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Palaeontological Highlights of Austria

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Introduction

The oldest known fossils in Austria date back into the Ordovician. From this time on a broadly continuous fossil record is preserved up to the Holocene. Since an encyclopaedic or monographic presentation is impossible within this volume, nine case studies of different stratigraphic levels (Fig. 1) were selected to call attention to this remarkably good fossil documentation. These case studies include records on invertebrate fossils from several time slices from the Late Palaeozoic to the Miocene, as well as on vertebrates from the Miocene and Pleistocene and on plant fossils from the Devonian and Early Miocene. This selection was based on several aspects, which are of palaeoecologic, palaeobiogeographic, evolutionary, or stratigraphic importance or a combination of these disciplines.

Devonian Calcareous Green Algae

(BERNHARD HUBMANN)

Two major occurrences of Devonian calcareous green algae are discernible within Austria: in the Palaeozoic of Graz and in the Carnic Alps (Fig. 2). In both areas, the Devonian green algae appear in discrete layers often associated with accumulations of reef-building organisms (corals and stromatoporoids), or are concentrated in well-defined patches within some layers. Despite these prominent occurrences, Devonian green algae are not well-known. Most previous studies focused on the description of mound-building Carboniferous to Permian calcareous algae from the Carnic Alps (HOMANN 1972, FLÜGEL & FLÜGEL-KAHLER 1980).

In the Graz Palaeozoic nappe complex calcareous green algae are known from Emsian to Eifelian limestones within the uppermost tectonic nappe. They are well-preserved and locally make up the major part of the rock (HUBMANN 1990). Besides *Zeapora gracilis,* distinguished by large rounded cortical filaments, *Pseudolitanaia graecensis* and *Pseudopalaeoporella lummatonensis* occur (Fig. 3). *Pseudolitanaia graecensis* is built up of straight thalli containing club-shaped filaments and *Pseudopalaeoporella lummatonensis* is characterized by a typically poorly-calcified medullar zone and delicate cortical filaments.

There are two localities known with autochthonous algal occurrences in the Graz Palaeozoic. One is characterized by *Pseudopalaeoporella lummatonensis* with dispersed thalli of *Pseudolitanaia*. Contrary to all expectations, these algae are found in marly lithologies suggesting very bad environmental conditions for photoautotrophic organisms. The other locality exhibits *Zeapora* mass occurrences within carbon-rich limestones (HUBMANN 1993, 2000).

Comparable occurrences in the Carnic Alps are not known. Algae are found scattered in pure limestones, here. Austria's oldest halimedacean green algae occur in Lochkovian strata (PALLA 1966, 1967; HUBMANN 1994): *Paralitanaia carnica,* together with the typically bowl-shaped lanciculoid *Lanciculella gortanii* and *Quasilancicula wolfi* (Fig. 3). From Eifelian to Givetian limestones we know examples of *Pseudopalaeoporella lummatonensis.* The latter is the only algal taxon which is in common in both the Carnic Alps and the Graz Palaeozoic (HUBMANN & FENNINGER 1993), suggesting biogeographic relations during Middle Devonian times. The two areas are disconnected today by the most prominent fault system of the Eastern Alps, the Periadriatic Lineament, separating the Southern Alpine from the Austroalpine Zone.

The occurrence of *Pseudopalaeoporella lummatonensis* may be of importance to large-scale biogeographic correlations. Both Austrian occurrences, those of the Carnic Alps and the Graz Palaeozoic, are interpreted as remnants of shallow marine environments with algal life belonging either to the northern shelf areas of Gondwana or to peri-Gondwanan terranes. With the exception of the Cantabrian moun-

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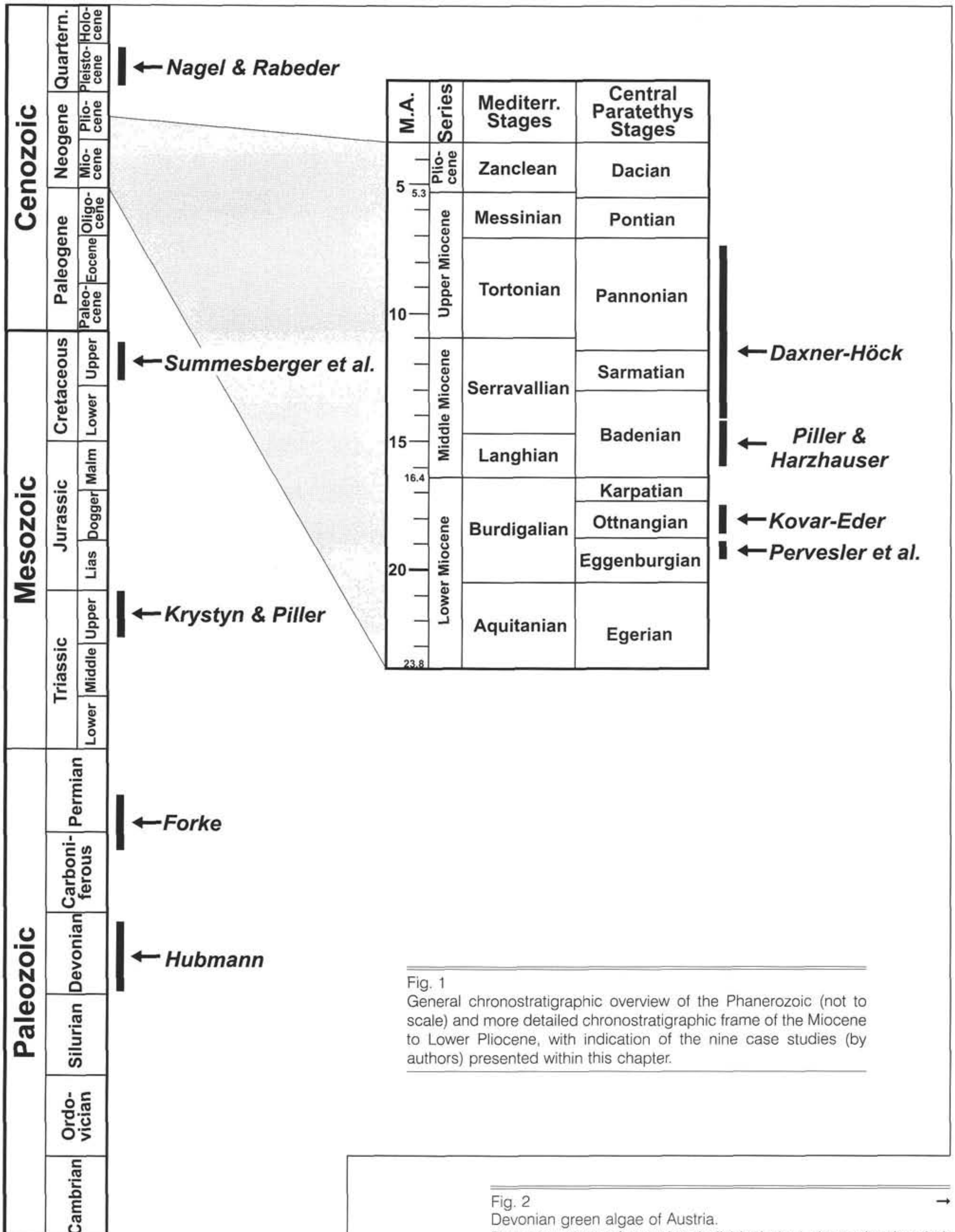
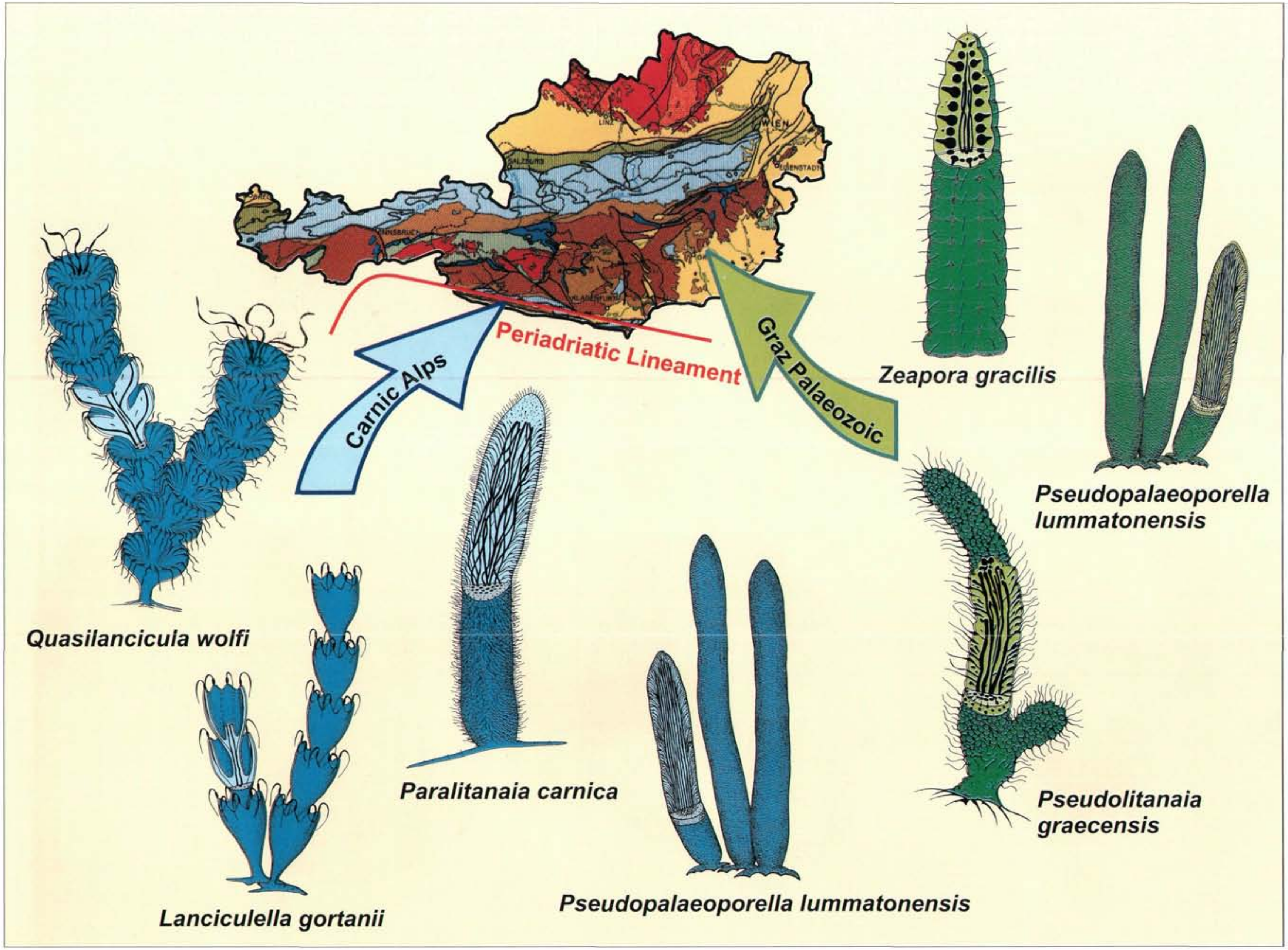


Fig. 1
General chronostratigraphic overview of the Phanerozoic (not to scale) and more detailed chronostratigraphic frame of the Miocene to Lower Pliocene, with indication of the nine case studies (by authors) presented within this chapter.

Fig. 2 →
Devonian green algae of Austria.
Reconstructions of complete individual algal plants showing their internal anatomy in cut parts. Note differences in colour. Blue coloured specimens belong to the "Southalpine Flora" of the Carnic Alps and green coloured to the "Austroalpine Flora" of the Graz Palaeozoic. Arrows point to main algal type locations on a simplified geological map of Austria.


Periadriatic Lineament
Carnic Alps
Graz Palaeozoic
Zeapora gracilis
Pseudopalaeoporella lummatonensis
Quasilancicula wolfi
Paralitanaia carnica
Pseudolitanaia graecensis
Lanciculella gortanii
Pseudopalaeoporella lummatonensis

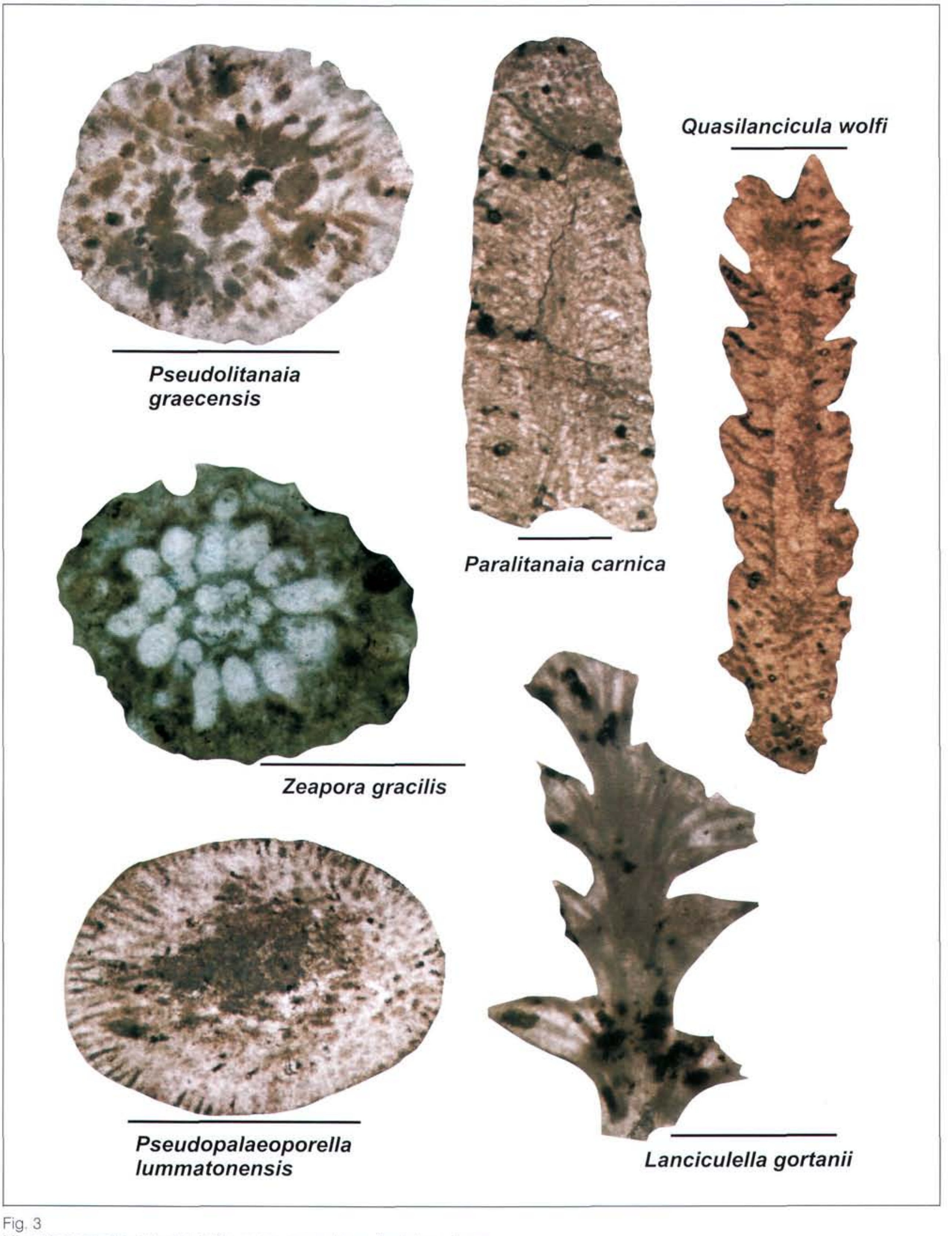


Fig. 3
Microphotographs of Austria's Devonian green algae. Scale bar: 1 mm.
Pseudolitanaia graecensis (HUBMANN 1990), *Zeapora gracilis* PENECKE 1894, *Pseudopalaeoporella lummatonensis* (ELLIOTT 1961) in cross sections. Specimens originate from the Barrandei-Limestone (Eifelian) of the Graz Palaeozoic.
Paralitanaia carnica HUBMANN 1994, *Quasilancicula wolfi* (JOHNSON 1964), *Lanciculella gortanii* (PALLA 1966) in longitudinal sections. Specimens originate from the Rauchkofel-Limestone (Lochkovian) of the Carnic Alps.

tains, several other findings of *Pseudopalaeoporella lummatonensis* belong to similar environments at the northern margin of the Rheic Ocean (i.e., Rhenohercynian Zone, Russian platform). This suggests that the depositional basins of the Carnic Alps and the Graz Palaeozoic were interconnected, and implies a biogeographic association of North Gondwana with the ancient northern hemisphere during the Devonian.

Late Palaeozoic Fusulinaceans from the Carnic Alps (HOLGER C. FORKE)

Soon after the Variscan orogeny the eastern part of the Southern Alps was flooded by a shallow, tropical sea. Following this transgression a group of larger benthic foraminifera, the fusulinaceans, colonized the area. They flourished and rapidly evolved in this westernmost part of the Palaeotethys during the Late Carboniferous and Early Permian, some of them reaching a large size (up to 3 cm in length). At the end of the Early Permian tectonic movements led to a regression of the sea and it was only during the Late Permian that the fusulinaceans had a short comeback in the Southern Alps before they died out completely close to the P/T – boundary.

Their rapid evolution, wide distribution and frequency in the shelf sediments of the Late Palaeozoic make the fusulinaceans a preferential group for biostratigraphic subdivisions. The distinct palaeobiogeographic distribution patterns of families and genera help to improve plate tectonic reconstruction during the Carboniferous and Permian.

Due to the well-preserved and rich fossil fauna, the fusulinaceans of the Carnic Alps were already objects of investigation in the last century. Starting with the first discovery by SUESS (1870), brief descriptions given by STACHE (1874) and GORTANI (1906) followed and a classical monograph was written by SCHELLWIEN (1898). Later on, the study of fusulinaceans of the Carnic Alps was intimately connected with the names of Franz and Gustava Kahler, documented in their more than 60 years continuous work (for full references, see FLÜGEL & MÖRTL 1997). They were the first to describe the foraminifers from measured stratigraphic sections. They elaborated a biozonal scheme for the Late Palaeozoic sediments of the Carnic Alps (KAHLER 1986) and tried to correlate them with fusulinacean faunas of Middle Asia, the Southern Urals and the Donets basin (KAHLER 1939, 1974, 1984, 1992).

Palaeobiology, Palecology

The fusulinaceans are characterized by a multilayered, micrognanular wall and a commonly planispirally involute arrangement of chambers. The wall is composed of equidimensional, subangular grains of calcite and seems to be rather secreted than agglutinated (GREEN et al. 1980; HAGEMANN & KAESLER 1998). The test shape is variably discoidal or globular, but predominantly spindle-shaped (fusiform). Their external structures are rather poor and uniform. Axial, sagittal and sometimes tangential sections are necessary to study their internal features, which are essential for the determination of taxa.

The life cycle of the fusulinaceans is still not well understood, but megalospheric forms predominate in most genera. Few microspheric specimens are reported in some genera, characterized by their skew-coiled inner volutions.

The ecological requirements are difficult to assess, because the fusulinaceans are exclusively Palaeozoic in age. Comparisons with Recent foraminifers like the alveolinids, having similar size and shape, can be misleading. The possible mode of life is deduced from accompanied facies analysis. Different groups within the fusulinaceans can be related to various environments ranging from clastic influenced near shore habitats to lagoonal, outer shelf or bioohermal facies types (e.g., ROSS 1969). From these data, an epibenthic life in shallow water is inferred and a symbiosis with algae is discussed (ROSS 1972).

Biostratigraphy

In the Late Palaeozoic sediments of the Southern Alps the fusulinaceans take the leading role as index fossils for biostratigraphy, because other important groups, like conodonts or ammonoids are rare or absent. Furthermore, some large and characteristic fusulinaceans can be easily distinguished with a hand lens in the field, serving as a powerful tool for mapping geologists.

The biostratigraphic subdivision of the sediments in the Carnic Alps is based on three major intervals recognizable in the evolution of the family Schwagerinidae (Fig. 4). The phylogenetic lineage from *Protriticites*→*Montiparus*→*Rauserites* (characterized by the developing keriothecal wall structure, the gradual loss of tectoria and increasing size of the test) and their coexistence with other fusulinacean genera enables us to establish several faunal assemblages in the lower part of the Auernig Group (DAVYDOV & KRAINER 1999, FORKE & SAMANKASSOU 2000). The upper part of the Auernig Group and the lower part of the Rattendorf Group (Lower *"Pseudoschwagerina"* Limestone, LPL) are dominated by large schwagerinids with irregularly folded septa belonging to the genus *Daixina*. Their test shape tends to change from elongated fusiform species in the Auernig Group to inflated, almost globular species in the LPL, separated as subgenus *Daixina (Bosbytauella)*. Additionally, the first appearance of species of the *Rugosofusulina stabilis* group, of the genera *Rugosochusenella* and *"Occidentoschwagerina"* is characteristic for the LPL (Figs. 4, 5) (KAHLER & KRAINER 1993, FORKE et al. 1998). These genera become widespread in the third interval, and are accompanied by a peculiar fauna of highly inflated Schwagerinidae, probably belonging to several independent lineages (Figs. 4, 6). This third interval comprises the Grenzland Fm., Upper *"Pseudoschwagerina"* Limestone and Trogkofel Limestone.

During the latest Carboniferous and Early Permian (Rattendorf Group) the fusulinaceans underwent a rapid diversification and occupied different ecological niches. Careful examination of all stratigraphic horizons within the sections are necessary to obtain insight into the whole fossil fauna and to establish a refined biozonal scheme. Several faunal assemblages of the three intervals are closely related to specific facies types and the appearance of species and genera then merely depends on changes of the depositional environment.

The next major step in the evolution of the fusulinaceans, with the first appearance of ancestral and early representa-