POLSKIE TOWARZYSTWO MINERALOGICZNE - PRACE SPECJALNE
MINERALOGICAL SOCIETY OF POLAND – SPECIAL PAPERS
Zeszyt 26, 2005; Volume 26, 2005

Danuta OLSZEWSKA-NEJBERT[1], *Krzysztof NEJBERT*[1]

THE PHOSPHORITE CONCRETIONS FROM THE EOCENE GLAUCONITIC SANDS OF MIELNIK AREA, EASTERN POLAND

Abstract: Phosphorite concretions from the Eocene glauconitic sands of Mielnik consists of the quartz, K-feldspar, and glauconite as a framework, and carbonate-fluorapatite (francolite) as a matrix. The concretions have grown in anoxic condition, from interstitial waters in the quartz-glauconitic sands accumulated in a shallow basin, during synsedimentary or early-diagenetic stage, during the relatively high sea-level. The concentration of the phosphorite concretion conglomerat as a lag deposit took place during the low sea-level, when the development and velocity of the bottom currents took place.

Keywords: phosphorite concretions, carbonate-fluorapatite, Eocene, Mielnik, eastern Poland

INTRODUCTION

The 0.3 – 0.6 m thick horizon of phosphorite concretions forms a very characteristic element of the quartz-glauconitic sands of Eocene age, in the Mielnik, eastern Poland (Figs. 1-2**.** The studied horizon was long regarded as Oligocene age (Giedroyć 1886). The comparison with equivalently, paleontologically documented deposits, from of northern part of the Lublin Upland, indicates their Late Eocene age (Uberna 1981). The present Authors provide the preliminary data on the petrography, mineralogy, and genesis the concretions. The EPMA and XRD techniques were applied.

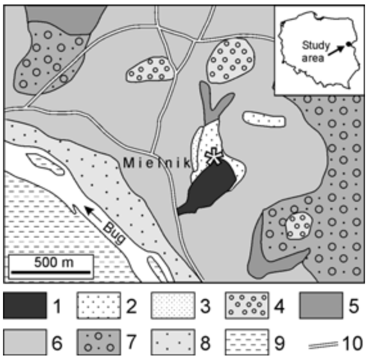


Fig. 1. Geologic sketch-map of Mielnik (after Staśkiewicz 1971, modified). The asterisk indicates the location of samples. UPPER CRETACEOUS: 1 – white chalk; PALEOGENE: Eocene and ?Oligocene: 2 – glauconitic-quartz sands and clays; NEOGENE: Miocene: 3 – quartz sands; Pleistocene: 4 – gravels and boulders of end moraine; 5 – tills; 6 – sands and boulders overlying on the tills; 7 – sands and boulders of fluvioglacial accumulation; 8 – sands of accumulation terrace; Holocene: 9 – muds and sands of flood-plain terrace; 10 – roads.

THE TYPES OF THE CONCRETIONS

The concretion, depended on their shape are grouped into six groups (Fig. 3). Group A is represented by spheroid concretions, 2 to 15 cm in diameter (Fig. 3A). Group B comprises the snow-man-like concretions with their longer axis up to 18 cm long (Fig. 3B)

Faculty of Geology, University of Warsaw, Al. Żwirki i Wigury 93, 02-089 Warszawa, Poland, e-mail: don@uw.edu.pl, knejbert@uw.edu.pl

Concretions of group C look like three jointed spheroid concretions and are called here triple bulb with maximum size up to 20 cm (Fig. 3C). Group D comprises oval-shape concretions (Fig. 3D) with their longer sizes vary between 3 and 16 cm. The concretions of group E look like *Ophiomorpha* burrows (Fig. 3E) and sometimes like *Thalassinoides* burrows (Fig. 3G). The concretions of group F are irregular in shape (Fig. 3F) and are rather small, up to 5 cm in size. The most of the concretions are contained within weakly cemented quartz-glauconitic sands or sandstone, with admixture of small quartz gravels; rarely, the concretions are contained within more strongly cemented conglomerate (Fig. 3H).

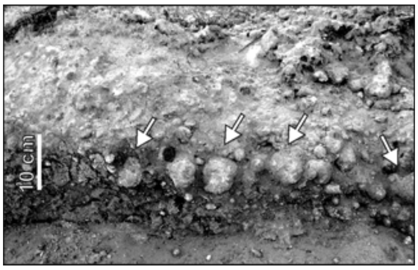


Fig. 2. The horizon with the phosphorite concretions, north-western wall of the quarry in Mielnik. The middle part of horizon enriched in large cobbles of phosphorite concretions (arrowed).

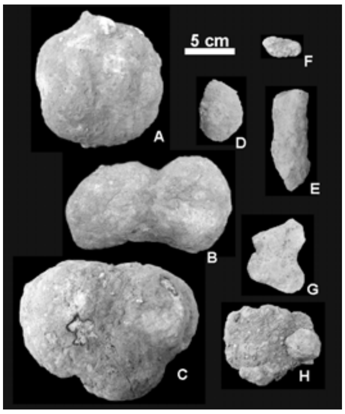


Fig. 3. Morphological varieties of the phosphorite concretions from the phosphatic horizon from Mielnik: A – spheroid cobble; B – snow-man-like concretion; C – triple bulb; D – oval-shape concretion; E – *Ophiomorpha* burrow-like concretion; F – irregular concretion; G – *Thalassinoides* burrow-like concretion; H – fragment of the phosphorite conglomerate

The phosphatic horizon is tripartite in its character. The bottom 10-15 cm thick, is dominate by small, oval and irregular concretions of groups D and F. Large-sized concretions of groups A, B, C and D are common in the middle, 15-25 cm thick part of the horizon. Large concretions of group A are particularly characteristic element for this part of the horizon (Fig. 2). The topmost, 20-25 cm thick, is dominated by concretions of groups D, E, and F with their sizes below 6 cm. Shark teeth and crabs are characteristic element of the upper part.

MINERALOGY AND PETROGRAPHY OF THE CONCRETIONS

The concretions are composed of terrigenic components (mainly quartz, quite common K-feldspar, rare monazite, zircon, and amphibole), and allogenic components (different in size glauconitic pellets), and authogenic components, represented by carbonate fluorapatite (CFA) – francolite (Fig. 4).

The concretions are cemented in its character. The angular grains of quartz and K-feldspar are rather small, below 200 µm. The glauconitic pellets are not deform and differ in size from 50 to 500 µm (Fig. 4B). The glauconite colour in concretions varies from green to brown, sometimes, to dark brown. The discoloration is a result of iron oxidation contained in the glauconite. CFA coating the terrigenic and allogenic grains with thin rim, up to 20 µm. Although, the content of terrigenic and allogenic grains is high, the concretions still represent phosphatic wackestone (Fig. 4).

CFA (francolite) has a typical chemical composition for that sedimentary phosphate minerals (Table 1). It is worth to note that francolite precipitated around grains. No trace of replacement of early existed grains. Such relationships indicate the early or contemporaneous process of glauconitization of pellets and the crystallization of CFA.

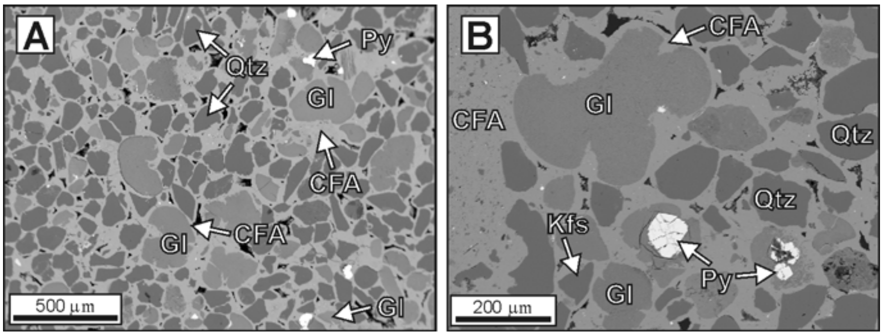
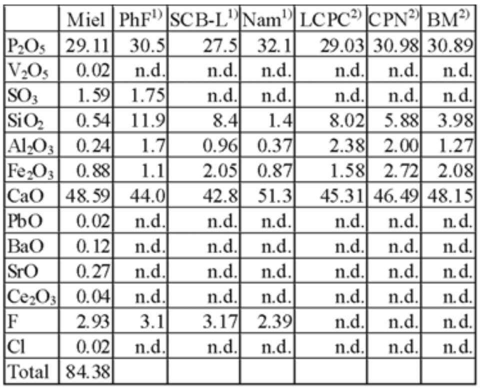


Fig. 4. Petrography of the phosphorite concretions (BSE image, 15 keV, 10 nA): A – phosphatic wackestone, the inner part of phosphate concretion showed the cemented character of the concretion; B – phosphatic wackestone, thin rims, coated the terrigenic and allogenic grains, in the concretion CFA – carbonate-fluorapatite (francolite), Qtz – quartz, Kfs – potassium feldspar, Gl – glauconitic pellets, Py – pyrite; the relicts of primary porosity visible as a very small black fields

DISSCUSSION AND CONCLUSIONS

The modern apatite-glauconite associates are connected with the outer shelf and upper slope, at the depth 350-460 m, in the East Australian (O'Brien *et al.* 1990) or, at the depth 300-385 m, in Peru and Chile (Burnett 1980) continental margins. But only in the latter case the upweling was a main mechanism for phosphogenesis (*e.g.* Baturin 1982; Föllmi 1996). The Eocene basin in the studied area represented rather shallow, semirestricted epicontinental basin or even embayment. The deeper marine sedimentation was far away from studied area. The upwelling was hardly a mechanism responsible for the formation of phosphorite concretions in the Eocene of Mielnik. Similar conclusion present Knudsen, Gunter (2002) about the Permian Phosphoria Formation.



	Miel	PhF[1)]	SCB-L[1)]	Nam[1)]	LCPC[2)]	CPN[2)]	BM[2)]
P_2O_5	29.11	30.5	27.5	32.1	29.03	30.98	30.89
V_2O_5	0.02	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
SO_3	1.59	1.75	n.d.	n.d.	n.d.	n.d.	n.d.
SiO_2	0.54	11.9	8.4	1.4	8.02	5.88	3.98
Al_2O_3	0.24	1.7	0.96	0.37	2.38	2.00	1.27
Fe_2O_3	0.88	1.1	2.05	0.87	1.58	2.72	2.08
CaO	48.59	44.0	42.8	51.3	45.31	46.49	48.15
PbO	0.02	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
BaO	0.12	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
SrO	0.27	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Ce_2O_3	0.04	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
F	2.93	3.1	3.17	2.39	n.d.	n.d.	n.d.
Cl	0.02	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Total	84.38						

Table 1. Major element concentration in francolite from the Eocene phosphorite concretions from Mielnik and comparison with phosphatic rocks of similar composition from other locations; Miel – Mielnik, the average data based on 8 analyses; PhF – Phosphoria Formation; SCB-L – Southern California Border-Land; Nam – Namibia, LPCP – London Clay phosphorite concretion; CPN – Crag phosphorite nodule; BM – 'Boxstone' matrix; 1) – data after O'Brien *et al.* (1990); 2) – data after Balson (1980); n.d. – no data

The modern phosphorite concretions form within the anoxic zone in the topmost part of the sediments down to approximately 10-18 cm below the sediment-water interface (O'Brien *et al.* 1990). It means that even the large concretions of various shape from Mielnik could have grown during a single episode of phosphogenesis. The anoxic conditions favourable for phosphogenic processes, appear usually during the periods of relatively high sea-level (*e.g.* Krajewski 1984, O'Brien *et al.* 1990). The concentration of the phosphate concretions as a lag deposit took place during the low sea-level, when the development and velocity of the bottom currents took place. The sediment became oxic, what broke the processes of glauconitization and phosphatization (compare O'Brien *et al.* 1990). Simultaneously the glauconite were oxidized to the brownish colours.

The differentiation and distribution of the concretions in the studied horizon indicate that it originated during several phosphogenic episodes. The following scenario led to development of phosphatic horizon: supply of the terrestial material and organic production (pellets) → glauconitization of pellets and phosphatization under anoxic conditions during the slow or break of sedimentation in the relatively high sea-level → the winnowing of fine material by bottom currents and concentration of concretions as a lag deposits during the relatively low sea-level. Such scenario repeated, at least three times in Mielnik. The middle stage was the longest for phosphogenesis due to grown the big forms in size, up to 20 cm.

The chemical composition of francolite from the studied concretions corresponds closed to phosphatic rocks (Table 1) from Phosphoria Formation, Southern California Border-Land, Namibia (O'Brien *et al.* 1990) and from eastern England Tertiary phosphorites (Bolson 1980). The recent or very young phosphorites have much lower content of P_2O_5 (about 10-12 %; O'Brien *et al.* 1990). The wackestone texture and relicts of primary porosity indicate that the concretions are synsedimentary.

The episodes of phosphogenesis are known in the Late Eocene of North Sea Basin (Bolson 1990). However, the particular relation of phosphatic horizon from Mielnik to phosphogenic episodes in Europe needs additional studies.

The authors' special thanks go to Piotr Dzierżanowski, Grzegorz Kaproń, Lidia Jeżak, Jan Trąbiński and Grzegorz Widlicki. The study was supported from the research grants of the University of Warsaw: BW 1686/17.

REFERENCES

BALSON P.S. 1980. The origin and evolution of Tertiary phosphorites from eastern England. *J. Geol. Soc. London*, 137, 723-729.

BALSON P.S. 1990. Episodes of phosphogenesis and phosphorite concretion formation in the North Sea Tertiary. In: Notholt A.J.G., Jarvis I. (eds), Phosphorite Research and Development., *Geol. Soc. Spec. Publ.*, 52, 125-137.

BATURIN G.N. 1982: Phosphorites on the sea floor. Origin, composition and distribution. *Devel. Sed.*, 33, 1-343.

BURNETT W.C. 1980: Apatite-glauconite associations off Peru and Chile: palaeo-oceanographic implications. *J. Geol. Soc. London*, 137, 757-764.

FÖLLMI K.B. 1996: The phosphorous cycle, phosphogenesis and marine phosphate-rich deposits. *Earth-Sci. Rev.*, 40, 55-124.

GIEDROYĆ A. 1886. Recherches sur la formation geologique du terrain du gouvernement Grodno et des parties limitrophes du Royaume de Pologne et de Lithuanie. *Pam. Fizjograf.*, 6, 3-16.

KNUDSEN A. C., GUNTER M. E. 2002: Sedimentary phosphorites – An Example Phosphoria Formation, Southeastern Idaho, U. S. A. *Rev. Mineral. Geochem.*, 48, 363-389.

KRAJEWSKI K. P. 1984: Early diagenetic phosphate cements in the Albian condensed glauconitic limestone of the Tatra Mountains, Western Carpathians. *Sedimentology*, 31, 443-470.

O'BRIEN G.W., MILNES A.R., VEEH H.H., HEGGIE D.T., RIGGS S.R., CULLEN D.J., MARSHALL J.F., COOK P.J. 1990: Sedimentation dynamic and redox iron-cycling: controlling factors for the apatite-glauconite association on the East Australian continental margin. In: Notholt A.J.G., Jarvis I. (eds), Phosphorite research and development., *Geol. Soc. Spec. Publ.*, 52, 61-86.

STAŚKIEWICZ E. 1971: An estimation of the extend of the chalk deposits of Mielnik, based on its geological setting. [In Polish]. *Unpublished M. Sc. thesis*, Institute of Geology, Warsaw University.

UBERNA J. 1981: Upper Eocene phosphate-bearingdeposits in northern and eastern Poland. *Bull. Acad. Polon. Sci.*, 24, 81-90.