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).

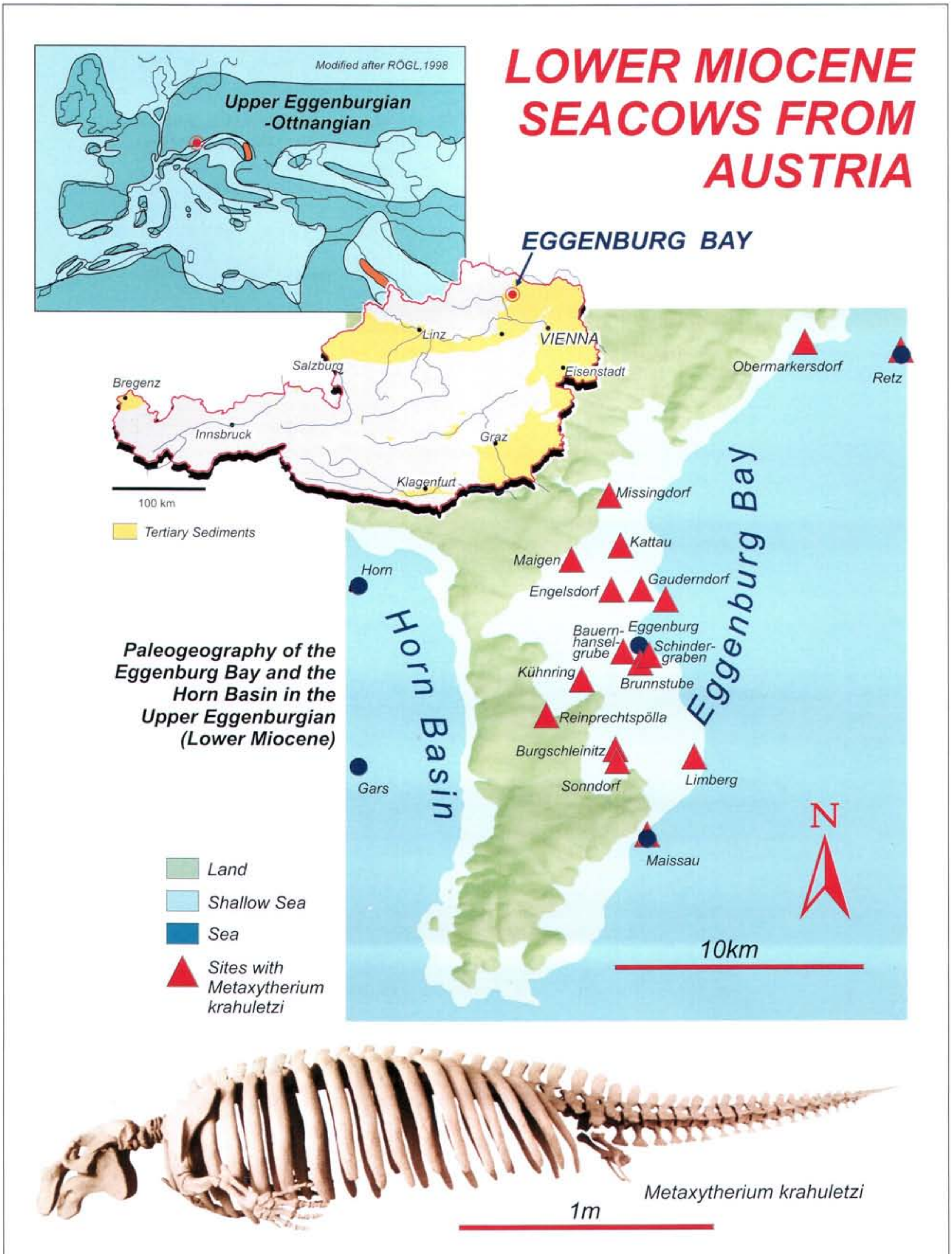

Fig. 17

Skeleton (bottom) and occurrences of Lower Miocene *Metaxytherium krahuletzi* in the Eggenburg Bay and palaeogeographic reconstruction of the Mediterranenan and Paratethys (top).

The Burgschleinitz Formation consists of alternating, poorly sorted medium to fine sands with intercalated gravels. Sedimentary structures such as cross-bedding, lamination and current ripples, as well as typical molluscs and trace-fossils of the *Ophiomorpha* type indicate deposition in intertidal to shallow subtidal areas. Frequent coquinas, escape structures, hummocky cross-stratification and crystalline block layers, mostly containing bones of vertebrates, can be interpreted as the result of heavy storm events. The sediments of the Burgschleinitz Formation are primarily the result of a wave dominated, storm influenced shallow marine facies deposited in bays sheltered by islands formed of crystalline rock.

The Burgschleinitz Formation in the Kühnring sandpit consists of silty medium to fine sands deposited in the shallow marine sublittoral environment of a narrow bay open to the northwest. The foraminifera and molluscs in these sands are typical settlers on marine sandbottoms with seagrass. The top of this formation is a coarse clastic facies with bones of *Metaxytherium krahuletzi, Schizodelphis sulcatus, Brachyodus onoideus, Tapirus* sp. and teeth of crocodiles, breams and sharks like *Carcharocles megalodon* (DOMNING & PERVESLER in press, PERVESLER et al. 1995, 1998). Lithology of the inverse graded coarse layer at the base of a coarse clastic facies shows all the characteristics of a debris flow. This sediment body slid from the crystalline elevation into the shallow marine bay and probably filled an area of 60,000 m^2 with a 0.7 to 2.3 m thick layer, deplanating the relief. The debris flow integrated crystalline components from the near hinterland, as well as better reworked sediment portions and molluscs from the shallow marine areas. The top of the debris flow is covered with crystalline slabs 10 to 50 cm in diameter, occasionally up to 80 cm. Several more or less articulated skeletons of the seacow *Metaxytherium krahuletzi* (five adults and two juveniles) were found anchored by the crystalline slabs upon this debris flow. The fact that all sirenian bones were deposited exclusively on the debris flow proves that the animals belonged to the same population and died coincidentally.

Shallow marine sediments of the Burgschleinitz Formation in the old sandpits near Sonndorf contain two distinct layers with *Metaxytherium krahuletzi* bones. The lower bone layer is intercalated into a mollusc-shell-layer consisting of subtidal molluscs and also contains fossils of cirripeds, decapods, sharks, rays and fishes (Osteichthyes). The seacow specimens of this layer are more or less isolated bones belonging to *Metaxytherium krahuletzi*. The base of the upper bone layer is a mollusc-shell-layer with molluscs from the intertidal. The bone layer itself contains not only seacows, but also bones of *Brachyodus* and turtles and the teeth of sharks, rays and braces. The *Metaxytherium krahuletzi* remains, mostly ribs and vertebrae, but also skull fragments from adult and juvenile individuals, are dispersed over the horizon with no evidence of any articulation.

The *Metaxytherium krahuletzi* bone layers in the Eggenburg Bay seem to derive from mass mortality events and are always connected with increasing hydrodynamic energy in shallow marine nearshore depositional areas (deeper intertidal or shallow subtidal). Heavy storm events could have caused the death of these herbivorous animals by damaging their food resource.

Oberdorf N Voitsberg (Styria, Austria) – a Key Section in the Vegetation History of Early Miocene European Continental Deposits (JOHANNA KOVAR-EDER)

The Köflach-Voitsberg lignite area is situated at the northwesternmost margin of the Styrian Basin, 30 km W of Graz (Fig. 18). Oberdorf, the last Austrian opencast mine in operation, was subject to detailed, joint geoscientific investigations. The basin fill there has a thickness of about 300 m and is part of the Köflach/Voitsberg Formation (Fig. 18d). According to the sedimentological results, the deposits are exclusively of fluvial/lacustrine origin (HAAS 1998, 1999). The largely xylo-detritic and detrito-xylitic main seam of about 30 m thickness originated in a non-marine lowmoor (KOLCON & SACHSENHOFER 1998, 1999). Vertebrate assemblages at roughly 100-105 m have been dated to the Early Miocene, Ottnangian (Central Paratethys stage), MN 4 (Neogene mammal zone). The polarity change 13 m above the main seam was therefore correlated to C5Dr/C5Dn of the Geomagnetic Polarity Time Scale, 17.6 M.a. (DAXNER-HÖCK et al. 1998, MAURITSCH & SCHOLGER 1998). A tuffite at the base of the main seam can probably be correlated to the "Lower Rhyolite Tuffs" in the Pannonian Basin, indicating a (Late) Eggenburgian/Early Ottnangian age of this part of the sequence (HAAS 1999).

Assemblages of dispersed plant organs (leaves, fruits/seeds, and pollen/spores) were preserved in different parts of the sequence. The detailed palaeoenvironmental reconstruction is partly based on the systematic evaluation of the plant assemblages at all fossiliferous levels (HAAS et al. 1998).

A number of plant species have never been described before, e.g., some members of the tea family (KOVAR-EDER & MELLER 2000). Others are reported from Austria for the first time, e.g., *Magnolia liblarensis* (magnolia), *Cephalotaxus* (plum-pine), several laurel species and *Viola* (violet).

In the case of certain woody plants such as *Trigonobalanopsis* (beech family) and *Cercidiphyllum* (Katsura), vegetative and reproductive organs are preserved.

In the sediments at the base of the main seam, *Trigonobalanopsis* is best represented by leaves, cupules and pollen (KOVAR-EDER et al. 1998a, MELLER et al. 1999). These evergreen trees were probably common in the species-diverse hinterland forests.

Mass occurrences of *Cercidiphyllum* (KATSURA) leaves are bound to the hanging wall sediments, where they are frequently associated with fruits (Fig. 19a, c). Even fragments of twigs with adherent short shoots have been discovered in the fossil state for the first time (Fig. 19b); pollen grains of *Cercidiphyllum* have also been determined (KOVAR-EDER et al. 1998b).

The plant assemblage from the tuffite at the base of the main seam partly resulted from a volcanic eruption that coincided with the season in which many woody plants were flowering; deciduous ones were leafless or in the state of opening their buds; fruits and seeds had not yet developed. Buds/bud scales, lumps of immature pollen and leaves of evergreen woody species were stripped off their mother plants and quickly deposited in a backswamp together with ash and lapilli. Other plant material already accumulated in the backswamp previous to the tephra fall out (KOVAR-EDER et al. a, submitted; Fig. 20).