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, microgranular 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 biohermal 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-

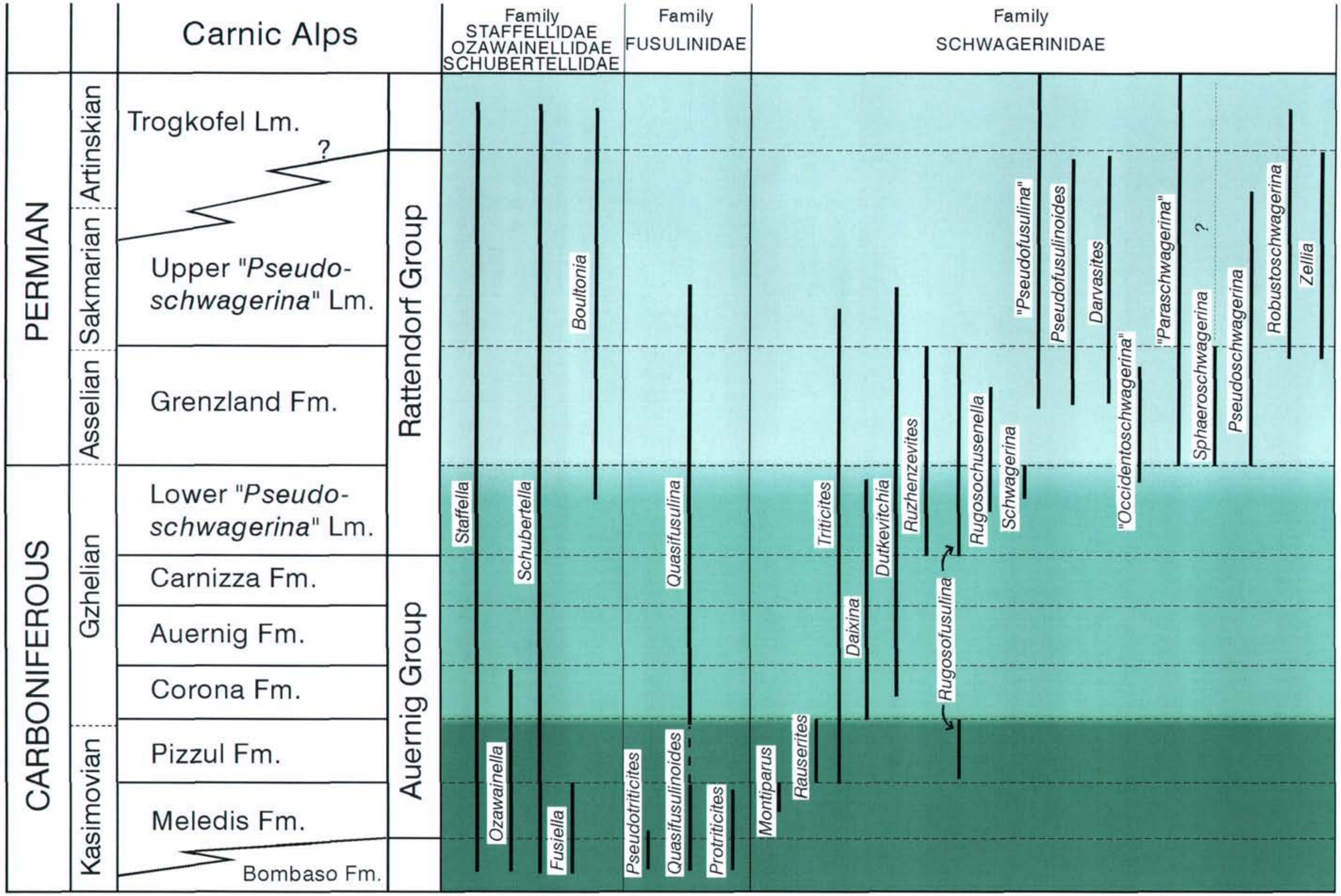

Fig. 4
Ranges of fusulinacean genera in the Upper Carboniferous to Lower Permian sediments of the Carnic Alps, Austria/Italy.

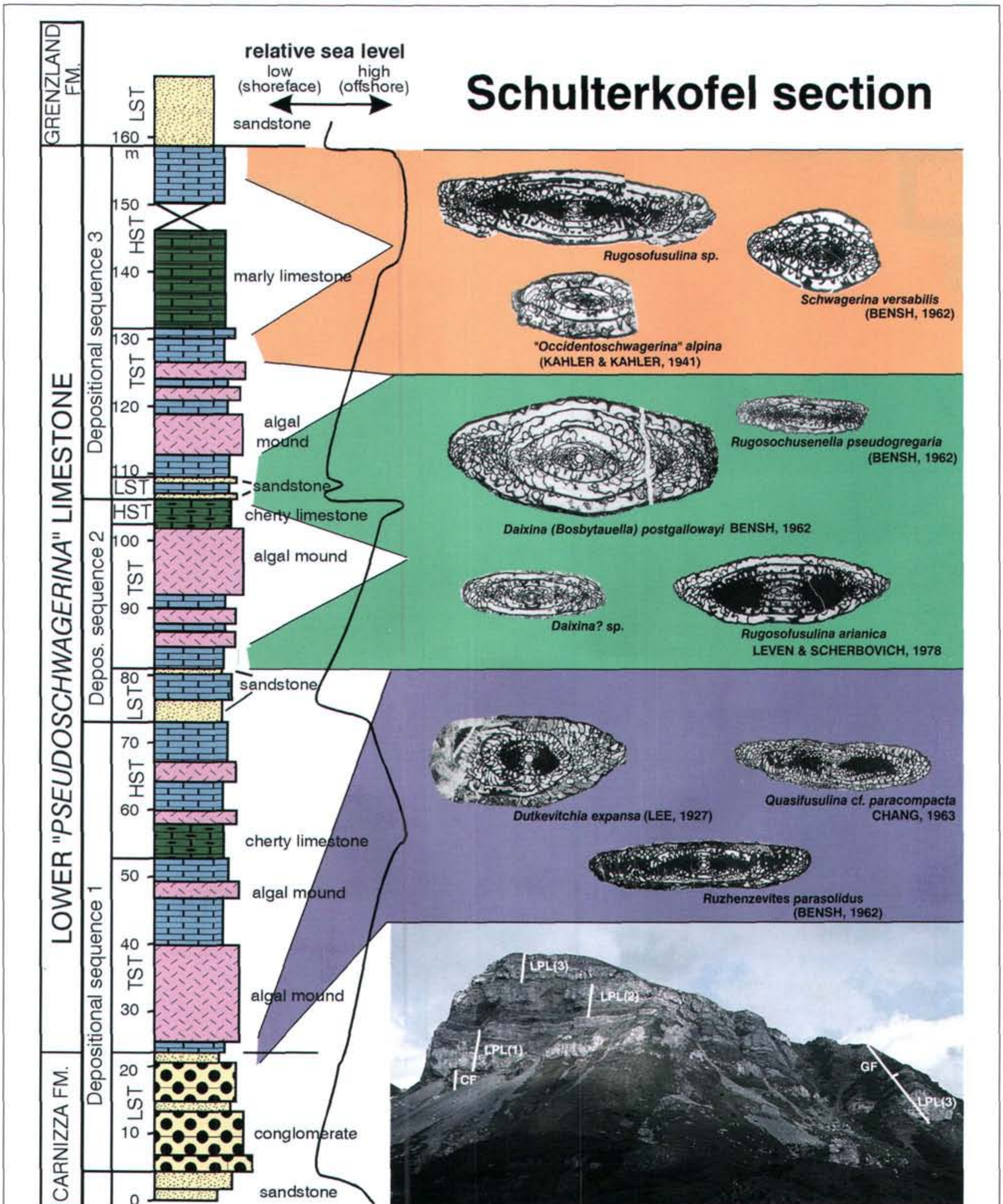

Fig. 5
Distribution of fusulinacean assemblages in the Lower *"Pseudoschwagerina"* Limestone of the Schulterkofel section, Carnic Alps, Austria/ Italy (data from FORKE et al. 1998). HST: highstand systems tract; TST: transgressive systems tract; LST: lowstand systems tract.

tives of the verbeekinid family, can only be traced in the Southern Alps in deposits of isolated outcrops along the Italian border (Goggau Limestone) and boreholes of the Adriatic Sea (SARTORIO & ROZZA 1991).

Palaeogeography

During the Late Carboniferous and Early Permian several palaeobiogeographic provinces developed, depending on how geographic or palaeoclimatic barriers evolved through

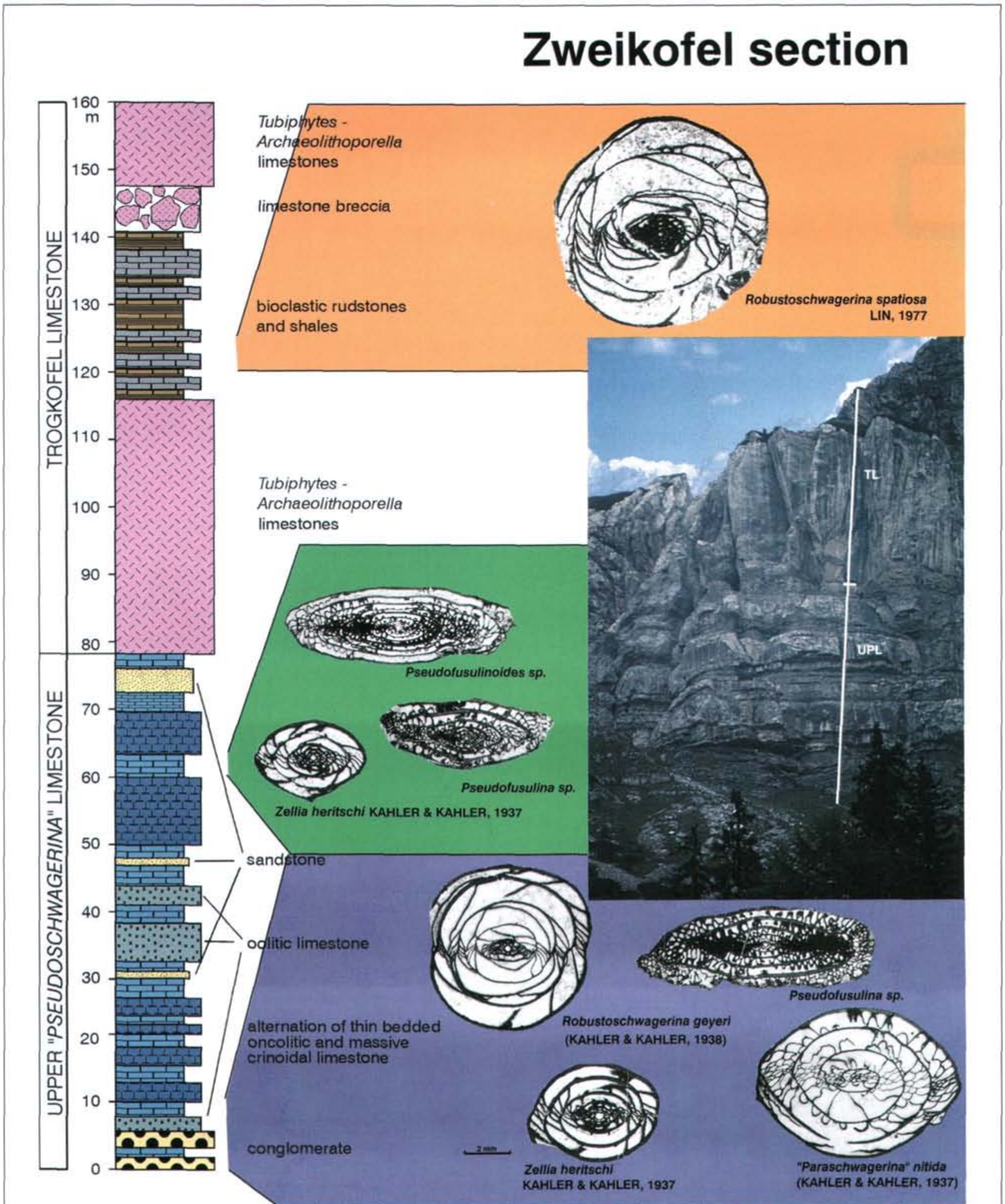

Fig. 6
Distribution of fusulinacean assemblages in the Upper „*Pseudoschwagerina*" Limestone and Trogkofel Limestone of the Zweikofel section, Carnic Alps, Austria.

this time (Fig. 7). The most extensive and complex one is the Palaeotethys Province. The Franklinian and Uralian Province stretches along the western, northern and eastern shelf of the Euramerican craton and is connected with the Palaeotethys Province along the Pre-Urals trough. The third is the Midcontinent-Andean Province, formed by the southern part of North America and the northern parts of South America. A fourth province encloses some displaced ter-

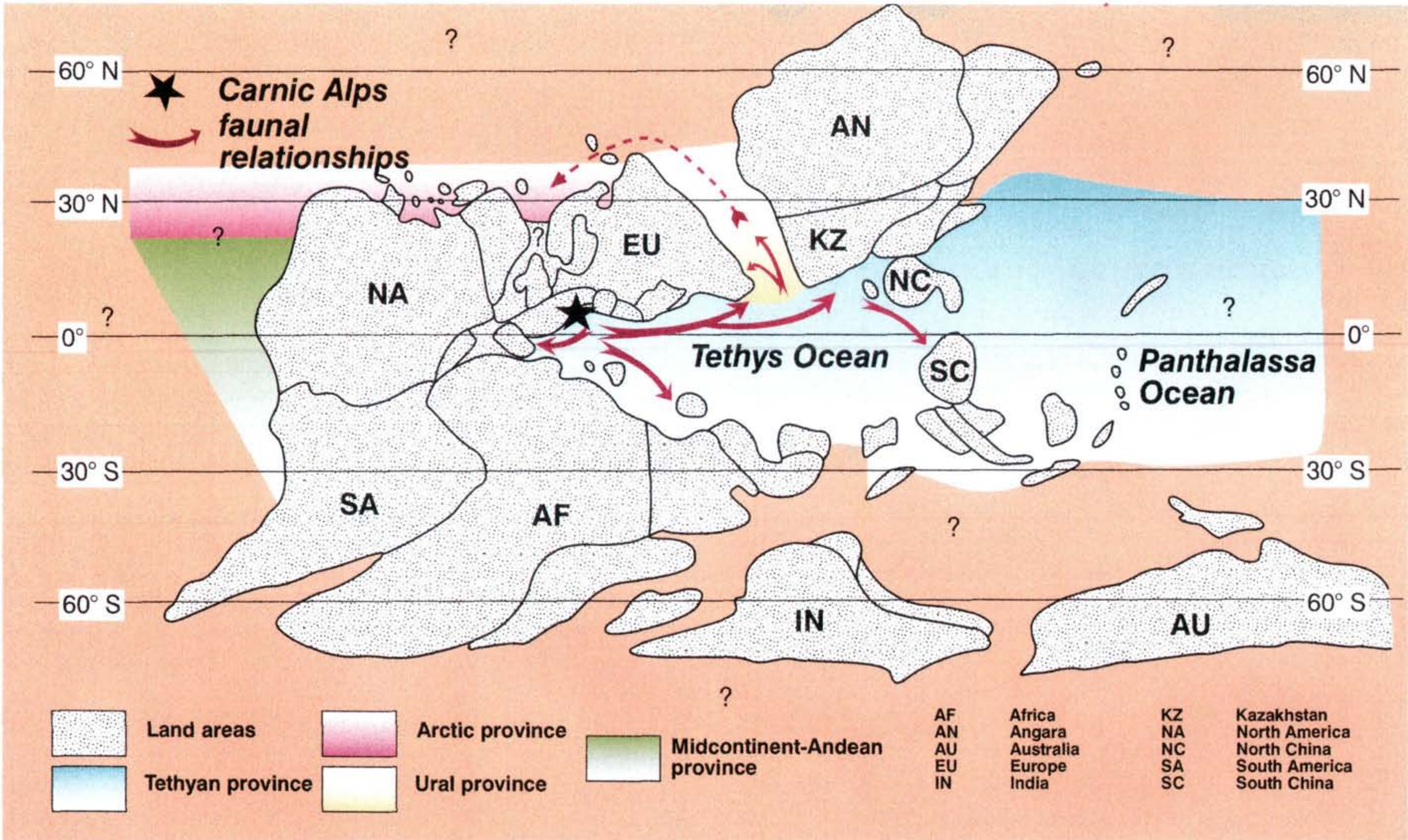

Fig. 7
Palaeogeography of the Late Carboniferous and faunal relationships of fusulinaceans from the Carnic Alps, Austria/Italy.

ranes along western North America, probably located somewhere within Panthalassa during the Late Palaeozoic (ROSS 1967).

The Carnic Alps were situated in the westernmost part of the Palaeotethys Province. The fusulinacean fauna were located in the lower part of the Late Carboniferous strata (Kasimovian) and are closely related to the fauna of the Cantabrian Mountains and Middle Asia (VILLA et al. in press) and, to a lesser degree, also to the fauna of the Russian Platform. During the Gzhelian and Asselian widespread faunas occur, which migrated up to the Northern Urals and Spitsbergen and perhaps even to North America. During the Sakmarian the faunal connections with the Urals ceased. This could have been caused either by the closure of the Pre-Urals trough in the south or by the northward shift of Pangaea. The migration of the fusulinacean faunas from and to the Carnic Alps then becomes restricted to the Palaeotethys.

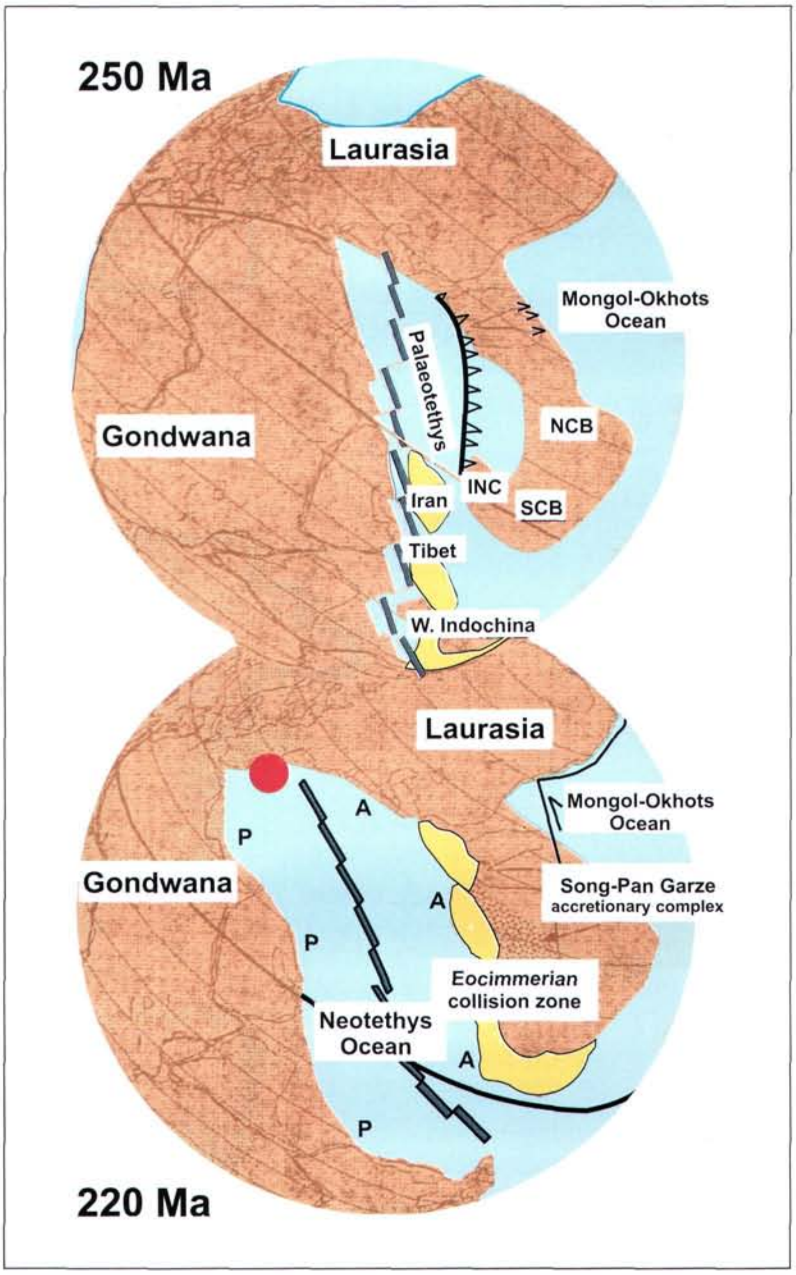

Fig. 8
Palaeogeography of the Tethys during the time slices 250 Million years and 220 Million years b. p. (A = active margin of the Neotethys, P = passive margin of the Neotethys, INC = Indochina block, NCB = North China Block, SCB = South China Block, red dot = approximate position of the Northern Calcareous Alps).

Austria as the World Famous Window to Triassic Tropical Sealife

(LEOPOLD KRYSTYN, WERNER E. PILLER)

Parallel to the collision of the two landmasses of Gondwana and Laurasia in Late Palaeozoic time the Tethys ocean was born as a palaeogeographic, palaeoclimatic and especially palaeobiogeographic entity. When introducing this name in 1893, the great Austrian genius of geology E. SUESS referred primarily to Neumayr's ideas on the "Centrales Mittelmeer" (Central Mediterranean Sea). But one of the major arguments for the Tethys was the astonishing similarity between Austrian and Himalayan Triassic ammonite faunas. However, what was then believed as a continuous oceanic realm between Gondwana and Laurasia from the Palaeozoic till the late Mesozoic is now seen in a very different way. The Permo-Triassic Tethys alone has a remarkable and, for the non-specialised reader, confusing plate tectonic history. Within its proper limits, a so-called Neotethys ocean was created at the expense of the Palaeotethyan one (Fig. 8). New seafloor spreading south of the northdrifting Gondwana-fragmented Cimmerian blocks led to the subduction of the Palaeotethys ocean beneath Laurasia (ŞENGÖR 1984, STAMPFLI et al. 1991). Two fundamentally different Triassic Tethyan margins are the important result of this tectonic history, a narrow active margin to the north and northeast, respectively (= A of Fig. 8) and a wide passive one along the southern and western shore (= P of Fig. 8). According to currently popular reconstructions (DERCOURT et al. 1993, BESSE et al. 1998), the Neotethys ocean extended from less than 25° south of the equator to about 30° north. It had an elongated shape of more than 10,000 km length and about 3,000 km width. During the Triassic, the sea-level reached an all-time low and the earth is generally recognised as having had a warm and extremely arid climate indicated by the extensive deposition of evaporites far from the equator. Uniform tropical conditions therefore prevailed in the Tethys ocean with 25-30 °C sea surface temperatures. Bottom water temperatures must have been well above 10 °C, if the assumption of an island barrier diminishing bottom water exchange between Tethys and Panthalassa ocean is correct. All these points may explain the high degree of faunal similarity, as well as of biotic diversity