Deciphering the Gosau Group – a Challenge for Cretaceous Palaeontology

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The mixed siliciclastic-carbonatic Gosau Group – named after the village Gosau in Upper Austria (Fig. 13) – is renowned for its fossil content all over the world. Monographs on corals by Reuss, Felix and Oppenheim, on bivalves by Zittel, on ammonites by Hauer and Redtenbacher, on gastropods by Zekeli and on vertebrates by Bunzel have contributed to this reputation (KOLLMANN & SUMMESBERGER 1982). On a world wide scale, the spectrum of depositional environments and fossil assemblages render the Gosau Group one of the keys for understanding the relationship among tectonic movements, sedimentology, palaeoecology, evolution and biostratigraphy in the Upper Cretaceous/ Paleogene interval.

The Gosau Group was deposited in extension- and strike-slip controlled depocenters on top of the northern, accretionary margin of the Austroalpine microplate (WAGREICH & FAUPL 1994). The highly fossiliferous Lower Gosau Subgroup (Upper Turonian to Campanian; Fig. 14) consists of terrestrial to deep neritic deposits. The Upper Gosau Subgroup (Santonian to Eocene) is composed of bathyal to abyssal deposits.

The Gosau Realm – a Tethyan-Boreal Transition Area?

During the Late Cretaceous, the area of the Austroalpine tectonic unit was situated at 30-32° N (MAURITSCH & BECKE 1987). This extrapolates to a distance of approximately 1,800 km from its present position, which is about 47° N. It was part of a climatic belt with monsoonal atmospheric circulation (PARRISH & CURTIS 1982, PRICE et al. 1995). Sediments and fossils of the Lower Gosau Subgroup indicate prevalent tropical to sub-tropical, humid to sub-humid atmospheric conditions. Small-scale cycles in non-marine successions record short-term climatic changes.

Gastropod assemblages of the inner shelf shallow water environments of the Lower Gosau Subgroup containing actaeonellid and nerineacean gastropods are typically Tethyan (SOHL 1987, KOLLMANN 1992). The diversity is comparable to other Tethyan occurrences (KOLLMANN et al. 1998). In contrast to this, the rudist fauna, which generally is understood as a Tethyan element, is impoverished, compared to the South Tethyan realm (peri-Adriatic platforms) and the North Tethyan shelves in southern France and in the Pyrenees (SANDERS et al. 1997). Assemblages of the Northern Calcareous Alps are distinguished by a predominance, both in diversity and abundance, of hippuritids over radiolitids. In the Central Alpine Gosau Group, which palaeogeographically was situated during deposition further south, rudist genera and species of South Tethyan affinity are present (KÜHN 1960). Thus, a palaeobiogeographic boundary was intermittently situated in the area of the Austroalpine tectonic unit (SANDERS 1998).

The impoverishment of the rudist assemblages is interpreted as a transitional status between the Tethyan and Boreal realms. This is supported by the benthic foraminiferal assemblages. Carbonate shelf successions of the Lower Gosau Subgroup are characterized by lituolacean, textulariacean and miliolid foraminifera. Compared to penecontemporaneous peri-Adriatic carbonate platforms and those of Southern France and the Pyrenees, benthic foraminiferal assemblages of the Lower Gosau Subgroup are impoverished. Common Tethyan elements (e. g., *Dicyclina, Rhapydionina, Pseudocyclammina, Accordiella, Broeckinella, Spirocyclina*) are absent. Finally, middle shelf and neritic assemblages of foramol composition indicate a co-occurrence of Tethyan and Boreal mollusc taxa (see KOLLMANN 1992, DHONDT 1987, SANDERS et al. 1997, CHRISTENSEN 1997, 1998).

The rich and diverse fauna of planktic foraminifera of the hemipelagic marls of the Upper Gosau Subgroup is Tethyan in its composition (HERM 1962). Nevertheless, rare findings of *Belemnitella* in slope and transitional deposits indicate a migration of boreal elements (CHRISTENSEN 1997) into deep-water environments and therefore a restricted vertical reproduction of realms.

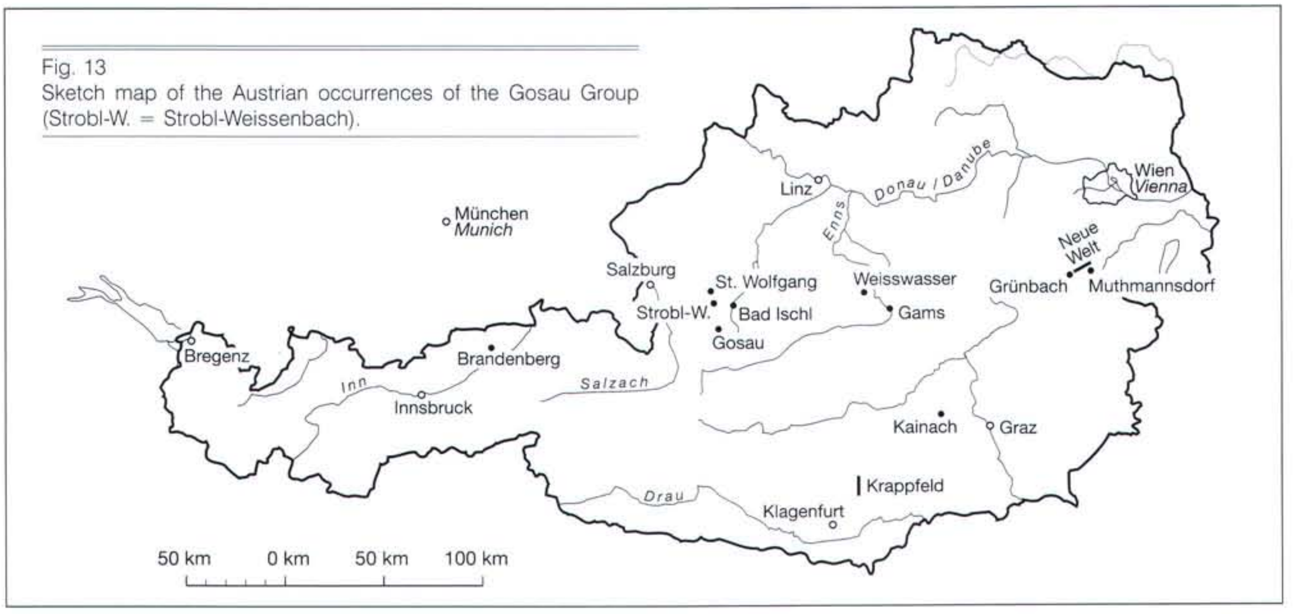
The Lower Gosau Subgroup – a Wealth of Facies

The sequence development during deposition of the Lower Gosau Subgroup was mainly controlled by fault-induced subsidence related to the dynamics of the Alpine accretionary wedge (SANDERS et al. 1997). Its exceptionally wide range of facies and diversity of fossil assemblages (WAGREICH & FAUPL 1994) is due to several factors: The articulated morphology of the older substratum, facies compartmentalization in the terrestrial to marine shelf environment, high rates of both subsidence and sediment accumulation, mixed siliciclastic-carbonate deposition and environmental changes. Patterns of sequence development of the Lower Gosau Subgroup and change of biotic assemblages within a sequence stratigraphic frame have been described by SANDERS et al. (1997). Two shelf types with different depositional history have been distinguished (Fig. 15):

Type A shelves are characteristic of the early development of the Lower Gosau Subgroup, and show little direct evidence for syndepositional faulting. Commonly, they were relatively steep, wave-dominated, with a siliciclastic sedimentation. Mainland beaches and barrier beaches in front of restricted-marine to freshwater marshes (Fig. 15a) or of fan deltas occurred. In open lagoons, nerineids, actaeonellids, radiolitids, sponges, calcareous green algae, miliolid and lituolacean foraminifera thrived. In areas of intermittently reduced siliciclastic input of the inner shelf, coral-rudist mounds and -biostromes accumulated locally. On the outer shelf to upper slope, mainly silts and muds with ammonites, epifaunal and infaunal non-rudist bivalves (inoceramids, nuculaceans) and with planktic and benthic foraminifera were deposited (SANDERS et al. 1997).

Rocky shores and gravelly carbonate beaches developed along transgressive coasts without river deltas or fan deltas. In areas of low siliciclastic input, regressive carbonate shelves developed (Fig. 15b). Their inner shelf facies belt shows a development of skeletal mounds (hermatypic scleractinians, rudists) and rudist biostromes. It is followed landwards by a dissipative shore zone of bioclastic dunes, an open lagoon with rudist biostromes and, at their landward end, narrow microtidal marshes (SANDERS et al. 1997). Biostromes of hippuritids and/or of radiolitids are common

Fig. 13
Sketch map of the Austrian occurrences of the Gosau Group (Strobl-W. = Strobl-Weissenbach).



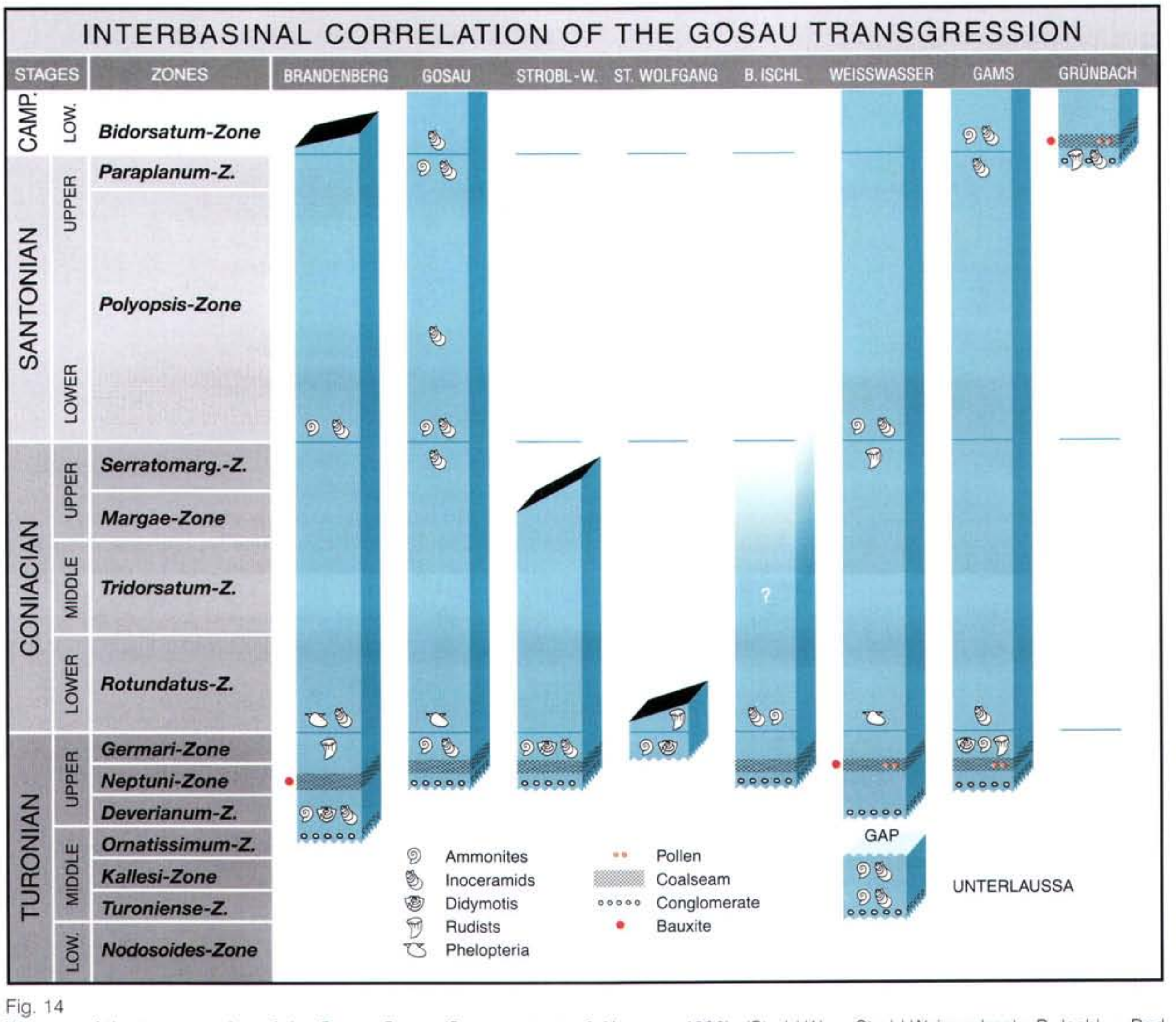


Fig. 14
The age of the transgression of the Gosau Group (SUMMESBERGER & KENNEDY 1996); (Strobl-W. = Strobl-Weissenbach; B. Ischl = Bad Ischl).

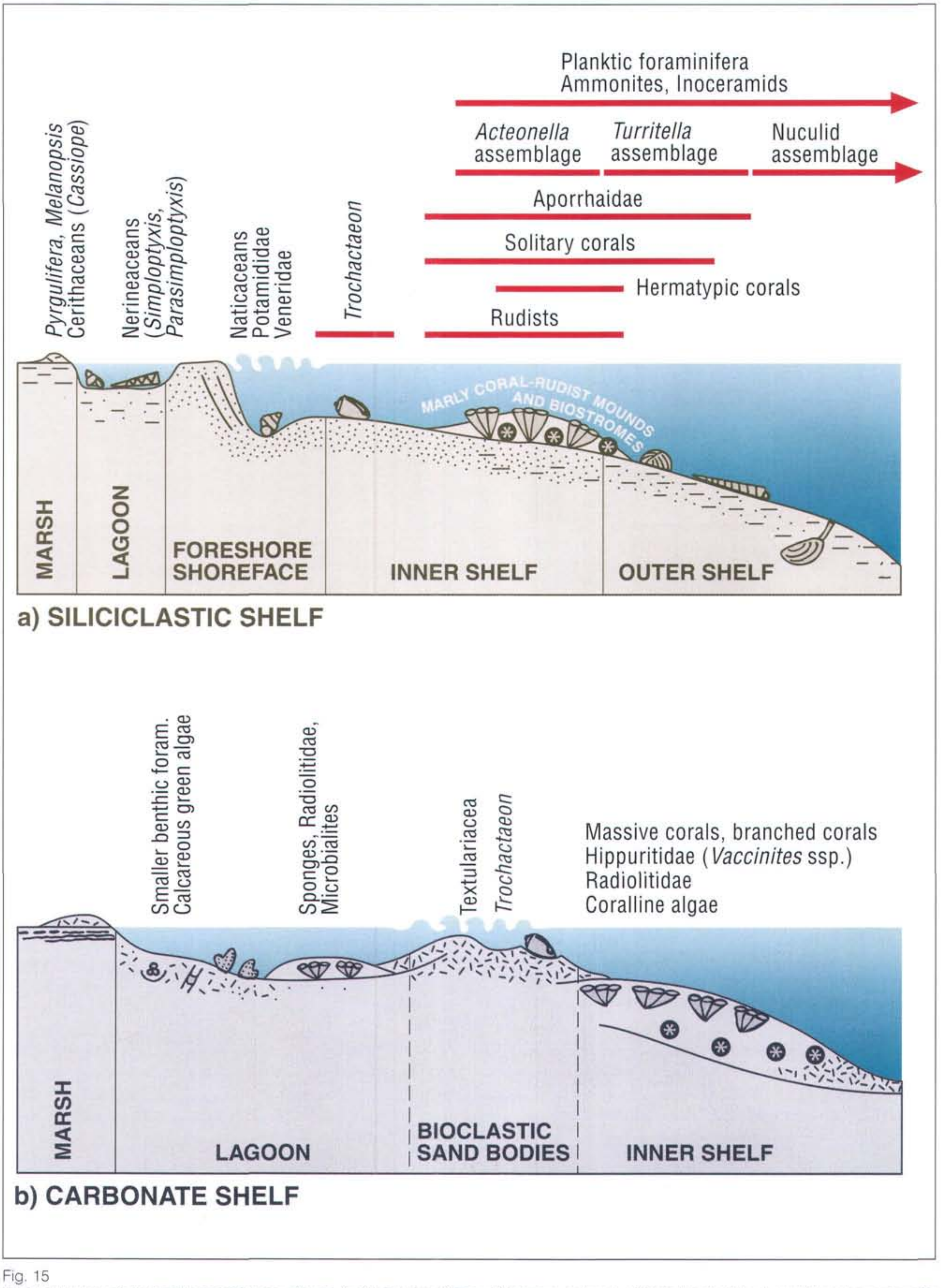
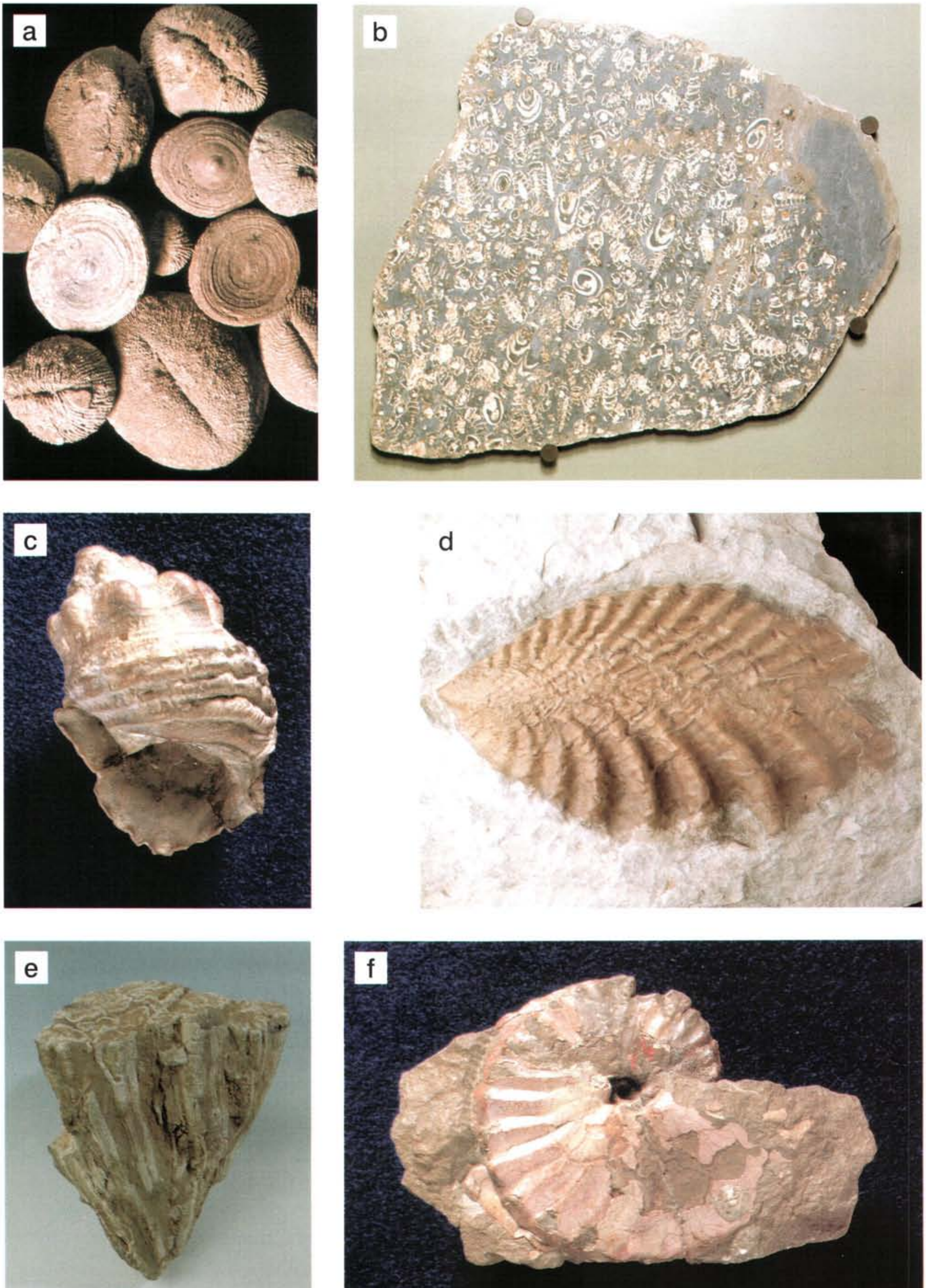


Fig. 15

Reconstruction of the fossil assemblages of type A of the Lower Gosau Subgroup at the a) siliciclastic shelf (top) and b) at the carbonate shelf (bottom) (SANDERS et al. 1997).


a
b
c
d
e
f

both within successions deposited from carbonate shelves and from siliciclastic lagoonal to inner shelf environments (SANDERS & PONS 1999). SANDERS et al. (1999) have further recorded a reef of densely packed, large scleractinians of Santonian age. In the mid to outer shelf environment contemporaneous to the carbonate shelves, mainly siliciclastic silts and muds were deposited.

Assemblages of scleractinian corals are represented by both colonial and solitary forms. Corals are either constituents of biostromes and skeletal mounds to more than 10 meters thick or occur, typically in high abundance as isolated specimens in siltstones to marls that have been deposited in an open lagoonal to inner shelf environment (BEAUVAIS 1982, HÖFLING 1985, BARON-SZABO 1997). The coral assemblages are similar to those of the North Tethyan shelves of southern France and the Pyrenees, as well as to the South Tethyan realm in Slovenia and Serbia (TURNSEK 1997, BEAUVAIS 1982, BARON-SZABO 1997).

Type B shelves (not figured) are characterized by a rocky to gravelly shore. It slopes steeply over a narrow shoreface into a deep, muddy shelf. The shore deposits of these shelves contain abundant fragments of coralline algae, echinoids, branched bryozoans, articulate brachiopods, epibenthic ostreans and lagenid foraminifera. Rudists and particularly hermatypic corals are very rare to absent. Organic-rich, muddy silts to silty muds characterize the deep shelf environment. Fossil assemblages contain infaunal and epifaunal bivalves (nuculids, exogyrids, large flat inoceramids), echinoids, gastropods (naticids, turritellids), ammonites, rare crinoids, both benthic and planktic foraminifera, and siliceous sponges.

Type B shelves developed in late stages of of the Lower Gosau Subgroup. Commonly, they were preceded by subaerial exposure and karstification, faulting and deep erosional truncation. Both the substratum and the successions show direct evidence for syndepositional faulting. Shortly afterwards, a marked acceleration of subsidence led to deposition of the Upper Gosau Subgroup.

The Upper Gosau Subgroup – a Story of Drowning

The Upper Gosau Subgroup consists of deep-water clastics and hemipelagic slope deposits. The boundary towards the Lower Gosau Subgroup is diachronous. The biostratigraphic position of the boundary varies between Upper Santonian and uppermost Campanian within an interval of 12 Ma. It is characterized by an unconformity and a small but significant stratigraphical gap in some basins.

Hemipelagic marls are rich in planktic foraminifera (>90%). They occur together with benthic foraminifera of the upper to middle bathyal zone (FAUPL & WAGREICH 1992). Turbiditic deep water associations were intermittently deposited below the local CCD (WAGREICH & FAUPL 1994). In other localities marly limestones which are rich in planktic foraminifera indicate a depostion above the CCD.

In K/Pg boundary sites within deep water facies of the Gosau group a well-developed boundary clay (PREISINGER et al. 1986, LAHODYNSKY 1988) is present.

The Gosau Group in the Global Network of Biostratigraphy

The fossils of the Gosau Group (see examples in Fig. 16) provide palaeobiogeographical and palaeoecological and biostratigraphic evidence. The most common biomarkers of the outer to middle shelf environments are ammonites, inoceramids, planktic foraminifera and nannoplankton (SUMMESBERGER et al. 1999). Typically, several groups of biomarkers are present. Their biostratigraphic resolution is commonly at biozone to substage level.

Shallow-water carbonates have yielded assemblages of benthic foraminifera and rudists. Initial results in dating the terrestrial to marginal-marine successions of the Lower Gosau Subgroup by means of palynomorphs are promising. They provide good evidence of a Campanian age of the diverse, angiosperm-dominated flora of Grünbach and the dinosaur fauna of Muthmannsdorf both situated in the basin of Neue Welt (Fig. 13; DRAXLER 1997).

← Fig. 16
a) *Cunnolites* sp.; x 0.6. In general, the solitary coral *Cunnolites* is present in monospecific or paucispecific assemblages. Its modern analogue is represented by the genus *Fungia*. – b) Late Cretaceous gastropod mass occurrences of the genera *Nerinea* and *Trochactaeon* occurred in proximal inner shelf environments. Windischgarsten/Upper Austria; x 0.1. – c) *Megalonoda reussi* (HOERNES), Turonian, Gams/Styria; x 0.9. – d) *Cladoceramus undulatoplicatus* ROEMER; Lower Santonian, Brandenberg/Tyrol. Large flat inoceramid bivalves inhabited mud bottoms of the outer shelf. x 0.2. – e) Bouquet of *Hippurites* sp.; *Hippurites* is most commonly subordinate in abundance, but locally is present in paucispecific thickets; x 0.25. – f) *Barroisiceras haberfellneri* (HAUER), the lectotype, Gams/Styria. Late Turonian; x 1. – a) – e) stored at the Museum of Natural History, Vienna; f, stored at the Austrian Geological Survey, Vienna.

Lower Miocene Seacows from Austria

(PETER PERVESLER, REINHARD ROETZEL, DARYL P. DOMNING)

The seacow *Metaxytherium krahuletzi* DEPÉRET, 1895, was a halitheriine dugongid which populated shallow marine areas with seagrasses in the Central Paratethys and adjacent Lower Miocene seas of Europe. With reference to the molar patterns and the size of the tusks this plant-eating mammal was not only feeding on leaves, but also on shallow buried rhizomes of seagrasses and was probably an ecological generalist (DOMNING & PERVESLER in press). The deflection of its rostrum is comparable to that of the bottom-feeding Recent Dugong and indicates the same feeding strategy as for the *Metaxytherium krahuletzi*. The type material and nearly all known specimens have been collected from outcrops in the shallow marine Burgschleinitz Formation of the Eggenburg Bay (Fig. 17) (ABEL 1904, DAXNER-HÖCK 1971, PERVESLER et al. 1995, 1998) and are of Late Eggenburgian age.

Upper Oligocene to Lower Miocene sediments are widespread along the eastern border of the Bohemian Massif in Lower Austria. These sediments are terrestrial to marine in origin and are erosive residuals of a former closed sediment cover on the eroded crystalline basement. Tertiary tectonics (active to the present day) reactivated old fracture systems within the crystalline and created small basins (e.g., Horn Basin, Eggenburg Bay).