Final report of OTKA/NKFIH K112708 project (2015-2019):
Hidden richness: Mesozoic and Tertiary benthic assemblages

The objective of this project was the taxonomic, palaeoecological and palaeobiogeographical study of different Mesozoic and Cenozoic (Paleogene and Neogene) benthic assemblages. Our results were presented in 2 books, 19 book sections, 24 scientific papers (cumulative impact factor: 24.655); 25 abstracts and conference field guides. Some additional manuscripts are near to be finished and submitted.
Our research and publication activity can be summarized in the framework of the following 38 topics (organized according to geological ages, from older to younger; published results first and manuscripts in preparation later).

Mesozoic benthic assemblages

1. First evidence of brachiopod diversification after the end-Triassic extinction from the pre-Pliensbachian Internal Subbetic platform

- Conference poster: BAEZA-CARRATALÁ, J.F., DULAI, A. & SANDOVAL, J. (2018): First brachiopod diversification in the Early Jurassic of the Subbetic Platform (South-Iberian Paleomargin, Spain). – In: Abstract Volume of 8th International Brachiopod Congress, *Permophiles, Newsletter of the Subcommission on Permian Stratigraphy*, Number **66**, Supplement 1: 18-19.

- Published paper: BAEZA-CARRATALÁ, J. F., DULAI, A. & SANDOVAL, J. (2018): First evidence of brachiopods diversification after the end-Triassic extinction from the pre-Pliensbachian Internal Subbetic platform (Sinemurian, South-Iberian Paleomargin). – *Geobios*, **51**(5): 367-384. (**IF: 1,211**).

Lower Jurassic brachiopods are widely known in the External Betic Zone. Their occurrence was so far virtually restricted to the easternmost Subbetic Zone where they underwent a diversity burst and radiation event during the late Sinemurian–early Pliensbachian interval, leading to a bloom in brachiopod diversity from the early Pliensbachian onwards. Taxonomical and palaeobiogeographical analyses performed in a newly recorded assemblage from the most offshore areas of the Subbetic Basin (Granada province, Spain) reveals that this diversification event occurred earlier than expected hitherto, probably in the Turneri–Obtusum chronozones, as similarly observed in the most intra-Tethyan basins such as the Northern Calcareous Alps and Transdanubian Ranges, illustrating the recovery of the background conditions for the establishment of diversified brachiopod communities after the end-Triassic extinction event. A new rhynchonellide species, *Alebusirhynchia vorosi*, is formally described among the ten different taxa recorded for the first time in this area. The Mediterranean paleobiogeographical affinities revealed by the brachiopod assemblage emphasizes that the onset of the Mediterranean/Euro-Boreal bioprovinciality and the initial brachiopod diversification in the pre-Pliensbachian Internal Subbetic platform took place earlier in the Sinemurian as well, following the Euro-Boreal monotypic record previously reported in this region.

2. Sinemurian (Lower Jurassic) brachiopods from the Western Gerecse Mts

- Published paper: WETTSTEIN, E., VÖRÖS, A., DULAI, A. & PÁLFY, J. (2019): Sinemuri (alsó-jura) brachiopodák a Nyugati-Gerecséből. (Sinemurian (Lower Jurassic) brachiopods from the Western Gerecse (Hungary)). – *Földtani Közlöny*, **149**(2): 105-140.

Diverse Sinemurian brachiopod fauna was collected from the Hierlatz Limestone at the localities of Nagy-Teke Hill, Nyerges Hill and Alsó-Látó Hill by the Hungarian Natural History Musem and the participants of the summer field expedition of the Eötvös University

(Budapest). The collected brachiopod material consists of 2470 specimens, 1321 of which were identified at species level. On the basis of their external morphology, 36 species of 21 genera were identified; in addition, two taxa were identified at genus level. In a few cases the identification was facilitated by studying the internal morphology (serial sectioning) of a specimen and applying statistical methods. All taxa were illustrated by photographs. Diagnostic Mediterranean taxa were found at all the three localities. The Mediterranean character of the fauna supports the palaeogeographic picture that, in the Early Jurassic, the Mediterranean microcontinent – including the Gerecse area – was isolated from the Eurasian and African shelves by deep-sea belts; these deep-sea barriers hindered the dispersal of brachiopods. In the Jurassic the Gerecse, representing the north-eastern part of the Transdanubian Range, was an area with dissected submarine bottom topography. The western part of the Gerecse was an elevated submarine area (Gorba High), while the eastern Gerecse formed a deeper basin. The submarine elevation and its transitional zone towards the basin were the sites of intermittent accumulation of the biodetrital Hierlatz Limestone. The differences between the taxonomic composition of the three localities are revealed by quantitative palaeoecological analyses and can be explained partly by the local environmental differences, and partly by the episodic nature of the extensional tectonic movements.

3. Mid-Valangian extinction and turnover of Tethyan brachiopods: a signal of the Weissert Event

- Conference presentation: VÖRÖS, A., FŐZY, I. & DULAI, A. (2018): Brachiopodák és a kora-kréta Weissert-esemény. – In: VIRÁG, A. & BOSNAKOFF, M. (szerk.): *Program, Előadáskivonatok, Kirándulásvezető, 21. Magyar Őslénytani Vándorgyűlés,* Félixfürdő, pp. 35-36.

- Conference poster: VÖRÖS, A., DULAI, A. & FŐZY, I. (2018): Brachiopods and the Early Cretaceous Weissert Event (Bakony Mountains, Hungary). – In: Abstract Volume of 8th International Brachiopod Congress, *Permophiles*, *Newsletter of the Subcommission on Permian Stratigraphy*, Number **66**, Supplement 1: 120.

- Manuscript near to submission: VÖRÖS, A., FŐZY, I., DULAI, A., PRICE, G.D. & SZÍVES, O. (in prep.): Mid-Valanginian extinction and turnover of Tethyan brachiopods (Bakony Mountains, Hungary): a signal of the Weissert Event. – *Palaeogeography, Palaeoclimatology, Palaeoecology*,

The studied brachiopod material was collected from 10 well-dated sections and 11 other localities in the Bakony Mountains, Hungary. The sections straddle the stratigraphic interval from the Kimmeridgian to the Barremian. The brachiopod material is extremely diverse and abundant in international standard: the 1313 identified specimens represent 34 species of 14 genera. The overwhelming part belongs to the Pygopidae (1043 specimens); the most abundant genera of the family are *Antinomia* (419), *Triangope* (323), *Pygope* (225) and *Pygites* (76). Nucleatidae are represented by 183 specimens; rhynchonellids appear subordinately (87 specimens). The brachiopod fauna, collected bed-by-bed, together with ammonoids from 10 sections, offers exceptional possibility to determine the stratigraphic ranges of the brachiopod species at a level of substage or even ammonoid zone. Our present data base is almost unique; similar results were published only from the Polish Carpathians (Pieniny Klippen Belt). The stratigraphic ranges recorded in the Bakony sections show that the five most abundant brachiopod species occurred from the Late Kimmeridgian to the Berriasian (partly even to the Early Valanginian). Further six species appeared in the Early Tithonian, some of them occurred also in the Early Valanginian. A less diverse assemblage was restricted to the Late Berriasian to Early Valanginian interval. None of the above mentioned species crosses the base of the Late Valanginian; most of them disappeared abruptly at this level. A fundamental faunal change appeared in the lowermost ammonoid

zone of the Late Valanginian. In the Hárskút sections (HK-12, Édesvíz) a poorly preserved, almost monospecific brachiopod fauna (*Fortunella praemoutoniana*, *Lingularia* sp.) was collected in the Verrucosum Zone. Lingulides are regarded as typical "disaster taxa"; on the other hand, the minute *F. praemoutoniana* was found exclusively this horizon, what may point to special adaptation to harsh environment. Considering all above pieces of information, we postulate a biotic crisis in the marine biota at the time of the Verrucosum Zone in the area studied. Afterwards, an abundant and diverse brachiopod fauna appeared in the Late Valanginian, but with a complete turnover of species within the genera *Nucleata* and *Triangope*. *Pygope* and *Antinomia* disappeared ultimately. The species *Pygites diphyoides*, which was not recorded in lower stratigraphic levels, abounds in masses in the Hauterivian. This abundant assemblage of low diversity persisted to the Barremian. The complete turnover of brachiopod species at the Verrucosum Zone and the appearance of disaster forms, restricted to the same horizon, are synchronous and are apparently in causal relationship with the Weissert oceanic anoxic event, proved by isotope geochemical study in the section HK-12. The effect of the Valanginian Weissert event on the change of brachiopod faunas can be recognized in other parts of Europe. The brachiopod ranges, published from the Polish Carpathians, are interrupted in the Valanginian Verrucosum Zone; on the other hand, no turnover was recorded after this hiatus. In the sections of the Gargano peninsula (southern Italy), platform drowning, nannoconid crisis and mass accumulation of brachiopods were recorded synchronously with the Weissert event. The monospecific mass occurrence of *Peregrinella* brachiopods was interpreted as a chemosynthesising community fostered by methane-bearing cold seeps brought by local fracture system. This local phenomenon could hardly be in causal relationship with the global anoxia, but the synchroneity is remarkable. The common triggering factor might be a peak of activity of the Paranà Large Igneous Province.

4. Upper Triassic phosphatic brachiopods from Csővár-1 borehole (N Hungary)

- Manuscript in preparation: GÖRÖG, Á., KARÁDI, V., DULAI, A., SZEITZ, P. & TÓTH, E.: Upper Triassic Discinidae brachiopods from Csővár-1 borehole (N Hungary). Phosphatic Discinidae brachiopods are rare members of Triassic brachiopod assemblages. Solving by acetic acid, the Csővár-1 borehole samples (150.8–154.3 m) yielded more than 30 fragmentary dorsal valves of *Discinisca* sp. All specimens are very small-sized fragments (500-800 μm). On the basis of theoretical completion the largest specimens are about 2 mm. Known Triassic discinides are generally 10-30 mm in diameter, which would refers to juvenile specimens in case of the Csővár material. However, the growth lines at the edge of largest specimens are dense and strong, suggesting adult specimens of a micromorphic species. Three parts of the shell detached (protegulum, post-larval shell, adult shell). Hexagonal pattern of internal side of protegulum refer to siliceous tablets of the larval shell, known only at very few Paleozoic and Recent forms.

5. Lower Jurassic brachiopods from Glasenbach Gorge (Austria)

- Manuscript in preparation (DULAI, A.): Rich Pliensbachian brachiopod fauna was identified from the Glasenbach Gorge near Salzburg (Northern Calcareous Alps, Austria). Large-sized brachiopods contains 16 well-known deep-water species (*Apringia piccininii*, *A. diptycha*, *A. paolii*, *Prionorhynchia flabellum*, *Lokutella palmaeformis*, *Pisirhynchia pisoides*, *Liospiriferina globosa*, *Rhapidothyris beyrichi*, *Rh. delorenzoi*, *Securithyris adnethensis*, *S. filosa*, *Linguithyris aspasia*, *Zeilleria mutabilis*, *Z. bicolor*, *Antiptychina*? *rothpletzi*, *Bakonyithyris pedemontana*). Small-sized brachiopods were also found in the washed residues of the soft marl, and these micromorphic forms mainly belong to *Zellania* and koninckinid forms, but some thecideids are also present.

Paleogene benthic assemblages

6. Eocene Polyplacophora from Hungary

- Published paper: DELL'ANGELO, B., SOSSO, M., KROH, A. & DULAI, A. (2015): Polyplacophora from the Eocene of Gánt, Hungary. – *Bulletin of Geosciences* **90**(2): 359-370. (**IF: 1.515**)

The only species of Polyplacophora known from the Eocene of Gánt was *Tonicia pannonica*. Re-examination of the type material of this species indicates that the two syntypes of Szőts belong to two different species. One of those syntypes (the tail valve) is designated as lectotype herein, in order to provide stability to nomenclature by preserving the generic attribution of the species *pannonica* to the genus *Tonicia*. New samples were collected near the type locality, and the nearly 200 valves recovered belong to four species: *Tonicia pannonica*, *Lepidochitona gantensis* sp. nov., *L. szoetsi* sp.nov., and *L. viciani* sp. nov. The paralectotype of *Tonicia pannonica*, an intermediate valve, was excluded from that species and attributed to *Lepidochitona szoetsi* sp. nov.

7. Exceptional Lutetian mollusc fauna from Damery (Paris Basin, France)

- Conference poster: NÓNAY, F., DULAI, A. & SZABÓ, M. (2017): Kivételes megtartású középső-eocén (lutetiai) fauna a Párizsi-medencéből (Damery). – In: VIRÁG, A. & BOSNAKOFF, M. (eds): Program, Előadáskivonatok, Kirándulásvezető, 20. Magyar Őslénytani Vándorgyűlés, Tata-Tardos, 2017. május 25-27, p. 30.

- Published paper: DULAI, A., NÓNAY, F. & SZABÓ, M. (2017): Kivételes megtartású középső-eocén (lutetiai) fauna a Párizsi-medencéből (Damery). (Exceptional Middle Eocene (Lutetian) fauna from the Paris Basin (Damery.) – *Annales Musei historico-naturalis hungariaci*, **109**: 147-170.

The Hungarian Natural History Museum's palaeontological collection has been enriched with well-preserved and diverse fossil material due to the donation of Jutta and Josef Deinas. The fossils represent various periods of geological time and originate from several different localities. One of the most spectacular parts of the collection is a middle Eocene fossil assemblage from the Paris Basin, Damery, which partly make up for the foreign comparative material which was destructed in 1956. The fossil collection, which is almost as well-preserved as the recent specimens, is made up of 2300 Mollusca, which represent 70 species (2034 Gastropoda specimens: 51 species; 288 Bivalvia specimens: 20 species). Besides the Mollusca the solitary coral species occur the most frequently in the material (5 species). After washing of the sandy sediments from the large Gastropoda shells we obtained more than ten thousand small sized fossils. In most cases the small gastropods (3321 specimens: 61 species) and the bivalves (6200 specimen: 45 species) represent different species than the large ones, thus the Damery collection is made up of altogether 96 Gastropoda and 58 Bivalvia species. Moreover, the microfossil material contains several different groups which do not occur among the large specimens (Dasycladales, Foraminifera, Ostracoda, Bryozoa, Polyplacophora, Echinodermata, Cirripedia, Annelida, Decapoda, and otolith). This material will serve as a useful comparative material during study of the not so well-preserved Hungarian faunas.

8. Cenozoic fossils in a paleolithic archaeological site at Mogyorósbánya

- Conference poster: MARKÓ, A. & DULAI, A. (2017): A szokottnál fényesebb kavics vagy szebb kagyló. – Kőkor kerekasztal – A kőkor kutatóinak 8. konferenciája, 2017. december 8., Magyar Nemzeti Múzeum, Budapest, 1 p.

- Published paper: MARKÓ, A., DULAI, A. & DOBOSI, V. (2018): '…finding a smoother pebble or prettier shell than ordinary' – Non-utilitarian artefacts in the Upper Palaeolithic – a case study from Mogyorósbánya (Transdanubia). – *Acta Archaeologica Academiae Scientiarum Hungaricae*, **69**: 227-252.

During the excavations of the Upper Palaeolithic site at Mogyorósbánya several non-utilitarian artefacts were found. Beside the earlier published piece of fossil resin (amber) and lumps of red ochre, more than one hundred Paleogene and Neogene fossil molluscs, large foraminifers, corals and trace fossils from at least three different geological formations, as well as numerous fragments of phyllite were documented. Pebbles of this soft shale were most probably collected from the alluvium of the Danube river. The majority of the pieces show clear traces of scraping and along the periphery of the largest artefact rhythmic incisions are visible. Even if this piece is not a ready-made object, it can be compared to the limestone and sandstone pebbles found on the Epigravettian site of Pilismarót-Pálrét. Another interesting artefact of unknown function is a carefully shaped but strongly fragmented piece with sharp edge. Fossils of the Eocene Epoch were easily accessible in the region of Mogyorósbánya, while the nearest fossiliferous outcrops of the Oligocene and Pannonian sediments are found 15–17 km in south-eastern direction from the site. Few gastropod shells show unambiguous traces of human modification. Typically, among the 16 *Melanopsis* fossils found in a single square meter only three pieces were manufactured. On the other hand, the majority of the *Dentalium* and worm tube fragments were cut and their surfaces show intense rounding and shine. The not modified *Nummulites*, corals and large internal casts of gastropods were most probably collected by Prehistoric humans because of their unusual form. This interesting group of the Mogyorósbánya artefacts and are compared to the fossils published from the Pilisszántó I rockshelter and to the not modified fossils from Moravia and Romania.

9. Microfacies and palaeoenvironmental interpretation of Eocene sediments of the Gerecse Mountains

- Published book section: KERCSMÁR ZS. (2018): Eocén. – In: BUDAI T. et al.: A Gerecse hegység földtana. Magyarázó a Gerecse hegység földtani térképéhez (1:50 000). Magyar Bányászati és Földtani Szolgálat, Budapest, pp. 57-106.

The microfacies and palaeoenvironmental interpretation of Eocene formations of the Gerecse Mts were discussed in the Eocene section of the explanatory book (Gánt Bauxite Formation, Dorog Formation, Csernye Formation, Csolnok Formation, Tokod Formation, Kincses Formation, Szőc Limestone Formation, Padrag Marl Formation).

10. Palaeoceanographic history of the Hungarian Palaeogene Basin

- Published paper: OZSVÁRT, P. (2018): A Magyarországi Paleogén Medence paleo-oceanográfiája bentosz foraminiferák paleoökológiai vizsgálata alapján. (Palaeoceanographic history of the Hungarian Paleogene Basin using a palaeoecological analysis of benthic foraminifera.) – *Földtani Közlöny*, **148**(3): 235-254.

16 late Paleogene (Lutetian–Rupelian) boreholes and sections from the Hungarian Paleogene Basin were investigated for their benthic foraminiferal faunas in order to reconstruct its palaeoecological and palaeoceanographic evolution. In the mentioned ecological interpretation of the temporal distribution of foraminiferal assemblages, multivariate statistical methods were used. These methods included Q-mode principal factor analysis (PFA) and BFOI (Benthic Foraminiferal Oxygen Index) analysis. On the basis of the Q-mode principal factor analysis, the faunas are characteristic for inner neritic (0-30 m water depth) to upper bathyal environments (approximately 30-500 m water depth). The composition of the benthic foraminiferal fauna and the results of the Q-mode principal factor analysis indicate tropical–warm conditions from the beginning of the Middle Eocene. A change in the

temperature of the bottom water can be detected from the late Middle Eocene time, and estimated temperatures indicate temperate–cold conditions during this period. On the basis of the BFOI (Benthic Foraminiferal Oxygen Index) analysis, the Middle and Late Eocene are characterised by two short eutrophic events ($POMZ_1$ and $POMZ_3$) and two significant eutrophic ($POMZ_2$ and $POMZ_4$) events. These periods are characterised by evidence of a low diversity of fauna, with a high dominance of low-oxygen tolerant (infaunal) species. The eutrophic events suggest that there was a second-order sea-level fall and restricted deep water circulation, while the oligotrophic and high oxic conditions might have been caused by colder, well-oxygenated bottom water masses from the SE Tethyan Realm. Evidence suggests that these oligo- to mesotrophic periods were characterised by a high diversity of fauna, with a significant dominance of epifaunal species. The initial stage of the significant subsidence history coincides with the $POMZ_2$ period at the end of the NP17 zone. This demonstrates clearly that the evolution of the Hungarian Paleogene Basin was strongly influenced by significant palaeoceanographic events.

11. Study of Eocene borehole samples in Hungarian Natural History Museum

- Conference presentation: DULAI, A. & KERCSMÁR, ZS. (2015): Rejtett gazdagság: eocén bentosz együttesek a Dunántúli-középhegység fúrásmintáiban. – In: BOSNAKOFF, M. & DULAI, A. (eds): *Program, Előadáskivonatok, Kirándulásvezető, 18. Magyar Őslénytani Vándorgyűlés*, Varbó-Fónagyság, 2015. május 14-16, pp. 12-13.

- Conference poster: KERCSMÁR, ZS. (2017): A nyergesújfalui Búzás-hegy középső-eocén korallfaunája. – In: VIRÁG, A. & BOSNAKOFF, M. (eds): *Program, Előadáskivonatok, Kirándulásvezető, 20. Magyar Őslénytani Vándorgyűlés*, Tata-Tardos, 2017. május 25-27, p. 22-23.

- Conference poster: KERCSMÁR ZS. (2019): Mészalga (Corallinacea) zátonyépítmény a Dorogi-medence eocén rétegsorában. – In: BOSNAKOFF, M. & FŐZY, I. (eds): *Program, Előadáskivonatok, Kirándulásvezető, 22. Magyar Őslénytani Vándorgyűlés*, 2019. május 30 – június 1., Döbrönte, pp. 21-22.

- Published book: DULAI, A. (ed.): Eocén élővilág a Kárpát-medencében. Üvegház – 22 millió éven át. [Eocene wildlife in the Carpathian Basin. 22 million years-long greenhouse.] – Természettár Könyvsorozat, Magyar Természettudományi Múzeum, Budapest, 328 pp.

Contents:

V. Eocene fossils of Hungary

V.1. Mangrove swamps and associates: Eocene fossil plants (B. ERDEI)

V.2. Huge property in the cellar: money of Saint László (nummulits) (T. KECSKEMÉTI)

V.3. Huge pin-heads: other large foraminifers (GY. LESS)

V.4. Hidden richness: small foraminifers in the microscope (P. OZSVÁRT)

V.5. In the train of reefs: corals, red algae and nummulite-banks (ZS. KERCSMÁR, A. DULAI)

V.6. Soft body, hard shell and incredible diversity: molluscs (A. DULAI)

V.7. Invertebrates' paradise in the tropical shallow seas (A. DULAI, K. ZÁGORŠEK, M. HYŽNÝ)

V.8. Sanguinary predators and peacefully swimming small fishes: shark teeth, fish mandibles and otoliths (M. SZABÓ, L. KOCSIS)

V.9. „Cows" grazing in the sea (M. SZABÓ)

V.10. Dog sized rostrated rhinos – Terrestrial vertebrate fossils from the Hungarian Eocene (M. GASPARIK)

VI. Ancient animals, modern methods

VI.1. Invisible help: isotopes in serve of paleontology (L. KOCSIS, P. OZSVÁRT)

VI.2. Continental climate reconstruction in Europe during the late Paleogene (L. KOCSIS, P. OZSVÁRT)

VII. Some outlooks

VII.1. What's the news in the neighbourhood? Eocene of the Transylvanian Basin (SZ. A. KÖVECSI, GY. LESS)

VII.2. The centre of the Eocene world: the Paris Basin (A. DULAI)

VIII. References

12. Eocene brachiopod fauna of the Thrace Basin (Turkey)

- Conference presentation: DULAI, A., ÖZCAN, E. & LESS, GY. (2018): Eocene brachiopods of the Thrace Basin (NW Turkey). – In: Abstract Volume of 8th International Brachiopod Congress, *Permophiles, Newsletter of the Subcommission on Permian Stratigraphy*, Number **66**, Supplement 1: 45.

- Manuscript in preparation: DULAI, A., ÖZCAN, E. & LESS, GY.: Eocene brachiopods of the Thrace Basin (NW Turkye): systematics, stratigraphy, palaeoecology and palaeobiogeography

Until now, Eocene brachiopods were almost unknown from the Thrace Basin. This study focuses on the brachiopod fauna from the Eocene shallow marine units, cropping out widely in the Thrace Basin in NW Turkey. Some of the studied sections are located at the northern (Şamlar, Akören, Kirklareli, Çatalca, Karabarun, Hacimaşli) while others are located at the southern part (Tayfur, Beşyol, Mürefte, Gizliliman, Dereköy) of the Thrace Basin. The studied micromorphic brachiopods were collected from Ypresian, upper Lutetian and lower Bartonian samples at the southern part, while they are from upper Bartonian to upper Priabonian layers at the northern area. We have coverage of nearly the whole Eocene of the Thrace Basin, although the sample sizes are rather uneven. Most samples are from the Bartonian sediments, upper Lutetian and upper Priabonian materials are less numerous, while Ypresian is minimal. Altogether 2.200 specimens represent 22 brachiopod species of 12 genera. Most common species belong to *Lacazella mediterranea*, *Terebratulina tenuistriata* and *Orthothyris pectinoides*, but the most diverse is the genus *Argyrotheca*, which is represented by 7 different species. Several other genera occur in smaller quantity (*Novocrania*, *Rugia*, *Bronnothyris*, *Joania*, *Platidia*, and *Minutella*?). The studied brachiopod material yielded some new species (*Rugia* n. sp. 1, *Rugia* n. sp. 2, *Minutella*? n. sp.). The upper Lutetian and lower Bartonian layers of the Gizliliman section (Gökçeada Island)

contain relatively numerous representatives of two new species of a new genus belonging to the Family Megathyrididae (Megathyrididae n. gen., n. sp. 1, n. sp.2). Stratigraphically, *Lacazella*, *Argyrotheca* and Megathyrididae n. gen. are equally important in the upper Lutetian. The lower Bartonian samples are dominated by cementing *Lacazella*, but *Argyrotheca* and *Orthothyris* are also common. *Lacazella* is much less significant in upper Bartonian and the dominant brachiopod is *Terebratulina*, which is nearly absent in the older layers. *Argyrotheca* and *Joania* are also significant in upper Bartonian. *Lacazella*, *Orthothyris* and *Terebratulina* are equally important in the limited Priabonian samples.

13. Eocene brachiopods from the Transdanubian Range

- Manuscript in preparation (DULAI, A.): About 500 micromorphic brachiopod specimens were collected from Kincsesbánya representing ten species (mainly megathiridids, and some cancellothyrids and thecideids). Some of these species are recorded for the first time from Hungary (*Argyrotheca altavillensis*, *A. lunula*, *A. megapora*, *Bronnothyris bronni*). This material recorded the earliest known bloom of the genus *Joania* with 3 different species.

About 150 micromorphic brachiopod specimens were collected from the Búzás Hill („coral graben") at Nyergesújfalu representing a monospecific assemblage of *Argyrotheca tokodensis*. This species was described by Bitner & Dulai (2008) from Tokod-Sárisáp locality, also rich in diverse corals, so this species seems to be connected to coral-bearing facies.

14. The Eocene-Oligocene climate transition in the Central Paratethys

- Confrence presentation: OZSVÁRT, P., KOCSIS, L., NYERGES, A., GYŐRI, O., PÁLFY, J. & DULAI, A. (2017): The Eocene-Oligocene climate transition in the Central Paratethys. – *13th Workshop on Alpine Geological Studies*, University of Belgrade, Zlatibor, p. 82.

- Published paper: OZSVÁRT, P., KOCSIS, L., NYERGES A., GYŐRI, O. & PÁLFY, J. (2016): The Eocene-Oligocene climate transition in the Central Paratethys. – *Palaeogeography, Palaeoclimatology, Palaeoecology*, **459**: 471-487. (**IF: 2.525**)

We studied two boreholes (Cserépváralja-1 and Kiscell-1) with continuous sedimentary records across the Eocene-Oligocene climate transition from the Central Paratethyan area. Assemblages of benthic foraminifera display a shift in dominance by epifaunal taxa in the late Eocene to shallow and deep infaunal taxa in the early Oligocene. Using the benthic foraminiferal oxygen index (BFOI), a decreasing trend of bottom-water oxygen levels is established across the Eocene-Oligocene transition (EOT), leading to the development of dysoxic conditions later in the early Oligocene.

Trends in $\delta^{18}O$ and $\delta^{13}C$ values measured on tests of selected benthic and planktic foraminifera roughly parallel those of the global record of stepped EOT $\delta^{18}O$ increase and deviate only later in the early Oligocene, related to the isolation of the Paratethys. The overall similarity of the isotope curves and the presence of a planktic-benthic ecological offset suggest that the original isotope trends are preserved, despite the systematically more negative $\delta^{18}O$ values. Of different scenarios, a quasi-uniform diagenetic overprint by fluids with low $\delta^{18}O$ values, during burial or uplift, appears best supported. We conclude that the globally established isotopic expression of Antarctic ice sheet growth across the EOT may be recognizable in the Paratethys. Deviations from the global trends after the EOT were caused by regional paleoceanographic changes induced by the progressing Alpine orogeny and sea-level change, which led to a restricted connection with the open ocean, freshwater influx from increased precipitation, and gradual development of bottom-water oxygen depletion.

15. Early Oligocene selachians from the Kiscell Formation

- Published paper: SZABÓ, M. & KOCSIS, L. (2016): A preliminary report on the Early Oligocene (Rupelian, Kiscellian) selachians from the Kiscell Formation (Buda Mts, Hungary),

with the re-discovery of Wilhelm Weiler's shark teeth. – *Fragmenta Palaeontologica Hungarica*, **33**: 31-64.
An early Oligocene (Rupelian, Kiscellian), partially published shark tooth material, unearthed from the Kiscell Clay (Budapest, Hungary) is shortly reviewed. A few shark taxa have been published by Wilhelm Weiler in 1933 and 1938, and some of this material was re-discovered in the Hungarian Natural History Museum. The described shark taxa are *Notorynchus primigenius*, *Hexanchus agassizi*, *Heptranchias howelli*, *Araloselachus cuspidatus*, *Carcharias* spp., *Carcharoides catticus*, *Isurolamna gracilis*, *Otodus* (*Carcharocles*) *angustidens*, *Alopias* cf. *exigua*, *Carcharhinus* sp., and *Physogaleus latus*. The results indicate a relatively diverse shark fauna with mixed ecological needs. The revised list of the local selachian taxa suggests that a detailed review of all Kiscell shark material (collected in the last century), placed both in public and private collections, is needed.

16. Late Oligocene (Chattian) brachiopods from Germany

Published paper: DULAI, A. & VON DER HOCHT, F. (2020): Late Oligocene brachiopods from NW Germany, with description of a new Platidiinae genus, *Germanoplatidia* n. gen. – *Rivista Italiana di Paleontologia e Stratigrafia* **126**(1). (**IF: 1,232**)
Upper Oligocene brachiopods of NW Germany were studied in two collections: the Naturalis Biodiversity Center (Leiden, the Netherlands) and the F. von der Hocht private Collection (Kerpen, Germany). Overall, six brachiopod taxa have been identified. Generic attributions of "*Rhynchonella*" *supraoligocaenica* (*Aphelesia*) and "*Terebratula*" *pusilla* (*Germanoplatidia* n. gen) are solved. Chattian occurrence of *Aphelesia* is the first confirmed record of the genus in the Paleogene. Chattian record of the well-known Neogene *Discinisca fallens* confirms that faunal change within brachiopods happened before the Paleogene/Neogene boundary. Similarly to the Mediterranean *Terebratula-Aphelesia* association, a less obvious *Pliothyrina-Aphelesia* co-occurrence can be distinguished in the upper Oligocene Pre-North Sea. Along with some previously recognized genera (*Orthothyris*, *Bronnothyris*, *Rugia*), a further brachiopod evolutionary lineage was found to survive from the Mesozoic to the Paleogene (*Aemula-Germanoplatidia* n. gen.). According to the morphological characters of the genus and sedimentological characters of the surrounding deposits, *Germanoplatidia* n. gen. lived on sandy bottom environments, and attached to small hard objects in the fine sediment by a pedicle longer than in *Aemula*. Half of the identified species are endemic in Pre-North Sea. We have documented the first record of *Argyrotheca bitnerae* from the Pre-North Sea; this recently described species shows a cosmopolitan distribution in the European Cenozoic.

Neogene benthic assemblages

17. Central Paratethyan Miocene brachiopods in Naturalis collection

- Published paper: DULAI, A. (2015): Central Paratethyan Middle Miocene brachiopods from Poland, Hungary and Romania in the Naturalis Biodiversity Center (Leiden, the Netherlands). – *Scripta Geologica*, **149**: 185-211.
The world-famous collection of Naturalis Biodiversity Center in Leiden contains abundant fossil material, including brachiopods from the Central Paratethys (nine collecting sites from Poland, and one locality each from Hungary and Romania). More than 1400 (partly fragmentary) brachiopod specimens represent nine species of eight genera: *Lingula* cf. *dregeri*, *Discinisca leopolitana*, *Discradisca polonica*, *Cryptopora nysti*, *Gryphus* cf. *miocaenicus*, *Argyrotheca cuneata*, *A. bitnerae*, *Joania cordata* and *Megerlia* sp. Most of the identified species are already known from the Central Paratethys, but the Leiden collection contains a new *Argyrotheca* species (*A. bitnerae*), which was described recently in a separate paper (on the basis of more material, but including also Naturalis specimens). Most of the

studied brachiopods confirm earlier records known from the literature, but in some cases important new information is available on the distribution of the identified taxa within the Central Paratethys. These are, respectively, the first record of *Discinisca leopolitana* from Rybnica and Monastyrz, the genus *Gryphus* from Rybnica and from the Miocene of Poland, *Argyrotheca bitnerae* from Karsy, and *Joania cordata* from Várpalota. This is the first identification of *Argyrotheca cuneata* from Korytnica and Lăpugiu de Sus (earlier this form was mentioned under different names from these localities). One of the studied *Discradisca polonica* specimens was attacked by a predatory gastropod; this is the first record of predatory drill holes on phosphatic-shelled brachiopods in the Central Paratethys.

18. Neogene stratigraphy of the Mecsek Mts

- Published field trip guidebook: SEBE, K., CSILLAG, G., DULAI, A., GASPARIK, M., MAGYAR, I., SELMECZI, I., SZABÓ, M., SZTANÓ, O. & SZUROMI-KORECZ, A. (2015): Neogene stratigraphy in the Mecsek region. Field trip guidebook. – In: BARTHA, I.-R., KRIVÁN, Á., MAGYAR, I. & SEBE, K. (eds): Programme, Abstracts, Field Guidebook, 6th Workshop on the Neogene of Central and South-Eastern Europe, 31 May – 3 June 2015, Orfű, Hungary; pp. 102-124.

19. Geochemical study of *Megathiris detruncata*

- Conference presentation: KOCSIS, L., DULAI, A. & YUNSI, M. (2016): A *Megathiris detruncata* brachiopoda faj stabilizotópgeokémiai vizsgálata az eocéntól napjainkig. – In: BOSNAKOFF, M. & VIRÁG, A. (eds): *Program, Előadáskivonatok, Kirándulásvezető, 19. Magyar Őslénytani Vándorgyűlés*, Kozárd, 2016. május 26-28, pp. 22-23.

- Conference presentation: KOCSIS, L., DULAI, A. & YUNSI, M. (2016): Climatic and ecological constrains using stable isotope chemistry of *Megathiris detruncata*. – *Goldschmidt Conference*, 26 June – 1 July 2016, Yokohama, Japán, Goldschmidt Conference Abstracts, p. 1560.

- Conference presentation: KOCSIS, L., DULAI, A., YUNSI, M. & CIPRIANI, A. (2018): Geochemical study of *Megathiris detruncata*, a brachiopod species known since the Eocene in Europe. – In: Abstract Volume of 8th International Brachiopod Congress, *Permophiles, Newsletter of the Subcommission on Permian Stratigraphy*, Number **66**, Supplement 1: 63-64.

- Published paper: KOCSIS, L., DULAI, A., CIPRIANI, A, VENNEMANN, T. & YUNSI, M. (2020): Geochemistry of recent and fossil brachiopod calcite of *Megathiris detruncata* (Terebratulida, Megathyrididae): A modern baseline study to trace past environmental conditions. – *Chemical Geology*, **533**: 119335 (**IF 2018: 3,618**)

Modern and fossil calcareous shells of the terebratulide brachiopod *Megathiris detruncata* have been investigated for stable oxygen and carbon isotope and elemental (Mg, Sr, Mn, Fe, Ba) compositions to assess the possibility of using this species to trace past environmental conditions. Modern shells were collected from the Mediterranean Sea and the Atlantic Ocean, while fossil specimens were sampled from late Eocene to Pleistocene deposits in Europe. We mainly analysed bulk shells (i.e., primary and secondary layers together) but, in some cases, their single median and lateral septa, ventral and dorsal valves. The oxygen and carbon isotope compositions of the modern shells indicate that *M. detruncata* mineralizes the bulk of its calcite shell in equilibrium with seawater. In addition, their Mn, Ba, and Fe concentrations are low with few exceptions from the Atlantic Ocean where high Fe/ Ca ratios can probably be related to locally enhanced Fe availability. The Sr/Ca ratio ranges narrowly between 1.4 and 1.7 mmol/mol, while the Mg/Ca ratio has larger variability from about 23 to 45 mmol/mol. The $\delta^{18}O$ derived temperatures do not correlate with Mg/Ca, suggesting that Mg is likely affected by greater vital effects. Physiological control on biomineralization might also explain the somewhat larger spread of $\delta^{13}C$ between different valves of the same individual

and will require further testing by in situ analyses. The fossil *M. detruncata* shells have a compositional range much larger than modern specimens, with large intra-shell and intra-site variabilities indicative of partial or full alteration. Altered fossils, characterized by low $\delta^{18}O$ and $\delta^{13}C$ values, low Mg/Ca and Sr/Ca, and high Mn/Ca and Fe/Ca ratios are often associated with clear signs of re-crystallization and/or secondary calcite precipitation within the shells. We used fossil samples without obvious recrystallization features and chemical and isotopic compositions similar to modern specimens to discuss environmental parameters such as temperature and $\delta^{18}O_{seawater}$ at the given time. We recognized variable local controls on seawater isotopic compositions in the Paratethys from the Oligocene until the Middle Miocene, and we propose somewhat warmer habitats for the *M. detruncata* in the Aquitaine Basin in southwestern France during the Late Oligocene. Isotope variation recorded in the Plio-Pleistocene Mediterranean shells are instead best explained by changing glacial-interglacial conditions.

20. Sporadic Pliocene brachiopods in Naturalis Biodiversity Center

- Published paper: DULAI, A. (2016): Sporadic Pliocene and Pleistocene brachiopods in Naturalis Biodiversity Center (Leiden, the Netherlands): Records from the Mediterranean, and the North Sea Basin. – *Fragmenta Palaeontologica Hungarica*, **33**: 65-98.

The Cenozoic Mollusc Collection of the Naturalis Biodiversity Center (NBC) contains several Pliocene and some Pleistocene brachiopods from the Mediterranean (5 Italian localities), and from the North Sea Basin (3 English localities, 1 French locality, 4 Dutch localities). The studied samples altogether yielded more than 1000, mostly fragmentary specimens (8 genera, 8 species). The Italian Pliocene (and Pleistocene) assemblage is dominated by large terebratulids (*Terebratula ampulla*), while rhynchonellids (*Aphelesia bipartita*) and cancellothyridids (*Terebratulina retusa*) are rare. The Coralline Crag samples of England are characterized by large terebratulids (*Pliothyrina sowerbyana*) and lingulids (*Glottidia dumortieri*), the zeilleriid *Macandrevia cranium* is rare. The only French locality yielded few brachiopods, with relatively higher diversity (*P. sowerbyana* is more common, the others are rare: *G. dumortieri*, *M. cranium*, *Argyrotheca* cf. *plicata*). The Dutch Pliocene samples are dominated by mostly fragmentary lingulids (*G. dumortieri*), while the others are much less common (*Notosaria nysti*, *P. sowerbyana*, *T. retusa*, *M. cranium*). This is the first photo documentation of *N. nysti*.

21. First record of Discinidae brachiopods from the Miocene of Hungary

- Published paper: DULAI, A. (2017): First record of Discinidae brachiopods from the Miocene of Hungary. – *Fragmenta Palaeontologica Hungarica*, **34**: 63-74.

Although Discinidae brachiopods are rare components of Neogene benthic assemblages, several records were published from the Miocene of the Central Paratethys (Poland, Ukraine, Czech Republic, Austria, and Bulgaria). However, until now discinid brachiopods have never been mentioned from Hungary. Recently, remains of one species, *Discradisca* cf. *polonica* (Radwańska et Radwański, 1984) were found at two Middle Miocene (Badenian) localities of the Bakony Mts. Two fragments were discovered in old washed samples (Pusztamiske Formation) from the Szabó sand pit of Várpalota in the collection of the Hungarian Natural History Museum, Budapest. The same species is much more numerous in a new material collected at Nyirád locality. Here hundreds of very eroded and fragmentary discinids were found in the Pusztamiske Formation, while the overlying Leitha Limestone Formation contains less, but sometimes more or less complete specimens. *D. polonica* seems to be restricted to shallow water environments. The Hungarian record is one of the most southern known occurrences of discinid brachiopods in the Central Paratethys (together with the very limited Bulgarian material).

22. New Miocene brachiopods from Tetti Borelli (Italy)

- Conference presentation: DULAI, A. (2017): Új Brachiopoda nemzetségek az európai neogénből. – In: Virág, A. & Bosnakoff, M. (eds): *Program, Előadáskivonatok, Kirándulásvezető, 20. Magyar Őslénytani Vándorgyűlés*, Tata-Tardos, 2017. május 25-27, pp. 13-14.

- Conference presentation: DULAI, A. (2017): New Neogene brachiopod records from the Mediterranean (Malta and Italy). – In: *Book of Abstracts of the 15th Congress of RCMNS*, 03-06 September, 2017, Athens, Greece, p. 147.

- Published paper: DULAI, A. (2019): New data on the Late Miocene brachiopod fauna of Tetti Borelli (Piedmont, N Italy). – *Rivista Italiana di Paleontologia e Stratigrafia*, **125**(1): 125-145. (**IF 2018: 1,232**)

After a small brachiopod fauna was published in 2010 from the Tortonian Sant'Agata Fossili Formation of Tetti Borelli (N Italy), two new and more numerous brachiopod collections turned up from this locality. The Roest Collection in the Naturalis Biodiversity Center (Leiden, the Netherlands), and the Pavia-Giuntelli Collection in the Department of Earth Sciences of Torino University (Torino, Italy) contain 199 and 131 specimens, respectively. Based on the study of these collections, the Tetti Borelli brachiopod fauna is now much better known and more diverse. Additionally to the previously described six species (*Cryptopora lovisati*, *Eucalathis* aff. *tauriniensis*, *Megathiris detruncata*, *Joania* aff. *falunica*, *Megerlia truncata*, *Lacazella mediterranea*), another four taxa have been found (*Lingula* sp., *Terebratulina retusa*, *Joania cordata*, *Argyrotheca* sp.), and a new Megathyrididae genus and species (*Borellithyris gaetanii* n. gen. n. sp.) has been discovered. Another new species (*Eucalathis giulioi* n. sp.) is introduced on the basis of a dorsal valve of the Roest Collection and a previously illustrated ventral valve from the Janssen Collection. This is the sixth known fossil *Eucalathis* species, most of which are described on the basis of a few specimens. The Tetti Borelli brachiopods are mostly resedimented with different degree of transport, but the minute rhynchonellide *Cryptopora* seems to be more or less autochthonous.

23: Late Miocene (Tortonian) brachiopods of the Betic Range (Guadix Basin, Alicante region)

- Poster presentation: BAEZA-CARRATALÁ, J.F., DULAI, A., GIANETTI, A., SORIA, J.M. & TENT-MANCLÚS, J.E. (2018): A new late Tortonian brachiopod assemblage from the Mediterranean-Atlantic seaway (Guadix Basin, SE Spain). – In: Abstract Volume of 8th International Brachiopod Congress, *Permophiles, Newsletter of the Subcommission on Permian Stratigraphy*, Number **66**, Supplement 1: 17-18.

- Published paper: GIANETTI, A., BAEZA-CARRATALÁ, J. F., SORIA-MINGORANCE, J.M., DULAI, A., TENT-MANCLÚS, J.E. & PERAL-LOZANO, J. (2018): New paleobiogeographical and paleoenvironmental insight through the Tortonian brachiopod and ichnofauna assemblages from the Mediterranean-Atlantic seaway (Guadix Basin, SE Spain). – *Facies*, **64**: 24. (**IF: 1,719**)

The paleogeography of the Late Neogene Atlantic-Mediterranean seaway via the Betic-Rifean Domain is quite complex due to the presence of several marine corridors. The study of transitional basins in these seaways is crucial to understand the configuration and evolution of the Mediterranean-Atlantic inter-connection. A mixed skeletal-siliciclastic sandstone succession located in one of these transitional areas (Guadix Basin, Southern Spain) was studied from a comprehensive paleontological standpoint focused on the main benthic assemblages (foraminifera, brachiopods, and trace fossils), integrating the data with the study of planktic foraminifera for an accurate biostratigraphic framework. Brachiopods are mostly represented by the *Aphelesia-Gryphus* assemblage. Two trace fossil assemblages were

observed, dominated by *Ophiomorpha* with *Bichordites* (1) and *Macaronichnus* (2), respectively. The benthic foraminiferal assemblage is mostly represented by *Planulina* and *Cibicides*. The data gathered from the benthic communities reveal habitats with high-energy and turbulent conditions in an outer neritic-upper bathyal bathymetric range. Brachiopods from the Alicún section show a Mediterranean paleobiogeographic affinity. They were constrained in the Late Tortonian to the restricted basins of the Betic-Rifean Seaway and after the Messinian Salinity Crisis proliferated in both Mediterranean- and Atlantic-type basins of the Betic-Rifean Domain. The Guadix Basin contributed to the Mediterranean-Atlantic faunal inter-connection through the Betic-Rifean Seaway during the Late Tortonian and facilitated the earliest Pliocene expansion of brachiopods in the Mediterranean.

24. Neogene Discinidae brachiopods of the North Sea Basin

- Conference presentation: DULAI, A. (2017): Neogene brachiopods of the North Sea Basin. – In: MELO, C.S. & ÁVILA, S.P. (Eds): Conference program and abstracts of the VI Regional Committee on Neogene Atlantic Stratigraphy: RCANS 2017, 10-13 July 2017, Ponta Delgada, Azores, Portugal, p. 31.

- Manuscript in preparation: DULAI, A., HELWERDA, R. & VAN DER VOORT, J. (in prep.): Miocene Discinidae brachiopods from the southern part of the North Sea Basin (Winterswijk-Miste, the Netherlands) with description of Discinidae n. gen., n. sp.

In cooperation with Naturalis Biodiversity Center (Leiden, the Netherlands), the Middle Miocene Discinidae brachiopods of the famous Dutch locality, Winterswijk-Miste are studied. Although brachiopods are extremely rare in this molluscs-dominated assemblage (only some micromorphic rhynchonellid *Cryptopora lovisati* additionally to discinides), the discinides are represented by three different species. *Discinisca fallens* was already mentioned from here but this is the first record of *Discradisca multiradita* from the locality, and first sure record of this species from the North Sea Basin. A third form of discinide brachiopods represents a new species of a new genus. This species was also recorded from Haamstede borehole material in the collection of the Naturalis Biodiversity Center. Compared with the other two discinide species, this new form is characterized by relatively large-sized thick shell, and extremely eccentric apex of the dorsal valve. The outer ornamentation is represented by numerous radial ribs.

25. Pliocene brachiopod fauna of Estepona area (Spain)

- Manuscript in preparation: DULAI, A. & MULDER, H.J. (in prep.): Early Pliocene brachiopods of the Estepona area (Spain).

A rich Early Pliocene brachiopod fauna collected by Henk Mulder (the Netherlands) is studied from Estepona (Spain). Earlier a single brachiopod paper was published from this area by Bitner & Martinell (2001) describing only four macromorphic brachiopod. The new collection (more than 1500 specimens) yielded several small-sized micromorphic species, and the preliminary fauna list consists of 16 species (*Novocrania turbinata*, *Aphelesia bipartita*, *A. margineplicata*, *Cryptopora nysti*, *Terebratula terebratula*, *T. ampulla*, *Gryphus* sp., *Terebratulina retusa*, *Argyrotheca cuneata*, *A. bitnerae*, *Joania cordata*, *Megathiris detruncata*, *Megerlia truncata*, *M. eusticta*, *Stenosarina* sp., *Lacazella mediterranea*). This is the most diverse Pliocene brachiopod fauna in Spain.

Decapod crustacean studies by Matús Hyžný

The Hungarian Natural History Museum keeps one of the largest Cenozoic Decapoda collection in Europe. This huge collection was collected and donated to the Museum by late Pál Müller. Large part of the collection was delivered to the Museum in 2015, after death of

Pál Müller. This collection is partly unpublished and is continuously studied by Matús Hyžný, acolyte and professional successor of Pál Müller. By the support of this OTKA project, he published significant parts of the HNHM Decapoda collection, and used also this basic collection as comparative material for many other studies and published papers.
The Eocene, Oligocene and Miocene decapod crustaceans deposited in the MBFSz (Budapest) were also documented. Altogether 462 items (about 1 000 specimens) were examined, photos were taken of most of them. Selected type specimens were also photographed. The documentation will be used for future publications. Revision of the fossil decapods of Eger has been started: material deposited in the Bakony Museum in Zirc and the Mátra Museum in Gyöngyös was studied. From the Wind brickyard (stratotype locality of the Egerian Stage) at least four decapod taxa were determined; other four species were identified at the localities of Vécsei-völgy and Kiseged.

26. Badenian decapods of Hungary

- In press book: HYZNY, M. & DULAI, A. (2020): *Badenian decapod crustaceans of Hungary*. – GeoLitera Kiadó, Szeged.

Cenozoic decapod crustaceans (Arthropoda: Malacostraca: Decapoda) belong to the most valuable collections of the Department of Palaeontology and Geology of the Hungarian Natural History Museum. Especially those from the Badenian strata of Hungary are of great importance. Thousands of specimens are deposited here, including type specimens of some 25 taxa. The entire collection of Badenian decapods is the result of the efforts of Pál Müller (1935-2015). A necessity of a revision of the type collection of Badenian decapods to meet criteria of modern taxonomic practice together with evaluation of the new acquisition of personal collection of late Pál Müller will result in an annotated catalogue. In its published form it contain not only an updated synopsis of all Badenian decapods of Hungary with diagnoses and information on their geographic distribution, but also a new high-quality photographic documentation. It is intended to serve both scholars for taxonomical purposes and collectors for the updated first-reference book on Badenian decapods found in the area of nowadays Hungary. Within the length of 220 pages, the contents include: 1. Introduction; 2. Pál Müller – his life and work on decapods; 3. Decapod crustaceans (introduction to decapods); 4. Paratethys during the Badenian; 5. Localities with Badenian decapod crustaceans – general overview (synoptic tables); 6. Systematic section – catalogue/atlas (75 plates); 7. Selected assemblages.

27. New Oligocene *Homarus* lobster species from Hungary

- Published paper: TSHUDY, D., HYŽNÝ, M., DULAI, A. & JAGT, J.W.M. (2018): Appraisal of the fossil record of *Homarus* (nephropid lobster), with description of a new species from the Upper Oligocene of Hungary and remarks on the status of *Hoploparia*. – *Journal of Palaeontology*, **92**(2): 170-182. (**IF 1,584**)

The fossil record of the clawed lobster genus, *Homarus*, is appraised. The taxonomic history of *Homarus* and *Hoploparia* is summarized, and a list of species recognized for each is provided. A tabulation of all fossil species of the family Nephropidae permits assessment of nephropid species diversity through time. A new species of *Homarus*, *H. hungaricus*, is recorded from the upper Oligocene (Chattian) Mány Formation at Mány, northern Hungary. The species is known by a single specimen consisting of a partial cephalothorax, a pleon minus telson, and partial chelipeds. *Homarus* is now known by two extant species (*H. americanus* and *H. gammarus*) and six fossil taxa, one of Early Cretaceous (Albian; *H. benedeni*) and five of Cenozoic age (*H. hungaricus* n. sp., *H. klebsi*, *H. lehmanni*, *H. morrisi*, and *H. percyi*). The new fossil *Homarus* differs from modern congeners in aspects of carapace and pleon ornamentation and, especially, cutter claw shape. This is the fourth Oligocene

occurrence of a nephropid species; all are *Homarus* and all are from Western Europe. *Homarus* makes its appearance in the fossil record in the Early Cretaceous (Albian) and then is not known again until the Paleogene, despite the fact that nephropid lobsters in general are well known from the Late Cretaceous. Nephropid lobsters are better known from the Cretaceous than from the Cenozoic. Both raw species numbers and numbers corrected (normalized) for epicontinental sea coverage show that shelf-dwelling nephropid lobsters were most diverse during the Late Cretaceous.

28. Commemoration on Pál Müller, one of the most eminent palaeontologists working on Paleogene and Neogene benthic assemblages of Hungary

- Published paper: HYŽNÝ, M., VAN BAKEL, B.W.M., DULAI, A., FRAAIJE, R.H.B., JAGT, J.W.M. & KROBICKI, M. (2015): In memoriam Pál Mihály Müller (14 July 1935-13 September 2015). – *Crustaceana* **88**(12-14): 1457-1462. (**IF: 0,473**)

29. The first fossil isopod from Hungary

- Published paper: HYZNY, M. & DÁVID, Á. (2017): A remarkably well-preserved terrestrial isopod (Peracarida: Isopoda: Armadillidiidae) from the upper Oligocene of Hungary, with remarks on the oniscidean taphonomy. – *Palaeontologia Electronica*, 20.1.5A: 1-11.

Isopods rank among the more successful and diverse peracaridan crustaceans, the clade of oniscidean isopods (pill-bugs and wood-lice) being one of the few pancrustacean groups to have successfully invaded terrestrial habitats. Yet, the majority of fossil occurrences of oniscidean isopods stem from amber deposits and only under very special circumstances are they preserved in marine settings; such an occurrence is recorded herein. A single, specifically indeterminate, specimen of *Armadillidium* from upper Oligocene strata at Eger (Hungary) is interpreted as a drowned individual that found itself trapped on a piece of driftwood or was caught by waves while walking on the seashore. The animal was preserved virtually intact and close to a natural posture. A near-perfect preservation of the isopod's cuticular surface indicates their potential to be preserved in marine siliciclastic settings under specific conditions.

30. The early polychelidan lobster *Tetrachela raiblana*

- Published paper: AUDO, D., HYŽNÝ, M. & CHARBONNIER, S. (2018): The early polychelidan lobster *Tetrachela raiblana* and its impact on the homology of carapace grooves in decapod crustaceans. – *Contributions to Zoology*, **87**(1): 41-57. (**IF: 1,97**)

Polychelidan lobsters, as the sister group of *Eureptantia* (other lobsters and crabs), have a key-position within decapod crustaceans. Their evolutionary history is still poorly understood, although it has been proposed that their Mesozoic representatives largely inhabited shallow-marine environment and only later sought refuge in deep water. This view has recently been challenged, so the evolutionary history of polychelidans is in a need of re-appraisal. The earliest representatives, such as *Tetrachela* from the Late Triassic of Austria and Italy, are of great importance because of their potential in investigation of life habits of early polychelidans. *Tetrachela* lived in a relatively deep water, however, its well-developed eyes suggest an environment where light was still present. With its massive dorsoventrally flattened body plan, *Tetrachela* was probably benthic; the shape of its mandible and stocky first pereiopods suggest it was a scavenger and/or fed on slowly moving or sedentary animals. The carapace of *Tetrachela* has a peculiar groove pattern, which leads us to redefine some elements of the nomenclature of grooves used for polychelidans. Based on the present revision we propose that the second incision and its associated groove correspond to the hepatic groove, not the postcervical or the branchiocardiac grooves as interpreted previously.

This revision allows us to review the homologies of cephalothoracic groove between polychelidans and other notable groups of decapod crustaceans.

31. A middle Miocene decapod faunule from Granada (Spain)

- Published paper: DÍAZ-MEDINA, G., OSSÓ, A. & HYŽNÝ, M. (2018): A middle Miocene decapod faunule from Granada (Spain), with remarks on distribution pattern of the crab *Portunus monspeliensis*. – *N. Jb. Geol. Palaont. Abh.*, **288**(2): 129-141. (**IF: 0,76**)

A decapod crustacean faunule is reported from the middle Miocene strata cropping out near Murchas (Granada Basin, southern Spain). The association consists of the brachyuran crab *Portunus monspeliensis* and primarily the axiidean shrimp *Eucalliax* sp. Based on calcareous nannoplankton, the age of the association is estimated to be late Langhian (MNN5a zone). The preservation of decapod remains suggests only some transport if any prior to burial. The depositional setting of the studied strata is interpreted as shallow marine, not exceeding 30 m in depth. The presence of *P. monspeliensis* in the Granada Basin links the roughly coeval Mediterranean populations with those from the Atlantic.

32. *Jexea kuemeli* from the Middle Miocene of Tunjice Hills (Central Slovenia)

- Published paper: GASPARIC, R. & HYŽNÝ, M. (2018): *Jaxea kuemeli* Bachmayer, 1954 (Malacostraca, Gibbiidea, Laomediidae) from the Middle Miocene of Tunjice Hills (Central Slovenia). – *Geologija*, **61**(1): 111-119.

In the present paper we report on several new specimens of *Jaxea kuemeli* Bachmayer, 1954 from the Middle Miocene laminated sandstones from Košiše in Tunjice Hills. New and well-preserved material from shallow water environment of Laško Formation allows the re-evaluation of *Jaxea* cheliped morphology. The report enhances our knowledge of the variability of tooth formula in the cheliped of *Jaxea kuemeli* and opens questions about interspecific variations connected to temporal or ecological factors. We also discuss the environmental preferences of the species which is so far known exclusively from the Paratethys Sea.

33. Taphonomy of ghost shrimps

- Published paper: HYŽNÝ, M., DUANE, M.J., REININK-SMITH, L.M., EASTOE, C. & HUDÁCKOVÁ, N. (2018): Taphonomy of ghost shrimps (Decapoda: Axiidea: Callianassidae) associated with their burrows within a middle Miocene mud volcano complex of Persian (Arabian) Gulf, Kuwait. – *Palaeogeography, Palaeoclimatology, Palaeoecology*, **511**: 218-231. (**IF 2.375**)

Shallow-marine strata of the Ghar Formation exposed along the Kuwait arch in the north of Kuwait contains fields of mud volcanoes associated with an assemblage dominated by pectinid bivalves and callianassid ghost shrimps. The depositional palaeoenvironment is interpreted to be intertidal to subtidal with the water depth not exceeding 50 m and with normal to hypersaline conditions. Based on the microfossil assemblage a middle Miocene age (early Langhian) is inferred, suggesting a longer stratigraphic span of the formation despite the previous studies treating the Ghar Formation as strictly early Miocene. Callianassid body fossils and numerous trace fossils assignable to *Ophiomorpha* have been identified. Ghost shrimp remains consisting of isolated cheliped elements are assigned to *Neocallichirus* (s.l.), which is the likely producer of *Ophiomorpha* burrows as documented by cheliped elements present within burrows and in the substrate around them. Stable isotopes discrimination modelling confirmed that fluids in the substrate were derived from at least two sources implying the presence of active mud volcanoes in the environment inhabited by ghost shrimps. Effusive activity of mud volcanoes further enhanced disarticulation and fragmentation of callianassid remains. The micritic matrix of ghost shrimp exoskeletons is

indicated to have resulted from a mixture of local seawater with fluid of continental origin. This ghost shrimp occurrence is the first formal report of fossil decapod crustaceans from Kuwait.

34. Isolated decapod crustacean fingers from the Miocene (Langhian) of the Vienna and Carpathian Foreland basins

- Published paper: HYŽNÝ, M., KOČI, T., KOČOVÁ VESELSKÁ, M. & KROH, A. (2018): Isolated decapod crustacean fingers from the Miocene (Langhian) of the Vienna and Carpathian Foreland basins (Czech Republic). – *Neues Jahrbuch für Geologie und Paläontologie – Abhandlungen*, **289**(3): 331-338. (**IF: 0,76**)

From Czech middle Miocene (Langhian; Badenian) localities a number of isolated cheliped fingers of decapod crustaceans were identified. Material was collected from Kienberg in the northern Vienna Basin and Hluchov in the south-eastern Carpathian Foreland Basin. In the present contribution cheliped fingers from these localities are documented by SEM and were identified as snapping shrimps of the genus *Alpheus* (Decapoda: Caridea: Alpheidae). Numerous additional fragmentary specimens represent several morphotypes of brachyuran claws of uncertain identities. Snapping shrimp claw fingertips exhibit two morphotypes, possibly reflecting sexual dimorphism. The novel occurrence at Hluchov is the second formal report of fossil alpheid shrimps from the Czech Republic.

35. Revision and redescription of *Palaeopinnixa mytilicola*

- Published paper: HYŽNÝ, M. & ARTAL, P. (2018): Revision and redescription of *Palaeopinnixa mytilicola* Vía Boada, 1966 (Malacostraca: Decapoda: Brachyura) from the Miocene (Langhian) of Spain, with an appraisal of the, genus *Palaeopinnixa*. – *Paläontologische Zeitschrift*, **92**: 577-586. (**IF: 1,275**).

Hexapodid crabs exhibit great similarities to representatives of other crab families (e.g., Chasmocarcinidae, Pinnotheridae), especially if ventral portions and appendages are not preserved. In such cases, assignment to the family level is often difficult. *Palaeopinnixa mytilicola* from the middle Miocene (Langhian) of Catalonia (Spain) was classified into Hexapodidae based on similarities with the type species of *Palaeopinnixa* confidently assigned to the respective family by previous workers. Newly collected material of *P. mytilicola* exhibits numerous previously unknown details, including ventral portions of both males and females, allowing unambiguous assignment to Hexapodidae. In the light of discoveries made within the last decade, the genus *Palaeopinnixa* is appraised. Preservation aspects are discussed; it is argued that cuticle preservation may have a major impact on species recognition within *Palaeopinnixa*.

36. Middle Miocene decapod crustacean assemblage from the Tuzla Basin (Bosnia and Herzegovina)

- Published paper: GAŠPARIČ, R., HYŽNÝ, M., JOVANOVIĆ, G., ĆORIĆ, S. & VRABAC, S. (2019): Middle Miocene decapod crustacean assemblage from the Tuzla Basin (Tušanj, Bosnia and Herzegovina), with a description of two new species and comparison with coeval faunas from Slovenia. – *Palaeontologia Electronica*, 22.1.9A 1-21. (**IF 2017: 1.41**)

A decapod assemblage consisting of three species is described from the upper Langhian (lower Badenian) of the Tuzla Basin in Bosnia and Herzegovina. The assemblage is dominated by *Retropluma minuta* sp. nov. (Brachyura, Retroplumidae) and accompanied by *Munidopsis salinaria* sp. nov. (Anomura, Galatheoidea) and *Portunus monspeliensis* A. Milne Edwards, 1860 (Brachyura, Portunidae). Based on the calcareous nannoplankton, the studied assemblage is assigned to the upper part of the NN5 Zone. The studied assemblage is considered to have inhabited a shallow, near-shore depositional setting, as suggested by the

microfossil association. *Munidopsis*, *Portunus* and *Retropluma* have previously been reported from Slovenia, the area closest to the Tuzla Basin with known decapod fossils. Contrary to shallow-marine settings of the localities studied herein, *Munidopsis* and *Retropluma* from Slovenian localities are reported from deeper-marine settings. The occurrence of near-complete individuals of *Retropluma* minuta sp. nov. suggests a wider bathymetric range of the genus in its evolutionary past than it has today.

37. Research on Paratethyan decapods

- Conference presentation: HYZNY, M. (2017): Fossil decapod crustaceans of Hungary: a synopsis. – In: VIRÁG, A. & BOSNAKOFF, M. (eds): *Program, Előadáskivonatok, Kirándulásvezető, 20. Magyar Őslénytani Vándorgyűlés*, Tata-Tardos, 2017. május 25-27, p. 18-19.

- Conference presentation: HYŽNÝ, M. (2019): Research on Paratethyan decapods: state of art and future directions. – In: GASPARIC, R. (ed.): *Book of Abstracts, 7th Symposium on Mesozoic and cenozoic decapod crustaceans*, Ljubljana, 17-21 June, 2019, pp. 59-62.

- Conference presentation: HYŽNÝ, M., KOVALCHUK, O., DIMITRIU, S., GRADIANU, I., PRIKRYL, T., STEF ANIAK, K. & SWIDNICKA, E. (2019): Decapod crustaceans in the Paratethyan Oligocene fish beds: a synopsis. – In: GASPARIC, R. (ed.): *Book of Abstracts, 7th Symposium on Mesozoic and cenozoic decapod crustaceans*, Ljubljana, 17-21 June, 2019, pp. 57-58.

38. Revision of Oligocene *Glyphithyreus sulcatus*

- Submitted paper: HYŽNÝ, M:, GAŠPARIČ, R. & DULAI, A.: Revision of *Glyphithyreus sulcatus* from the Oligocene of Hungary and Slovenia. – Geologija,

Plagiolophus sulcatus Beurlen, 1939 from the Oligocene (Rupelian) Kiscell Clay of Hungary is revised. The holotype is refigured for the first time since its original publication. Additional material from the Oligocene (Chattian) of Trbovlje, Slovenia is considered conspecific with *P. sulcatus*. The attribution of the species to the genus *Glyphithyreus* as proposed by Karasawa & Schweitzer (2004) is confirmed. *Glypthithyreus sulcatus* differs from its congeners in possessing protogastric regions sub-triangular in outline and having fewer and coarser tubercles on the elevated carapace regions.