good preservation of original fabries permit identifieation of the primary gypsum sequenee and facies. The equivalent lithostratigraphic units form a succession of layers from *a'* to *n'* (Fig. 5). It is suggested the gypsum to anhydrite transformation was completed at depth during

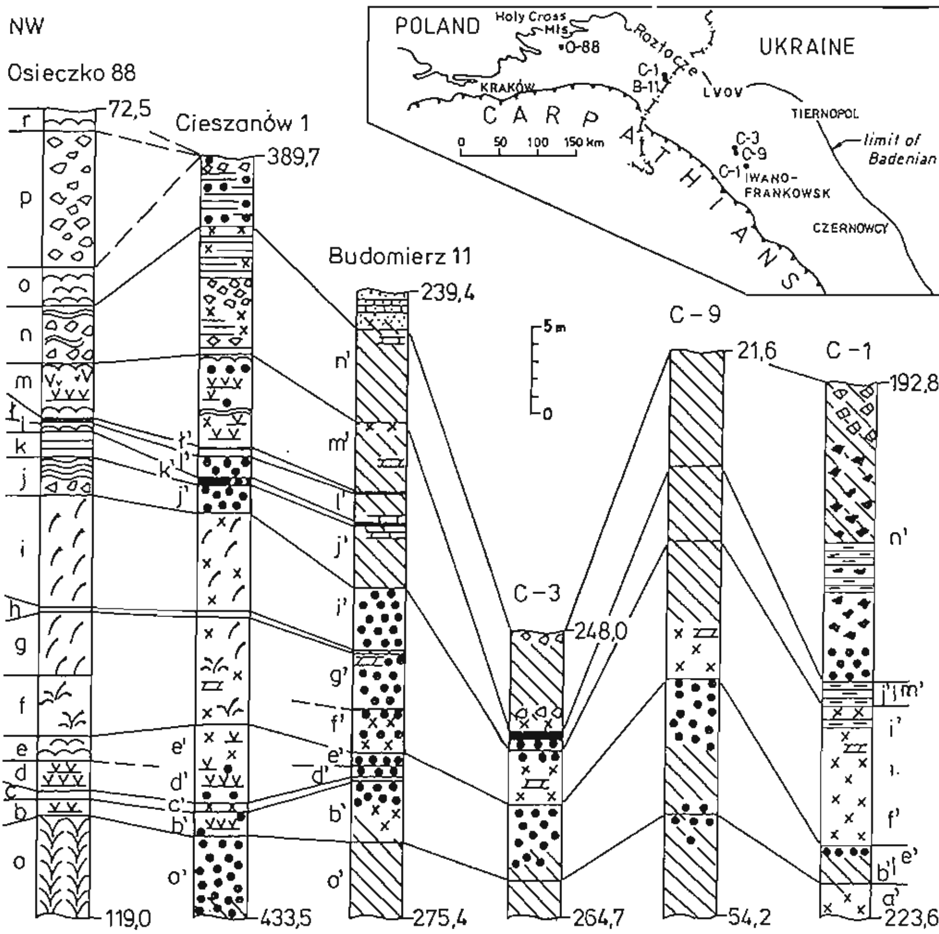


Fig. 5. Lithostratigraphic correlation of sulphate sections in the northeastern Carpathian Foredeep of Poland and Ukraine

For explanations see Fig. 3

Korelacja litostratygraficzna profili siarczanowych w północno-wschodniej części zapadliska przedkarpackiego Polski i Ukrainy

Objaśnienia na fig. 3

burial diagenesis related to tectonic evolution of the area. During rehydration (replacement of anhydrite by secondary gypsum), effects of burial diagenesis were overprinted by gypsum porphyroblasts, veins of fibrous gypsum, and pseudomorphs after anhydrite laths (Figs. 3, 4).

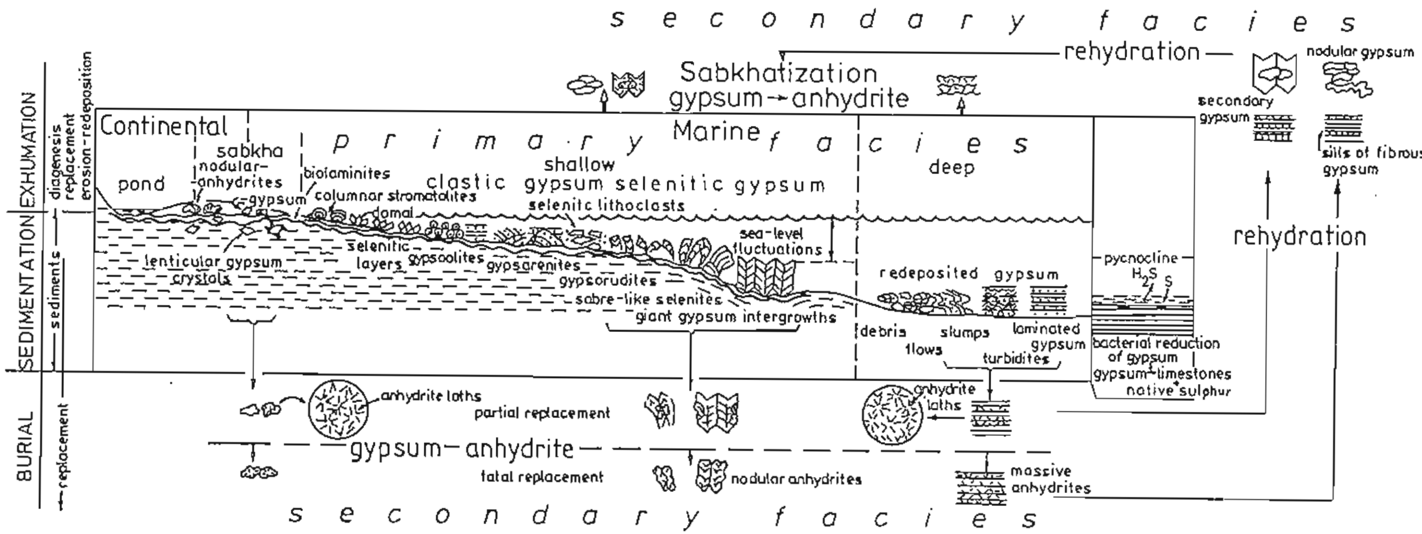


Fig. 6. Inferred sedimentary environments and diagenesis of sulphate deposits in the northeastern Carpathian Foredeep (after J. M. Rouchy, 1982; B. C. Schreiber, 1982; A. Kasprzyk, 1993*b*)

Interpretacja środowiska sedymentacji i diagenezy utworów siarczanowych w północno-wschodniej części zapadliska przedkarpackiego (według J. M. Rouchy'ego, 1982; B. C. Schreiber, 1982; A. Kasprzyk, 1993*b*)

CONCLUSIONS

The facies variations of the sulphate deposits are an expression of distinct palaeoenvironmental conditions in the peripheral areas of the Badenian evaporitic basin in the northeastern Carpathian Foredeep. They comprise subaqueous (relatively deep- and shallow-water) as well as subaerial settings (Fig. 6). Comparison of the facies in both sectors studied (Fig. 5) indicates the similar evolution of sulphate sedimentation and diagenesis over the large area of the basins.

Bottom-nucleated selenites grew in calm, high-salinity, barred subbasins (lagoons or salinas), a few metres deep. On the margin, clastic gypsum deposits were remobilized and redeposited in the deeper parts of the basin by subaerial or subaqueous mass flows. The sea-level fall preceded the development of the sabkha facies association including nodular sulphates, gypsifcrous microbial-peloidal and stromatolitic carbonates, and siliciclastic facies with a distinct assemblage of sedimentary structures: cross and irregular lamination, ripples and grading (Fig. 6). Based on the distribution of nodular facies throughout the section (Figs. 3, 4), and the lithofacies sequence, it may be suggested that the replacement of subaqueous gypsum by nodular anhydrite — a process termed *nodulization* by T. M. Peryt *et al.* (1993), and *sabkhatization* or *sabkhization* by B. C. Schreiber (1982) and S. Lugli, G. Testa (1993) — was initiated during low stands of sea level (Fig. 6).

Gypsum deposits of the Carpathian Foredeep were submitted to burial alterations into anhydrite, which did not completely destroy primary lithologic features. The different gypsum facies have their equivalents in anhydrite sections (Figs. 3–5). Gypsum to anhydrite transformation is a common feature of burial diagenesis of sulphate sediments. Considering the anhydrite distribution and fabrics, it is supposed that the gypsum was affected by several stages of alteration during early as well as late diagenesis (Fig. 6). The primary gypsum deposits were subjected to episodic subaerial exposure following falls in relative sea level. Resulting unstable physicochemical regimes favoured the gypsum to anhydrite transformation in a scenario described by D. J. Shearman (1985) and S. Lugli, G. Testa (1993). Accordingly, the nodular facies in the Badenian gypsum presumably record early diagenetic modification of the original, predominantly salina sediments. During gypsum sedimentation, sea level fell several times resulting in repetitive development of nodular facies. The effects of deep-burial alteration overlap the original fabrics and textures, as well as early diagenetic fabrics of the rock.

In the conditions of increased migration of meteoric waters, initiated by tectonic activity and (or) local uplift and exhumation, anhydrites were partly or completely rehydrated and replaced by secondary gypsum. Occasionally, the original fabrics of the former rocks were preserved.

A comparable facies variation and succession through the sulphate section over a large area of the northeastern Carpathian Foredeep indicate a uniform environment and similar evolution of diagenesis.

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Alicja KASPRZYK

KORELACJA UTWORÓW SIARCZANOWYCH ZAPADLISKA PRZEDKARPACKIEGO W STREFIE PRZYGRANICZNEJ POLSKI I UKRAINY

Streszczenie

Utwory siarczanowe badenu zapadliska przedkarpackiego (fig. 1) są wykształcone jako gipsy pierwotne, anhydryty i gipsy wtórne. Gipsy pierwotne występują w peryferyjnej części zapadliska przedkarpackiego, tworząc stałą, szeroko rozprzestrzenioną sekwencję 18 litotypów, od *a* do *r* (fig. 2). Ku południowi, wraz ze wzrostem głębokości, gipsy pierwotne są zastępowane przez anhydryty i gipsy wtórne. Utwory te były przedmiotem badań litologiczno-petrograficznych i sedymentologicznych w pięciu otworach wiertniczych zlokalizowanych w rejonie Lubaczowa (SE Polska) i Drohobycza (W Ukraina) — figura 1, w celu ich wzajemnej korelacji.

Zbadane utwory siarczanowe wykazują duże zróżnicowanie litofacjalne i bogaty inwentarz struktur sedymentacyjnych i diagenetycznych (fig. 3 i 4). W anhydrytach i gipsach wtórnych obserwuje się relikty oraz pseudomorfozy pierwotnych struktur skał gipsowych, takie jak: wielkie zrosty krystaliczne, poziomy selenitów typu *grass-like* i *cavoli*, agregaty selenitowych kryształów szablastych i chaotycznie zrośniętych, laminację: równoległą — poziomą i falistą, przekątną, nieregularną, smużystą, konwolutną i zaburzoną, uziarnienie frakcjonalne oraz struktury z obciążania. Struktury te dowodzą, że anhydryty powstały w efekcie dehydratacji gipsów pierwotnych. Litotypy *a–r*, wyróżnione w sekwencji gipsów północnej części zapadliska przedkarpackiego, znajdują odpowiedniki w profilach gipsów częściowo lub całkowicie zastąpionych przez anhydryty i gipsy wtórne, co pozwala na korelację utworów siarczanowych Polski i Ukrainy w skali regionalnej (fig. 2–5).

Wyniki badań litologiczno-sedymentologicznych umożliwiają rekonstrukcję środowiska sedymentacji i diagenezy utworów siarczanowych w północno-wschodniej peryferyjnej części zapadliska przedkarpackiego (fig. 6). Gipsy rozwijały się w zmiennych warunkach sedymentacji — od subakwalnych (względnie głęboko- i płytkowodnych) do subaeralnych. Epizodyczne obniżenie poziomu morza prawdopodobnie zainicjowało długotrwały proces diagenetycznych przeobrażeń gipsów. Zachowanie pierwotnych cech strukturalnych ma pewne implikacje co do warunków, w jakich proces ten zachodził. W strefie przypowierzchniowej lub na powierzchni, w warunkach podwyższonej temperatury i (lub) koncentracji solanek porowych, miała miejsce dehydratacja i „nodulizacja" wcześniej powstałego osadu gipsowego. Rozmieszczenie litofacji anhydrytu gruzłowego w profilu może wskazywać, że w trakcie sedymentacji osadów siarczanowych, w strefie brzeżnej i na obszarach płycizn kilkakrotnie doszło do wynurzeń. Dalsze stadia dehydratacji zachodziły w późnej diagenezie, w efekcie pogrążenia (fig. 6). Zróżnicowanie litologiczno-petrograficzne anhydrytów to efekt kilkuetapowego procesu dehydratacji gipsów.

W warunkach zwiększonej migracji wód meteorycznych, zainicjowanej tektoniczną przebudową i (lub) lokalnymi wynurzeniami, anhydryty uległy częściowej lub całkowitej hydratacji i zastąpieniu przez gips wtórny.