

## A Palynological Study of the Subdivision of the Cardita Shales (Upper Triassic) of Bleiberg, Austria

### Palynologische Studie zur Gliederung der Cardita-Schiefer (Obertrias) von Bleiberg, Österreich

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Whit 3 Figures

#### Zusammenfassung

Drei Carditaschiefer-Horizonte aus dem Bergbau Bleiberg (Kärnten, Österreich) wurden sporenstratigraphisch untersucht, um die Möglichkeit einer Feingliederung der karnischen Stufe der alpinen Trias mittels Mikrosporen zu prüfen.

Insgesamt wurden 14 Proben aus den drei Cardita-Schiefen analysiert, wobei 52 Sporengattungen mit 82 Arten gefunden wurden. Bestimmte Sporengesellschaften gestatteten eine Unterscheidung der drei Schieferhorizonte. Wechselnde Prozentsätze einiger Gattungen und das begrenzte Vorkommen einiger weniger häufiger Sporenformen wurden als Grundlage zur Identifizierung der Schiefer herangezogen. Folgende Sporengattungen und Arten scheinen für die Feinstratigraphie von Bedeutung zu sein:

#### 1. Schiefer:

*Taeniaesporites krauseli* LESCHIK (h)  
*Araucariacites*  
*Aratrisporites* (ss)  
*Decussatisporites*  
*Parvisaccites* spp.  
*Monosulcites* cf. *minimus* COOKSON  
*Leschikisporis aduncus* (LESCHIK)

#### 2. Schiefer:

*Aratrisporites* (h)  
*Araucariacites*  
*Taeniaesporites krauseli* LESCHIK (ss)  
*Cycadopites*  
*Rimaesporites*  
*Zebrasporites Kahleri* KLAUS  
*Cycadopites* aff. *Marsupipollenites*

#### 3. Schiefer:

*Araucariacites*  
*Taeniaesporites krauseli* LESCHIK  
*Aratrisporites*  
*Klausipollenites* (h)  
*Cycadopites* aff. *Marsupipollenites*

\*) Final report of eight months palynological training program submitted to the UNESCO-Post Graduate Training Center for Geology, Vienna/Austria, by Dr. E. KAVARY, Geologist, National Iranian Oil Company, Tehran, Iran.

## Abstract

Fossil spores and pollen of the Cardita shales from the Bleiberg area have been analysed for establishing further stratigraphical subdivisions of the Upper Triassic rocks. Counting analysis of 52 genera and 82 related species from 14 available samples proved that each individual shale unit of the section could be recognized by some of their important spore population assemblages. The changes in percentage of a few genera and a restricted occurrence of several other groups of pollen and spores were only used as the key indices in recognizing the different shale units. Important genera and species that were found to be good stratigraphical indicators were: *Aratrisporites*, *Araucariacites*, *Taeniaesporites krauseli*, *Klausipollenites*, *Parvisaccites*, *Rimaesporites*, *Decussatisporites*, *Cycadopites*, *Monosulcites cf. minimus*, *Leschikisporis aduncus* and *Zebrasporites Kahleri*.

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This work in general was carried out at the Palynological Laboratory of the Geological Survey of Austria under personal guidance of Doz. Dr. W. KLAUS. The author takes this opportunity to place on record his sincere gratitude for introducing him to the field of Palynology and to select such an interesting topic as Triassic Palynology, for the preparation of a final study. The advices in respect of spore identification, preparation methods, nomenclature, stratigraphy, the valuable discussions on taxonomy and on the preliminary results contributed much to the successful completion of this work. The demonstrations on spore microphotography and counting analysis contributed in no less measure.

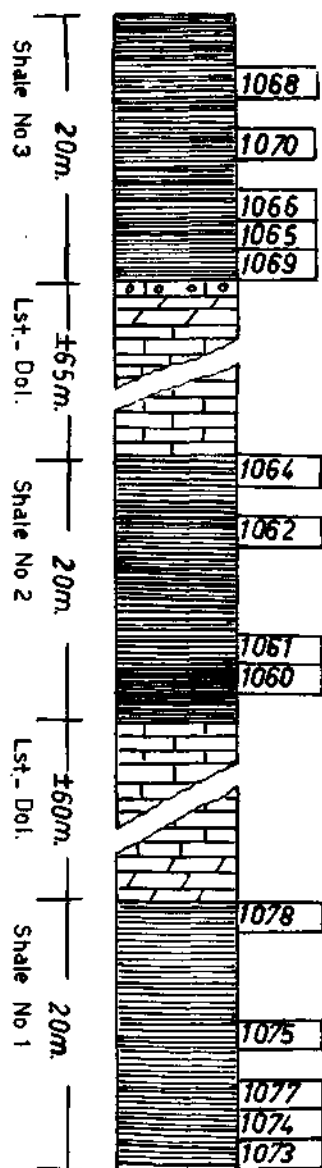
The author is much obliged to the National Iranian Oil Company for having accorded permission to participate in the first program of the UNESCO-Post Graduate Training Center for Geology at Vienna.

## Introduction

This work is a part of Dr. KLAUS' research program on the subdivision of the Upper Triassic of the East Alps. Upon the earlier results (KLAUS 1959, 1960) it appeared to be successful to follow spore investigations on a regional basis. KLAUS concluded on the basis of a statistical analysis of three Cardita shales (Lower part of Upper Triassic) from Mezica (Yugoslavia near the Austrian border) that identification of each shale could be possible in this area.

It was one of the main subjects of this report to examine if the same possibilities could also be found in a similar stratigraphic horizon at a distance of approx. 100 km. in the western direction.

The work involves the palynological investigations of 14 samples from the "Antonio-Middle Shaft" (Cardita shales of the Bleiberg area) (Lat. 46° 37'; Long. 31° 19'). This section is about 16 km. west of the town of Villach, Carinthia, Southern Austria. The samples were received by the courtesy of



GENERALIZED LITHOLOGY INDICATING THE  
LOCATION OF SAMPLES

*Text Fig.1*

Text Fig. 1.

Dr. L. KOSTELKA, Chief Geologist of Bleiberg Bergwerks-Union (Mining-Union), Austria, and have been made available to the author by the Palynological Laboratory of the Geol. Survey of Austria, Vienna.

The examined samples are from three different shale units (Cardita shales, Carnian stage \*). They are separated from each other by 60—65 m. of limestones, dolomitic at places, especially between the first and the second shale units (Text Fig. 1). The lower most unit consists of black to dark grey hard compacted shaly material with a trace of carbonaceous matrix, in a few samples. The middle unit (Shale No. 2) consists of stratified black calcareous material and is softer and more laminated towards the upper reaches. The upper most unit (Shale No. 3) consists of slightly dark grey shaly material. It is darker and denser at the base, but more carbonaceous and lighter in colour at the top.

All treated samples were productive and yielded a good number of spores and pollen. Concentration and/or preservation of the microflora differed from sample to sample, but in most cases the middle unit shale samples had a greater recovery. They contained more desirable assemblages.

The objectives of this study were to record the stratigraphical markers of each shale unit and to establish a possible palynological basis for reliable correlation of the different shale units within the lead mining district of the Bleiberg area. With these purposes in view, the author undertook the statistical population analysis of the microflora of the three different lithological units of the Cardita shale assemblages.

#### Previous Investigations of Upper Triassic Sediments in Alpine-Regions

The first note on the microflora of the Carnian stage of Austria was recorded by KLAUS in 1959. In 1960, he also published a comprehensive report on the spores and pollen of the same age. In this critical report he cleared the confusion then existing on some different genera by illustrating the important diagnostic features. He also expressed the opinion that some spores may prove to be valuable in making finer stratigraphic divisions of the Triassic period.

BHARADWAJ & SINGH (1963) listed 40 species from the Upper Triassic coals of Austria (Lunz). These forms are mainly made up of trilete and monosaccate grains. The author's conclusion indicates that the Upper Triassic microflora acts as a transitional stage between predominantly striated-winged grains of the Lower Triassic and nonstriated-winged grains of the Liassic or the Younger Mesozoic ages. Another contribution to the study of fossil spores and pollen of the Upper Triassic Alpine-Region is of PAUTSCH (1958) from the Swierczyna, Poland.

From the adjacent countries of Austria, the works of LESCHIK (1955), Switzerland; MÄDLER (1964), Germany; and VENKATACHALA & GOĆZAŃ (1964), Hungary, have also been referred though, they are not from the Alpine-Region and are not exactly of the same stratigraphic horizon.

#### Preparation of Samples

The laboratory procedures adopted in preparation of the samples are based on the principal techniques that are commonly employed in the Palynological Laboratory of the Geol. Survey of Austria, Vienna.

\*) Carnian stage is the lower part of Upper Triassic in East Alp, and it corresponds to Lower-Middle Keuper of Germany.

The successful step in destruction of the organic residues has been adopted from ERDTMAN's method with a minor modification introduced by KLAUS. As modified, this method is applicable to various kinds of sediments and not only to modern herbarium, peat and/or lignits.

All the calcareous shale samples were made to undergo the stages hereby described. Intensity treatment and the duration of each process was different for different samples. They were applied according to the individual needs of the studied materials.

The samples were powdered, cooked with HCl and washed three times. Later the residues were boiled with 70% HF and were washed thrice. The washed materials were then treated with HCl and centrifuged. At this stage the samples were divided into two parts. With one part the modified ERDTMAN's method was carried out. In this process the chlorination step was done first and later acetolysis. The second part was also processed by the same method but after the heavy liquid separation with Bromoform. The pollen bearing residues from the two different parts were compared to assess the preferability of the techniques and in many cases the results were almost the same.

Shaly samples without calcareous matrix were also treated with the above techniques except for omitting the first HCl treatment.

### The Palynokoinum

The three different Cardita shale units were very rich in microflora. Fossil spores and pollen such as *Triletes*, *Monoletes*, *Monosaccites* and *Disaccites* are present in all samples and only the abundance of the above mentioned groups was found to change from one to another sample.

The spore assemblages of the Cardita shales show some similarities to the Upper Triassic coals of Lunz (BHARADWAJ & SINGH) but they were found to be more similar and identical with the assemblages of Cardita- and Halobia layers of Austria (KLAUS) and the Middle Keuper of Switzerland (LESCHIK).

Systematic description of the examined specimens are not given in this report as they have already been treated and dated elsewhere at full length. An attempt is only made here to list all the names of the identified forms of the various samples. All the vertical ranges of these forms are not restricted to the Carnian stage and some have already been reported from higher or lower stratigraphic horizons than Upper Triassic.

### SPORITES

#### Triletes

##### Azonoletes

##### Laevigati:

- Aulisporites astigosus* (LESCHIK)
- Aulisporites canalis* LESCHIK
- Calamospora nathorsti* (HALLE)
- Calamospora sinuosus* LESCHIK
- Carnisporites hercynicus* MÄDLER
- Dictyophyllidites harrisii* COUPER
- Dictyophyllidites lunzensis* (KLAUS)
- Leschikisporis aduncus* (LESCHIK)

*Todisporites fissus* BHARADWAJ & SINGH  
*Todisporites major* COUPER  
*Todisporites minor* COUPER  
*Todisporites* sp.

#### Apiculati:

*Apiculatisporis hirsutus* (LESCHIK)  
*Apiculatisporis lativerrucosus* (LESCHIK)  
*Apiculatisporis parvispinosus* (LESCHIK)  
*Conbaculatisporites mesozoicus* KLAUS  
*Conbaculatisporites sparsus* (BHARADWAJ & SINGH)  
 cf. *Concavissimisporites* sp. DELCOURT & SPRUMONT  
*Conosmundasporites othmari* KLAUS  
*Osmundacidites alpinus* KLAUS  
*Osmundacidites congestus* (LESCHIK)  
 cf. *Raistrickia* sp.  
*Trilites tuberculiformis* COOKSON  
*Trilites klausi* BHARADWAJ & SINGH  
*Verrucosisporites morulae* KLAUS

#### Murornati:

*Anulispora punctus* (KLAUS)  
*Camazonosporites rudis* (LESCHIK)  
*Corrugatisporites* aff. *klukiformis* NILSSON  
*Corrugatisporites* sp.  
*Lycopodiacidites kuepperi* KLAUS  
*Microreticulatisporites opacus* (LESCHIK)  
*Tigrisporites halleinis* KLAUS  
*Zebrasporites fimbriatus* KLAUS  
*Zebrasporites kahleri* KLAUS

#### Zonales

##### Zonotriletes

##### Zonati:

*Styxisporites cooksonae* KLAUS

#### Monoletes

##### Zonomonoletes:

*Aratrisporites coryliseminis* KLAUS  
*Aratrisporites paraspinosus* KLAUS  
*Aratrisporites scabratus* KLAUS  
*Saturnisporites fimbriatus* KLAUS  
*Saturnisporites fischeri* KLAUS  
*Saturnisporites granulatus* KLAUS

#### Aletes

##### Psilonapiti:

*Peroaletes convolutus* BHARADWAJ & SINGH

## POLLENITES

### Saccites

#### Disaccites

##### Disaccitriletes:

*Illinites* sp.  
*Triadispora crassa* KLAUS  
*Triadispora staplini* (JANSONIUS)  
cf. *Vitreisporites signatus* LESCHIK

##### Disaccimonoletes:

*Chordasporites singulichorda* KLAUS  
*Ovalipollis grebeae* KLAUS  
*Ovalipollis lunzensis* KLAUS  
*Ovalipollis mohrensis* (LESCHIK)  
*Ovalipollis rarus* KLAUS  
*Ovalipollis* distinct species.  
*Protosacculina* cf. *glabrescens* MALJAWKINA  
*Striatites* sp.  
*Taeniaesporites krauseli* LESCHIK

##### Disaccitriletes:

*Alisporites* sp.  
*Microcadytidites fastidioides* (JANSONIUS)  
*Minutosaccus potonie* MÄDLER  
*Parvisaccites* sp.  
*Klausipollenites* sp.  
*Pityosporites neomundanus* LESCHIK  
*Pityosporites* cf. *ruttneri* KLAUS  
*Platysaccus* sp.  
*Scopulisporites* cf. *toralis* LESCHIK  
*Rimaesporites*

#### Monosaccites:

*Ellipsovelatisporites plicatus* KLAUS  
*Enzonalsporites tenuis* LESCHIK  
*Patinasporites densus* LESCHIK  
*Patinasporites* cf. *funiculus* LESCHIK  
*Patinasporites iustus* KLAUS  
*Patinasporites toralis* LESCHIK

### Circumpolles

#### Singulipollenites:

*Duplicisporites granulatus* LESCHIK  
*Duplicisporites punctatus* LESCHIK  
*Paracirculina maljawkinae* KLAUS  
*Partitisporites novimundanus* LESCHIK

## Napites

*Araucariacites australis* COOKSON

## Monocolpates

*Cycadopites accerimus* (LESCHIK)

*Cycadopites distinct species.*

*Cycadopites* sp. aff. *Marsupipollenites*

*Monosulcites* cf. *minimus* COOKSON

*Decussatisporites martini* LESCHIK

*Decussatisporites distinct species.*

## Method of Statistical Analysis

In counting analysis, 150 grains and, wherever possible 200 grains were counted for each slide of the samples. Counting area for all the slides has been 324 sq. mm. (18 × 18 mm.) The counting was made at random, but always starting from the lower left corner of the slide.

Identification of the forms during the counting was based upon the photographs prepared from the grains of various slides from different samples. In some cases shrinkage and poor preservation of these specimens prevented the exact specific identification. So the generic level of the counted grains were taken under consideration during the calculation of percentages.

## Sporestratigraphy of the Shales

Each individual shaly member of the Cardita shales of the Bleiberg area could be recognized by counting analysis of the spore assemblages.

The method of statistical analysis employed in this investigation proved that some spores appear to be much of importance for stratigraphical subdivisions. This justifies KLAUS' view that it is possible to make smaller stratigraphic divisions within the Triassic sediments with the aid of some spores.

From 52 genera and 82 recognized species only 14 groups could be separated as good stratigraphical indicators (Text Fig. 2). These groups are considered to be important as they act as the microfloristic indices for finer stratigraphic division in Cardita shales.

## Distinguishing groups of Shale No. 1:

This lithological unit is identified by a high percentage of *Taeniaesporites krauseli* LESCHIK followed by *Araucariacites* and *Aratrisporites* in order of predominance (Text Fig. 3). It is also characterized by the apparent restriction of *Decussatisporites*, *Parvisaccites* spp., *Monosulcites* cf. *minimus* COOKSON, and *Leschikisporis aduncus* (LESCHIK). The very minor percentage of *Klausipollenites* and *Rimaesporites* (Text Fig. 2) may also be of value in this unit.

## Distinguishing groups of Shale No. 2:

This unit is identified by the highest percentage of *Aratrisporites*, associated with a low percentage of *Araucariacites* and a small representation of *Taeniaesporites krauseli* LESCHIK in comparison with the other units. The *Cycadopites* and *Rimaesporites* appear to extinct towards the top within this unit. The *Zebrasporites kahleri* KLAUS, though extremely rare, is a good marker for this



lithological unit as it is presumably found only in this unit. The first occurrence of *Cycadopites* aff. *Marsupipollenites* is also noteworthy.

### Distinguishing groups of Shale No. 3:

This shale unit is distinguished by the absence of *Araucariacites* and the higher proportion of *Taeniaesporites kraeuseli* LESCHIK with respect to *Aratrisporites*. Furthermore, an increased representation of *Klausipollenites* and *Cycadopites* aff. *Marsupipollenites* in comparison with the middle shale unit are of great value.

The *Enzonalsporites* and the different species of *Patinasporites* were found in all samples and they show a tendency to decrease in proportion in the second unit (Text Fig. 2). This tendency of decrease in quantity may or may not be of much stratigraphic importance but it probably reflects some ecological factors at the time of their existence.

Although the above proposed stratigraphic markers could be of some value in the Bleiberg area, the validity of them for broader correlations could not be completely reliable unless they were determined by some additional works in other different areas.

### Summary and Conclusions

It has already been mentioned that the purpose and the scope of this study has been to identify the spore horizon indicators. From the investigations of the microflora of the Cardita shales (Carnian) it would seem very likely that the statistical analysis would be helpful in recognizing each lithological unit.

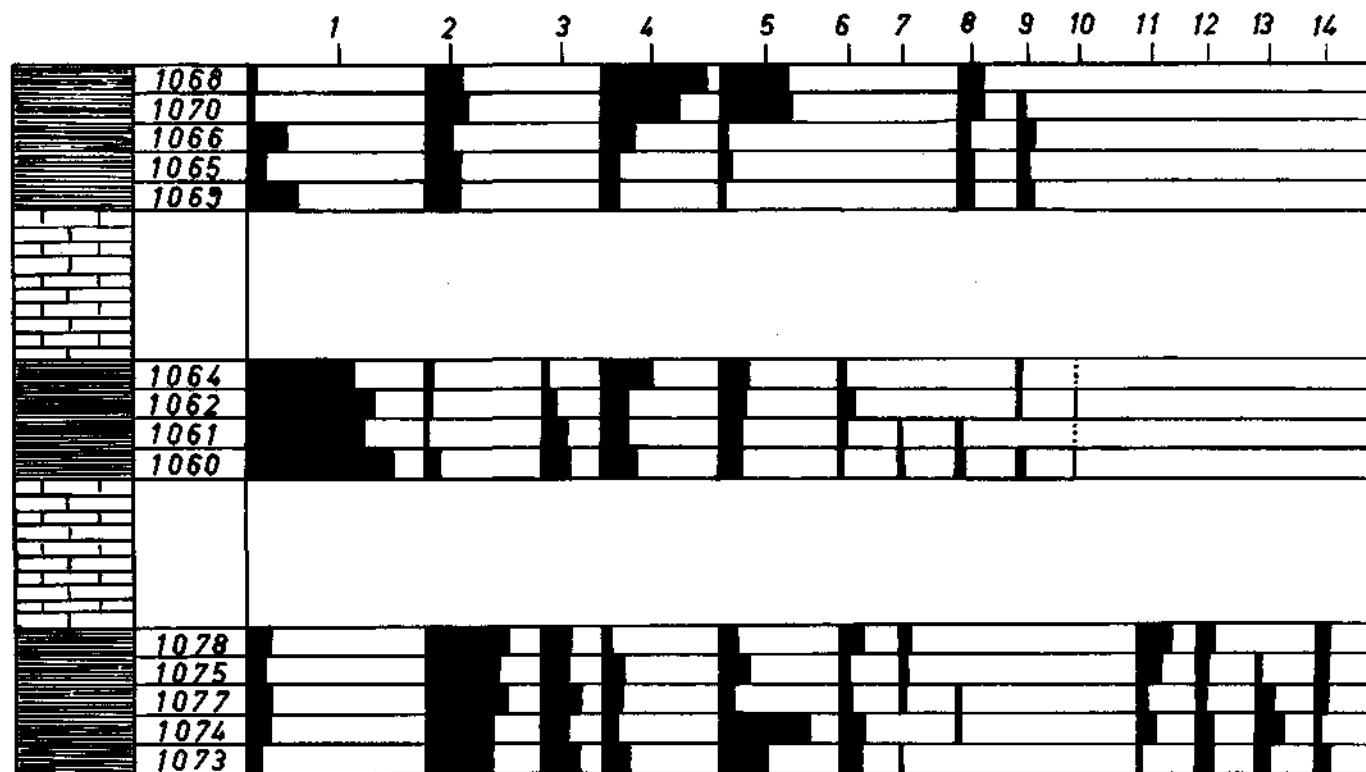
Not all fossil spores and pollen assemblages were useful in this connection, but only some were of great value, as stratigraphic markers. The least valuable forms were *Triletes* whereas *Monoletes* and *Disaccites* were of importance. Appearance or disappearance of some forms coupled with the great abundance of a few genera in all the shale units have been used as a tool in further stratigraphic division of the section.

The first shale is recognized by the greatest abundance of *Taeniaesporites kraeuseli* LESCHIK, lower percentage of *Araucariacites* and least occurrence of *Aratrisporites*. This shale is also represented by a restricted presence of *Decussatisporites*, *Monosulcites* cf. *minimus* COOKSON, *Parvisaccites* and *Leschikisporis aduncus* (LESCHIK).

The predominance of *Aratrisporites* and the least value of *Taeniaesporites kraeuseli* LESCHIK are the best criteria for the recognition of the second shale. Lower percentage of *Araucariacites* and the rare occurrence of *Zebrasporites Kahleri* KLAUS may also be considered as the auxiliary forms that distinguish this unit. Furthermore, *Cycadopites* has apparently disappeared at the top of this shale unit.

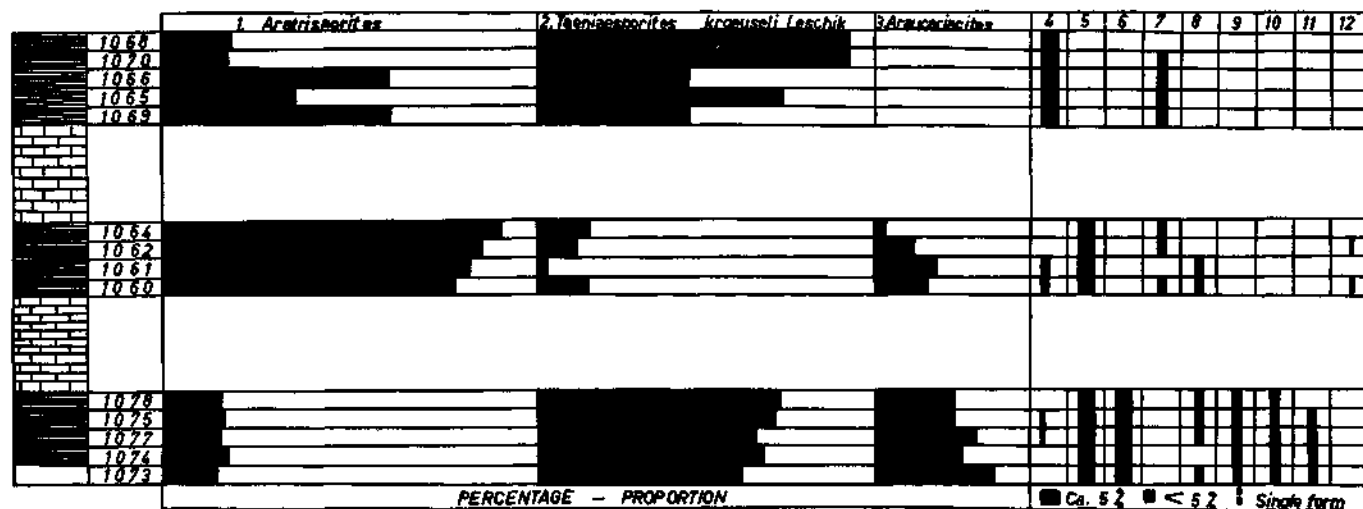
The third shale can be easily identified by the absence of *Araucariacites* and greater percentage of *Taeniaesporites kraeuseli* LESCHIK, in comparison with *Aratrisporites* and the relative abundance of *Klausipollenites* and the occurrence of *Cycadopites* aff. *Marsupipollenites*. The last two forms, however, were more predominant in this unit rather than in the middle unit.

At the moment, the author is unable to provide a complete evidence in support of his suggestions in regard to the above proposed microfloristic indices. However, he hopes that this work is a contribution for further exhaustive and detailed investigation of the spore stratigraphy of the Upper Triassic.



### SPOREDIAGRAM OF CARDITA SHALES BLEIBERG

Text Fig. 2. 1. Aratrisporites, 2. Taeniaesporites kraeuseli Leschik, 3. Araucariacites, 4. Enzonasporites & small Patinasporites, 5. Patinasporites iustus Klaus, 6. Cycadopites, 7. Rimaesporites, 8. Klausipollenites, 9. Cycadopites aff. Marsupipollenites, 10. Zebrasporites, 11. Decussatisporites spp., 12. Monosulcites cf. minimus Cookson, 13. Leschikisporis aduncus (Leschik), 14. Parvisaccites.



Text Fig. 3. 1. Aratrisporites, 2. Taeniaesporites kraeuseli Leschik, 3. Araucariacites, 4. Klausipollenites, 5. Cycadopites, 6. Decussatisporites spp., 7. Cycadopites aff. Marsupipollenites, 8. Rimaesporites, 9. Monosulcites cf. minimus Cookson, 10. Parvisaccites, 11. Leschikisporis aduncus (Leschik), 12. Zebrasporites.

It is noteworthy that the investigation has also resulted in the identification of at least three distinct forms which deserve new specific names. They are 1. specimens of *Decussatissporites* with fewer but broader stripes; 2. specimens of *Cycadopites* aff. *Marsupipollenites* with verrucated sculptures, a distinct horizontal leasure on the proximal side and a large pronounced distal sulcus and 3. specimens of *Ovalipollis* with large air sacs and a very dominant proximal slit. These features clearly demonstrate the transitional stage between this genus and the genus *Illinites*.

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