Badenian (Middle Miocene) Ecosystems

(WERNER E. PILLER, MATHIAS HARZHAUSER)

The Vienna Basin, located between the Eastern Alps, the West Carpathians and the western part of the Pannonian Basin (Fig. 22), is embedded in the very complex tectonic evolution of the east Alpine area (DECKER 1996, DECKER & PERESSON 1996) and represents one of the best studied pull-apart basins of the world (ROYDEN 1985, 1988, WESSELY 1988). Besides its importance from a tectonic point of view the Vienna Basin was – similar to other European Tertiary Basins (e.g., Paris Basin, London Basin, Mainz Basin) – the focus of early geological studies particulaly due to its rich fossil content (e.g., STÜTZ 1807, PREVOST 1820, SUESS 1885, SCHAFFER 1907). Another important aspect, which distinctly enhanced our stratigraphic, sedimentologic and tectonic knowledge involved the large hydrocarbon reservoirs, which were explored during the last 60 years.

The Vienna Basin is part of the Paratethys, which formed together with the Mediterranean Sea after the disappearance of the Tethys ocean (see STEININGER & WESSELY, this volume). Due to its isolated position for most of the time a regional stratigraphic stage system different from that of the Mediterranean had to be established (e. g., RÖGL & STEININGER 1983, SENES & STEININGER 1985, STEININGER et al. 1988, 1990, RÖGL 1998).

The pull-apart mechanism became active during the Karpatian (STEININGER et al. 1986, SEIFERT 1992, DECKER 1996). Older sediments (Eggenburgian – Ottnangian) at the base of the northern part of the Vienna Basin belong to an earlier piggy-back basin of the Molasse cycle (STEININGER et al. 1986, PILLER et al. 1996, DECKER 1996). Between the Karpatian and Pannonian (comp. Fig. 1) the subsidence in the central Vienna Basin reached up to 5.5 km (WESSELY et al. 1993). The interplay of highly active synsedimentary tectonics with rapid changing trans- and regression cycles (RÖGL & STEININGER 1983, RÖGL 1998) produced a complex facial pattern inside the basin, depending on distance from land and on position of particular tectonic blocks.

The basement of the basin is built by those Alpine-Carpathian nappes bordering the basin on the surface (comp. block diagram in Figs. 23-25). The Neogene sediment fill of the basin reaches a thickness of up to 6,000 m. At the base mainly clastic sediments are developed representing fluvial facies. A fully marine development over the entire basin was established only in the Early Badenian (Lower Lagenid Zone). These sediments consist not only of clastics, but also carbonates were deposited. This facial development with local coral reefs and widespread coralline algal limestones is restricted to the Badenian since during the Sarmatian a reduction in salinity and/or increase in alkalinity (RÖGL

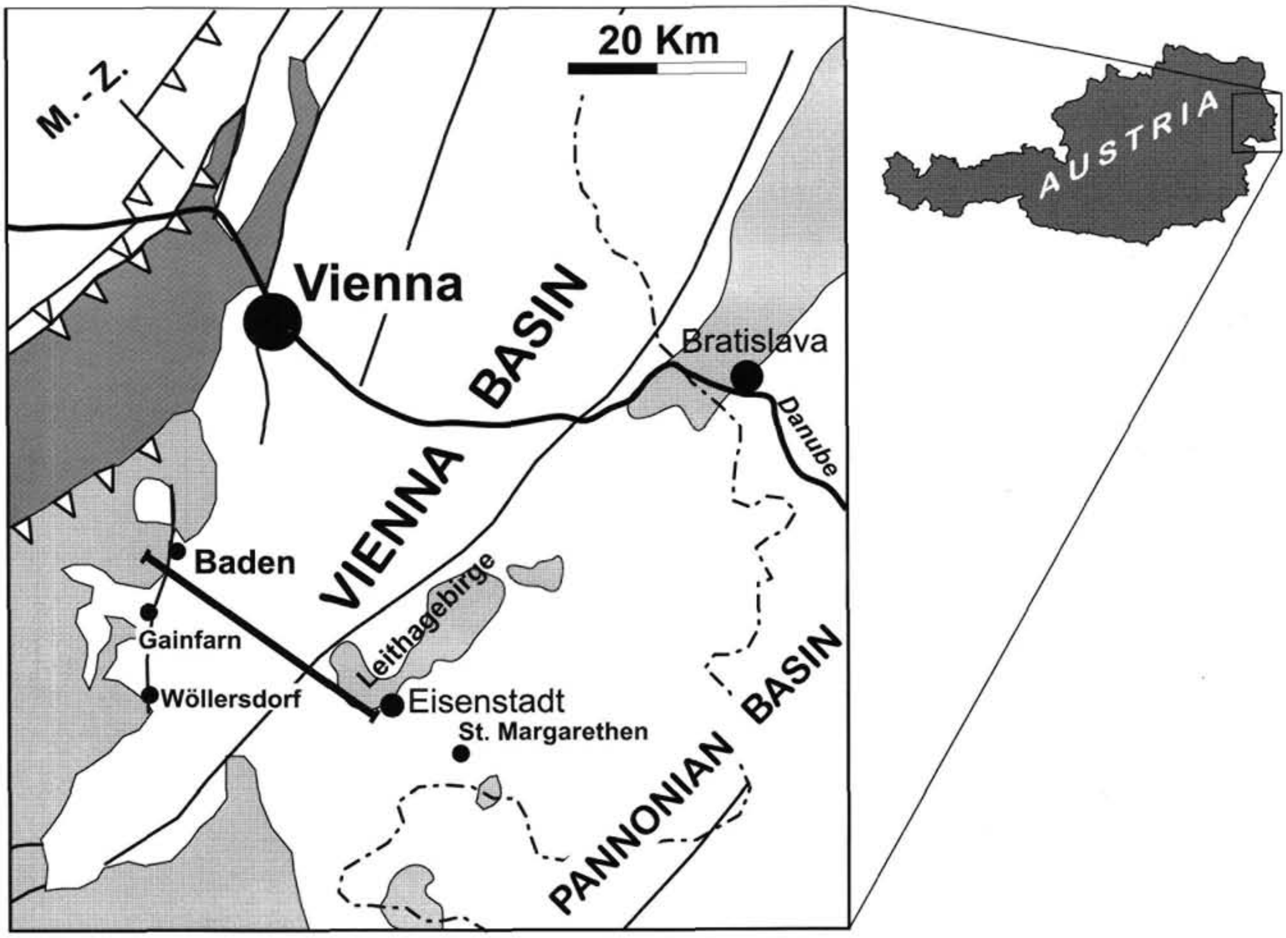

Fig. 22
Location map and highly simplified tectonic structures of the southern Vienna Basin and western Pannonian Basin. The shaded areas framing the basin are part of the Alpine – Carpathian nappe systems. M.-Z.: Molasse Zone. The black line between S' Baden and Eisenstadt marks the section shown in the block diagram of Figs. 23-25.

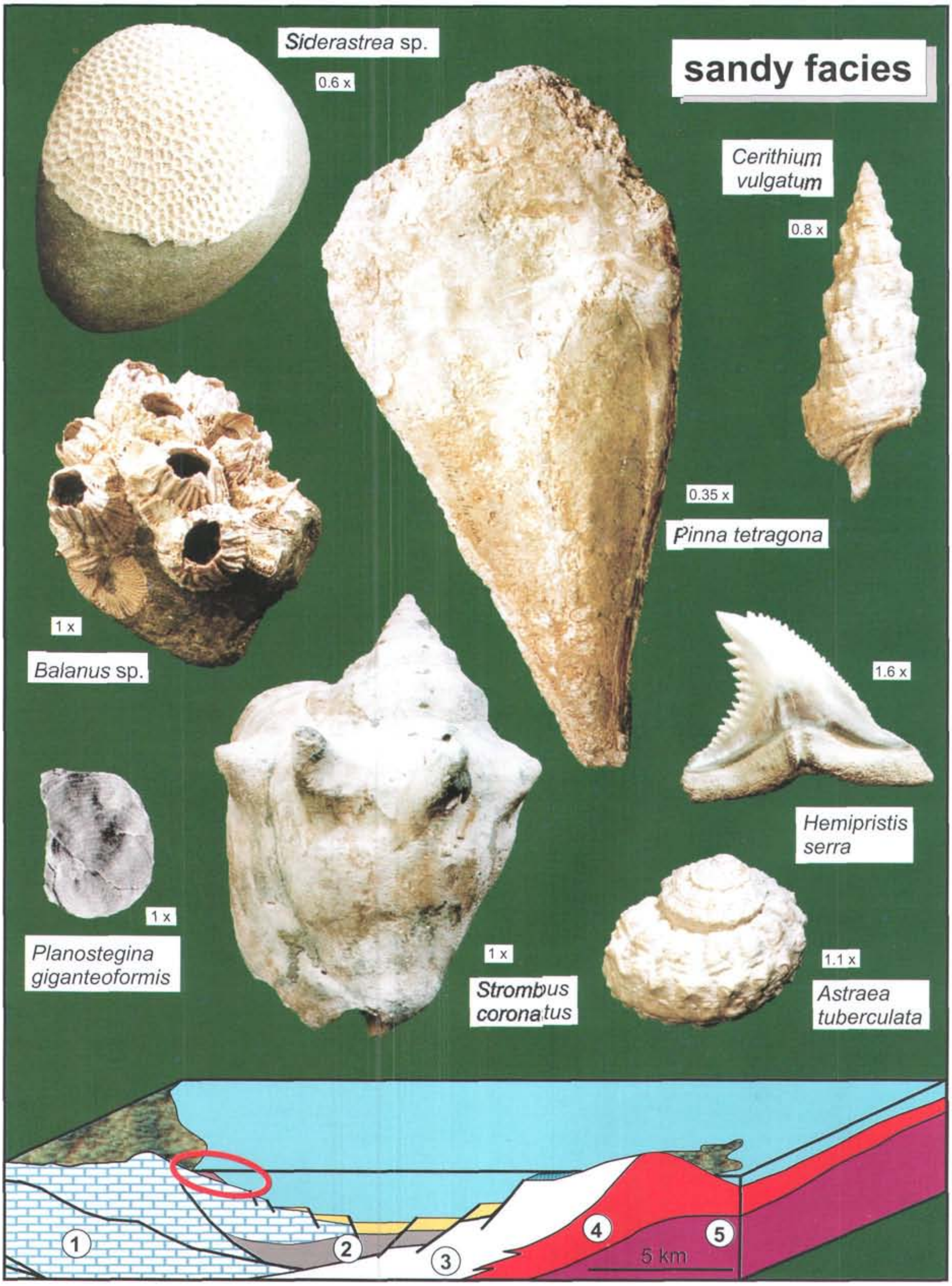

Fig. 23
Typical Badenian biota of the sandy facies (Gainfarn Sands), particularly of the western margin of the Vienna Basin (red ellipsis in the basal block diagram of figure). The front face of the block diagram represents the section between S' Baden and Eisenstadt (marked in Fig. 22) and is a reconstruction of the Vienna Basin during the Badenian after KOLLMANN et al. (1982). The Miocene sediments are shown in yellow (central basin), light blue (Leitha Limestone at the western flank of the Leithagebirge) and pink (sandy facies along the western margin – red ellipsis). All other signatures represent rocks of the Alpine – Carpathian nappe systems forming the basement of the basin (1: Northern Calcareous Alps, 2: Greywacke Zone, 3: Mesozoic of the Central Alps, 4: Crystalline of the Central Alps, 5: Crystalline of the Carpathians).

1998) already started leading to non-marine and subsequently continental conditions in the Pannonian – Pontian. Although tectonic subsidence was high, the basin was rapidly filled due to the short distance to the source of clastic sediments; the basin cycle is therefore limited to the Middle Miocene.

The general biostratigraphic subdivision (PAPP et al. 1978) into Lower Badenian (Lower and Upper Lagenid Zone), Middle Badenian (*Spiroplectammina* Zone) and Upper Badenian (*Bulimina-Bolivina* Zone, *Rotalia* Zone) is based on typical foraminiferal assemblages, reflecting in fact an ecostratigraphic sequence. This sequence documents a salinity reduction in the uppermost Badenian. The zonal scheme works well in central basinal sections, in marginal positions, however, reliability is limited. Besides these assemblages, planktic foraminifers and certain benthic groups are also of special importance, e.g., uvigerinids, bolivinids and to some extent calcareous nannoplankton (e.g., STEININGER 1977, FUCHS & STRADNER 1977, PAPP et al. 1978, HAUNOLD 1995).

Due to the major marine transgression at the beginning of the Middle Miocene (RÖGL & STEININGER 1983, 1984, RÖGL 1998), subtropical biotas entered the Paratethys. Within the Vienna Basin, facial and biotic development roughly reflects a distinction between marginal and central basin facies.

The most complex facies pattern is developed along the basin margins in dependence on the hinterland and coastal morphology. In general, siliciclastics and carbonates can be differentiated, both exhibiting a rich facial and biotic diversity. The western border of the southern Vienna Basin is highly influenced by the clastic sediment input from the Northern Calcareous Alps. Around the Leithagebirge (Fig. 22), which was an island, a chain of islands or a shoal during the Badenian, autochthonous carbonate sediments dominate (irrespective of sometimes thick basal transgressive deposits).

The coastal development along the western margin shows strong fluvial influx at some locations, expressed by thick conglomerates dominated by material derived from the Northern Calcareous Alps as well as the Flysch Zone. The conglomerates and their components sometimes contain biota such as pebble-incrusting coralline algae, oysters, balanids and corals (Fig. 23). In some places, steep rocky shores with large boulders are also preserved, exhibiting dense settlement by boring bivalves. Wide coastal or marginal areas are covered by sands (Gainfarn Sands) with a rich and excellently preserved fauna (Fig. 23) dominated by molluscs such as *Cerithium, Xenophora, Pinna* and *Strombus*, partly reflecting sea-grass settlement. The soft bottom of the sandflats was inhabited by a vast number of venerids, glycymerids and the index fossil *Megacardita jouanetti* (BASTEROT). Conids and turritellids are represented in exceptional diversity and proper preservation has even allowed for the reconstruction of a fossil symbiosis between hydractinians and hermit crabs.

The basinal facies, the Baden Tegel, is a marl with variable sand and clay content. Intercalated into the marls are sandy layers. This latter material is gravitationally transported from marginal sources. The marls and sandy interbeddings are highly fossiliferous, containing extremely rich microfauna (foraminifers, ostracods) and macrofauna, as well as calcareous nannoplankton. Both micro- and macrofauna have been well-documented since the 19th century (e.g., D'ORBIGNY 1846, REUSS 1849, KARRER 1861, HÖRNES 1856, 1870, HÖRNES & AUINGER 1879). Macrofossils are represented by solitary scleractinians, brachiopods, decapod crustaceans, molluscs, fish remains (teeth and otoliths) and cetaceans. In the sediments of the Lower Badenian the foraminiferal fauna is extremely rich, containing not only planktic and smaller benthic representatives but in the sandy interbeddings also larger forms as *Amphistegina, Planostegina* and *Borelis melo*. The high diversity and good preservation of molluscs (gastropods, bivalves, scaphopods; Fig. 24) is remarkable. Their composition is strongly predominated by Turridae and other carnivorous snails associated with infaunal bivalves and thin-shelled pectinids and reflects soft-bottom communities in deeper circumlittoral environments. A marked decrease in herbivorous forms probably indicates a reduction in light-intensity. In these habitats of weak agitation and fine sedimentation muricids display remarkable fragile ornamentations. The depositional depth of this fine-clastic material can be interpreted as being not deeper than 50-200 m (PAPP & STEININGER in: PAPP et al. 1978, TOLLMANN 1985). Although subsidence of the basin during the Badenian was very rapid, the relatively shallow water depth can be explained by a high sedimentation rate leading to a sediment accumulation of approx. 1,500 m in the central basin during the Badenian (e.g., WESSELY 1988).

The most widespread facies unit along the Leithagebirge and the Ruster Höhenzug, as well as at certain sites along the western margins of the Vienna Basin with reduced terrigenous input (e.g., around Wöllersdorf), is the Leitha Limestone. The name of this unit was already established by KEFERSTEIN (1828) and is also well-known outside the Vienna Basin. The unit was redefined by PAPP & STEININGER in: PAPP et al. (1978), who considered the broad facial range. Due to its high abundance of coralline red algae (Fig. 25), this Leitha Limestone is also well-known as *Nullipora* or *Lithothamnium* Limestone. The first description of a fossil coralline red algae out of this limestone – *Nullipora ramosissima* REUSS 1847 – is historically important. The original material of this taxon was recently rediscovered and the species was assigned to the genus *Lithothamnion* (PILLER 1994). In general, the limestone is characterized by the occurrence of coralline algae in various growth forms (Fig. 25), ranging from rhodolith dominated types to branched facies (maërl). Coral buildups of limited size are developed only locally. Such buildups are rare along the western margin of the Vienna Basin due to the high terrigenous input and are represented only by small patch reefs. The best-developed coral buildups are present at the southern tip of the Leithagebirge, where the limestones reach the greatest spatial extent and the thickest sequences (about 50 m). Due to the island position no major terrigenous influx restricted coral growth here. Particularly at the southern tip of the Leithagebirge water currents or relatively strong waves favoured their growth. The corals are represented mainly by various taxa of *Porites*, accompanied by *Tarbellastraea*, *Caulastrea*, *Acanthastrea* and *Stylocora* (PILLER & KLEEMANN 1991) (Fig. 25).

Additionally, typical faunal elements of the Leitha Limestone are thick-shelled bivalves such as *Macrochlamis nodosiformis* (SERRES) and ostreids, forming beds up to five meters thick. Among echinoids infaunal clypeasterids, which lived shallowly burrowed in the loose algae debris are

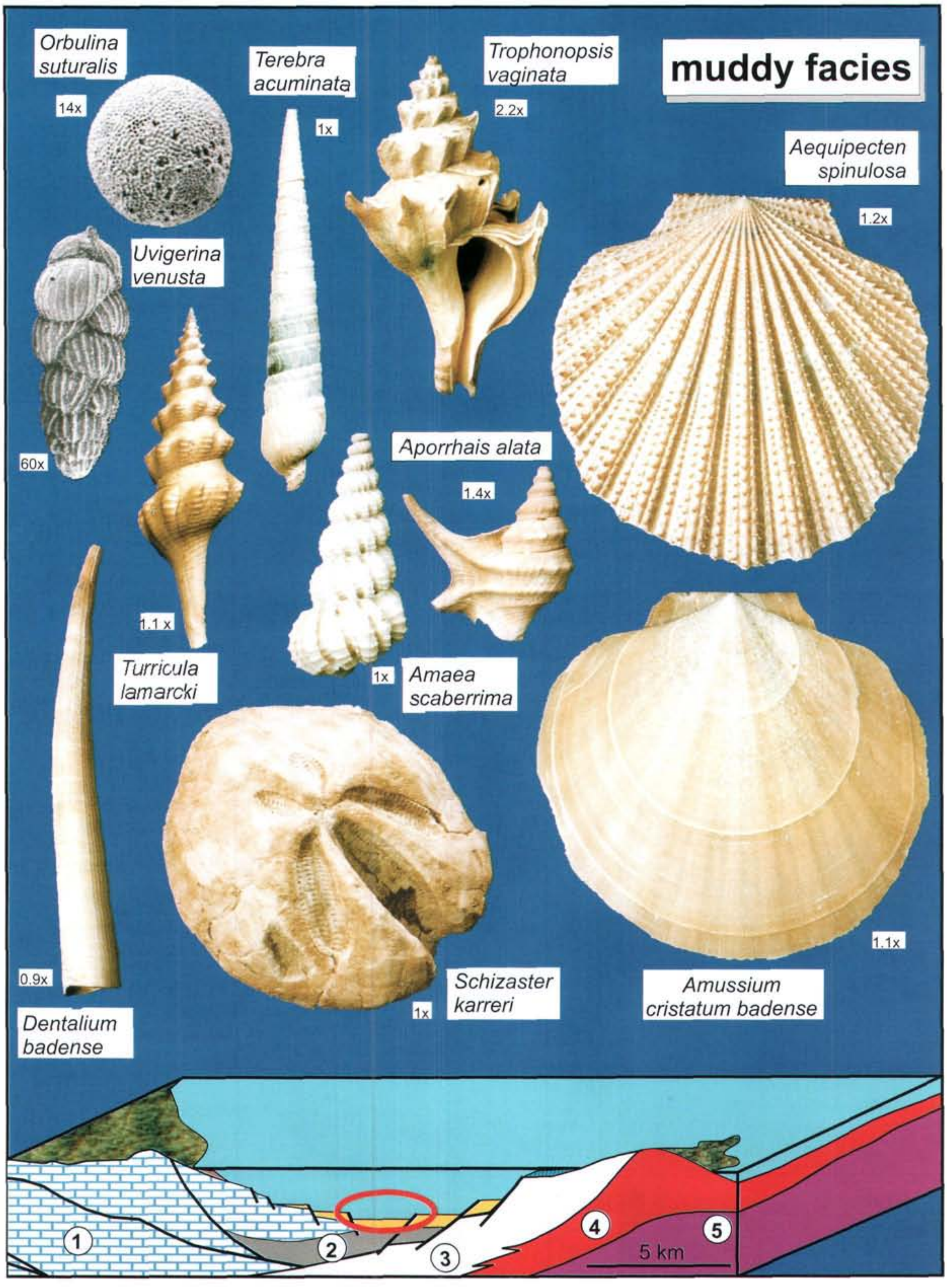

Fig. 24
Typical Badenian biota of the muddy facies (Baden Tegel) of central basinal sediments (red ellipsis in the basal block diagram of figure). For further explanations see Fig. 23.

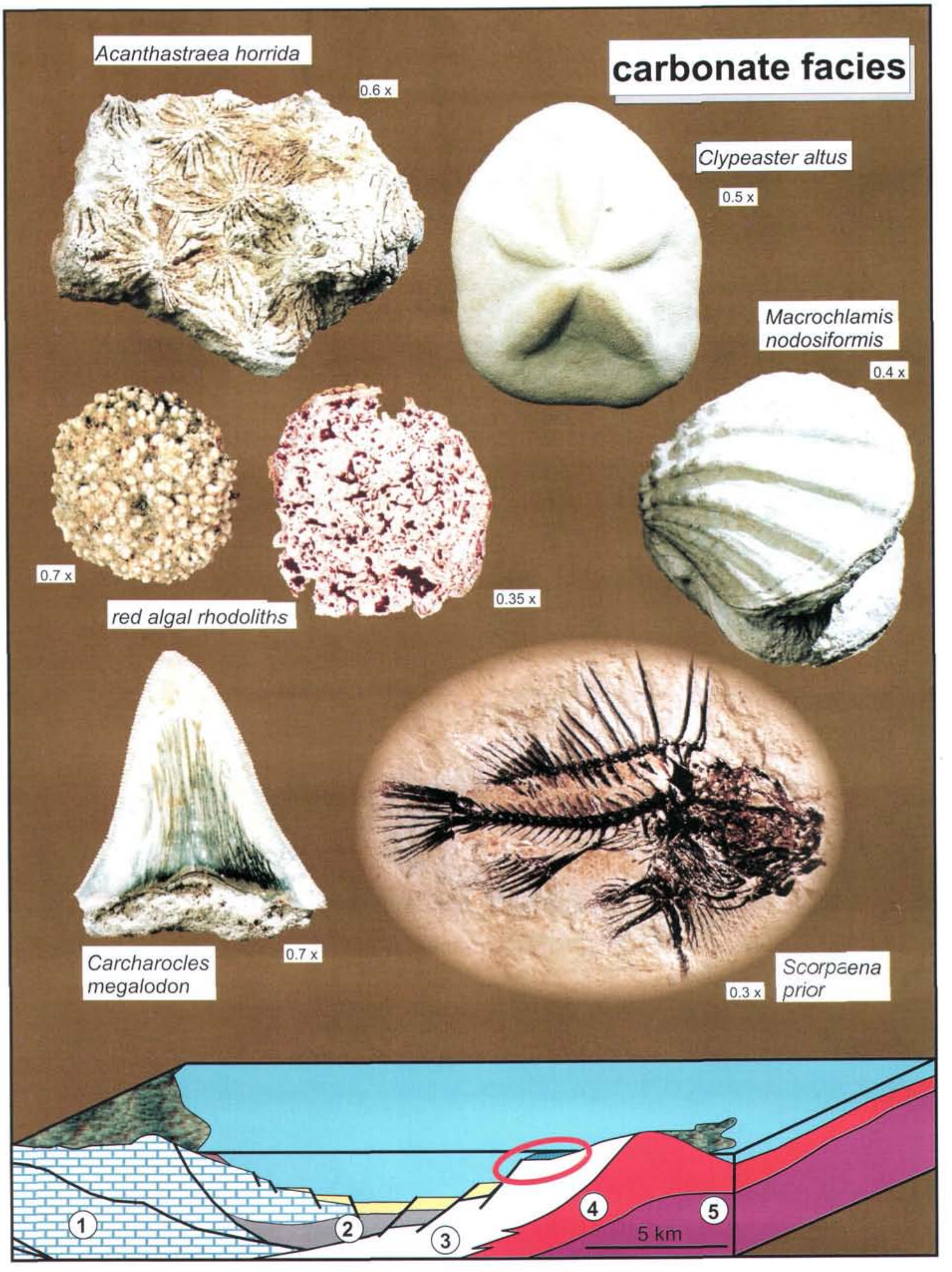

Fig. 25
Typical Badenian biota of the carbonate facies (Leitha Limestone), particularly at the western margin of the Leithagebirge (red ellipsis in the basal block diagram of figure). For further explanations see Fig. 23.

common, as well as large shark remains (Fig. 25) and crustaceans (BACHMAYER & TOLLMANN 1953).

An exceptional "Fossillagerstätte" occurs at St. Margarethen in Burgenland (Fig. 22), where an excellently preserved fish fauna occurs (SCHULTZ 1993, CHANET & SCHULTZ 1994) in fine-grained, partly laminated, marly limestones. Besides scorpenids (Fig. 25), the oldest known parrot fish is also recorded from here (BELLWOOD & SCHULTZ 1991). The depositional environment was recently interpreted as very shallow marine, partly representing a flooded intertidal flat (PILLER et al. 1996).

Miocene Primates from Austria

(GUDRUN DAXNER-HÖCK)

Catarrhine primates came from Africa and appeared for the first time in Europe at the end of the Early Miocene. They had a wide distribution across Western and Central Europe and Southwest Asia during the Middle and Late Miocene.

In Austria their existence has been demonstrated in the Molasse Zone in Upper and Lower Austria, as well as from the Vienna basin northeast and southeast of Vienna, and in the "Lavanttal" (Carinthia) and Aflenz Basin (Styria), which

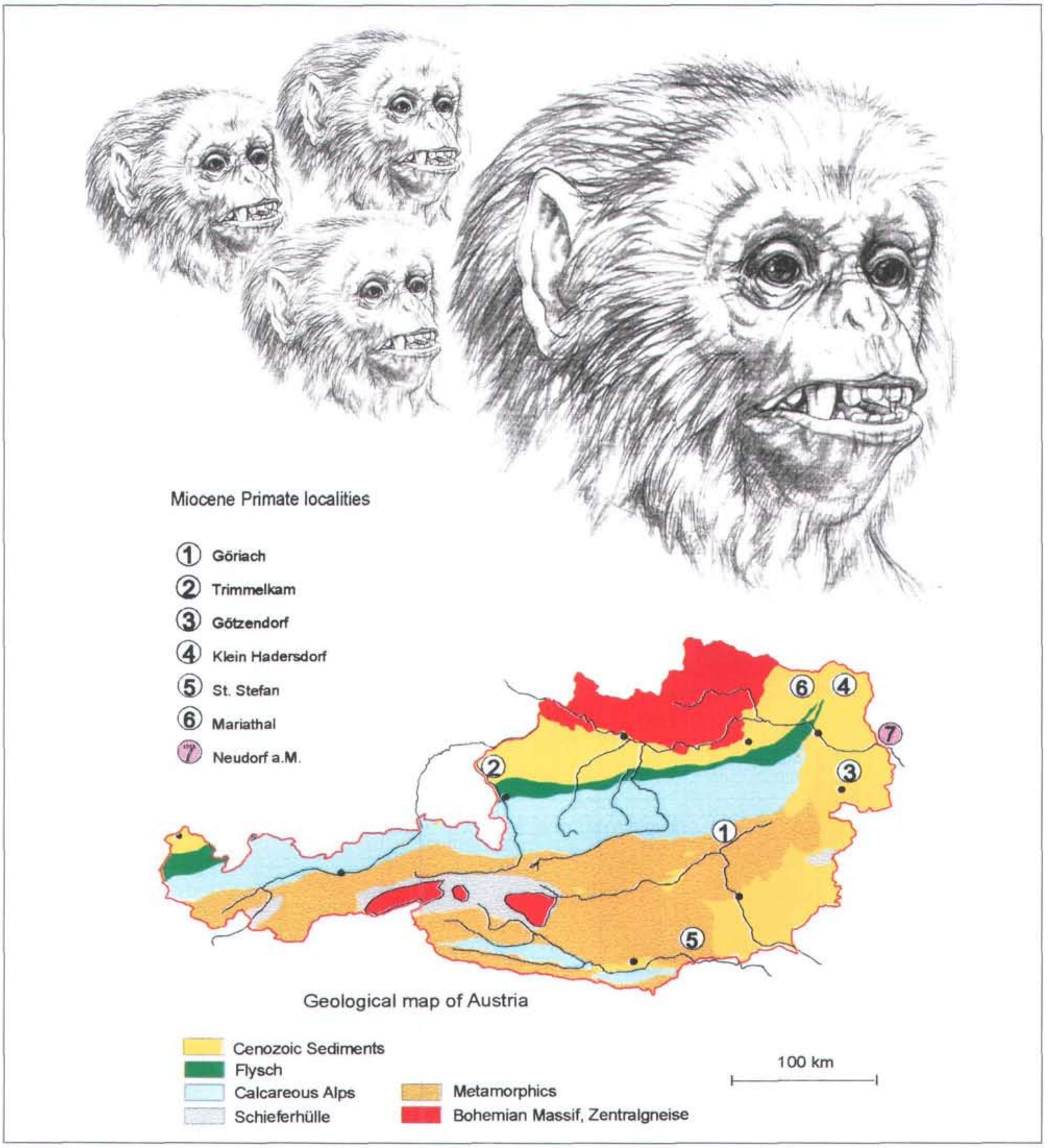

Fig. 26
Geographical position of Miocene primate localities from Austria and Slovakia.