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FORAMINIFERS AS AN INDICATOR OF PALEOBATHYMETRY IN THE GOSAU GROUP OF EASTERN AUSTRIA

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Abstract: Paleoecological studies indicate environmental changes during selected time horizons within the Upper Cretaceous sediments from three localities of the Gosau Group in Austria. Foraminiferal assemblages were studied from the localities Grünbach-Neue Welt, Weissenbachalm and Spital am Pyhrn. Paleobathymetric changes have been reconstructed using plankton/benthos ratio, percentual abundances of selected genera and species diversity. Three depth levels with three groups of dominating species were recognized from the Late Turonian to Early Santonian sediments of the Grabenbach Formation at Weissenbachalm locality. From the Grünbach-Neue Welt area the Grünbach Formation (Early Campanian) and Piesting Formation (Late Campanian-Early Maastrichtian) comprise transitional assemblages from shallow-water, neritic marls to bathyal hemipelagics and turbidites. The character of foraminiferal assemblages of the Weisswasser Formation indicates shallow-water shelf conditions during Late Santonian and Early Campanian. The deeper water Wurberg Formation contains richer foraminiferal assemblages with higher species diversity.

Key words: Austria, Northern Calcareous Alps, Gosau Group, Upper Cretaceous, paleoecological study, foraminifers.

Introduction

Lee & Anderson (1999) wrote "The modern foraminifers are one of the most important groups of marine protozoa on the earth which play a significant role in the global biochemical and ecological cycles of organic compounds. We can propose that they have had the same position also during history of earth as an indicator of paleoenvironmental changes.". This paleoecological study of foraminiferal assembages from the Gosau Group of the Northern Calcareous Alps shows, on the basis of ecological data of selected genera by Murray (1991), Lommerzheim (1991) and Koutsoukos & Hart (1990) (Table 1) paleobathymetric and paleotemperature changes during the Late Cretaceous in the area of the Gosau Basin in Austria. Foraminiferal assemblages were studied from the localities Weissenbachalm, Grünbach-Neue Welt and Spital am Pyhrn (Fig. 1). This study was done within the Visegrád 45-2001-IVF Project and partly also within Grant Project No. 205/99/1551 supported by the Grant Agency of the Czech Republic and the bilateral cooperation between the Czech Geological Survey, Praha and Geologische Bundesanstalt, Vienna.

The characterization of studied localities

Weissenbachalm locality

The small E-W striking Gosau deposits of the Weissenbachalm area (Lower Gosau Subgroup) is situated in the extremely tectonically deformed central part of the Northern Calcareous Alps. The deposits of the Gosau Group are represented by an approximately 25 m high outcrop of grey marls (Hradecká et al. 1999a). From the main profile of the Weissenbachalm (Grabenbach Formation) five samples (WB4, WB6, WB5, WB16) have been studied. Several other isolated outcrops (WB1, WB2, WB9, WB10, WB21, WB3, WB8, WB22, WB23, WB7, WB2, WB11, WB17) were sampled and studied for additional information.

Grünbach-Neue Welt area

The classical area of the Grünbach-Neue Welt Gosau Group is situated SE of the Hohe Wand mountain range, close to the eastern margin of the Northern Calcareous Alps. From this area only isolated samples from the Piesting Formation (former "Inoceramus Marls"), (Summesberger et al. 2000) from Grünbach, Zweiersdorf, Dörfles, (Grü8, ZW3-9, Dö1) and the Grünbach Formation (former "Coal-Bearing Serie"), the sample Mai1, have been collected (Hradecká et al. 1999b).

Spital/Pyhrn locality

The samples of Gosau sediments from the region north of Spital am Pyhrn belong to the marl-sandstones succession of the fan delta complex of the Wurberg Formation and marl to siltstone storm deposits of the Weisswasser Formation (Kreuss 1994; Hofmann, personal communication).

Methods

During these preliminary paleoecological interpretations in the studied regions, only basic, classical methods such as the plankton/benthos ratio, quantitative analyses — percentual abundance of selected genera and the species diversity were applied. Quantitative analyses were done from the identical quarto of the size fraction > 0.063 cm. From a consistent volume unit of one cubic centimetre (1 cm^3) a minimum of 200 specimens was counted. Diversity was determined using the Simpson equation.

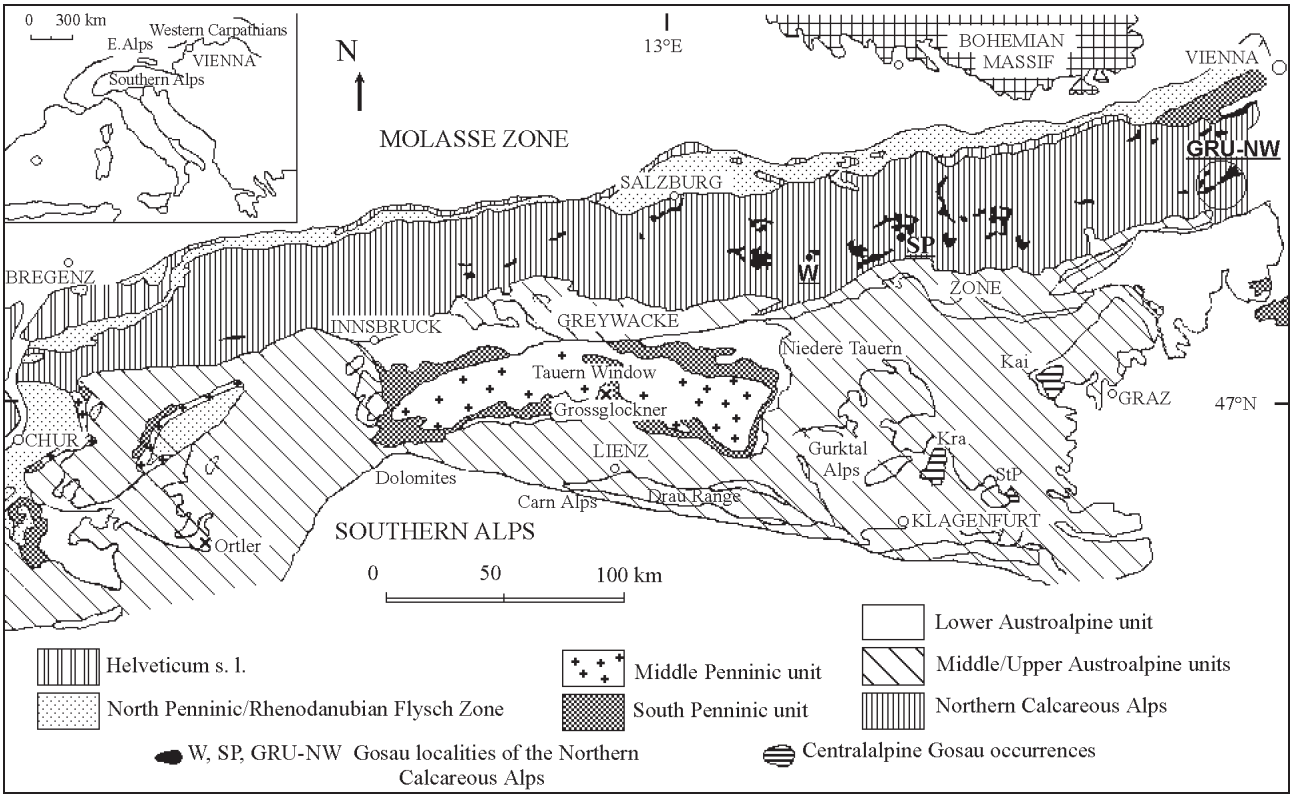

Fig. 1. The position of the studied localities of the Gosau Group in the Northern Calcareous Alps in Austria.

Table 1: Ecological data for selected genera according to Murray (1991), Lommerzheim (1991) and Koutsoukos & Hart (1990).

Ammobaculites	infaunal free; muddy sediment; detritivore; brackish-marine; temperate-tropical; brackish marsches and lagoons; inner shelf–upper bathyal
Archaeoglobigerina	plankton; warm-temperate
Bolivina	infaunal-epifaunal free; muddy sediment; ?detritivore; marine; cold-warm; inner shelf–bathyal
Gaudryina	epifaunal, attached; hard substrates; ?passive spension feeder; marine; warm-temperate; 50-500 m; shelf and upper bathyal
Globigerinelloides	plankton; cold-temperate
Globotruncana/Globotruncanita	plankton; warm-temperate
Gyroidina/Gyroidides	epifaunal, free; fine sands and mud; ?detritivore; marine; cold; shelf–bathyal
Hedbergella	plankton; cold-temperate
Haplophragmoides	infaunal, free; mud-sand; ?detritivore; marine; 35–1235 m; temperate-cold; marshes–bathyal
Hoeglundina	infaunal, free; mud; ?detritivore; marine; temperate-cold; outer shelf–bathyal
Lenticulina	epifaunal, free; mud; ?detritivore; marine; cold; outer shelf and bathyal
Pararotalia	epifaunal, free; ?
Pulenia	infaunal, free; mud; detritivore; marine; cold; outer shelf to bathyal
Quinqueloculina	epifaunal, free or clinging; plants or sediment; herbivore; marine-hypersaline; 32–65 ‰; cold-warm; hypersaline lagoons, marine shelf, rarely bathyal
Rugoglobigerina	plankton; warm-temperate
Spirillina	epifaunal, clinging; hard substrates; marine; temperate-cold; 1–100 m; inner shelf
Trochammina	epifaunal or infaunal, free; sediment; herbivore or detritivore; 0–60‰; cold-warm 0–30 ºC; 0 to 6000 m; intertidal shelf, bathyal, abyssal

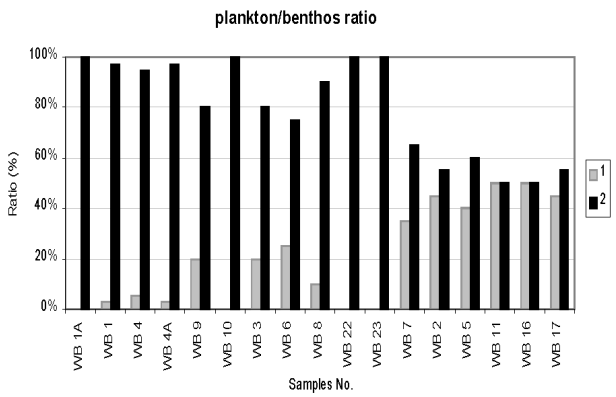

Fig. 2. Plankton/benthos ratio of the foraminiferal assemblages from the Weissenbachalm sediments.1 — plankton, 2 — benthos.

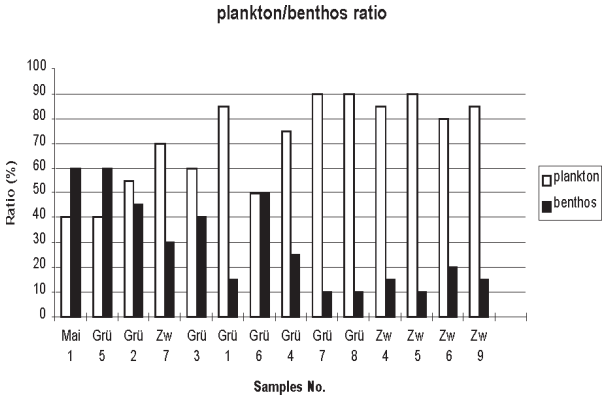

Fig. 4. Plankton/benthos ratio of the foraminiferal assemblages from the Grünbach-Neue Welt Gosau Group sediments.

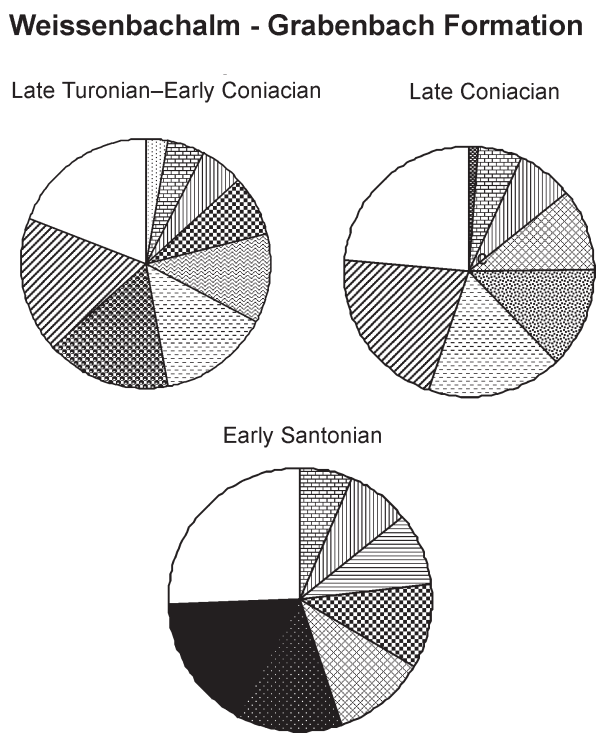

Fig. 3. The percentual abundances of selected genera from the Weissenbachalm Grabenbach Formation (Lower Gosau Subgroup). Legend same as Fig. 6.

Paleoecological results

On the basis of the studies of Butt (1981) and Wagreich & Faupl (1994) in respect to foraminiferal paleoecology and paleobathymetry in the Gosau Group, the following have been recognized at the Weissenbachalm locality (Hradecká et al. 1999a).

1 — Shallow-water conditions with water depths of about 10–20 m, pertaining to the inner neritic environment sensu Wagreich & Faupl (1994), were determined in samples WB1, WB4, WB9, WB10, on the basis of the abundance of benthic foraminifers such as *Quinqueloculina, Spirillina* and *Spiroloculina.* These species tolerated not only cold but also warm water. The plankton/benthos ratio is about 20–30 % (Fig. 2). The genus *Hoeglundina* is characteristic for the shallow-water facies of these Gosau Group sediments.

2 — The second group of samples (WB3, WB6, WB7, WB8) contains many calcareous species of the genera *Praebulimina, Gavelinella* and *Gyroidinoides,* nevertheless their tests are smaller in size. The plankton/benthos ratio ranges between 40–60 %. Small juvenile tests of *Globigerinelloides* and *Heterohelix* dominate the planktonic assemblages. The foraminiferal assemblage probably represents the middle neritic environment with water depths of 30–100 m (Wagreich & Faupl 1994).

3 — The third group of samples (WB2, WB5, WB11, WB16, WB17) belongs to the stratigraphic interval of the Late Coniacian–Early Santonian. Rich plankton-dominated assemblages (about 70 %) also contain abundant benthic species belonging to the genera *Gavelinella, Praebulimina, Dentalina* and *Lenticulina*. Where paleobathymetry is concerned, the sedimentation took place in the deepest parts of the shelf sea, which represents the outer neritic environment.

4 — All three foraminiferal assemblages from the Grabenbach Formation of the Weissenbachalm locality show evidence of the shallow-marine facies of the Lower Gosau Subgroup as described by Wagreich & Faupl (1994) within the Late Turonian–Campanian interval. Nevertheless, changes in foraminiferal assemblages related to a gradual sea-level rise were recorded during the Coniacian. The predominance of *Quinqueloculina* (40–95 %) in samples WB21, WB22, WB23 suggests the occurrence of closed small basins with hypersaline conditions (Höfling 1985) (Fig. 3).

In the Grünbach-Neue Welt area two paleobathymetric zones were determined on the basis of the plankton/benthos ratio (Fig. 4).

1/ Outer neritic of Early Campanian age — sample Mai1 (Grünbach Formation) and samples Grü2,3,5 and Zw7 (Piesting Formation) of Late Campanian age.

2/ Upper-middle bathyal in the Late Campanian–Early Maastrichtian interval.

Both facies belong to the transition between shallow-water macrofossil-rich marls and bathyal hemipelagites and turbidites (Piller et al. 1997; Wagreich & Summesberger 2001), (Fig. 5). Paleobathymetry based on the plankton/benthos ratio (40–

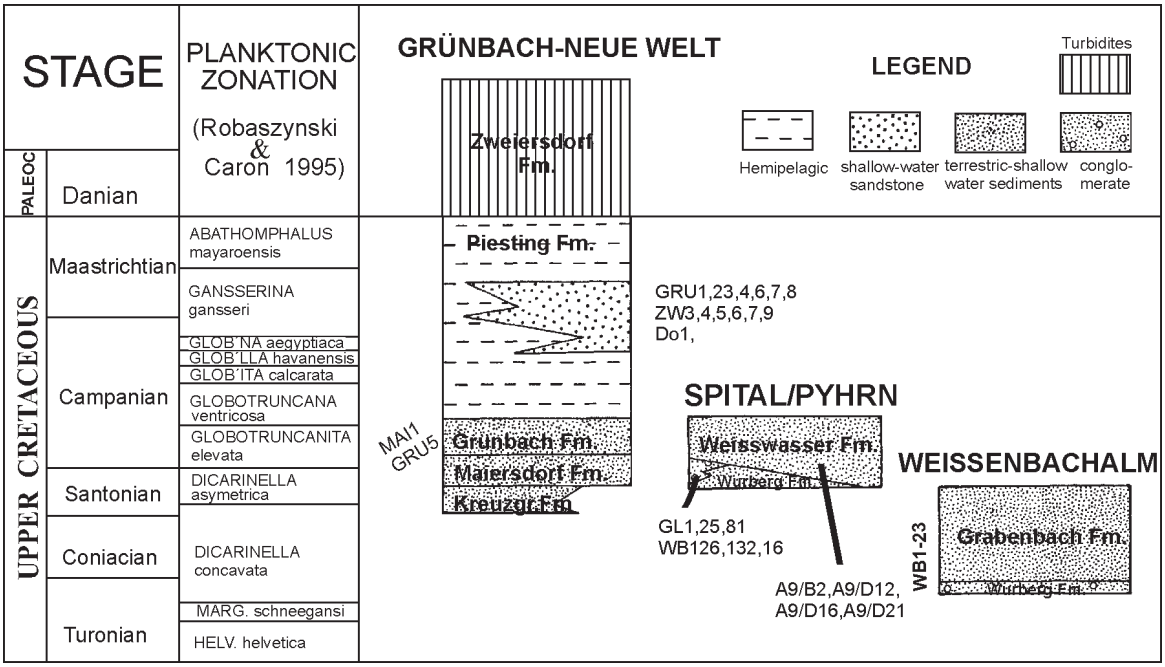

Fig. 5. Upper Cretaceous lithostratigraphy of the Gosau Group in studied localities (based on Summesberger et al. 2000; Wagreich & Summesberger 2001; Kreuss 1994).

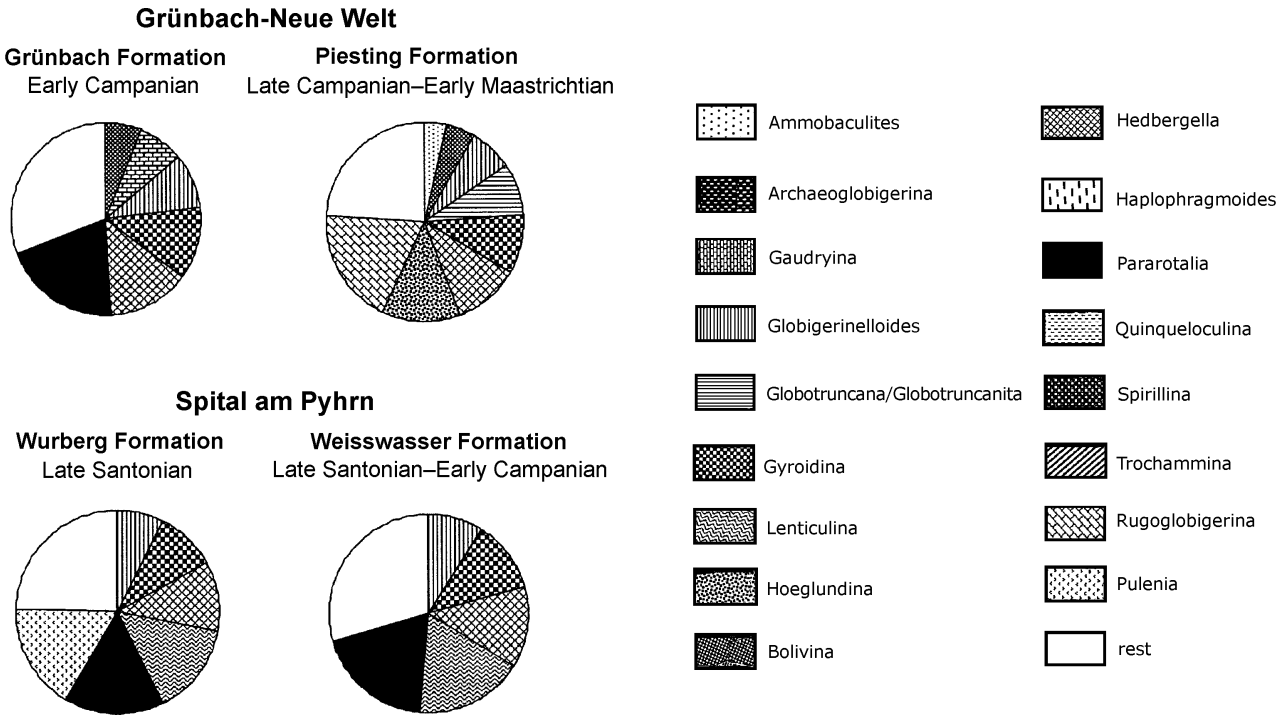

Fig. 6. The percentual abundances of selected genera from the Grünbach-Neue Welt Gosau Group (Piesting Formation + Grünbach Formation) and Spital/Pyhrn (Weisswasser Formation, Wurberg Formation).

60 %) indicates water depths of about 200 m, which implies an outer neritic environment. The Late Campanian and Early Maastrichtian sediments were probably deposited in a deeper marine environment (upper-middle bathyal) dominated by keeled planktonic species of the genera *Globotruncana, Globotruncanita* and *Globotruncanella* (80–90 %).

The foraminiferal assemblages indicate a mixture of cold and warm water-preferring taxa. *Gyroidinoides, Haplophragmoides, Lenticulina* etc. are present in an association of typical Tethyan species, which suggests an influence of cold water currents in the deeper water environment (Fig. 6). The change in water temperatures from warm to cool-temperate during the

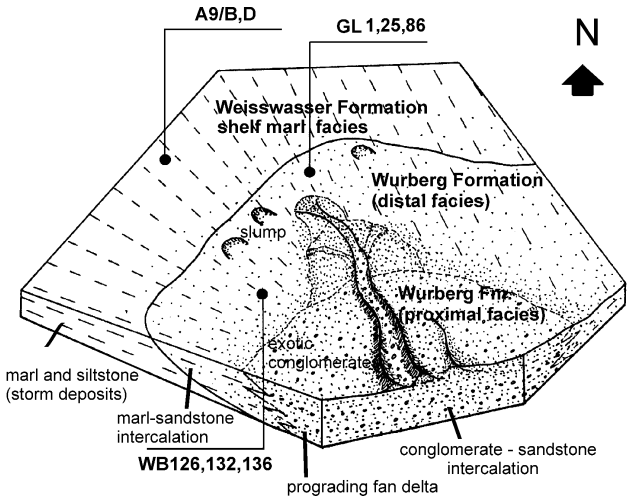

Fig. 7. Reconstruction of the Late Santonian-Early Campanian paleogeography of the Spital/Pyhrn locality (according to Kreuss 1994).

Campanian probably corresponds to a global climatic event (Lommerzheim 1991).

The washed material from the Weisswasser Formation at Spital/Pyhrn locality contained poor foraminiferal assemblages characterized by low diversity. Within the benthic species specimens of the calcareous benthic genus *Hoeglundina* predominate (Fig. 6). This prevalence over planktonic species and the presence of rather cold-preferring species may suggest cooler temperate environments.

The content of planktonic species was 1–20 %. This difference is probably caused by sudden basin subsidence and the local deepening of the basin (Wagreich 1989).

The character of foraminiferal assemblage indicates shallow-water shelf conditions (Fig. 7) with water depths probably about 30–100 m (Wagreich & Faupl 1994).

The sediments from the Wurberg Formation (distal facies) contain richer foraminiferal assemblages (Fig. 6). The diversity was slightly higher — 57 foraminiferal species were found. The presence of *Stensioeina* as a representant of deeper water depths (Wicher & Bettenstaedt 1957) may indicate fluctuations of the sea level in an otherwise shallow-water environment. We interprete paleo-water depths of about 100–200 m (Wagreich & Faupl 1994).

Conclusion

Paleoecological studies of the foraminiferal assemblages from three localities of the Gosau Group showed environmental changes during certain stratigraphic levels of the Upper Cretaceous.

During these first paleontological interpretations in the studied region, only basic ecological methods were applied. For a more detailed study in the future the gained data based on multivariate methods such as cluster analyses, principal coordinate analyses etc. could be interesting for the paleoecological studies in this area.

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