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MICROSCOPIC INVESTIGATIONS OF BORE-HOLE MUDS FROM OIL WELLS:

I. THE POTOK BELT AND THE KROSNO AREA
II. GENERAL REMARKS [1]

(*4 Figs.*)

INTRODUCTION

In the year 1894, I began microscopic investigations of bore-hole muds from oil wells, made possible by a grant obtained from the Wydział Krajowy Galicji (The Department for Affairs of Galicia). Since that time, I have published two short notes [2] on the subject. More detailed results are given in the present paper, three years after the beginning of the work. This delay was caused by several reasons.

Firstly, there was a lack of material from definite horizons for comparison, a fact already mentioned [3] in an earlier note. The cuttings from wells are obtained in a state suitable for microscopic investigations. However, this material does not show the petrographic features of the beds drilled through, which up to now constitute one of the principal criteria for the determination of horizons in Carpathian rocks. The drilling logs, even if available, cannot help much. It is rare to find there other determinations than „hard" or „soft rock", „clay" or „shale" and at the most a very subjective determination of colour. In such conditions, the investigation of the microfauna from the oil wells was postponed until the fauna of other, better defined levels was studied, at least partly.

The lack of agreement between various authors on the geological structure of the Carpathians also created many difficulties. The boundary between the Cretaceous and the Tertiary is, to some degree, arbitrarily given and therefore the age of a fauna could not be judged a priori on the basis of occurrence in a certain horizon. It was necessary to select for study faunas from horizons widely accepted as being firmly established. These investigations gave a surprising result, viz. the finding of Tertiary in the Ropianka Beds of Eastern Galicia [4].

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[1] Paper published in Polish 1898. The present translation comprise the most valuable parts of the Polish text (Editorial note).

[2] *Kosmos* 1895. Fasc. XI and XII. *Nafta* 1898 No. 4.

[3] Foraminifera of the red clay from Wadowice. *Proc. Math. Sc. Faculty. Acad. Sc.*, vol. 30.

[4] Galicia — ancient name for Southern Poland (Editorial note).

No wonder then, that slow and careful work was required in the study of fauna from the oil-bearing strata, for which there were often no petrographic data and the age of which was frequently determined only on the basis of the visible overlying beds. A large and systematically sampled collection material was necessary therefore, to fulfill the aim of the investigations. This aim was twofold.

Firstly, to find out whether the oil-bearing series recognized in the Carpathians viz. the Cretaceous, Eocene and Oligocene (leaving aside the Miocene of the Carpathians) are characterized, by faunistic differences and to what extent, what is the nature of these differences, and whether it is possible to distinguish sharply between the principal series on the basis of microfauna. Secondly, to check whether within one geological compler, that is, in one well or field, it might be possible to subdivide the strata on the basis of Foraminifera, to thus obtain more exact informations for the oil industry.

One might expect the answer to the first question to be the more important and that it should be reached before proceeding to the second one. During the course of the work, however, it was logical to answer the second question first. In the comparison of faunas from various horizons, these must be studied in detail. Therefore it is necessary to investigate one horizon, which can be used as a reference horizon in further work. During such an investigation of one horizon, the answer to the second question, positive or negative, is obtained if the material has been properly collected.

I. THE POTOK BELT

The oil-bearing strata of the neighbourhood of Krosno extend from Krościenko, across Białobrzegi and Toroszówka, to Potok. Their strike is generally marked by a low hill built of Menilite Shales, which overlie the oil-bearing strata and are exposed at one or more points in all the localities mentioned. Better exposures occur at Krościenko Niżne. The following continuous profile from top to bottom is seen here:

1. Sandstones determined by Tietze as the Krosno Beds (top of these not exposed)
2. Menilite shales up to 30 m thick
3. Grey marly shales up to 5 m thick
4. Bluish clays — up to 10 m thick
5. Red clays — wisible thickness up to 12 m.

Deeper lying beds were encountered at Krościenko Białobrzegi, Toroszówka and Potok.

With the exception of the Krosno Beds, all of the above complexes, as well as the underlying beds reached by drilling, yielded a rich foraminiferal fauna [1].

In spite of the difficulties opposing an exact determination of geological horizons, stemming from the large number of new species (exceeding 50 per cent), and from the fact that only few similar foraminiferal faunas are known, it can be stated that without doubt this fauna belongs to the early Tertiary, corresponding to the Bartonian — Ligurian stage,

[1] In original polish text detailed lists of species are given but the names of fossils are out of date, therefore the lists are not included in the translation (Editorial note).

known from elsewhere in the Carpathians. The topmost beds, the Menilite Shales, can be assigned to the Oligocene as they contain the diagnostic species *Nummulites budensis.*

The fauna of the underlying beds is uniform from the top to the lowest beds hitherto reached. Therefore, taking into account the concordance of these beds with the Menilite Shales, we must regard them as one single complex. This is further substantiated by the discovery of such typical Tertiary species as *Nummulites* sp. aff. *Leymeriei, Amphistegina subparisiensis, Alveolina* cf. *melo* at the base of the complex, for example, int he Duniecki well, Toroszówka, a depth of 451 m, and in the Duniecki well, Białobrzegi, at a depth of 225 m.

Even a brief consideration of faunal distribution leads to the conclusion that four horizons may be distinguished.

The first one (from the top) comprises the Menilite Shales. Their foraminiferal fauna, known from one locality only, differs characteristically from that of the remaining horizons. It consists exclusively of calcareous forms, belonging to the families *Nodosariidae, Rotaliidae, Nummulitidae.*

Most characteristic are here *Nummulites budensis, Rotalia lithotamnica, Orbitoides stella.*

The second horizon consists of marls underlying the Menilite Shales. These are characterized by a fauna, consistings almost exclusively of the genus *Globigerina.* This horizon is known from Krościenko, where it crops out in a natural exposure and was also found at Potok in the well of Sroczyński and Co. to a depth of 42 m, and in the Klobassa well No. IV to a depth of 8 m.

The third horizon consists of the oil-bearing strata proper, beginning under the bluish and red clays alredy mentioned and reaching to an unknown depth. This horizon is characterized by the presence of arenaceous and siliceous forms exlusively. With a few exceptions, all samples come from that zone which yielded the largest number of well preserved Foraminifers.

The presence of the fourth horizon is poorly marked, probably because of the fact that only few shafts reached it. In this horizon, calcareous forms are present as well as arenaceous ones. It was recorded in the shafts at Toroszówka and Białobrzegi mentioned above, where *Nummulites, Alveolina* and *Amphistegina* were found, and in the Kalinka well at a depth of 600 m, where, in addition to arenaceous Foraminifera, nine forms of calcareous Foraminifera and two ostracod species were found.

We will leave apart the first horizon corresponding to the Menilitic Shales, which are petrographically distinct and, owing the presence of cherts, easily recognizable, even in cuttings. The second horizon, although not thick (15—20 m), is more important, since it has a characteristic and easily recognizable microfauna, which permits an exact determination of the passage to the oil-bearing horizon. This passage would be otherwise difficult to define, since the grey, marly shales do not show characteristic petrographic features and are usually recorded as „grey shale" in the drilling logs.

The base of the oil-bearing strata proper belonging to the third horizon, which is characterized by the presence of a fauna consisting of arenaceous and siliceous forms only, cannot be defined exactly. The points, below which a mixed fauna was found, are so few and widely

spaced that the boundary between the third and the fourth horizon cannot be precisely established. With an average depth of 600 m, reached by the wells at Górny Potok still within the third horizon, and an average dip of 45°, the thickness of the third zone may be estimated as being 400—450 m.

When dealing with such a large thickness it would be important to note precisely changes in distribution of Foraminifera. Comparing in a more detailed way the lists of species from the individual wells, it may be readily seen that the number of species, forms and individuals decreases with increasing depth. Furthermore, some species, present throughout the zone, occur abundantly at a certain depth, either nearly excusively, as the case of *Reophax placenta,* or prevailing among other forms, as does *Cyclammina amplectens.* It is also seen that some species, such as *Dendrophrya robusta* are more common in the lowermost beds, while in the higher beds, they are represented by a few individuals only. On the other hand, other forms, such as almost the whole genus *Ammodiscus* are frequent and numerous in the higher beds, but disappear at greater depths.

The question now arises whether this distribution is related to changes in the rock sequence and corresponds to these or it is purely fortuitous. This question can be answered by scrutiny of a detailed profile of the area.

It would be difficult, or even impossible, to gather profiles of all wells over such a large area, since work at Toroszówka was been abandoned a few years age. Therefore I restricted these investigations to the Dolny Potok area, because most of the systematically collected samples came from there. The Management of the Hannover — Galicia Co., which already two years ago supplied many samples, kindly permitted the study of all the well logs and supplied all necessary information. This assistance is gratefully acknowledged. Thanks are also due to Engineer J. F a b i a ń s k i, who kindly provided well logs from the lease remaining under his supervision.

On the basis of about 40 well profiles, it was possible to draw a profile of the central part of the Potok field.

It follows, from the profiles and the localization sketch (Figs. 1—4) that the strata there form an oil-bearing anticline, with gently dipping limbs displaying dips of about 30° near the axis. The highest point of this anticline lies in Well No. 12 of the Hannower — Galicia Co. The axis of the anticline runs from that point towards h 7.20 min, across Well No. 12, 52, 31, 35, 39 and Well No. 9, Klobassa. The axis pitches to the West at an angle of about 12°.

The anticline comprises the following complexes, beginning at the top:

1. Bluish clays (locally passing into red clays, especially in the upper part), with thin intercalations of sandstones.
2. Granular sandstones, of average thickness 50 m, called I-st water-bearing sandstone in the wells of the Hannower-Galicia Co.
3. Red clays (about 60 m).
4. Bluish clays with thin sandstones (50 m).
5. Sandstones with intercalations of red clay (oil-bearing horizon, 50 m).
6. Bluish clays.
7. Water-bearing sandstone.

Deeper-lying strata were reached in one well only (No. 52), and therefore there are no data for a more precise subdivision of the lower complexes.

When the distribution of fauna of these complexes is studied, taking into account the above profile, it is clearly seen that the particular occurrences noted correspond exactly to the lithological sequence.

The characteristic abundant and exclusive occurrence of the species *Reophax placenta* is restricted to the lower part of the first bluish clays, forming a zone found in nearly all wells, from which a complete set of samples was available: in Well No. 23 at depths of 106 and 110 m, in No. 26 at 42—95 m, No. 27 at 130 m, No. 33 at 355—370 m, No. 34 at 320—370 m, No. 39 at 160—250 m, No. 40 at 126—165 m, No. 41 at 318—320 m. In consistency with the structure of the whole area in the Sroczyński lease, which is the highest and most westerly, this zone lies at a depth of 523—525 m and in the most southerly Pyszyński well, lying to the West, at the depth of 490—525 m.

About 100—120 m above this zone, another zone may be established, on the basis of numerous occurrences of the species *Cyclammina amplectens*. This zone was found in the western part of the area, in Well No. 33 of Hannover — Galicia Co. at 170—227 m, in No. 34 at 108—171 m, in No. 41 at 108—171 m, in the Klobassa Well No. 7, at 87 m, in the Perkins lease in Well No. 2 at 130 m, and on the Sroczyński lease at 80—137 m.

This zone is less distinct than the preceding, for the species *Cyclammina amplectens* constitutes about 50 per cent of individuals present.

At greater depths, distinct zones are absent. Generally they are characterized by the much less common occurrence of the genus *Ammodiscus*, usually represented by regular planispiral forms such as *A. polygyrus, A. angygyrus* and among the glomospiral forms, *A. charoides*, all of which have a wide vertical range. On the other hand, in the higher zones this genus is represented by numerous species and individuals. In the higher zones often several tens of specimens may be found in one sample, but in the lower zones only one or two specimens per sample are present. Instead the genus *Trochammina* is better represented in the lower zones, by more numerous species and by larger and better developed individuals.

Finally the oil-bearing zone is characterized by paucity of Foraminifera. Only few species, represented by few individuals, were found.

Only the species *Rhabdammina abyssorum, R. linearis* and *Dendrophrya robusta*, and especially the latter, occur as larger numbers of individuals.

Within this third horizon, partly overlapping with the fourth one, another zone can be distinguished, marked by the presence of two very characteristic species: *Reophax grandis* and *Dendrophrya robusta*. This zone was found at Białobrzegi in the Douglas lease at a depth of 380 m, in the Wiśniowski lease, Toroszówka, at 569 m. At Białobrzegi, it comes near to the mixed zone with *Amphistegina*, while at Toroszówka it approaches the zone with *Dendrophrya robusta*. However the limits of this zone and its position cannot be determined, since less samples were collected in the eastern part of the area and there are no profiles for comparison.

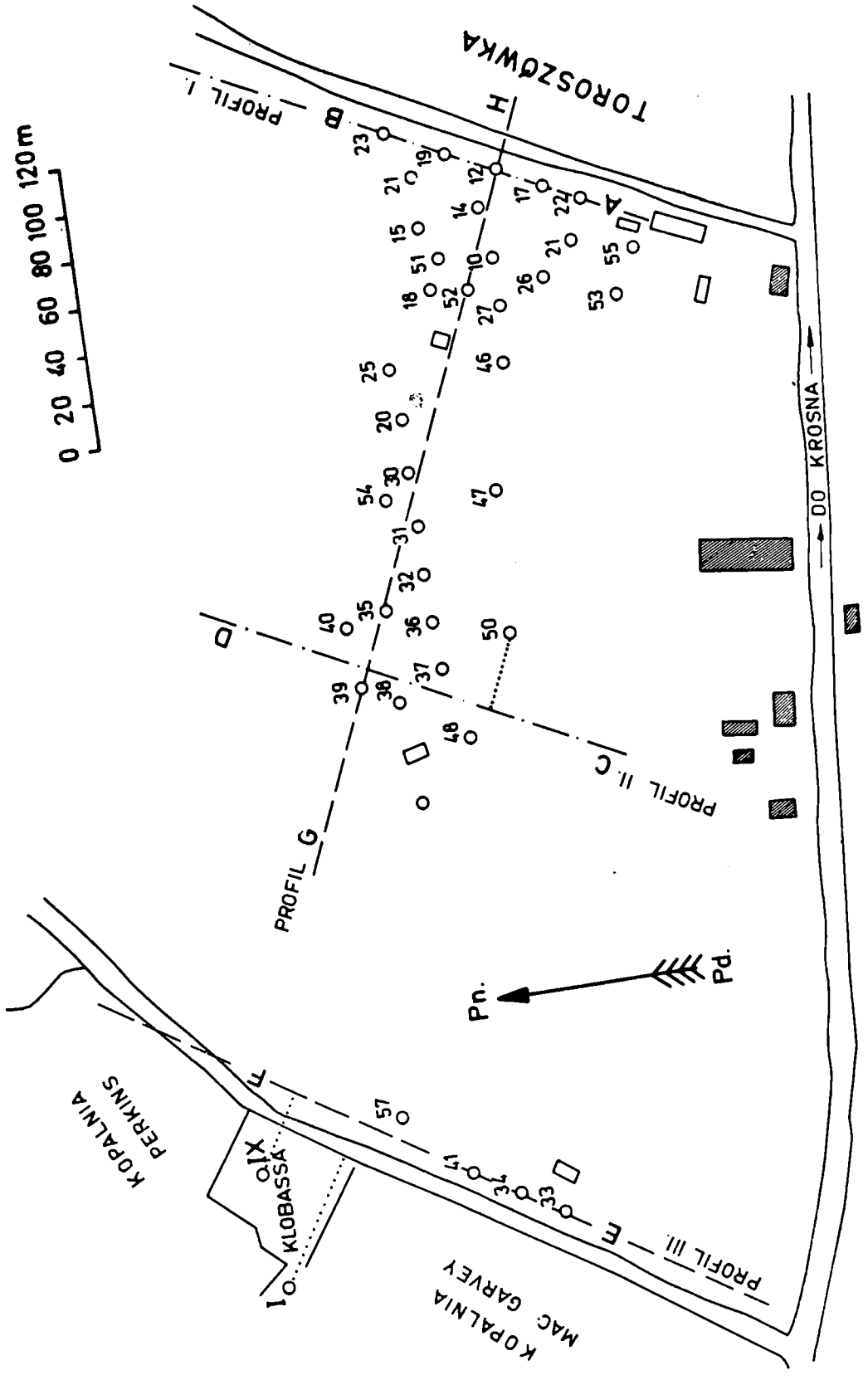

Fig. 1. Plan showing location of wells on the Hannower — Galicia Co. property at Potok. Kopalnia — Mine

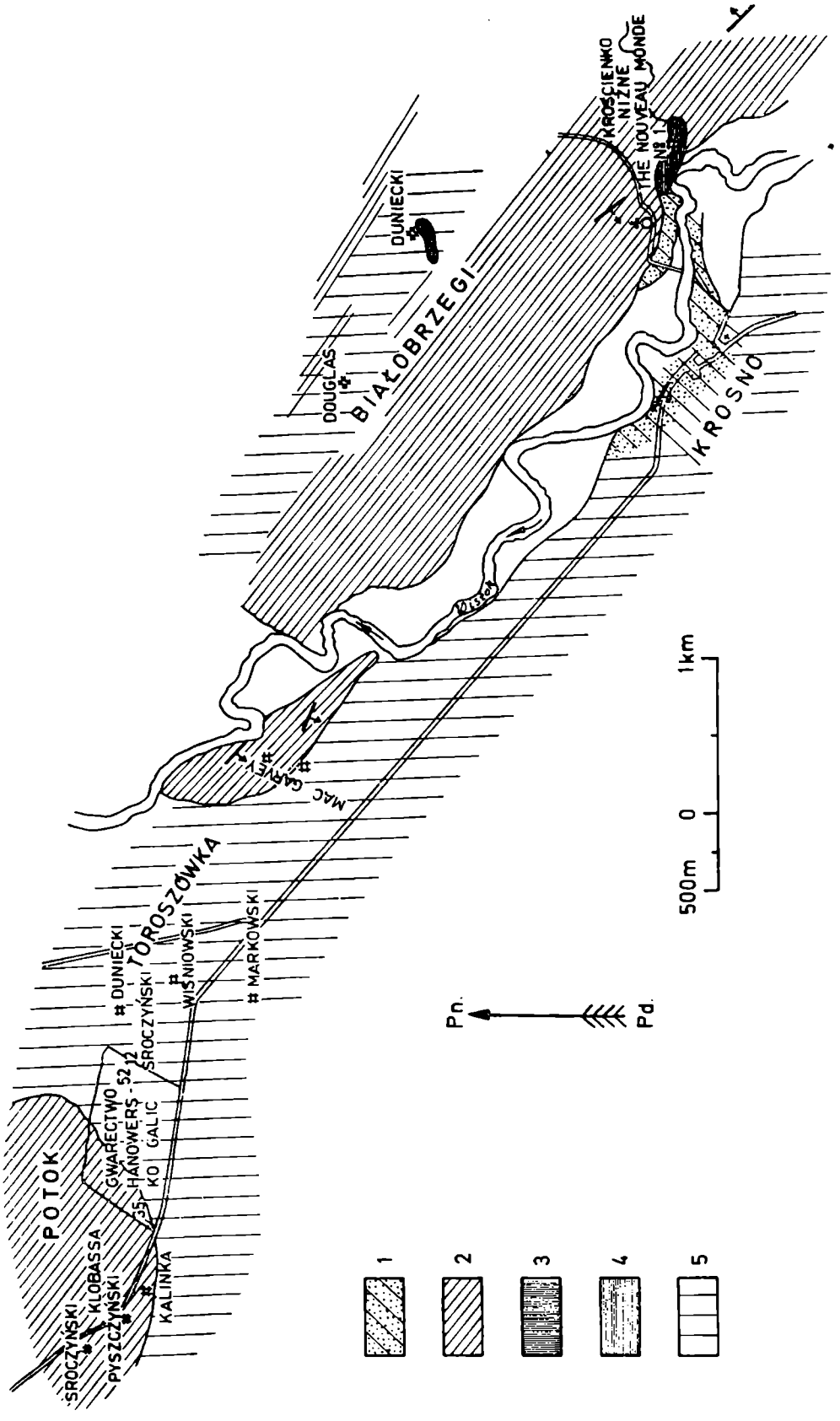

Fig. 2. Geological sketch of the oil-bearing belt Potok — Krościenko. 1 — Krosno Sandstones; 2 — Menilite Shales; 3 — Sub-Menilite Marls; 4 — Red and bluish clays; 5 — Diluvial loams

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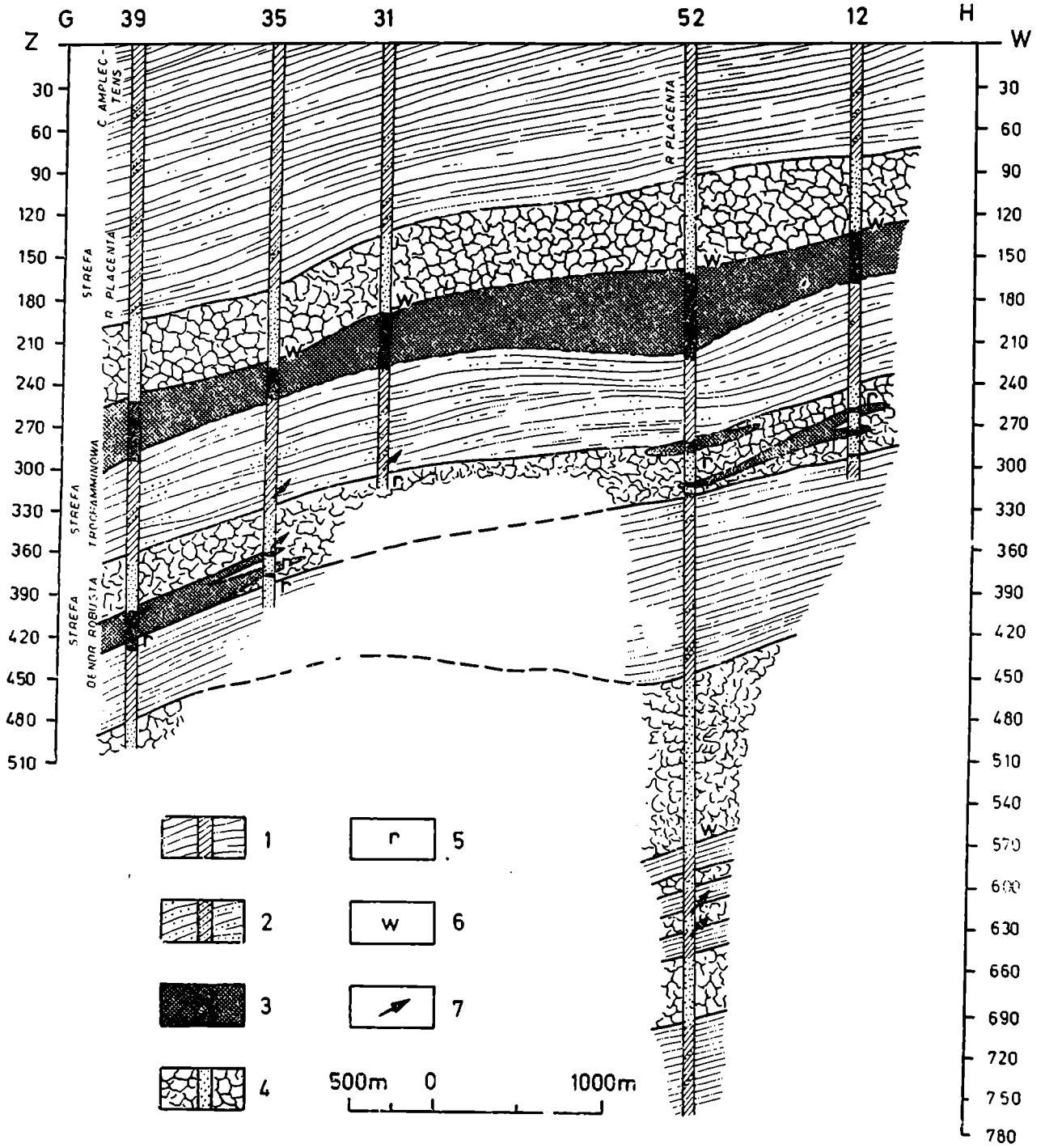

Fig. 3. Section across the Hannower — Galicia Co. property with foraminiferal zones marked. 1 — Grey and bluish shales; 2 — Shales and sandstones; 3 — Red shales; 4 — Sandstones; 5 — oil; 6 — water; 7 — gas; Strefa — Zone

Thus the following sequence of zones can be established:

Horizon I — only calcareous microfauna — (*Nummulites badensis*) — Menilite Shales,

Horizon II — only *Globigerina*,

Horizon III — only arenaceous microfauna zone with *Cyclammina amplectens*

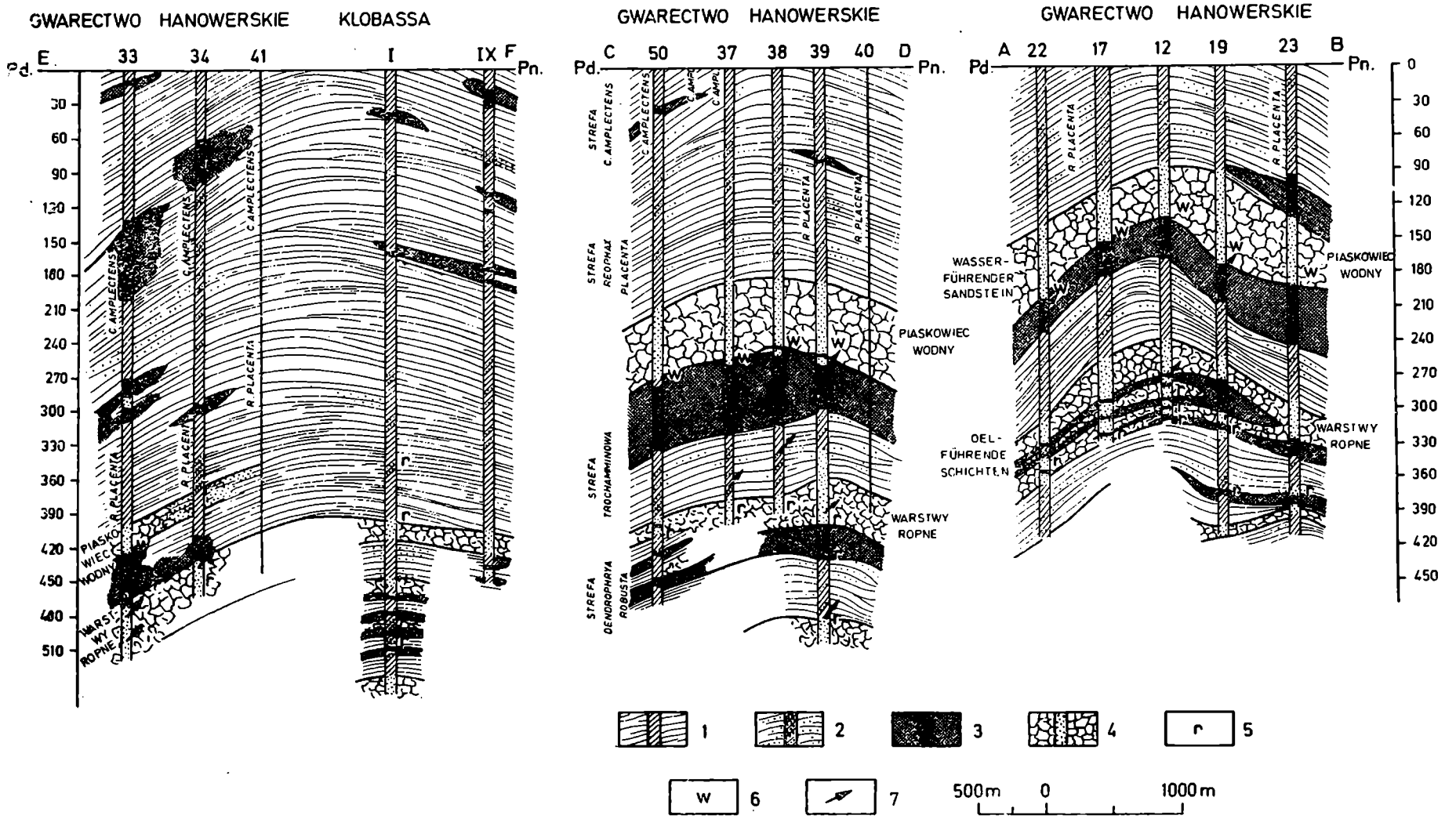

Fig. 4. Section across the Hannower—Galicia Co. property with foraminiferal zones marked. 1 — Grey and bluish shales; 2 — Shales and sandstones; 3 — Red shales; 4 — Sandstones; 5 — oil; 6 — water; 7 — gas; Piaskowiec wodny — Water bearing sandstone; Warstwy ropne — oil-bearing beds; Strefa — Zone

zone with *Reophax placenta*
zone with *Trochammina*
zone with *Dendrophrya robusta*
zone with *Reophax grandis*?

Horizon IV — mixed fauna (*Amphistegina, Nummulites* cf. *Leymeriei*).

The fauna at Krościenko provides proof that this sequence is not restricted to the Potok area, but is of wider lateral extent. The first horizon was found only there, as was the second horizon in a natural outcrop. The zone with *Cyclammina amplectens* of the third horizon is present in the red clays. The zone with *Reophax placenta* was found in Well No. 1 at a depth of 81—110 m. At greater depths, the genus *Ammodiscus* disappears.

Can such faunistic zones provide any information useful in oil exploitation? The answer will be given by an example.

The first water-bearing sandstone, well developed in the eastern part of the oil field and typically present in all wells, wedges out towards the west and is replaced by the so-called „bad rock", a sandstones alternating with shales which make drilling difficult [1]. Similarly, the upper shaly complex shows more numerous and thicker intercalations of red clays. The water-bearing sandstone was not found in the vicinity of the Klobassa lease. The logs here show only red and bluish shales, with thin intercalations of sandstones, occurring down to the oil-bearing horizon. Therefore it is very difficult to draw a general profile and to connect this with profiles of the eastern part of the oil field.

Our cross-section E-F (Fig. 4) across the western part of Hannower--Galicia Co. property and Wells No. 33, No. 34, No. 41, lying on the southern limb of the anticline in its northern part, can be extended to include the Wells No. I and No. IX on the Klobassa lease, although these lie slightly to the West of the section line.

In the profile of Well No. 33, water-bearing sandstone, although not thick, is still marked, while in the profile of Well No. 34, it is absent altogether. Judging from the depth in which this sandstone occurs, it lies in the gently dipping southern limb of the anticline. To connect the profiles of these two wells, usefullness the red clays at the top, it would be necessary to assume a very steep dip in the upper part and a horizontal position of beds in the lower part.

However, if the fauna is considered, the section becomes much more simple. The *Reophax placenta* zone occurs in Well No. 33 at a depth of 355—375 m, in Well No. 34 at 320—375 m. The *Cyclammina amplectens* zone occurs in Well No. 33 at 170—227 m, and in Well No. 34 down to 185 m.

There is no profile of Well No. 41 lying farther North, but the two zones are present there also: the *R. placenta* zone at a depth of 318—320 m, and *C. amplectens* zone at 108—171 m. The farther North one goes, the position of these two zones becomes shallower. Marking them on the section, one obtains a regular structure of the southern limb, corresponding exactly to that in the cross-section C—D (Fig. 4).

Why were oil-bearing strata not reached at Toroszówka?

This question will also be answered on the basis of our studies.

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[1] These details were supplied in personal communications from Mr. Phillip Lewicki and Mr. J. Fabiański.

The *R. placenta* zone lies about 250 m above the oil-bearing horizon on the lease of Hannower-Galicia Co. property and 275 m above the oil-bearing horizon at Krościenko, where Well No. 1 struck oil at a depth of 385 m.

The same zone was reached on the Markowski lease Toroszówka, at 385 m, and at 300 m in Well No. 7 and at 270 m in Well No. 8 on the Mac Garvey lease. Assuming a similar structure for the anticline in that direction, the oil-bearing horizon could be reached on these areas in a greater depth: on the Markowski lease at 625 m, and the MacGarvey lease at 550 m in Well No. 7 and at 520 m in Well No. 8.

Likewise in the Górny Potok, in the Pyszyński and Sroczyński wells, where this zone was reached at a depth of 525 m, the oil-bearing horizon should be expected at a depth of 775 m.

Therefore, our question whether within one oil-field microfaunal investigations can provide detailed information for oil mining can be answered positively. The same horizons and foraminiferal zones will not be encountered in all oil fields. Those described above occur in the Potok — Krościenko field. Others will be probably found elsewhere. Anyhow we have a clear example showing that microfaunistic investigations can provide information on the structure of strata, can supplement, check, and in doubtful cases elucidate the data usually provided by drilling logs, and with more detailed studies will probably give us more detailed information than the logs themselves.

GENERALS REMARKS

The foraminiferal material collected from various oil fields of Galicia is fairly rich, for about 1000 samples were collected from various horizons and wells and investigated during the past three years. However this material is still not adequate to provide definite conclusions regarding the occurrence of oil. The distribution of the samples is not uniform, as they were collected without a systematic plan, or were sent from oil wells.

The conclusion was reached that all wells in Tertiary strata give oil. Since there are no traces of oil in areas where Neocomian rocks occur undoubtedly as proved by fossils, e.g. the Cieszyn beds and the Wernsdorf beds in Silesia and Western Galicia, we are justified in modifying the above conclusion to say that oil in the Carpathians comes from and occurs in Tertiary beds only.

There are higher and lower oil-bearing horizons within these Tertiary beds. Further studies more exact and detailed will show whether it will be possible to distinguish them on a faunal basis.

Another reason for which the fauna of the oil-bearing beds is interesting, is the occurrence of siliceous and arenaceous forms exclusively. None of the known foraminiferal faunas, not only in the Tertiary but also in older formations, have this character. Although the older formations, especially the Palaeozoic ones, contain arenaceous forms more often and more abundantly and this was considered by Neumayr[1] to be a confirmation of his theory that the arenaceous forms are more primitive parent ones, but so far as I know, they are always

[1] Neumayr. Die Stamme des Tierreiches. I Band.

accompanied by calcareous forms. The same is true for the Mesozoic Era. In the Mesozoic and Tertiary rocks, the arenaceous forms are relatively rare, being somewhat more abundant only in the genus *Haplophragmium* and the family *Textulariidae*.

The first fauna with abundant arenaceous and siliceous forms was described by Rzehak from the Moravian Carpathians [1]. This fauna, like that described earlier by Karrer from the Vienna Sandstone, is poor and comprises arenaceous forms and also calcareous ones, showing a composition similar to that of the foraminiferal fauna from the red clays at Wadowice, described by the present writer.

The oil-bearing beds of the Potok and Toroszówka field are at least 500 m thick, and contain a fauna composed exclusively of arenaceous forms. It is impossible to have omitted or overlooked calcareous forms, as more than 200 samples from different points and various depths were examined. About a thousand samples from various oil fields in the Carpathians also contained arenaceous forms only.

This is a newly discovered phenomenon, which cannot be explained on the basis of scientific data derived hitherto. There are no analogous phenomena in palaeontology and also knowledge of the fauna of the Recent seas cannot help elucidate the problem.

We cannot find the answer to this problem in the memoir of Brady: Report of the Foraminifera dredged by H. M. S. Challenger, which will always remain a fundamental study for investigations of Foraminifera. Of the 354 dredgings of Challenger, which retrieved arenaceous forms living on the sea bottom, there were only 8 in which they were more abundant than the calcareous ones, and only two in which the calcareous forms were absent (Stations 120, 153, 195, 218, 238, 244, 246, 253, 265, 323). These stations are neither situated in a particular geographic area nor in a similar bathymetric zone. For example Station 120 lies at a latitude of 7° S near Pernambuco and the depth is 675 fathoms; Station 153 lies at the latitude 67° S near the ice barrier and the depth is 1675 fathoms. For the other Stations listed above, the depth ranged from 1070 to 3950 fathoms and the water temperature at the bottom varied in the range of 0—3°C. Arenaceous foraminifers cannot be considered as typically deep-water forms, since in the same Report, we find 7 other Stations (206, 224, 231, 241, 338) in which only calcareous forms were found at depths ranging from 1850 to 2425 fathoms and water temperature 0.6—2°C. Perhaps the arenaceous foraminifers became adapted to lower temperatures, for they are found in polar seas at smaller depth [2].

Two stations in which only arenaceous foraminifers were found (Stations 238 and 323), have depths of 3950 and 1900 fathoms and temperatures of 1°C and 0°C, respectively. In other stations, the bottom was covered always by *Globigerina* ooze or green or red clay, while in these two stations the bottom sediments consisted of dark or dark-brown clay.

These are the only data which could be used for the explanation of the conditions in which a similar fauna could occur. It is clear that these data are insufficient.

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[1] Verhandl. der geol. Reichsandstalt. 1887, p. 87, 134. 1888 p. 191—2.

[2] Brady, Über einige arktische Tiefseeforaminiferen etc. *Denks. Akad. Wiss. Wien.* Bd. XLIII.

Studies of the microfauna of the Carpathian rocks have shown that other faunas, similar in character to other Tertiary faunas occur also in the Carpathians. The fauna from Wola Łużańska and Folusz is a typical littoral Tertiary fauna. The fauna of the red clays from Wadowice, and the faunas of red clays from Żywiec and Pilzno, the descriptions of which are not yet published, can be regarded as deep-sea faunas. They differ in the abundance of arenaceous Foraminifera from other known Tertiary faunas, but similar faunas are known from the Moravian Carpathians.

The occurrence of this poorly understood fauna in all oil fields, which is a rule as indicated by the investigations carried out hitherto, while other normal faunas occur outside the oil fields, lead to the suggestion that this fauna can be related with the occurrence of oil.

Oil, as an organic produce of past epochs is not an ubiquitous and common phenomenon. In contradiction to the beautiful and convincing theory of E n g l e r, we do not find it in rocks where the abundance of fossils prove a florishing of organic life. Instead, oil is present in beds in which fossils are precious rarities, and only the puzzling hieroglyphs indicate the presence of some mysterious organisms. The conditions in which oil was formed and which provided the material for its formation, are unknown, but certainly they were extraordinary in some respect. It is not impossible that these conditions contributed also to the formation of the fauna which is found in oil-bearing beds.

There are not enough data to judge this hypothesis, as only one field was investigated in some detail. The hypothesis is advanced as a result of investigations carried out hitherto, leaving the finding of proof to future studies.

Before ending these remarks I wish to reply to the criticism of the method of the present study which was expressed in the past. This criticism was directed against Mr. W a l t e r, Mine Counsellor and indirectly concerns the study itself (Vide: Chemiker und Techniker Zeitung 1895 Nr. 21 „Einige Worte über die Petroleum Geologie des Herrn Bergrath H. W a l t e r"). Mr. W a l t e r replied to the criticism concerning him personally, and I wish to restrict my remarks to these points which concerned the study itself or its application.

Since the beginning of the present study Mr. W a l t e r was much interested in its progress and not only did he promote a motion to the Department for Affairs of Galicia for the allocation of a grant for this study, but he was also a devoted collaborator. The material now in the collections of the Department of Geology of the University of Jagellons was collected largely owing to his care and he undertook the tedious task of examining the majority of samples and to separate the Foraminifera. During this work, Mr. W a l t e r was able to make many observations which possibly were even wider than mine, as they comprised also the petrographic character of rocks, while I obtained selected foraminiferal material. Should he utilize these observations for practical purposes, or should he wait until the palaeontological study is finished, as the author of the above paper suggested?

In the mining industry, as in any branch of industry having contact with nature, observations are made and utilized before they are judged by science. Furthermore, they are often utilized in spite of the fact that science is unable to say the last word. This is a natural way, especially

as regards mining and palaeontology, which is still a young science in relation to the branch of industry within which it developed. Miners always had a knowlege of fossils, and certainly used their occurrence for practical purposes, in spite of wholly erroneous ideas on their nature, long before they were introduced into science and investigated. This is quite natural.

The advice given by the critic can be explained, that he did not understand the purpose of the present study. Such an assumption is substantiated by the following quotation from the critical paper:

„Es muss aber zugestanden werden, dass die bisherigen Resultate dieser Untersuchung die Möglichkeit einer sichern Bestimmung der Petroleum Horizonte auch nicht um einen Schritt vorwärts gebracht haben, da es bisher nicht gelungen ist gewisse Petroleum Foraminiferen zu finden, die nicht auch in anderen nichtpetroleumhältigen Horizonte vorkämen".

Anybody who has slight contact with geology and palaeontology knows that there are no such „oil foraminifera", similarly as there are no iron or, copper, coal, or salt fossils. It was not intended in the present study to find such „oil foraminifera". If such an aim would be considered, then it would be proper to call this study „Foraminiferenspielerei" as did the author of the discussed critical note.

The aim of the present study was merely to find a firmer basis for the geology of the Carpathians and the related oil industry than that provided by petrography and stratigraphy alone, and, as better preserved palaeontological material is lacking, to utilize the microfauna of the Carpathian rocks. It cannot be denied that observations based on palaeontological data give a sound guarantee of truth.

Kraków, 23. Jun. 1897