Ann. Naturhist. Mus. Wien, Serie A	112	489-506	Wien, Juni 2010

Fish teeth from the Middle Miocene of Kienberg at Mikulov, Czech Republic, Vienna Basin

By Ortwin SCHULTZ[1], Rostislav BRZOBOHATÝ[2], Oldřich KROUPA[3]

(With 3 figures, 3 plates and 2 tables)

Manuscript submitted on September 4th 2009,
the revised manuscript on March 5th 2010

Abstract

Thirty-two tooth-based taxa of fishes were recorded from the Kienberg-vineyard section (north-western part of the Vienna Basin): fifteen taxa of sharks, seven of rays and ten of teleosts. The section provides the richest and most diverse tooth association of the Late Langhian (uppermost Lower Badenian and the Middle Badenian) for the Vienna Basin and, together with Korytnica, for the whole Central Paratethys. The actualistic analysis of the tooth-based taxa indicates marine waters in a subtropical climate, with depths of no more than 60 m. A high proportion of reef-associated taxa are also present. The occurrence of *Cetorhinus maximus* in the upper part of the section may be indicative of a slight cooling. These results all concur with those obtained from the otoliths.

Keywords: Pisces, Osteichthyes, Chondrichthyes, Badenian, Central Paratethys.

Zusammenfassung

Zweiunddreißig Fisch-Taxa aus dem Profil Kienberg-Weingarten, nordwestliches Wiener Becken, werden auf Grund von Fischzähnen nachgewiesen: fünfzehn Haie, sieben Rochen und zehn Teleostier. Es handelt sich um die reichste und vielfältigste Fischzahn-Fauna des Oberen Langhium (oberstes Unter-Badenium bis Mittel-Badenium) des Wiener Beckens und gemeinsam mit der Fauna von Korytnica in der gesamten Zentralen Paratethys. Die aktualistische Auswertung ergibt ein marines Biotop nicht tiefer als 60 m in einem subtropischen Klima. Bei fast der Hälfte der Taxa handelt es sich um Riffbewohner. Der Nachweis von *Cetorhinus maximus* im oberen Profil-Abschnitt könnte auf eine schwache Abkühlung hinweisen. Alle dies Ergebnisse stimmen gut mit denjenigen der Otolithen überein.

Schlüsselwörter: Pisces, Osteichthyes, Chondrichthyes, Badenium, Zentrale Paratethys.

[1] Natural History Museum Vienna, Department of Geology & Palaeontology, Burgring 7, 1010 Vienna, Austria; e-mail: ortwin.schultz@nhm-wien.ac.at

[2] Department of Geological Sciences, Masaryk University, Kotlářská 2, 61137 Brno, Czech Republic; e-mail: rosta@sci.muni.cz

[3] Staňkova 8, 602 00 Brno, Czech Republic; e-mail: kroupa@scientist.com

Introduction

The well known Middle Miocene Kienberg locality is one of the most important fossils sites within the Vienna Basin. At present, there is an abandoned sandpit and many small outcrops on the terraces of a vineyard along a ridge (Fig. 1) about 3.5 km E of Mikulov (Czech Republic, Southern Moravia; 48.48.370´N; 016°41.140´E). Since the times of Reuss (1848) and Hoernes (1856, 1870) numerous palaeontological specimens from Kienberg have been collected, studied and recorded in systematical, stratigraphical and palaeogeographical works or deposited in collections of different middle European institutions. The historical research was summarized by Tejkal (1956) and recently updated by Brzobohatý et al. (2007). Fish teeth from Kienberg (*Cosmopolitodus hastalis*, *Carcharias acutissimus* and *Carcharias priscus*) were noted in Brzobohatý & Schultz (1978).

In the 1990's, numerous temporary excavations were carried out during independent activities by O. Kroupa, along a section on the western slope of the Kienberg ridge. Besides other groups, rich fish tooth and otolith assemblages were obtained through sieving with 0.4 mm sized mesh. The otoliths were taxonomically and palaeoenvironmentally evaluated by Brzobohatý et al. (2007). The present study deals with fish teeth and complements our knowledge on the Kienberg fossil fish fauna.

Geological Setting

Kienberg is located at the NW tip of the Vienna Basin which represented an intramontane basin in the NW part of the Central Paratethys (Fig. 2). In the early Middle Miocene, the basin was controlled by a pull-apart tectonic regime, bounded by the Flysch Waschberg-Ždánice Unit to the NW (e.g. Stráník et al. 1999). Eastward from the Falkenstein-Mikulov Faults the subsiding Sedlec Depression (Buday et al. 1967) was infilled by the sediments of the Lanžhot Formation (Lower Badenian) and the Hrušky Formation (Middle and Upper Badenian).

In the vicinity of Kienberg the Lower Badenian Sedlec Beds (chaotic coarse and blocky marine conglomerates) transgress over the rocks of the Ždánice Unit (Čtyroký 1993). Higher up, the sands, sandstones, algal sandstones and limestones and calcareous clays of the Hrušky Formation cover the Sedlec Member or lie directly on the Flysch sediments. The general succession of deposits on the western slope of the Kienberg ridge, together with the location of the samples bearing fish teeth, are illustrated schematically in the Fig. 3.

New data on nannoplankton, foraminifera and otolith assemblages suggest, in the section studied, a correlation of the Hrušky Formation with the uppermost Lagenidae (Zone?) *Spirorutilus carinatus* Zone of the Vienna Basin regional biostratigraphic zonation (Brzobohatý et al. 2007). This position corresponds to the uppermost Lower Badenian and the Middle Badenian, correlating with the Upper Langhian in the standard chronostratigraphic scale.

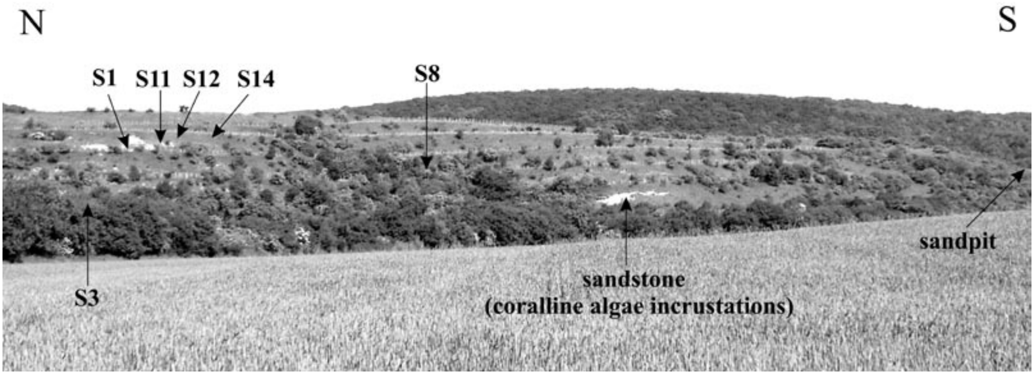


Fig. 1. General view of Kienberg Hill (Z. STRÁNÍK, June 2006); position of samples numbered as in the text.

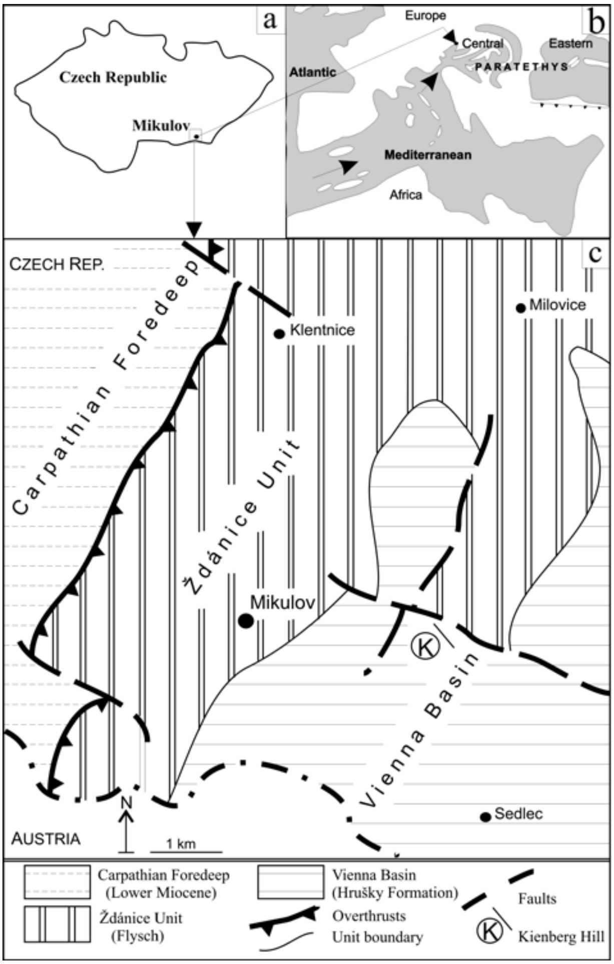


Fig. 2. Geographical (a), palaeogeographical (b – Middle Badenian, after RÖGL 1998, modified) and geological (c – after STRÁNÍK et al. 1999) position of Kienberg at Mikulov.

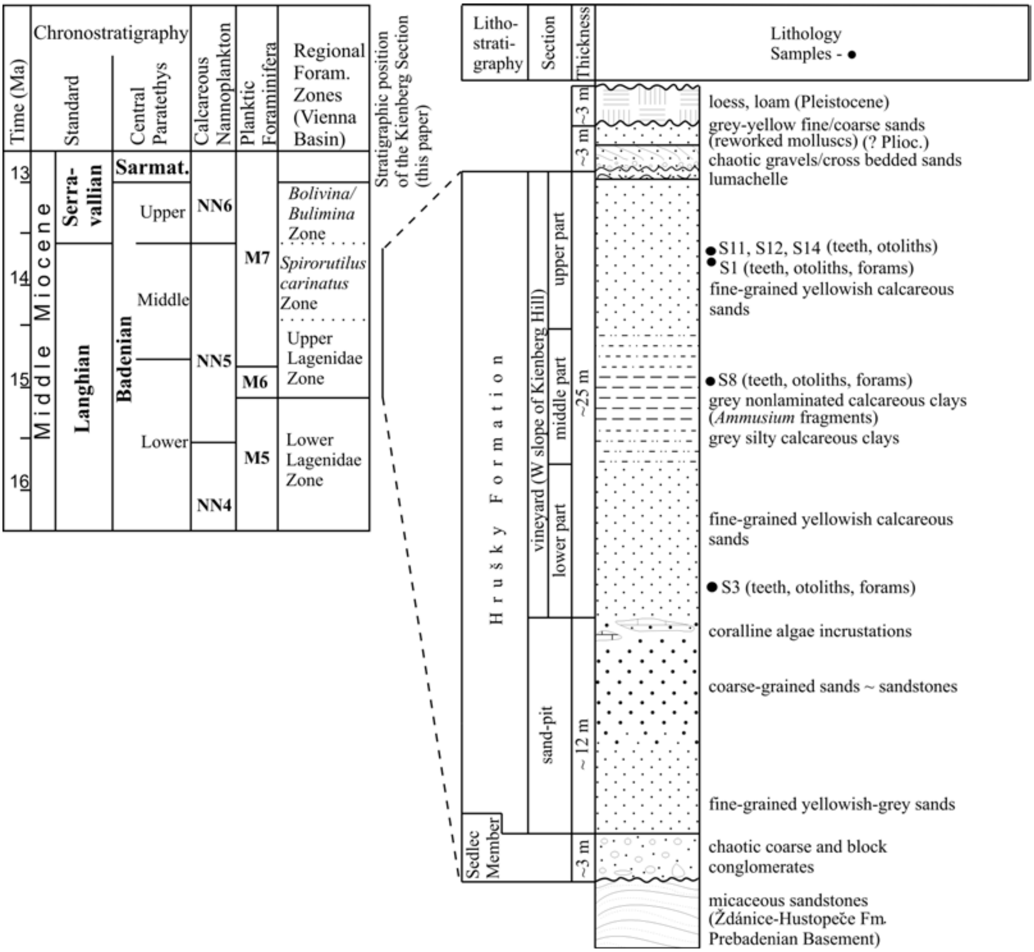


Fig. 3. Stratigraphic position, lithostratigraphy and lithology of the Kienberg section and position of samples – right. Middle Miocene chronostratigraphy and biostratigraphy (after GRADSTEIN et al. 2004; KOVÁČ et al. 2007).

Material

The material of the samples S1, S3, S8, S11 and S12 are deposited in the Oldrich KROUPA's private collections in Brno (OKFos), and sample 14 in the Natural History Museum in Vienna (NHMWien, Inv.Nr. 2006z0344/0001 to …/0012).

Taxonomic Remarks

The fish taxa present in the study area are well known and have been described in detail in numerous earlier publications on miocene fish faunas. Rather than repeating these descriptions we refer the reader to the papers by CAPPETTA (1970) and SCHULTZ (1971) and restrict our comments to a few remarks.

In CAPPETTA 2006 the shark species *dachiardii* is classified as *Premontreia* (*Oxyscyllium*) but CAPPETTA (pers. comm., 2009) informed us that the correct genus for this species is *Pachyscyllium* REINECKE, MOTHS, GRANT & BREITKREUZ, 2005.

Dipturus olisiponensis (pl. 2, fig. 13) is documented by two teeth only. This species was described by JONET (1968) from the Tortonian of Portugal and was unknown from the Paratethys before. We owe this determination to the kind information by H. CAPPETTA.

Results

With respect to fish teeth, the Kienberg locality stands out due to its high diversity (15 sharks + 7 rays + 10 teleosts = 32 taxa). There are only a very few number of Badenian localities in the Central Paratetyhs which show similar high diversity. However, at most of these other localities, only larger specimens were collected and no systematic survey of bulk samples was carried out. This has lead to an underrepresentation of small teeth in most collections and research results.

Thus, from most localities, only a small number of single specimens of a few species are documented. It is, however, noteworthy that sieve sampling by Gainfarn and Grund was not successful in recovering a considerable association of fish teeth.

Localities with a notable diversity of fish teeth are: Děvinská Nová Ves (11 sharks + 4 rays + 16 teleosts = 31 taxa. – SCHULTZ 1971; HOLEC 2001), Korytnica (12 + 7 + 8 = 30 taxa. – SCHULTZ 1977 and 1979), Vöslau in the southern Vienna Basin (15 + 3 + 7 = 25) and likewise, Retznei in the Styrian Basin (9 + 3 + 12 = 24).

The first locality is characterized by a diversity of teeth larger than 3 mm, while teeth sizes below 3 mm were lost during sieving. From Korytnica and Vöslau fish teeth were collected by both hand picking in the outcrop and by screening of bulk samples. In recent years, numerous specimens were collected from the locality at Retznei. When compared to Kienberg, and with particular reference to fish teeth, the most similar paleobiological situation, when considered together with the possibility for sieving and washing, would appear to be the locality Korytnica in Poland.

Relating to the rarity in the Badenian of the Central Paratethys, the following taxa should be mentioned: *Paragaleus pulchellus* (at present known only from Korytnica – SCHULTZ 1977), *Rhynchobatus pristinus* (known previously only from the Styrian Basin – HIDEN 1996), and

Dipturus olisiponensis (described from the Tortonian of Portugal and mentioned here, for the first time, from the Paratethys).

Additionally some rare taxa, e.g. *Cetorhinus maximus*, *Pachyscyllium dachiardii*, *Chaenogaleus affinis*, *Paragaleus* ? *pulchellus*, *Rhynchobatus pristinus*, *Trigonodon jugleri*, *Sphyraena substriata* and *Balistes muensteri* are now documented from Kienberg. Only a small number out of the total number of taxa known from the Vienna Basin are not represented in the Kienberg samples. Together with otoliths, the Kienberg locality represents the richest and most diverse fish fauna (98 species) known from Middle Badenian strata.

While the middle part of the Kienberg section yielded only rare Sparidae indet. (sample S8), important associations of fish teeth were discovered in the lower (S3) and especially in the upper part (S1, S11, S12, S14) of the section (Tab. 1). Both parts seem to be rather uniform from the fish teeth perspective. Only the presence of the species *Cetorhinus maximus* in the upper part could represent an appreciable difference.

An actualistic analysis (Tab. 2) of the fish teeth from the whole section shows that demersal and benthopelagic taxa (63%) dominate, whereas pelagic ones are represented by only two taxa (*Cetorhinus*, *Sphyraena*; 11%). Other groups (26%) include taxa with wider mode of life.

In respect of salinity, 42% of all taxa belong to purely marine groups, whereas 47% of taxa can live in both marine and brackish waters. Only 11% of taxa are also tolerant of freshwater environments. Purely freshwater elements were not identified.

From the bathymetric point of view, the overwhelming majority consists of littoral and shallow neritic taxa (63%). The presence of the genera *Chaenogaleus* and *Rhynchobatus* together with *Paragaleus*, *Diplodus* and *Sparus* advise of depths no more than 60 m. The remainder represents groups with wider bathymetric diapasone inclusive of an upper continental slope. Many taxa (42%) could indicate nearby bioherms or reef-imitating environments.

From a climatic point of view, tropical-subtropical and eurythermal (tropical-subtropical-moderate) taxa predominate (63% and 32%). Purely tropical fishes were not found, and only one species, *Cetorhinus maximus*, is characteristic of temperate waters.

The palaeoenvironmental evaluation of the fish teeth thus indicates sedimentation in a subtropical climate, in marine waters without brackish or fresh-water influx and in depths of shallow sublittoral, no more than 60 m.

The presence of the species *C. maximus* in the upper part of the section could represent the possibility of slight cooling at the end of sedimentation. The high portion of reef-associated taxa agrees with the Middle Badenian bioherms documented from boreholes in the NW tip of the Vienna Basin (Špička & Zapletalová 1965; Špička 1966).

Tab. 1. List of shark, ray and bony fish species in the Kienberg section. Cs = Caudal stings, D = dorns, Dt = dermal thorn, Gr = gill rakers, Jf = jaw fragment, Ph = pharyngeal bone, Pmx = praemaxilla, St = skin teeth, T = teeth, Tf = tooth fragments, Tp = tooth plates, V = vertebrae. ►

Taxon	Samples						Material	Iconography
	S1	S3	S8	S11	S12	S14		
Elasmobranchii								
Squalinae indet.						x	T	
Squalus sp.		x					T	Pl. 2, Figs 1, 2
Squatina subserrata (MÜNSTER,1846)	x	x					T	Pl. 2, Figs 3, 4
Carcharias acutissimus (AGASSIZ, 1843)		x					T	
Carcharias cuspidatus (AGASSIZ, 1843)	x						T	Pl. 1, Figs 12-15
Carcharias sp.						x	T	
Cosmopolitodus hastalis (AGASSIZ, 1843)	x						T	Pl. 1, Figs 9-11
Megaselachus megalodon (AGASSIZ, 1835)						x	T	Pl. 1, Figs 1, 2
Cetorhinus maximus (GUNNERUS, 1765)						x	Gr	
Pachyscyllium dachiardii (LAWLEY, 1876)		x		x		x	T	Pl. 2, Figs 5, 6
Chaenogaleus affinis (PROBST, 1879)	x	x		x		x	T	Pl. 2, Figs 7, 8
Paragaleus ? pulchellus (JONET, 1966)	x			x			T	Pl. 2, Fig. 9
Hemipristis serra AGASSIZ, 1835	x						T	Pl. 1, Figs 3-5
Carcharhinus priscus (AGASSIZ, 1843)	x					x	T	Pl. 2, Fig. 11
Galeocerdo aduncus (AGASSIZ, 1835)	x						T	Pl. 1, Figs 6-8
Sphyrna sp.	x						T	Pl. 2, Fig. 10
Batoidei indet.				x			Dt	Pl. 3, Fig. 1
Rhynchobatus pristinus (PROBST, 1877)						x	T	Pl. 3, Fig. 3
Dipturus olisiponensis (JONET, 1968)				x		x	T	Pl. 2, Fig. 12
Raja sp.		x						Pl. 2, Fig. 13
Dasyatis sp.		x		x		x	T	Pl. 3, Fig. 2
Aetobatus arcuatus (AGASSIZ, 1843)	x						Tp	Pl. 3, Fig. 4
Myliobatiformes indet.	x						Cs	Pl. 3, Fig. 5
Selachii indet.						x	St, Tf, V	
Teleostei								
Diplodus sitifensis (VALENCIENNES, 1844)	x	x					T	Pl. 3, Figs 6, 7
Diplodus sp.						x	T	
Pagrus cinctus (AGASSIZ, 1839)		x		x			T	Pl. 3, Figs 8, 9
Pagrus sp.		x					Jf	
Sparus umbonatus (MÜNSTER, 1846)	x	x		x		x	T, Tp, Pmx, Jf	Pl. 3, Fig. 11
Sparidae indet.	x	x	x	x	x	x	T, Tp, Pmx, Jf	
Trigonodon jugleri (MÜNSTER, 1846)						x	Ph	
Labridae indet.		x		x			Ph	Pl. 3, Fig. 12
Sphyraena substriata (MÜNSTER, 1846)		x		x		x	T	Pl. 3, Fig. 10
Balistes muensteri SCHULTZ, 2004				x			T	
Teleostei indet.	x	x		x			T	
Osteichthyes indet.		x		x	x	x	T, Pl, Pmx, V	

All these data agree very well with results formulated on the basis of otolith research including the highest diversity of cool-water gadoids in the upper part of the Kienberg section (Brzobohatý et al. 2007).

Scarce foraminiferal assemblages (Brzobohatý et al. 2007) and preliminary studies of bryozoa assemblages (Zágoršek et al. 2004) are also in agreement with such palaeoenvironmental interpretations.

Tab. 2. Ecological data (Quéro 2003, Froese & Pauly 2008) of the extant genera and species reviewed in the Tab. 1.

Genera Species	Environment						Climate			Bathymetry			Notice
	Demersal	Benthopelagic	Pelagic	Marine	Brackish	Fresh	Tropical	Subtropical	Moderate	Llitoral	Neritic	Continetal slope	
	D	Bp	P	M	B	F	T	S	M	L	N	Cs	
Elasmobranchii													
Squalus	D		P	M			T	S	M	L	N	Cs	
Squatina	D	Bp		M			(T)	S		L	N	Cs	+ burried
Carcharias	D		P	M			T	S		L	N		+ reef associated
Cetorhinus			P	M					M	L	N	Cs	cosmop.+ enclosed bays
Chaenogaleus	D			M			T	(S)		L	(N)		bathymetry: ? - 59 m
Paragaleus	D			M			T	(S)		L	N		bathymetry: - 100 m
Hemipristis	D			M			T	S		L	N		
Carcharhinus	D	Bp	P	M	B	(F)	T	S	(M)	L	N	Cs	<reef associated
Galeocerdo		Bp		M	B		T	S	M	L	N	(Cs)	
Sphyrna	D	Bp	P	M	B		T	S		L	N		+ (reef associated)
Raja	D			M	(B)		T	S	M	L	N	Cs	+ (burried)
Rhynchobatus	D			M	B		T	S		L	N		bathymetry:~60 m, (Ra)
Dasyatis	D			M	B	F	T	S	M	L	N		
Aetobatus		Bp		M	B		T	S		L	N		+ (reef associtaed)
Teleostei													
Diplodus		Bp		M	B		T	S		L	N	(Cs)	+ reef associated
Pagrus	(D)	Bp		M	B		(T)	S		L	N		+ reef associated
Sparus	D			M	B			S		L	N		bathymetry: < 1-30 m
Sphyraena			P	M	B		T	S	M	L	N		+ reef associated
Balistes	D		P	M			T	S		L	N		+ reef associated

Acknowledgements

We thank H. CAPPETTA and an anonymous reviewer for their constructive comments and for the valuable advice concerning *Pachyscyllium* and *Dipturus olisiponensis*. The photographs of the specimens from the Natural History Museum in Vienna (NHMWien) we owe Mrs. Alice SCHUMACHER.

References

For all references concerning only author's names of fossil species, we refer to

CAPPETTA, H. (2006): Elasmobranchii Post-Triadici (Index specierum et generum). – Fossilium Catalogus, I: Animalia, **142**: 472 pp., Leiden (Backhuys Publishers).

For all references concerning only author´s names of Recent species, we refer to

ESCHMEYER, W.N. (1998): Catalog of Fishes. – Special Publication of the Center for Biodiversity Research and Information, California Academy of Sciences, **1**: 1-2950.

AGASSIZ, L. (1833-44): Recherches sur les poissons fossiles. – **2**: XII + 310 + 336 pp., 149 tab.– **3**: VIII + 390 + 32 + 2 pp., 83 tab., Neuchatel.

BRZOBOHATÝ, R., NOLF, D. & KROUPA, O. (2007): Fish Otoliths from the Middle Miocene of Kienberg at Mikulov, Czech Republic, Vienna Basin: their paleoenvironmental and paleogeographic significance. – Bulletin de l´Institut royal des sciences naturelles de Belgique, Sciences de la Terre, **77**: 167-196, 7 figs, 2 tables, 9 pls., Bruxelles.

—— & SCHULTZ, O. (1978): Die Fischfauna des Badenien. – In: PAPP, A., CICHA, I., SENEŠ, J. & STEININGER, F.(eds): M4, Badenien. – Chronostratigraphie und Neostratotypen, **6**: 441-465, 5 Taf., Bratislava.

BUDAY, T., MENČÍK, E. & ŠPIČKA, V. (1967): Tektogeneze vnitrohorských depresí Karpat z hlediska stavby a reliéfu podloží Vídeňské pánve. – Rozpravy Československé akademie věd, Řada matematicko-přírodních věd, **77**/6: 1-67.

CAPPETTA, H. (1970): Les sélaciens du Miocène de la région de Montpellier. – Paläovertebrata, Mémoire extraordinaire 1970: 139 + 19 pp., 22 figs, 6 tab., 27 pls. – Montpellier.

ČTYROKÝ, P. (1993): Nové údaje o stratigrafii miocénu na listu 34-23 Břeclav. – Zprávy o geologických výzkumech v roce 1992: 18-21.

FROESE, R. & PAULY, D. (2008, eds): FishBase. – World Wide Web electronic publication.

GRADSTEIN, F.M., OGG, J.G., SMITH, A.G., BLEEKER, W. & LOURENS, L.J. (2004): A new Geologic Time Scale with special references to Precambrian and Neogene. – Episodes, **27**/2: 83-100.

HIDEN, H.R. (1996): Elasmobranchier (Pisces, Chondrichthyes) aus dem Badenium (Mittleres Miozän) des Steirischen Beckens (Österreich). – Mitteilungen der Abteilung für Geologie und Paläontologie am Landesmuseum Joanneum, **52-53**/1994-95: 41-109, 12 figs, 4 tab., 10 pls., Graz.

HOERNES, M. (1856): Die fossilen Mollusken des Tertiär-Beckens von Wien. I. Band: Univalven. – Jahrbuch der K.-K. geologischen Reichsanstalt, **3**: 1-736, 52 Taf., Wien.

—— (1870): Die fossilen Mollusken des Tertiär-Beckens von Wien. II. Band: Bivalven. – Abhandlungen der K.-K. geologischen Reichsanstalt, **4**: 1-479, 67 Taf., Wien.

Holec, Peter (2001): [Chondrichthyes and Osteichthyes (Vertebrata) from Miocene of Vienna Basin near Bratislava (Slovakia)]. – Mineralia Slovaca, **33**/2001: 111-134, 5 Abb., 5 Taf.

Jonet, S. (1966): Notes d'ichthyologie miocène portugaise. II. Les Carcharhinidae. – Boletim do Museu e Laboratório e Geológico da Faculdade de Ciencias, **10**/2: 65-88, 4 pls., Lisboa.

—— (1968): Notes d'ichthyologie miocène portugaise. V. Quelques Batoides.- Revista da Faculdade de Ciencias, (2a) C-Ciencias Naturais, **15**/fasc. 2: 233-257, 1 pl. – Lisboa.

Kováč, M., Andreyeva-Grigorovich, A., Bajraktarević, Z., Brzobohatý, R., Filipescu, S., Fodor, L.,Harzhauser, M., Nagymarosyi, A., Oszczypko, N., Pavelić, D., Rögl, F., Saftić, B., Sliva, L. & Studencka, B. (2007): Badenian evolution of the Central Paratethys Sea: paleogeography, climate and eustatic sea-level changes. – Geologica Carpathica, **58**/6: 579-606.

Lawley, R. (1876): Nuovi studi sopra ai pesci ed altri vertebrati fossili delle colline toscane. – 122 pp., 5 tav., Firenze.

Münster, G. (1846): Ueber die in der Tertiär-Formation des Wiener Beckens vorkommenden Fisch-Ueberreste, mit Beschreibung einiger neuen merkwürdigen Arten. – Beiträge zur Petrefacten-Kunde, **7**: 1-31, 3 Taf., Bayreuth.

Probst, J. (1877): Beiträge zur Kenntnis der fossilen Fische aus der Molasse von Baltringen. – Jahreshefte des Vereins für vaterländische Naturkunde in Württemberg, **33**: 69-103, Taf. 1-2, Stuttgart.

Quéro, J.C. (2003): Guide des poissons de l´Atlantique européen. – pp. 1-465, Delachaux et Niestlé S.A., Lonay (Switzerland).

Reinecke, T., Moths, H., Grant, A. & Breitkreuz, H. (2005): Die Elasmobranchier des Norddeutschen Chattiums, insbesondere des Sternberger Gesteins (Eochattium, Oberes Oligozän). – Palaeontos, **8**: 1-135, 60 Taf.

Reuss, A.E. (1848): Die fossilen Polyparien des Wiener Tertiärbeckens. Ein monographischer Versuch. – Naturwissenschaftliche Abhandlungen, **2**/1: 1-109.

Rögl, F. (1998): Palaeogeographic Considerations for Mediterranean and Paratethys Seaways (Oligocene to Miocene). – Annalen des Naturhistorischen Museums in Wien, Serie A, **90**: 279-310.

Schultz, O. (1971): Die Selachier-Fauna (Pisces, Elasmobranchii) des Wiener Beckens und seiner Randgebiete im Badenien (Miozän). – Annalen des Naturhistorischen Museums in Wien, **75**: 311-341, 1 Tab., 4 Taf. – Wien.

—— (1977): Elasmobranch and teleost fish remains from the Korytnica Clays (Middle Miocene; Holy Cross Mountains, Poland). – Acta Geologica Polonica, **27**/2: 201-209, 2 pls., Warszawa.

—— (1979): Supplementary notes on elasmobranch and teleost fish remains from the Korytnica Clays (Middle Miocene; Holy Cross Mountains, Central Poland). – Acta Geologica Polonica, **29**/3: 287-293, 1 pl., Warszawa.

—— (2004): A Triggerfish (Osteichthyes: Balistidae: Balistes) from the Badenian (Middle Miocene) of the Vienna Basin (Central Paratethys). – Annalen des Naturhistorischen Museums in Wien, Serie A, **106** (Kollmann-Festschrift): 345-369, 14 fig., 1 pl., Wien.

Stráník, Z., Čtyroký, P. & Havlíček, P. (1999): Geologická minulost Pavlovských vrchů. – Sborník geologických věd, Geologie, **49**: 5-32.

Špička, V. (1966): Paleogeografie a tektogeneze Vídeňské pánve a příspěvek k její naftově geologické problematice. – Rozpravy Československé Akademie Věd, Řada matematicko-přírodních Věd, **76**/12: 1-72.

—— & Zapletalová, I. (1965): K problému korelace a členění tortonu v československé části vídeňské pánve. – Sborník geologických Věd, Geologie, **8**: 125-160.

Tejkal, J., 1956. Mlži z tortonských písků z Kinberku u Mikulova. – Sborník ústředního ústavu geologického, Paleontologie, **22**: 229-319.

Valenciennes, A. (1844): Description de quelques dents fossiles de poissons trouvées aux environs de Staoueli, dans la province d'Alger. – Annales des sciences naturelles, (3) **1**: 99-104, pl. 1A, Paris.

Zágoršek, K., Holcová, K. & Vávra, N. (2004): Bryozoans localities from the Moravian part of Vienna Basin (preliminary results). – Scripta Facultatis Scientiarum Naturalium Universitatis Masarykyanae Brunensis, Geology, **31-32**/2001-2002: 35-46, Brno.

Plate 1

Figs 1, 2: *Megaselachus megalodon* (Agassiz, 1835), teeth, Kienberg, Hruška Fm., Sample 14 (OKFos. 80106, 74466). a: lingual view, b: labial view

Figs 3-5: *Hemipristis serra* Agassiz, 1835, teeth, Kienberg, Hruška Fm., Sample 1 (OKFos. 40410, 42754, 63236). a: lingual view, b: labial view.

Figs 6-8: *Galeocerdo aduncus* (Agassiz, 1835), teeth, Kienberg, Hruška Fm., Sample 1 (OKFos. 32653, 56686, 25619). a: lingual view, b: labial view.

Figs 9-11: *Cosmopolitodus hastalis* (Agassiz, 1843), teeth, Kienberg, Hruška Fm., Sample 1 (OKFos. 56691, 20226, 25684). a: lingual view, b: labial view.

Figs 12, 13: *Carcharias cuspidatus* (Agassiz, 1843), teeth, Kienberg, Hruška Fm., Sample 3 (OKFos. 32648, 25652). a: lingual view, b: labial view.

Figs 14, 15: *Carcharias cuspidatus* (Agassiz, 1843), teeth, Kienberg, Hruška Fm., Sample 1, (OKFos. 25649, 25650). a: lingual view, b: labial view.

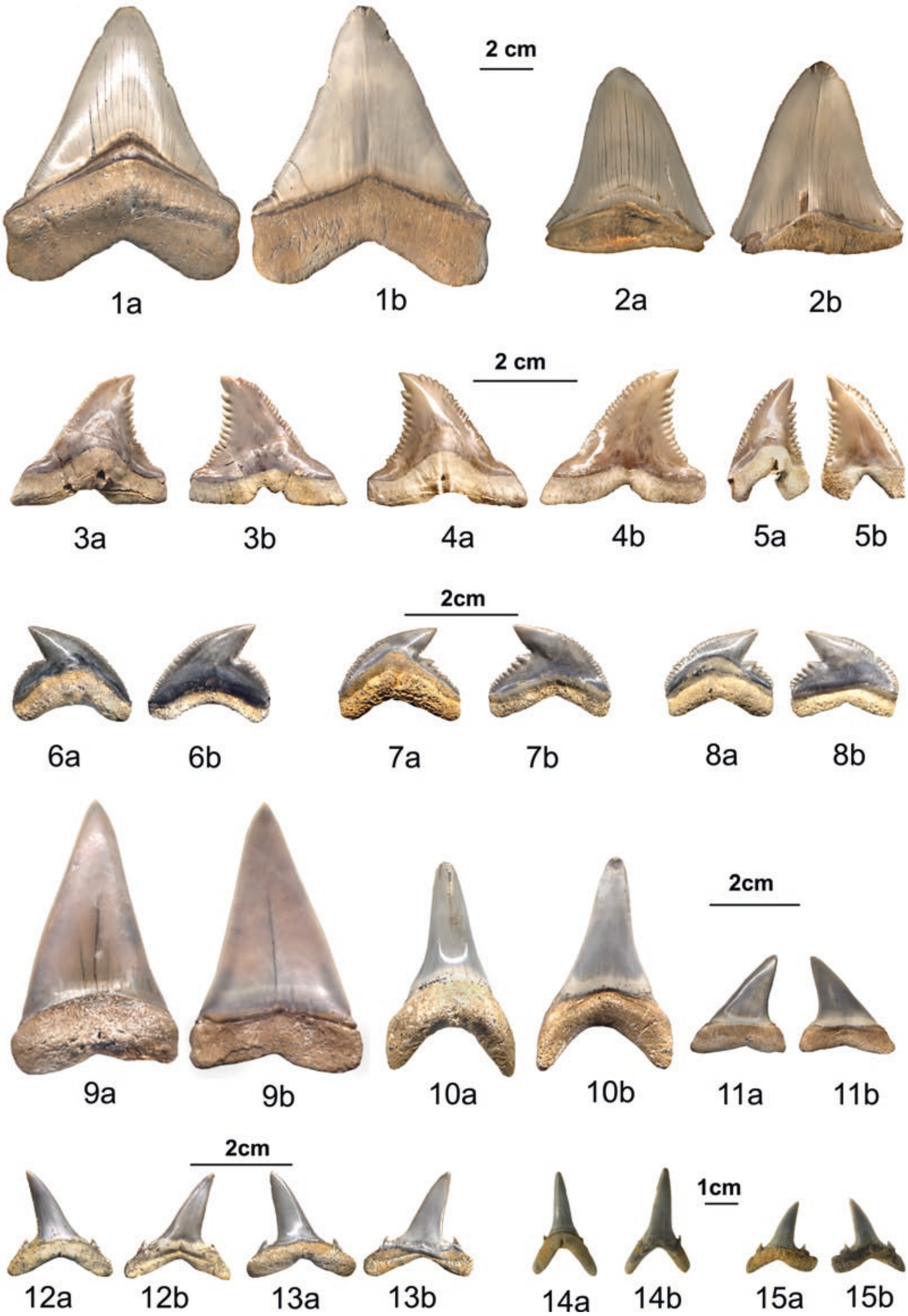

2 cm
1a
1b
2a
2b
2 cm
3a
3b
4a
4b
5a
5b
2cm
6a
6b
7a
7b
8a
8b
9a
9b
10a
10b
2cm
11a
11b
2cm
12a
12b
13a
13b
14a
14b
1cm
15a
15b

Plate 2

Figs 1, 2: *Squalus* sp., teeth, Kienberg, Hrušky Fm., Sample 3 (OKFos. 51123, 51124). 1, 2a: lingual view, 2b: labial view.

Figs 3, 4: *Squatina subserrata* (Münster, 1846), teeth, Kienberg, Hrušky Fm., Sample 1 and 3 (OKFos. 25622, 51128).

Figs 5, 6: *Pachyscyllium dachiardii* (Lawley, 1876), teeth, Kienberg, Hrušky Fm., Sample 3 (OKFos.51126, 51127). a: lingual view, b: labial view.

Figs 7, 8: *Chaenogaleus affinis* (Probst, 1878), lateral teeth, Kienberg, Hrušky Fm., Sample 3 and 11 (OKFos. 25625, 51125). a: lingual view, b: labial view.

Fig. 9: *Paragaleus pulchellus* (Jonet, 1966), lateral tooth, upper jaw, right, Kienberg, Hrušky Fm., Sample 11 (OKFos. 56896). a: lingual view, b: labial view.

Fig. 10: *Sphyrna* sp., lateral tooth, Kienberg, Hrušky Fm., Sample 1 (OKFos. 20229). a: lingual view, b: labial view.

Fig. 11: *Carcharhinus priscus* (Agassiz, 1843), tooth, lower jaw, Kienberg, Hrušky Fm., Sample 1 (OKFos. 20230). a: lingual view, b: labial view.

Fig. 12: *Dipturus olisiponensis* (Jonet, 1968), 13 – tooth, Kienberg, Hrušky Fm., Sample 3 (OKFos. 42090). a: lingual view, b: labial view, c: mesial view.

Fig. 13: *Raja* sp., dermal thorn, Kienberg, Hrušky Fm., Sample 3 (OKFos. 79514).

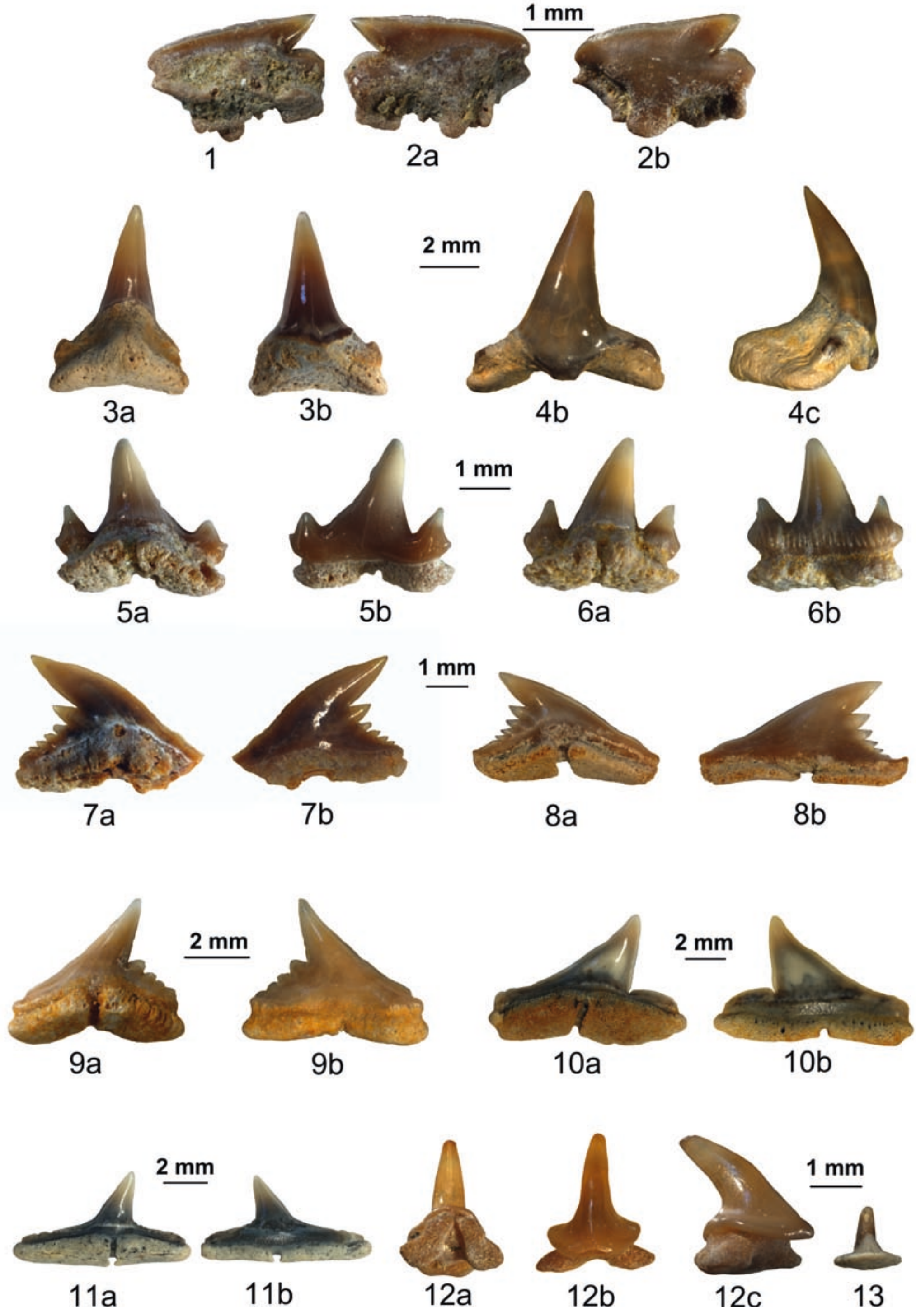

1 mm
1
2a
2b
2 mm
3a
3b
4b
4c
1 mm
5a
5b
6a
6b
1 mm
7a
7b
8a
8b
2 mm
9a
9b
2 mm
10a
10b
2 mm
11a
11b
12a
12b
12c
1 mm
13

Plate 3

Fig. 1: Batoidei indet., dermal thorn, Kienberg, Hrušky Fm., Sample 11 (OKFos. 63650).

Fig. 2: *Dasyatis* sp., tooth, Kienberg, Hrušky Fm., Sample 1 (OKFos. 51129). a: upper surface, b: profile.

Fig. 3: *Rhynchobatus pristinus* (Probst, 1877), tooth, Hrušky Fm., Sample 14 (NHM Wien 2006z0344/0011). a: upper surface, b: basal view.

Fig. 4: *Aetobatus arcuatus* (Agassiz, 1843), tooth plate of the lower jaw, Kienberg, Hrušky Fm., Sample 1 (OKFos. 25601). a: attached surface, b: oral view.

Fig. 5: Myliobatiformes indet., fragments of caudal stings, Kienberg, Hrušky Fm., Sample 1 (OKFos. 25605).

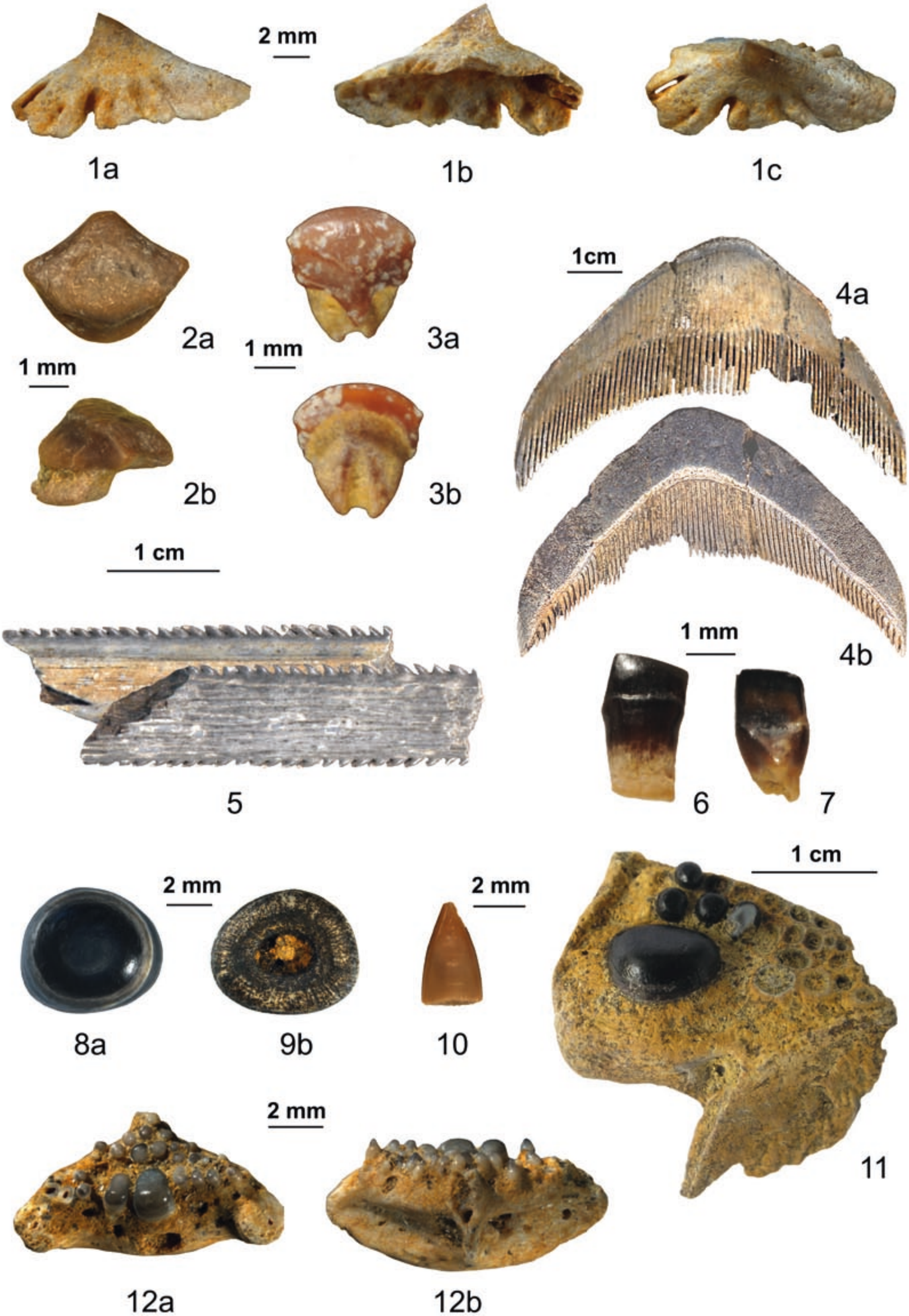
Figs 6, 7: *Diplodus sitifensis* (Valenciennes, 1844); front-teeth , Hrušky Fm., Sample 14 (NHMWien 2006z0344/0018). a: labial view, b: lingual view.

Figs 8, 9: *Pagrus cinctus* (Agassiz, 1836), tooth, Kienberg, Hrušky Fm., Sample 8 (OKFos. 49858).

Fig. 10: *Sphyraena substriata* (Münster, 1846), tooth, Kienberg, Hrušky Fm., Sample 1 (OKFos. 42 755).

Fig. 11: *Sparus umbonatus* (Münster, 1846), right fragment of the praemaxillare with five teeth and forteen tooth bases, Kienberg, Hrušky Fm., Sample 1 (OKFos. 26047).

Fig. 12: Labridae indet., lower pharyngeal jaw, Kienberg, Hrušky Fm., Sample 11 (OKFos. 56687).


2 mm
1a
1b
1c
1cm
4a
2a
3a
1 mm
1 mm
2b
3b
1 cm
1 mm
4b
5
6
7
1 cm
2 mm
2 mm
8a
9b
10
11
2 mm
12a
12b