



Paleobiological Characterization of the Karpatian Stage

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Abstract. Paleobiologically the Karpatian Stage can be considered as a transition between the Lower Miocene (Ottangian) and the Middle Miocene (Badenian). The marine biota is characterized during the Lower and Middle Karpatian by relatively cool water masses, widespread dysoxic bottom conditions, and the extended deposition of calcareous shales ("Schlier") in the basins. In the Upper Karpatian a general shallowing and warm water influx is observed, as exemplified by the rich molluscan faunas. A strong Mediterranean marine influence existed. Palynomorphs, plant remains, and vertebrate faunas indicate a warm temperate to subtropical humid climate and high precipitation.

Introduction

Cicha *et al.* (1962) defined the Karpatian Stage as a chronostratigraphic unit. A complete definition of the stage, including a description of a stratotype, was presented by Cicha *et al.* (1967). An extensive description was given of foraminifera, molluscs, ostracods, fish otoliths, diatoms, palynomorphs, and plant remains from the Neogene basins of Moravia and southern and eastern Slovakia. Based on these investigations, the new results are extended to the other basins of the Central Paratethys, including a revised stratigraphy.

Characterization of the Karpatian

The Karpatian begins with a transgressive cycle, which introduced a series of new marine faunal immigrants from the Mediterranean. The Lower to Middle Karpatian still has similarities with the Ottangian development. Cool to temperate water masses predominated. Siliceous fossils (sponge spicules and diatoms) were common in the Ottangian and Karpatian. The Karpatian foraminiferal assemblages increase in diversity, but planktonic species are mainly small globigerinas. A moderate rise in marine temperature during the

Karpatian was shown by Šutovská & Kantor (1992). In the Upper Karpatian, the water masses generally became warmer, especially in the shallow-water areas, reflected in the mollusc faunas. Occurrences of bryozoans and echinoderms are rare.

Distinctly stratified Karpatian horizons from the terrestrial environment and corresponding vertebrate faunas and floras are rare. According to results of both groups, the terrestrial environment is influenced by subtropical humid conditions. Recent studies of the Korneuburg Basin yield information on the continental conditions in the Upper Karpatian, with annual mean temperatures of about 17 °C, minimum temperatures of 3–8 °C in the coldest period, precipitation of up to 2000 mm, and minimum sea surface temperatures of 15–17 °C (Harzhauser *et al.* 2002).

The calcareous nannoplankton assemblages are characterized by *Helicosphaera ampliapertura*, *Sphenolithus heteromorphus*, *Coccolithus pelagicus*, *C. miopelagicus*, *Calcidiscus leptoporus*, *Cyclicargolithus floridanus*, and *Helicosphaera carteri*, dated as nannoplankton Zone NN4 (Ćorić *et al.* in press). In the type locality Slup, *Helicosphaera mediterranea*, *H. carteri*, *Pontosphaera multipora*, and *Braarudosphaera bigelowii* are relatively common; rare *Helicosphaera ampliapertura*, *H. scissura*, *Reticulofenestra pseudumbilicus*, *R. minuta*, and *R. haqii* were recorded. The stratigraphic extent of Zone NN4 is longer than the Karpatian, with a range up to the Lower Badenian. The base of the Karpatian is younger than the beginning of NN4. High percentages of *C. pelagicus* (up to more than 90%) were documented in the Molasse Basin (the borehole Roggendorf 1; Ćorić & Rögl in press) and Styrian Basin (Spezzaferri *et al.* a, subm.) during Karpatian. High abundance of this species indicates high nutrient levels in surface water and cooler, upwelling palaeoconditions.

The rich diatom assemblages of the Karpatian consist partly of long-ranging species, e.g., *Actinopterychus undulatus*, *Coscinodiscus* spp., *Paralia* spp., *Stephanopyxis* spp., and *Thalassiosira* spp. Stratigraphically important are short-ranging species such as *Raphidodiscus marylandicus*, *Denticulopsis praelauta*, *Lanceinis praeparilis*, and *Coscinodiscus pannonicus*. The general habit of the Karpatian diatom flora is more strongly related to the Lower Badenian than to the Lower Miocene.

Characteristic foraminiferal species for the Karpatian are very rare. The FAD of *U. graciliformis* is a single biostratigraphic event. Common are assemblages with a dominance of one or few species, such as *Pappina breviformis*, *P. primiformis*, *Uvigerina acuminata*, *U. aff. barbatula*, *Islandiella cruysi*, or *Amphimorphina haueriana*. In the Slovak basins, assemblages with *Marginulina hirsuta* and *U. cf. multicostrata* occur. These assemblages characterise the shelf to upper slope deposits, commonly with pyritized preservation, indicative for dysoxic bottom conditions. Deep-water assemblages of the basins are dominated by agglutinated species, e.g., *Bathysiphon filiformis*, *Haplophragmoides* spp., *Budashevaella* spp., *Cribrostomoides* spp., *Reticulophragmium karpaticum*, *Gaudryinopsis beregoviensis*, or *Spirorutilus carinatus*. Deposition depth was the upper bathyal, also under reduced oxygen conditions (Spezzaferri *et al.* in press b). Planktonic assemblages were dominated by small globigerinas, indicating cooler water. Warmer-water indicators, such as *Globigerinoides*, *Globorotalia*, or *Globoturborotalita woodi*, are restricted to single horizons. In the Upper Karpatian, warm-water fluxes occurred, indicated by the common occurrence of *Globigerinoides*.

Karpatian Ostracoda are known from the Alpine-Carpathian Foredeep of Moravia and Lower Austria, the Korneuburg Basin, and from the Styrian Basin ("Steirischer Schlier"). The most characteristic species of the Karpatian are *Loxoconcha vaisonna* and *Callistocythere karpaticensis*. *Aurila larieyensis* from the Korneuburg and Laa Formation has very rarely also been found in the Badenian. *Cytheridea paracuminata* has its first occurrence in the Karpatian but is also known from the Badenian.

The molluscan fauna is poor in taxa that are restricted to the Paratethys in the Karpatian. Among these, *Agapilia pachii* and *Turritella bellardii* are typical. Furthermore, several persistent species such as *Cyllenina ternodosa*, *Nassarius edlaueri*, and *Terebralia bidendata* experience a peak during the Karpatian. Immigration from the Mediterranean is witnessed by gastropods like *Phalium miolaevigatum* and *Gyrineum depressum* and bivalves like *Cardita elongata*, *Pecten revolutus*, *Costellamussiopecten cristatus*, and *C. pasinii*. The latter species actually re-invaded the Paratethys and, although it is frequently recorded from the Egerian sediments (= "*Flabellipecten burdigalensis*"), it disappeared from the region in the Eggenburgian. As noted above, a number of bivalve species have their first occurrence in the Paratethys during the Karpatian. This enables a good biostratigraphic differentiation from older deposits. The elements restricted to the Karpatian, such as *Modiolus excellens* or *Maetra (Barymaetra) nogradensis*, are regionally isolated records without much biostratigraphic significance. Although the Karpatian mollusc assemblage consists almost entirely of species that are also present during the Badenian, it can be well distinguished by the generally distinctly lower species richness. Moreover, the absence of *Hinnites crispus*, *Aequipecten elegans*,

or *Megacardita jouanneti* among many others is highly indicative for its older age. Otherwise, the typical Eggenburgian to Ottnangian elements such as *Flexopecten palmatus* and *Pecten hornensis* are probably absent (comp. Harzhauser *et al.* in press).

Fishes are well documented by otoliths, teeth, and skeletons from the Carpathian Foredeep, the Vienna and Korneuburg basins, with >50 nominal species. In the Foredeep, mesopelagic species of teleost fish (otoliths) dominate, whereas in the Vienna Basin the fauna indicates water depths that did not exceed 200 m. Interestingly, the mesopelagic species *Hygophum weileri* and *Lampanyctus carpaticus* are restricted to the Karpatian of the Central Paratethys and are not reported from the Mediterranean. *Ogilbia sovici*, *Batrachthys steiningeri*, and *Atractoscion? nolfi* are only known from the shallow littoral to sublittoral facies of the Korneuburg Basin, whereas *Paraplagusia roseni* occurs also in the Upper Burdigalian of Montpeyrroux, France. The genus *Dapalis*, common in the Ottnangian "Schlier" and the Rzehakia Beds, disappeared in the Karpatian. About 70% of Karpatian nominal species based on otoliths continued into the Lower Badenian. The most important species of this group are: *Diaphus cahuzaci*, *D. debilis*, *D. haereticus*, *Nezumia ornata*, *Phycis musicki*, *Brachydeuterus latior*, *Deltentosteus telleri*, and *Lesueurigobius vicinalis*. Cosmopolitan genera dominate in otolith fauna (27); 9 genera have an Atlantic distribution and 2 genera have an Indo-Pacific Ocean distribution.

Only few teeth of sharks and rays (Elasmobranchii) are known from the Foredeep and the Vienna Basin. The lanternshark *Etmopterus* lives today from the outer shelf to the upper slope, whereas catsharks (*Scylorhinus*) settle depths from the intertidal zone down to >2000 m. In the Pannonian realm (northern Hungary), shark teeth are reported from the Egyházasgerge (Karpatian age of fish teeth questionable) and Fót formations (e.g., *Carcharias*, *Isurus*). A large number of teleost and shark teeth have been selected from washing residues of littoral sediments of the Korneuburg Basin (Schultz 1998), including 16 species of Elasmobranchii and one ratfish (Holocephali).

Freshwater fishes from the Norian Depression and the Western Styrian Basin are known since the nineteenth century and still need revision. The main components are *Palaeoleuciscus*, *Gobius*, and *Morone*. From the Korneuburg Basin, *Esox*, *Carassius*, and *Barbus* are reported.

Amphibians and reptiles of the Korneuburg Basin have been described recently. The estuarine to freshwater setting provided a habitat for frogs, terrapins (*Trionyx*), turtles, and also an alligator (*Diplocynodon*). These assemblages indicate subtropical conditions for the Upper Karpatian.

In the Central Paratethys area, only a few terrestrial mammal assemblages—Obergänserndorf and Teiritzberg from the Korneuburg Basin—are definitely of Upper Karpatian age. These assemblages are characterized by the dominating rodent *Keramidomys thaleri*, by the absence of *Ligerimys*, and by the distinct evolutionary level of the rodents *Palaeosciurus sutteri*, *Spermophilinus besanus*, *Democricetodon mutilus*, *Prodryomys satus*, *Microdryomys koenigswaldi*, *Miodyromys biradiculus*, *Pseudodryomys ibericus*, and *Bransatoglis cadeoti* (Daxner-Höck 1998). These arboreal living glirid-eomyid-petauristid associations, and the tragulid *Dorcatherium* clearly point to forested wetland environments in the Korneuburg Basin.

Macrofloral elements directly dated as Karpatian are rare. The zonal vegetation on mesic habitats can be reconstructed as subtropical evergreen forests with a small proportion of deciduous trees, and the azonal vegetation as swamp and riparian forests dominated by *Glyptostrobus* and *Myrica*. Some diversified assemblages are based on fruits and seeds, e.g., from the Korneuburg Basin (Meller 1998). At the stratotype Slup, a few taxa have been identified: *Tetraclinis salicornioides*, *Daphnogene polymorpha*, *Spirematospermum* cf. *wetzleri* along with fragmentary dicotyl leaves. An alleged rich flora from the Norian Depression (e.g., Leoben Basin) is uncertain due to stratigraphic uncertainties, as is the flora from Magyaregregy (e.g., Hably & Thiébaud 2002).

Palynological investigations have been carried out on marine and brackish sediments, including the stratotype locality Slup. Pollen and spores indicate a subtropical to warm-temperate climate. Euxinic conditions in marine sediments are connected with mass occurrences of Prasinophyta and pyritization. Marsh and riparian facies are typical in marginal settings, and are more common than in the Eggenburgian-Ottnangian. In the basin facies, marine microplankton and pollen of Pinaceae are common.

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