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Quantitative palynological analysis of Julian clastic rocks from the lead-zinc deposit of Mežica

Kvantitativna palinološka analiza julijskih klastičnih kamenin v mežiškem rudišču

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Abstract

The calcareous-dolomitic sequence of the Karnian at Mežica is interbedded with three horizons of clastic rocks. Through the palynological assemblages of the 1st horizon a deltaic environment is reflected; spores of pteridophytes being abundant. An ammonoid biocoenose, reported from this horizon previously, may possibly not be autochthonous. The 2nd horizon is characterized by the spores of mangrove trees. In the 3rd horizon xerophytic elements prevail. By the frequency distribution of spores, pollen, and acritarchs a decreasing deltaic influence and an ever increasing marine influence is indicated from the 1st through the 2nd to the third horizon. By the combination *Camerosporites secatus and Ovalipollis pseudoalatus* the northern belt of the equatorial Karnian palynofloristic domain is recognized.

Kratka vsebina

V zaporedju apneno-dolomitnih plasti karnijske stopnje v Mežici so trije horizonti klastičnih kamenin. Palinološki facies 1. horizonta kaže na okolje rečne delte. Vsebuje veliko spor pteridofitov. Amonoidna biocenoza, o kateri poročajo v literaturi, pa verjetno ni avtohtona. Za drugi horizont so značilne spore vegetacije mangrova. V 3. horizontu prevladujejo kserofitni elementi. Iz pogostnosti spor, peloda in akritarhov izhaja, da je vpliv rečne delte na sedimentacijo postopno ponehaval od prvega prek drugega do tretjega horizonta in da je v tej smeri naraščal vpliv morskega okolja. *Camerosporites secatus* in *Ovalipollis pseudoalatus* pomenita, da je bila v karnijski dobi Mežica del severnega pasu širokega ekvatorialnega palinoflorističnega območja.

Introduction

Mežica lead-zinc mine is situated north of the Periadriatic lineament in the eastern part of the Northern Karawanken Alps (fig. 1). In the Karnian deposits of this region carbonate rocks - limestone and dolomite - prevail. Between the carbonates marles, shales and sandstones are interbedded. These clastic rocks have played an important role in the genesis of ore as well as in tectonic movements. The miners called them "Cardita" and/or "Raibler" beds (A. Zorc, 1955).

There are three horizons of clastic rocks, recently designated as the 1st, 2nd and the 3rd shale. Since the lithology of the 1st, 2nd and the 3rd shale is not uniform it is however incorrect to apply the term "shale". I. Štrucl (1971) mentioned in the "shales" the following types of rocks: shales, marles, marly limestone and sandstone. For this reason in this paper the terms 1st, 2nd, and the 3rd shale are changed into the 1st, 2nd and the 3rd clastic horizon.

Not only in the mining area but also in the Northern Karawanken Alps as a whole, these horizons are playing an important role in the stratigraphical subdivision of Karnian rocks (fig. 2). Because the tectonic setting is rather complicated the stratigraphical and structural position of individual clastic horizons is usually not clear, even when rare micro- or macrofossils occur.

The problem of the stratigraphical and structural position is well marked in exploration boreholes where a small part of rock is examined.

In the Mežica mining area there are still many unsolved geological problems. For example the clastic horizon bordering the lead-zinc deposit Graben to the south has an unknown stratigraphical and tectonic position. The question is whether the ore bearing reef limestone occurs in normal or in inverse position, and whether it is Cordevolian or Julian in age. A reliable answer to this question is important for the mining development in this area.

There are more problems in the southern part of the Northern Karawanken Alps where a lagoonal facies of Longobardian and Karnian age passes laterally into a deeper facies — the Partnach facies. In the absence of realistic criteria it has always been very difficult to correlate chronostratigraphically both facies.

Because of the possibilities of palynology in Triassic stratigraphy, we introduced palynological research as an aid to the solution of geological problems, important for the mining development.

Quantitative palynological analysis

Palynological research of the three clastic horizons in the Mežica mining area includes both qualitative and quantitative analysis. A paper on the qualitative analysis is in preparation.

The quantitative analysis is based on relative frequencies of morphological groups of palynomorphs. This method was introduced by H. Visscher and C. J. van der Zwan (1981). Histograms, corresponding to each of the clastic horizons are presented in fig. 2. The observed range of relative frequencies for each morphological group is shown in fig. 3. Additional statistical analysis is in progress. However, the information so far available about the quantitative distribution of palynomorphs in the three clastic horizons in the Mežica mining area is already a sufficient base for their stratigraphical subdivision on a local scale.

The histograms of fig. 2 represent the most characteristic examples of relative frequencies of morphological groups of palynomorphs found in assemblages from each of the three clastic horizons.

The histograms (N = 5) from the 1st clastic horizon are characterized by the bimodal distribution of morphological groups of palynomorphs. The highest peak is on the side of the typical hygrophytic elements. The small peak is found on the side of xerophytic elements.

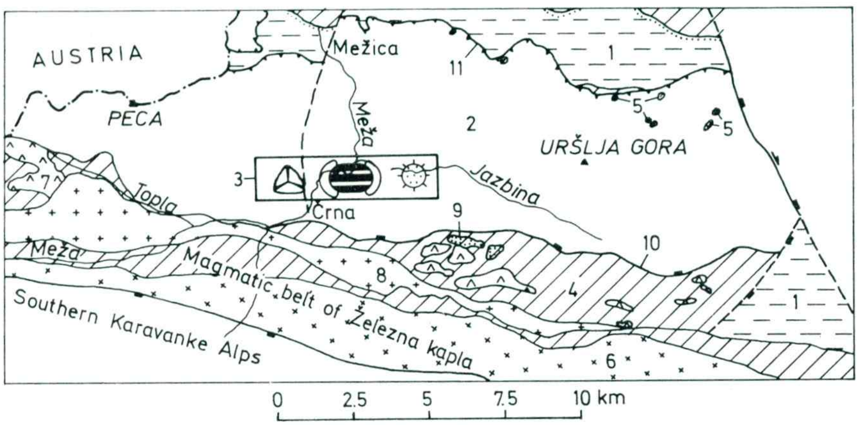


Fig. 1. Geology (after I. Štrucl, 1970) and location of the palynological samples examined in the Mežica mine

Sl. 1. Geologija (po I. Štruclu, 1970) in lokacija palinoloških vzorcev v mežiškem rudniku

1 Upper Miocene beds
Zgornjemiocenske plasti

2 Mezozoic beds
Mezozojske plasti

3 Palynologically examined area
Palinološko raziskano področje

4 Paleozoic mica schist, phyllite and greenschist
Paleozojski sljudni skrilavec, filit in zeleni skrilavec

5 Porphyritic dacite
Porfiritni dacit

6 Tonalite
Tonalit

7 Diabase
Diabaz

8 Granodiorite
Granodiorit

9 Erosional unconformity
Erozijska diskordanca

10 Fault with downthrown side
Prelom z ugreznjenim krilom

11 Overthrust
Nariv

A Monolete acavate spores
Monoletne akavatne spore

B Trilete acavate laevigate or apiculate spores
Triletne akavatne levigatne in apikulatne spore

C Trilete acavate murornate spores
Triletne akavatne murornatne spore

D Trilete cingulate and zonotrilete spores
Triletne cingulatne in conotriletne spore

E Aratrisporites group
Skupina Aratrisporites

F Porcellispora complex
Porcellispora kompleks

G Monosulcate pollen grains
Monosulkatni pelod

H Ovalipollis complex
Ovalipollis kompleks

I Alete (proto) bisaccate pollen grains
Aletni (proto) bisakatni pelod

J Samaropollenites

K Taeniate (proto) bisaccate pollen grains
Teniatni (proto) bisakatni pelod

L Triadispora complex
Triadispora kompleks

M Vesicate pollen grains
Vezikatni pelod

N (Proto) monosaccate pollen grains
(Proto) monosakatni pelod

O Circumpollis group
Circumpollis skupina

U Leiosphaeridia

V Micrhystridium

Z Dictyotidium

Y Veryhachium

U V Z Y Microphytoplankton — Acritarchs
Mikrofitoplankton — akritarhi

Hygrophile elements
Higrofilni elementi

A B C D E F G | H I J | K L M N O

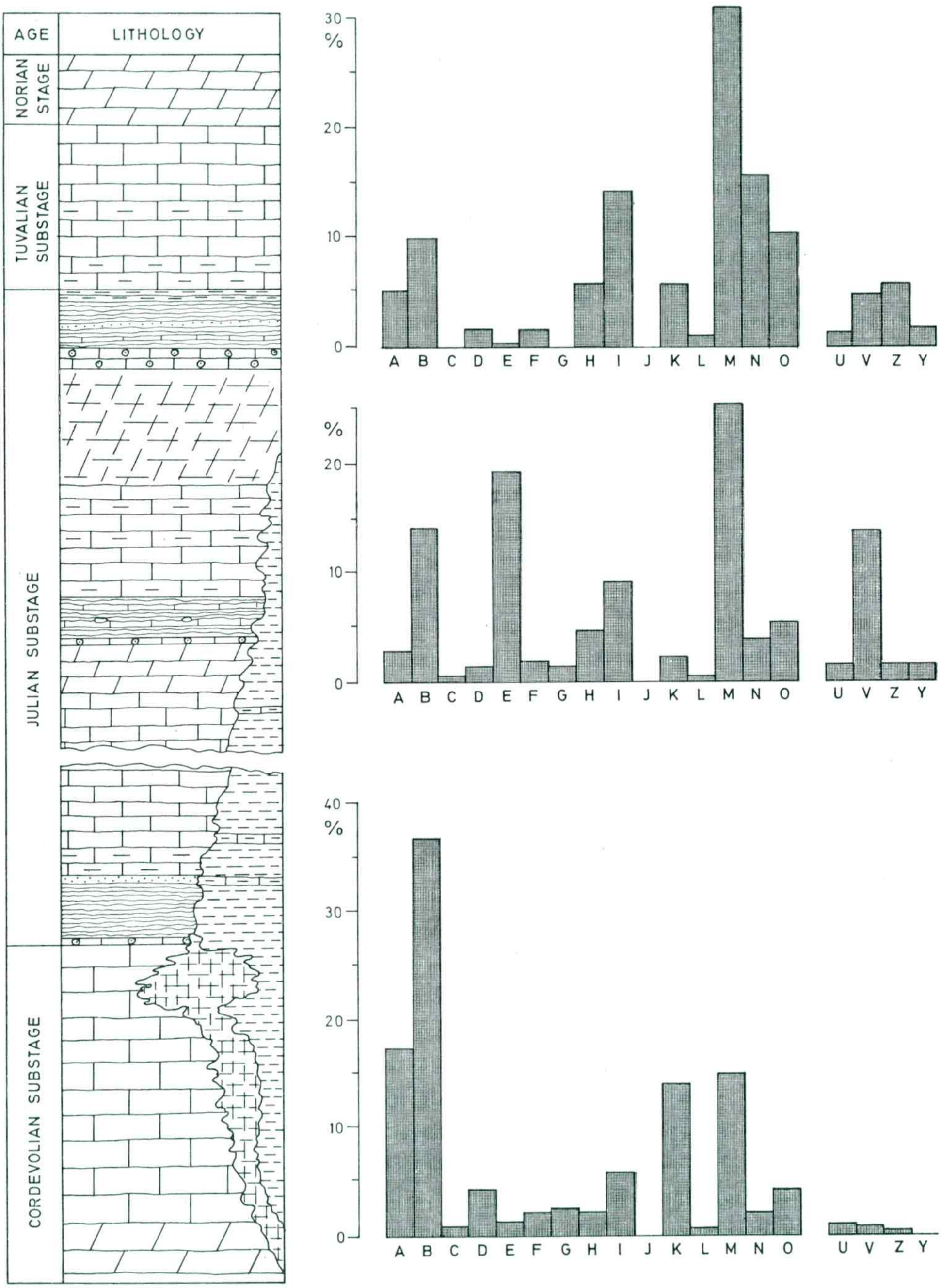
Xerophile elements
Kserofilni elementi

Fig. 2. Relative frequency distribution of the morphological groups of palynomorphs from three clastic horizons in the Mežica ore deposit (Code of the samples examined: M—7/+549, II/1 and III/1).

Method introduced by H. Visscher and C. I. van der Zvann (1981) Columnar section after J. Kušej

Sl. 2. Porazdelitev relativnih frekvenc morfoloških skupin palinomorf iz treh klastičnih horizontov mežiškega rudišča (Oznake vzorcev: M—7/+549, II/1 in III/1).

Metoda po H. Visscherju in C. I. van der Zwannu (1981). Stratigrafsko zaporedje po J. Kušeju


AGE
LITHOLOGY
NORIAN STAGE
TUVALIAN SUBSTAGE
JULIAN SUBSTAGE
CORDEVOLIAN SUBSTAGE
%
0
10
20
30
40
A B C D E F G H I J K L M N O
U V Z Y

The histograms (N = 3) from the 2nd clastic horizon are characterized by a third peak represented by the morphological group E (*Aratrisporites*). The prominence of the first and the second peaks varies considerably within individual assemblages. The peak of morphological group E is always very high.

The histograms (N = 3) from the 3rd clastic horizon are characterized by the absence of a peak on the side of the typical hygrophytic elements. The increase of the relative and the absolute frequency of the microphytoplankton is a new characteristic of this horizon.

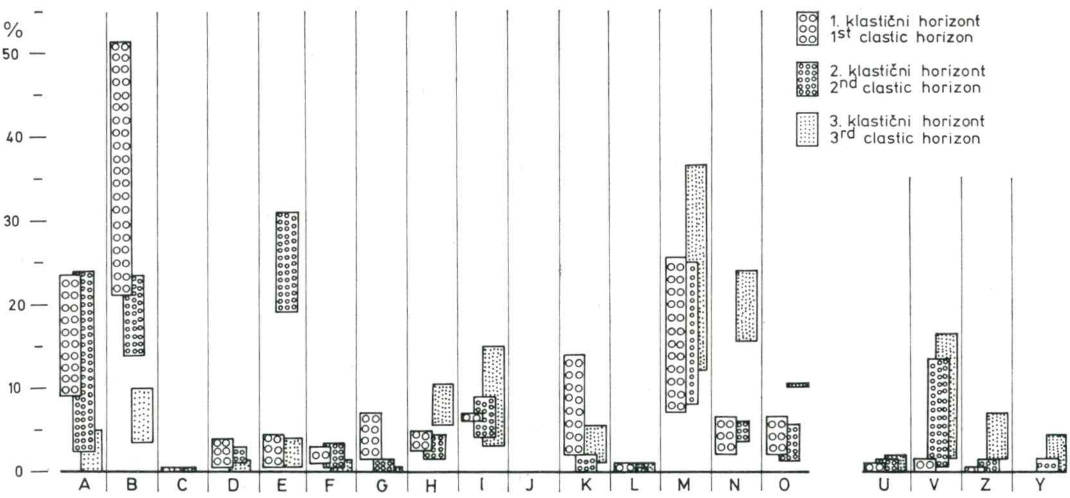


Fig. 3. Range of variation of the relative frequency for morphological groups of palynomorphs from the clastic horizons at Mežica

Sl. 3. Variacijske širine relativne frekvence morfoloških skupin palinomorf iz klastičnih horizontov v Mežici

From the quantitative analysis we may conclude that the morphological groups of palynomorphs A, B, E, G, M, N, O, V, Z have a constant distributional trend from the 1st through the 2nd to the 3rd clastic horizon (fig. 3). The clearness of this trend is obscured by the range of variation of the relative frequency for morphological groups from the 2nd clastic horizon (for example morphological group A) as well as by the range of variation of relative frequency of morphological group in samples taken just under the top of the 1st clastic horizon (for example maximum values of the relative frequency of groups M, N, and O). We believe that this irregularity could well be caused by the unstable-transitional-conditions in the time between deposition of the 1st and the 3rd clastic horizon.

The relative frequency of morphological groups A, B, and G is decreasing from the 1st to the 3rd clastic horizon. On the other hand the relative frequency of groups M, N, O, V, Z is increasing in the same direction. Stratigraphical discrimination between the 1st and the 3rd clastic horizon is possible on the base of the relative frequencies of morphologicah groups A, B, N, O, and Z. Additionaly we can use the maximum values of the relative frequency of groups G, M, V. The 2nd clastic horizon is discriminated from the 1st and the 3rd horizon by the value of the relative frequency of the morphological group E.

Distributional trends of spores, pollen grains and acritarchs from the 1st through the 2nd to the 3rd clastic horizon is shown on a diagram of mean values of relative frequencies (fig. 4). The prevailing hygrophytic elements in the 1st clastic horizon reflect the existence of a fluviatile-deltaic environment and we can speculate about a strong influence of this environment on the sedimentation of the 1st clastic horizon. Among the hygrophytic elements spores of pteridophytes, typical for the coal facies of the Alpine Lunz beds and the Germanic "Schilfsandstein" are dominant. The Lunz beds and the "Schilfsandstein" represent a fluviatile-deltaic coal-bearing facies within an arid climatic

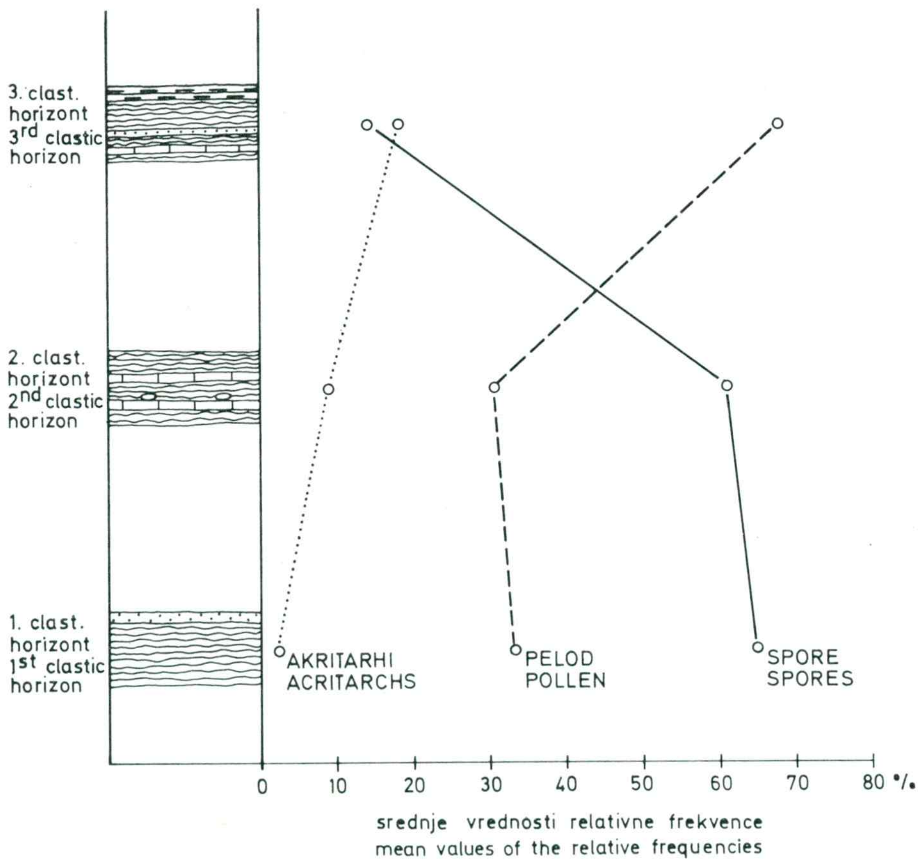


Fig. 4. Distribution trend of spores, pollen and acritarchs in the direction from the 1st towards the 3rd clastic horizon interbedded in the limestone and dolomite succession at Mežica

Sl. 4. Tendenca v porazdelitvi spor, peloda in akritarhov od 1. proti 3. klastičnemu horizontu v Mežici belt (H. Visscher & C. J. van der Zwar, 1981, 632). A regional arid background is evident by the small peak on the side of xerophytic elements. The relative frequency of hygrophytic and xerophytic elements in the 2nd clastic horizon varies considerably. From the information on fig. 3 one may deduce interruptions in the regime of fluviatile-deltaic environment. The peak of the xerophytic elements is sometimes rather prominent. The absolute frequency of xerophytic elements is also increasing. The peak of the *Aratrisporites* group suggests optimal conditions for the flourishing of lycopodiophytic mangrove vegetations, a new environment during the time of sedimentation of the 2nd clastic horizon.

The hygrophytic elements strongly decrease in the 3rd clastic horizon. Here we can always find a large peak on the side of the xerophytic elements. The elements of an upland flora and the flora of salt swamps of undoubted or presumed coniferalean affinity prevail. Our conclusion is that the fluviatile--deltaic regime had disappeared.

Relative and absolute frequencies of acritarchs are increasing from the 1st through the 2nd to the 3rd clastic horizon (figs. 3, 4). The formgenera *Leiosphaeridia* and *Micrhystridium* are supposed to have lived in more agitated water near the coastline (I. K. Lentin & G. L. Williams, 1980, 13; F. L. Staplin, 1961, 397). The first-mentioned authors also suggest that *Leiosphaeridia* and *Micrhystridium* characterize the beginning and the end of transgressions, the formgenus *Veryhachium* is not present in the 1st clastic horizon. According to A. Horowitz (1975, 75) this formgenus inhabited a more open, shallow and quiet marine environment. Some palynologists (W. A. Brugman) state that the formgenus *Dictyotidium* had the same ecological preference as *Veryhachium*. According to the distribution of spores, pollen grains and acritarchs in the 1st, 2nd and the 3rd clastic horizon it is supposed that the marine influence during the time of sedimentation of the 1st clastic horizon was subordinate. The marine influence was increasing in the 2nd clastic horizon, and completely prevails in the 3rd clastic horizon.

We expect that the research of oxygen and carbon isotope composition of the rock and the macrofauna from the three clastic horizons will confirm the picture as based on the distribution of spores, pollen grains and acritarchs.

From the 1st clastic horizon ammonoids are known (A. Ramovš, 1974, 128; B. Jurkovšek, 1978). Not only the present palynological but also sedimentological investigations (M. Pungartnik et all., in preparation) question the autochthonous nature of this ammonoid biocoenose.

Palynological assemblages of the three clastic horizons belong to the northern palynofloras of the wide equatorial palynofloristic domain. These assemblages are characterized by the *Camerosporites secatus-Ovalipollis pseudoalatus* association (H. Visscher & C. J. van der Zwan, 1980, 629).

Conclusions

(1) We can use the distribution of relative frequencies of morphological groups of palynomorphs for the palynostratigraphical discrimination of the three clastic horizons on a local scale. (2) The possibility of a palynostratigraphical discrimination may be practically applied with regard to the solution of stra-

tigraphical and tectonic problems related to mining geology. (3) Hygrophytic elements from the 1st clastic horizon, among which the spores of pteridophytes typical for the coal bearing facies of the Lunz beds and the "Schilfsandstein" prevail, reflect a fluviatile-deltaic environment. (4) By the frequency distribution of spores, pollen grains, and acritarchs an decreasing deltaic influence and an ever increasing marine influence is indicated from the 1st trough the 2nd to the 3rd horizon. (5) A new environment is reflected in the 2nd clastic horizon by the flourishing of a mangrove vegetation. (6) The influence of the fluviatile-deltaic regime disappears at the end of the 3rd clastic horizon. (7) At the time of deposition of the 3rd horizon prevail the xerophytic elements of an upland flora and the flora of salt swamps with an undoubted or presumed coniferalean affinity. (8) There is a question, whether the ammonoids from the 1st clastic horizon represent an autochthonous biocoenose. (9) Palynological assemblages belong to the northern palynofloras of the equatorial domain of Ladinian-Karnian times.

Acknowledgments

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Kvantitativna palinološka analiza julijskih klastičnih kamenin v mežiškem rudišču

Povzetek

V mežiškem rudišču se večkrat srečujemo s problemom določitve prave geološke lege določenih plasti. Kot primer naj navedemo problematiko v zvezi z nezanesljivo stratigrafsko uvrstitvijo klastičnega pasu, ki omejuje rudišče Graben proti jugu. Še vedno je sporno, ali gre v tem rudišču za normalno lego rudonosnega grebenskega apnenca pod klastičnim horizontom, ali za inverzno. Možnih je več interpretacij, ni pa potrebno posebej poudarjati, kako pomembna je za nadaljnje raziskave stratigrafska uvrstitev rudonosnega grebenskega apnenca.

Še več problemov se pojavlja v južnih delih severnih Karavank, kjer lagunske karbonatne sedimentne kamenine langobardske in cordevolske podstopnje zamenjujejo globokomorski sedimenti partnaškega faciesa. Kjer so te sedimentne kamenine v stiku z julijskimi plastmi, je njihova stratigrafska razmejitev problematična.

Da bi prispevali k reševanju geološke problematike, smo se lotili kvantitativne palinološke analize klastičnih horizontov v krovnini rudonosnega apnenca mežiškega rudišča. Pripravlja pa se tudi kvalitativna analiza inventarja (B. Jelen & J. Kušej neobjavljeno poročilo).

Uporabljena kvantitativna metoda temelji na določevanju relativnih frekvenc morfoloških skupin palinomorf. Metodo sta uvedla H. Visscher in

C. J. van der Zwan. Ustrezni histogram je za vsak klastični horizont prikazan na sl. 2. Variacijska širina vrednosti relativne frekvence posameznih morfoloških skupin palinomorf pa je dana na sl. 3. Statistična analiza je še v delu. Toda že sedanja stopnja poznavanja kvantitativne porazdelitve palinomorf v treh horizontih klastičnih kamenin mežiškega rudišča je omogočila njihovo razlikovanje na lokalnem nivoju tudi v primerih, ko njihov stratigrafski položaj ni bil določen.

Na sl. 2 vidimo histograme, ki kažejo značilno porazdelitev morfoloških skupin palinomorf v klastičnih horizontih julijske podstopnje na območju mežiškega rudišča.

Za histograme 1. klastičnega horizonta (N = 5) sta značilna dva viška; prvi, večji, na strani tipičnih higrofitnih elementov in drugi, manjši, na strani tipičnih kserofitnih elementov.

V histogramih 2. klastičnega horizonta (N = 3) se pojavi še tretji višek. Velikosti prvega in drugega viška sta lahko zelo različni. Tretji, ki ga da morfološka skupina E, je vedno visok.

Za histograme 3. klastičnega horizonta (N = 3) je značilno, da nimajo več viška tipičnih higrofitnih elementov. Dvig relativne frekvence mikrofitoplanktona je naslednja značilnost 3. klastičnega horizonta.

Kvantitativna analiza je pokazala, da imajo morfološke skupine palinomorf A, B, E, G, M, N, O, V, Z stalno porazdelitveno tendenco, ki je vidna iz zbirnega diagrama variacijskih širin na sl. 3. Razločnost porazdelitvene tendence v smeri od 1. proti 3. klastičnemu horizontu motijo variacijske širine relativne frekvence morfoloških skupin v 2. klastičnem horizontu (npr. morfološka skupina A 2. klastičnega horizonta) in relativne frekvence morfoloških skupin tik pod krovnino 1. klastičnega horizonta (npr. maksimalne vrednosti morfoloških skupin M, N, O). Motnje so verjetno posledica nestabilnih — prehodnih — razmer v dobi med 1. in 3. klastičnim horizontom. Za morfološke skupine A, B, G je značilno upadanje relativne frekvence od 1. proti 3. klastičnemu horizontu, medtem ko relativna frekvenca morfoloških skupin M, N, O, V, Z v isti smeri narašča.

1. in 3. klastični horizont se ločita med seboj po relativnih frekvencah morfoloških skupin A, B, N, O in Z. Dodatno so uporabne tudi visoke vrednosti relativnih frekvenc G, M in V. Drugi klastični horizont se loči od prvega in tretjega po vrednosti relativne frekvence morfološke skupine E.

Porazdelitveno težnjo spor, peloda in akritarhov od 1. proti 3. klastičnemu horizontu kaže diagram srednjih vrednosti njihove relativne frekvence na sl. 4.

V prevladovanju higrofitnih elementov v 1. klastičnem horizontu se odraža močan vpliv fluviatilno-deltnega okolja na sedimentacijo. Med elementi prevladujejo spore pteridofitov, tipične za premogov facies, npr. za lunškega ali schilfsandsteinskega, ki sta fluviatilna faciesa aridnega klimatskega pasu (H. Visscher & C. J. van der Zwan, 1981, 632). V manjšem višku na strani kserofitnih elementov in v njihovi majhni absolutni frekvenci se odraža vpliv aridnega zaledja.

Vrednosti relativne frekvence higrofitnih in kserofitnih elementov v drugem horizontu so zelo različne. Slika 3 kaže, da je v času njegove sedimentacije ponehaval vpliv fluviatilno-deltnega okolja. Zato se višek na strani kserofitnih elementov poveča, na levi pa zmanjša. Poveča se tudi absolutna frekvenca kserofitnih elementov. Veliki višek skupine *Aratrisporites,* tj. spor likopodofitov, tvorcev vegetacije mangrova, kaže na optimalno okolje za njihov razcvet, torej na novo okolje.

Higrofitni elementi so popolnoma nazadovali v času sedimentacije 3. klastičnega horizonta. Veliki višek se preseli na stran kserofitnih elementov. Prevladujejo elementi kopenske flore in flore slanih močvirij, ki bi mogli pripadati iglavcem. Vpliv fluviatilno-deltnega okolja na sedimentacijo je prenehal.

Relativna in absolutna frekvenca akritarhov naraščata od prvega proti tretjemu horizontu (sl. 3 in 4). Oblikovna rodova *Leiosphaeridia* in *Micrhystridium* sta značilna za energijsko razgibani priobalni pas in naj bi označevala začetek in konec transgresije (J. K. Lentin & G. L. Williams, 1980, 13; F. L. Staplin, 1961, 397). Oblikovni rod *Veryhachium* v 1. horizontu ne nastopa. *Veryhachium* je značilen za bolj odprto plitvo mirno morsko okolje (A. Horowitz, 1975, 75). Nekateri raziskovalci so mišljenja, da je imel oblikovni rod *Dictyotidium* podobno ekološko preferenco (W. A. Brugman, v razgovoru). Na podlagi porazdelitve spor, peloda in akritarhov predpostavljamo, da je bil morski vpliv v času sedimentacije prvega klastičnega horizonta neznaten. Porastel je v drugem in je bil najmočnejši v tretjem horizontu.

V 1. klastičnem horizontu so našli amonite (A. Ramovš, 1974, 128; B. Jurkovšek, 1978). Vendar palinološko-facialne in sedimentološke (Pungartnik et all., v pripravi za tisk) raziskave nasprotujejo možnosti obstoja avtohtone amonitne biocenoze v 1. klastičnem horizontu.

Združba peloda v julijskih klastičnih horizontih mežiškega rudišča pripada severnemu pasu širokega ekvatorialnega palinofloristčnega področja karnijske dobe, ki ga karakterizira palinoflora *Camerosporites secatus-Ovalipollis pseudoalatus.* Na jugu meji na osrednji pas mešane palinoflore z elementi severnega in južnega ekvatorialnega pasu *Camerosporites secatus-Ovalipollis pseudoalatus-Samaropollenites speciosus,* ki se razteza čez južno in zahodno obrobje Paleotetide (H. Visscher & C. J. van der Zwan, 1981, 629).

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Plate 1 — Tabla 1

1. Leschikisporis aduncus (morph. gr. A) × 600
2. Aulisporites astigmosus (morph. gr. B) × 600
3. Rogalskaisporites cicatricosus (morph. gr. C) × 900
4. Camerozonosporites rudis (morph. gr. D) × 600
5. Aratrisporites sp. (morph. gr. E) × 600
6. Porcellispora sp. (morph. gr. F) × 600
7. Cycadopites sp. (morph. gr. G) × 900
8. Ovalipollis pseudoalatus (morph. gr. H) × 600

morph. gr. = morphological group — morfološka skupina

Plate 1 — Tabla 1

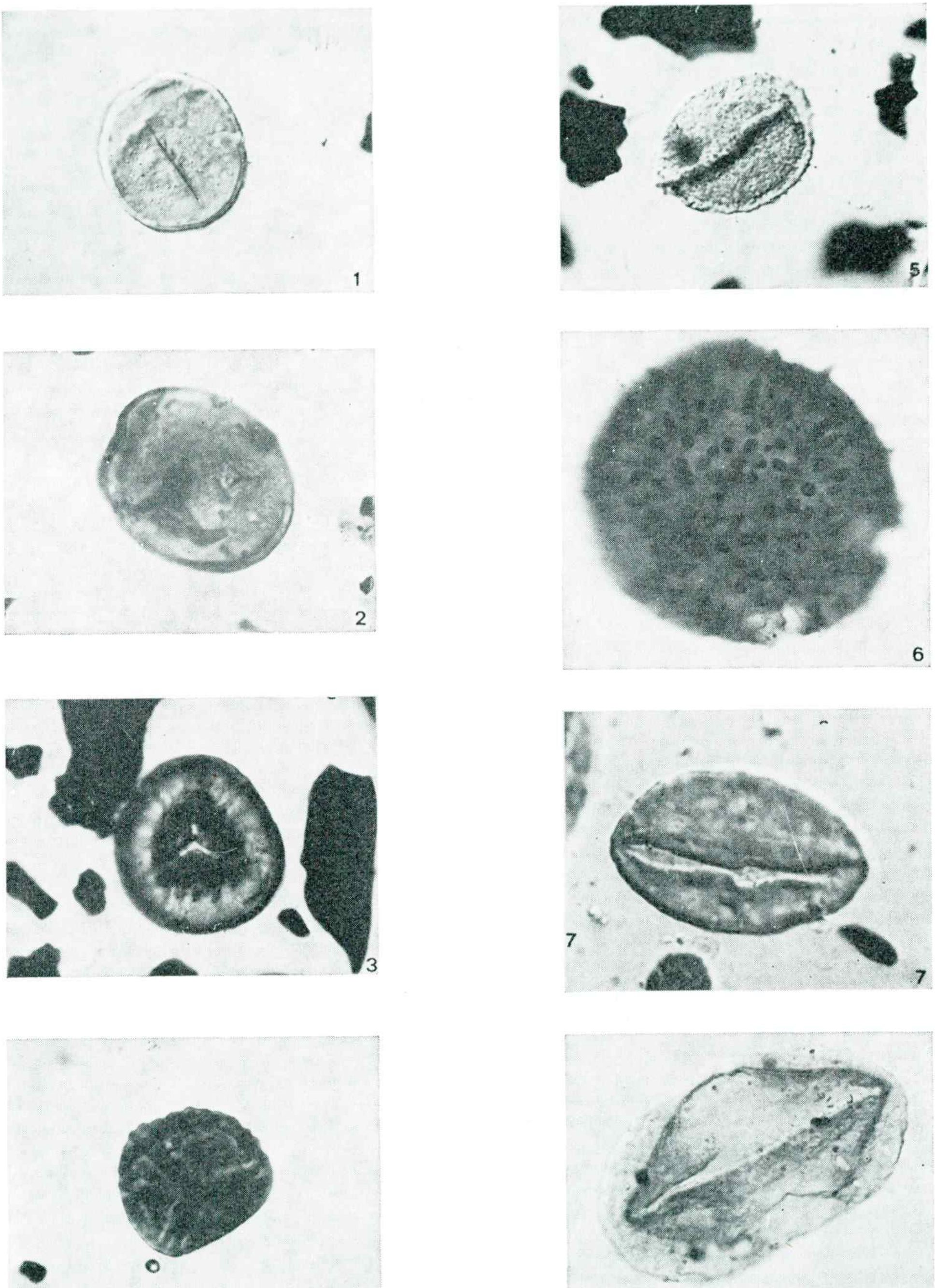

Plate 2 — Tabla 2

1 Alete (proto) bisaccate pollen grain (morph. gr. I) × 600
Aletni (proto) bisakatni pelod
2 Lunatisporites acutus/noviaulensis (morph. gr. K) × 600
3 Enzonalasporites vigens (morph. gr. M) × 600
4 Patinasporites densus (morph. gr. N) × 600
5 Paracirculina maljawkinae (morph. gr. O) × 600
6 Leiosphaeridia sp. (morph. gr. U) × 600
7 Micrhystridium sp. (morph. gr. V) × 600
8 Veryhachium sp. (morph. gr. Y) × 900
9 Dictyotidium tenuiornatum (morph. gr. Z) × 600

morph. gr. = morphological group — morfološka skupina

Plate 2 — Tabla 2