Paleontology

Dr. Árpád, Dávid

Paleontology

Dr. Árpád, Dávid

Publication date 2011

Tartalom

1. fejezet - Paleontology

BASICS OF PALEONTOLOGY

1. Fossils

1.1. Fossils and fossilization

Fossils (from Latin fossus, literally "having been dug up") are the preserved remains or traces of animals, plants, and other organisms from the remote past. Fossilization is an exceptionally rare occurrence, because most components of formerly-living things tend to decompose relatively quickly following death. In order for an organism to be fossilized, the remains normally need to be covered by sediment as soon as possible. However there are exceptions to this, such as if an organism becomes frozen, desiccated, or comes to rest in an anoxic (oxygen-free) environment. There are several different types of fossils and fossilization processes.

1.2. Conditions of fossilization

A very small amount of prehistoric life got fossilized. In order for this phenomenon to take place, conditions had to be exactly right. It was just like winning the prehistoric lottery.

Usually only the hard parts of an organism can become fossilized, such as teeth, claws, shells, and bones. The soft body parts are usually lost, except for in very special conditions.

There are many ways for an organism to get preserved, but I will explain the general way in which most fossils form. First of all, fossils only occur in sedimentary rock, no others. The best scenario would be in which an organism is buried at the bottom of a lake where it is then covered by a lot of sediment. In this type of environment, the organism is protected from other animals and natural elements that would cause the body's breakdown. It is crucial that the body be in an environment that allows for rapid burial. Areas in which there is a high rate of sediment deposition is ideal because of the presence of minerals and the increase of pressure.

There are other ways of preservation, too. One of them being petrification. Most people have seen petrified wood. This is how it happened: Long ago, dead logs were washed into a river and buried in the sand. Water with alkaline and dissolved silica went down through the sediments, and contacted the logs. The logs decayed, releasing carbon dioxide, which dissolved in the water and formed carbonic acid. The alkaline water was then neutralized, and the silica precipitated out of the solution. Very slowly, the cellulose of the wood is replaced, molecule by molecule, by the silica. Eventually, the wood is replaced in perfect detail by minerals. If other minerals are there, also, the wood could be stained pretty colours.

Organisms can also be preserved by carbonization. If a leaf falls into a stagnant, oxygen-poor swamp, it may not decay. If it gets covered in silt and subjected to heat and pressure, most of the leaf's organic material is released as methane, water, and carbon dioxide. The remainder is a thin film of carbon, showing the imprint of the leaf. Insects and fish can be preserved in this way too.

1.3. Different fossil types

The term “fossil” is used for any trace of past life. Fossils are not only the actual remains of organisms, such as teeth, bones, shell, and leaves (body fossils), but also the results of their activity, such as burrows and foot prints (trace fossils), and organic compounds they produce by biochemical processes (chemical fossils). Occasionally, inorganically produced structures may be confused with traces of life, such as dendrites. These are called pseudofossils. The definitions below explain the types of fossils found in the context of fossilization processes.

Whole body fossils: Whole body can be fossilized in special environments. Insects preserved in amber for example. Whole body of pleistocene mammoths can be found at Siberia in ice with their hair, flesh and blood (Pict. 1.1.).

Pict. 1.1. The whole body of a mammoth from Berezovka (www.mathisencordlary.blogspot.com)

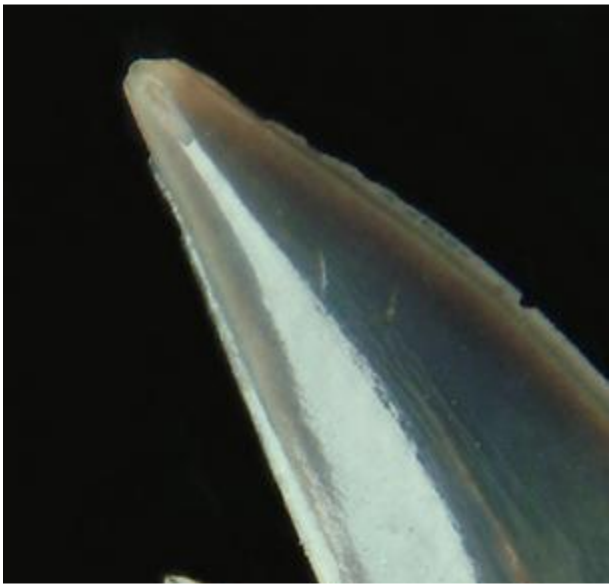
Pseudomorphs: In some case material of fossil skeleton can be changed because of the underground fluids (for example siliciferous fluids). These are very resistant and good preserved fossils, like petrified woods or bones (Pict. 1.2.)

Pict. 1.2. Early Miocene silicified wood

Encrustings: Fossil could have a concentrical, laminar mantle. It made by sponges, algae, bryozoans (Pict. 1.3.) or can be chemical in their origin.

Pict. 1.3. Bivalve shell encrusted by Bryozoa (www.blackcatmountain.com)

Body Fossils: The processes of fossilization are complex with many stages from burial to discovery as a fossil. Organisms with hard parts such as a mineralized shell, like a trilobite or ammonite, are much more likely to become fossilized than animals with only soft parts such as a jellyfish or worms. Body fossils of plants and animals almost always consist only of the skeletonized or toughened parts because soft tissues are destroyed by decay or by scavengers (Pict. 1.4.).



Pict. 1.4. Carcharias sp. – Middle Miocene shark tooth

Imprints: Imprints are simply the external moulds of very thin organisms, such as leaves and trilobites. They are often found in rocks such as sandstone, shale and volcanic ash (Pict. 1.5.).

Pict. 1.5. External mould of Cambrian trilobite in shale

Imprints of soft tissue: It is possible to infer a certain amount about the missing soft parts of fossils by comparing them to living relatives. Very fine graine sediments (like mud, ash) can be preserved the imprint of the soft body of medusa, insects or worms (Pict. 1.6.). Burgess-shale contains imprints of different organisms which don't have hard skeleton.

Pict. 1.6. External mould of Carboniferous dragon fly

Simple burial: Limy shells and plant remains often lie in the ground without much change. Cones, stems, stumps, and fern roots in peat bogs have been known to exist up to 40 million years with little change, except for some discoloration and slight decay. The remarkable preservation in these peat bogs is due to the high concentration of tannic acid. Mollusc shells, sea urchins with ages ranging from a few thousand years to 75 million years have been known to survive with little change, except the loss of colour.

Moulds: An organism will lie in sediment until the surrounding sediment becomes firm. Later the organism dissolves away. If there is no infilling of the cavity with mineral, sand or clay this is called a natural mould. The outside of the mould, which would have been the outer surface of the animal, is referred to as an external mould. This often has the fine detail of the surface of the original organism. The inside surface of the mould is referred to as the internal mould, (sometimes miscalled casts) (Pict. 1.7.).

Pict. 1.7. Cardium sp. – natural casts of bivalve sells in Early Miocene sandstone

Natural casts: The internal cast forms when sand or clay fills such things as empty shells of snails and clams, which are common (Pict. 1.8.).

Pict. 1.8. Internal cast of Middle Miocene bivalve shell

Trace fossils: Trace fossils, also called ichnofossils are structures preserved in sedimentary rocks that record biological activity. Though trace fossils are often less interesting to view, they are very important because they represent both the anatomy of the maker in some way as well as its behaviour. Trace fossils include footprints, tracks and trail marks, burrows, borings, feeding marks, and coprolites (fossilized droppings).

2. Classification of fossils

Fossils of animals are classified, as are living specimens, by observing the body structures and functions. While there are a few unique challenges in classifying fossils, the basic scheme of organization is the same. Going one step at a time can make fossil identification possible for anyone.

Biological classification systems have a long history. Aristotle, working in ancient Greece, sought to classify animals by comparing the essence of the species. His system was a detailed system that included descriptions of the body. He believed that all species related to earth, air, fire, and water and classified accordingly.

2.1. Classification of Linnaeus

At the end of 18th century, Carolus Linnaeus created another organizational system. His system was hierarchical, with increasingly detailed separations among members of the groups. Linnaeus' binomial nomenclature (giving two names as a unique identification) now encompasses all living things. The science of classification of organisms, living or extinct, is called taxonomy.

Subsequent groupings are formed on the same basis: similarity of features, even when the features are minute or on a chemical level.

The classification divisions are as follows:

Kingdom

Phylum

Class

Order

Family

Genus

Species

Kingdom Animalia

Phylum Vertebrata

Class Mammalia

Order Primates

Family Hominidae

Genus Homo

Species Homo sapiens (Linné, 1758)

The species group comprises similar individual organisms that interbreed and produce offspring; however with fossils, inconclusive evidence of reproductive isolation is not certain. The definition of a species is based on morphological (form and structure of an organism) criteria, and the chemical analysis of the organisms' shells (hard parts).

Genus refers to closely related species, such as hominides. Homo is one of the genus names for the Primates. Individual species include Homo sapiens, H. erectus, H. habilis and several others. Genus and species names are usually printed in italics, while names of groups, such as classes or orders, are not. In scientific works, the "authority" for a binomial name is usually given, at least when it is first mentioned.

Genera forms together into major groups of similar organisms called families. Family names always end in "ae".

Families group together into orders. Order names begin with a capital and usually (but not always) end in an "a".

Groups of orders form classes--the basis for most fossil research. The phylum Mollusca contains four classes: gastropoda, cephalopods, pelecypoda and scaphopoda.

Groups of classes form into plyla (plural of phylum). Some of the most common phyla include arthropoda (insects), platyhelminthes (tapeworms), chordata (fishes, retile, birds, mammals), mollusca (snails), and porifera (sponges).

Phyla group together to form kingdoms - the topmost group. Depending on what source you use, this group consists of seven kingdoms including bacteria, crenarchaeota, euryarchaeota, protoctista, plantae, fungi and animalia.

2.2. Cladistics

A different method of classification organisms, living or extinct, has gradually taken root over the Linnaean version, especially among professional biologists, palaeontologists and life scientists. The cladistic method of phylogenetic systematics, devised by the German biologist Willi Henning, uses the features of an organism as identification.

In the Linnaean system, the traits used to classify an organism are often a matter of discussion or opinion. In cladistics, these features are specifically identified as synapomorphies or unique derived characters. Since these unique characters appear only once, the organisms' descendants all share the same distinctive trait. Organisms containing the same unique features form a group called a clade. Subsequently, all members of a clade descended from the same common ancestor.

Cladograms objectively establish an organisms' common origin. As individual characteristics form, clades split up into subclades. This creates a family tree structure called cladograms. This branching system shows where additional characteristics (groups) appear, and the evolutionary relationship between groups and organisms. Cladograms are less prone to opinion and errors than the Linnaean version; however, for everyday purposes, the Linnaean system is still in use.

2.3. Origin of names

Usually, scientific names of fossils derive from the Latin or another ancient language. The terms are international and recognized throughout the scientific world, no matter the native language spoken. The meaning of scientific names comes from an organisms' physical characteristics, geographic location when found or the name of the discoverer. Scientific names are occasionally cumbersome, so nicknames are given; for example, the 'Dudley bug', a species of trilobite called Calymene blumenbachi, derived its nickname from the region in England where the fossil species is particularly common.

2.4. Classification of the biosphere

At the top of the taxonomic classification of organisms, one can find either Domain or Kingdom. For two centuries, from the mid-eighteenth century until the mid-twentieth century, organisms were generally considered to belong to one of two kingdoms, Plantae (plants, including bacteria) or Animalia (animals, including protozoa). This system, proposed by Carolus Linnaeus in the mid-eighteenth century, had obvious difficulties, including the problem of placing fungi, protists, and prokaryotes. There are single-celled organisms that fall between the two categories, such as Euglena, that can photosynthesize food from sunlight and, yet, feed by consuming organic matter.

American ecologist Robert H. Whittaker proposed a system with five kingdoms: Monera (prokaryotes—bacteria and blue-green algae), Protista (unicellular, multicellular, and colonial protists), Fungi, Plantae, and Animalia. This system was widely used for three decades, and remains popular today.

More recently, the "domain," a classification level higher than kingdom, has been devised. Also called a "Superregnum" or "Superkingdom," domain is the top-level grouping of organisms in scientific classification. One of the reasons such a classification has been developed is because research has revealed the unique nature of anaerobic bacteria (called Archaeobacteria, or simply Archaea). These "living fossils" are genetically and metabolically very different from oxygen-breathing organisms. Various numbers of Kingdoms are recognized under the domain category.

2.5. Significance of the fossils

Rock-forming fossils: There are biogén sedimentary rocks (bioliths) which contain mostly fossil fragments. Fossil plant remains build up the coal and diatomite, while fossil animal skeletons build up several limestones (reef-limestones, crinoid limeston).

Geochronological significance: There are so called index fossils which sign a period of the Earth history. These organisms has to be very common in the sediment, it has a big range, fast evolution and characteristic morphological pattern. Trilobites, conodonts, ammonites and foraminiferas are good index fossils of several periods.

Evolutional significance: Dollo’s law tell that evolution is not reversible. This hypothesis was first stated by Dollo in this way: "An organism is unable to return, even partially, to a previous stage already realized in the ranks of its ancestors.” According to this hypothesis a structure or organ that has been lost or discarded through the process of evolution will not reappear in exactly the same form in that line of organisms. Fossil groups has a progressive, a persistent and a regressive periiod in their evolution. But there are a lot of random phenomena in evolution which take harder the biostratigraphy. Persistentce is a phenomenon when species doesn’t change during millions of years. These are the living fossils like Ginkgo biloba, Lingula or Latimera. Convergence is another phenomenon. several organisms (for example dolphin and Ichthyosaurus) has similar morphology because of the similar environments and life habitats. Homeomorphy is a similar phenomenon to this but the organisms are in close relationship.

Environmental significance: There were organisms which didn't tolerant the change of the environmental factors (for example corals, sea urchins). They have a big environmental significance.

3. Evolution of the biosphere

3.1. Precambrian

Any consideration of the geological history of earth as it pertains to the genesis and evolution of life, that is, to paleobiology, must hold the sea as centric. Life began in the sea, and most extant life yet exists in the sea. The sea contains an incomprehensible diversity of life, mostly still undiscovered or described, ranging across all the domains of life. The sea is absolutely brimming with microscopic life, including bacteria that make their living by a constellation of different metabolic processes, and the Archaeans, among which are the extremophiles living in vents at temperatures well above the boiling point of water.

The sea was the mother of all life beginning some 3.8 billion years ago, and remains so today. The land-based animals each carry with them a miniature ocean, pulsing in their cells and circulatory systems. All life, including human, could be viewed as bags sea water containing the same mineral constituency as the ocean together with a dynamic dispersion of molecules that perform the biological processes that constitute life.

In all living cells - proteins answer for both form and function. Proteins are the active elements of cells that aid and control the chemical reactions that make the cell work. They receive signals from outside of the cell. They control the processes by which proteins are made from the instructions in the genes. They also form the scaffolding that gives cells their shape and as well as parts of the linkages that stick cells together into tissues and organs. A protein's shape determines its function, which, in turn, depends on its water-hating (hydrophobic) properties - to work proteins must be immersed in a miniature sea within the cell that does not greatly differ from the sea from whence it came. Life came from the sea, and the sea sustains life on earth, especially the many microbes that recycle the fundamental elements from which proteins are constructed (for example in the nitrogen cycle).

Archaean Time (3800 to 2500 mya): The atmosphere that existed during Archean time would be toxic to most extant life on our planet. Also, rocks were just beginning to form at the crust of the earth. It is believed that life on earth made its appearance in the seas during Archaean time. The first life is believed to be the Eubacteria (i.e., bacteria), single-celled prokaryotic organisms with no DNA-containing Nucleus. The earliest bacteria obtained energy through chemosynthesis (ingestion of organic molecules). They produced the oldest fossils that date to about 3500 mya, and are known as bacterial microfossils. Discovered in the 1970s in western Australia, these earliest fossils express what appear to be chemical signs of delicate chains of microbes that appear exactly like living blue-green algae (otherwise known as cyanobacteria). For billions of years, these bacteria formed extensive slimy carpets in shallow coastal waters, and before the end of Achaean-time 2.5 bya had also formed a thin crust on land. Known as stromatolites, these accretionary growth structures produced by the prokaryotes, and also possibly Arachaea and primitive Eukaryotes, became increasingly abundant during the Archaean, a fact of critical importance to the later evolution of life. However, an alternate hypothesis postulates that eukaryotes may have appeared in late Archaean time. Ancient shales of northwest Australia dated with uranium and lead to 2700 mya contain microscopic traces of oil containing sterols. Since eukaryotes are the only organisms on Earth that can make these molecules, these shale's support the theory that amoeba-like eukaryotes may have appeared early in life's history. Stromatolitic structures span the Precambrian and extend to modern time, though they are currently limited to several isolated environments. While science generally cannot determine the producing organism or organisms, stromatolite can indeed be beautiful expressions of the most ancient life on earth.

Proterozoic Era (2500 to 544 mya): During the Proterozoic realized events paramount to the further evolution of life, most notably the steady buildup of oxygen in the atmosphere. Stable continents formed. Bacteria and archaean microbes, some able to tolerate extremely hostile environments, became increasingly abundant. By about 1.8 bya, eukaryotic celled animals appear as fossils, These are the organisms that most people are most familiar with - all animals, plants, fungi, and protists which share fundamental characteristics such as cellular organization, biochemistry, and molecular biology. Cyanobacteria, photosynthetic Eubacteria that produce oxygen as a metabolism byproduct may have appeared of early as 3.5 billion years ago, but became common and widespread in the Proterozoic. The rapid build-up of oxygen in the atmosphere was primarily owing to their photosynthetic activity. Hence, cyanobacteria have been paramount in evolution and ecological change throughout earth's history. They have been attributed at least in part, because of the intense energy density of oxygen-burning aerobic metabolism of Eukaryotes, with the explosion of diversity in the late Precambrian into the Cambrian (the Cambrian Explosion). The other great contribution of the cyanobacteria is in the origin of plants. The chloroplast where plants make food is actually a cyanobacterium living within the plant's cells.

The cellular organelle mitochondria (and associated mitachondrial DNA) of animals, the center of aerobic energy production is believed evolved from aerobic bacteria. Similarly, and in a separate evolutionary event, chloroplasts of eukaryotic plants is belived evolved from the autotrophic, photosynthetic cyanobacteria.

The other great evolutionary innovation of the Eukaryotes that occured in the Proterozoic was the ability to reproduce sexually, making genetic diversity possible, and as a consequence, greatly enhanced the ability to adapt to and survive environmental changes. Unlike prokaryotic bacteria that are identical clones, sex enabled favorable mutations to persist and amplify in a population's genome. Multi-celled, soft-bodied marine organisms (metazoans) evolve.

The oldest fossils within Kingdon Animalia are Vendian age 650 to 544 mya, are found at nearly 30 locations around the world, and are most distinctive. The Ediacara Hills of Southern Australia, and the Vendian White Sea Region of Northern Russia are two of the more famous. Typically, the Vendian or Ediacaran fossils are preserved as thin impressions on bedding surfaces of fine to medium-grained sedimentary rocks. Ostensibly, these organisms were very thin, lacked any minerallized hard parts or well developed organs or organ systems, and had a quilt-like outer surface.

3.2. Precambrian evolve of the athmosphere and biosphere

Evolution of athmosphere and biosphere are in connection because these processes have an effect on each other. The primer athmosphere of the Earth loosed at 4,6-3,6 Ma years before. These athmosphere contained rare gases mostly. While the dominant gases of the secondary atmosphere are O2, N2 and CO2. N2 and CO2 came from volcanic activities, while the origin of O2 is the process of photodissociation and photosynthesis.

The initial formation of oxygen from photochemical dissociation of water vapor is found to provide the primitive oxygen in the atmosphere. Because of the Urey self-regulation of this process by shielding H2O vapor with O2, O3, and CO2, primitive oxygen levels cannot exceed O2~0.001 present atmospheric level (P.A.L.). The analysis of photochemistry of the atmospheric constituents is made possible by measurements of solar radiation with space vehicles and the now excellent data on uv absorption. The rates of oxidation of lithospheric materials are examined in this primitive atmosphere and, because of active species of oxygen present, found adequate to make unnecessary the usual assumption of high oxygenic levels in the pre-Cambrian eras to account for such lithospheric oxides. The appearance of an oxygenic atmosphere awaits a rate of production that exceeds O2 photodissociation and loss.

The rise of oxygen from the primitive levels can only be associated with photosynthetic activity, which in turn depends upon the range of ecologic conditions at any period. Throughout the pre-Cambrian, lethal quantities of UV will penetrate to 5 or 10 meters depth in water. This limits the origin and early evolution of life to benthic organisms in shallow pools, small lakes or protected shallow seas where excessive convection does not bring life too close to the surface, and yet where it can receive a maximum of non-lethal but attenuated sunlight. Life cannot exist in the oceans generally and pelagic organisms are forbidden. Atmospheric oxygen cannot rise significantly until continental extensions and climatic circumstances combine to achieve the necessary extent of this protected photosynthesis, over an area estimated at 1 to 10 per cent of present continental areas.

When oxygen passes ~0.01 P.A.L., the ocean surfaces are sufficiently shadowed to permit widespread extension of life to the entire hydrosphere. Likewise, a variety of other biological opportunities arising from the metabolic potentials of respiration are opened to major evolutionary modification when oxygenic concentration rises to this level. Therefore, this oxygenic level is specified as the “first critical level” which is identified by immediate inference with the explosive evolutionary advances of the Cambrian period (−600 m.y.). The consequent rate of oxygen production is expedited.

When oxygen passes 0.1 P.A.L., the land surfaces are sufficiently shadowed from lethal uv to permit spread of life to dry land. This oxygenic level is specified as the “second critical level” and by immediate inference is identified with the appearance and explosive spread of evolutionary organisms on the land at the end of the Silurian (−420 m.y.).

Subsequently, oxygen must have risen rapidly to the Carboniferous. Because of the phase lag in the process of decay, the change of atmospheric oxygen may have fluctuated as a damped saw-toothed oscillation through late Paleozoic, Mesozoic, and even Cenozoic times in arriving at the present quasi-permanent level (Fig. 1.1.).

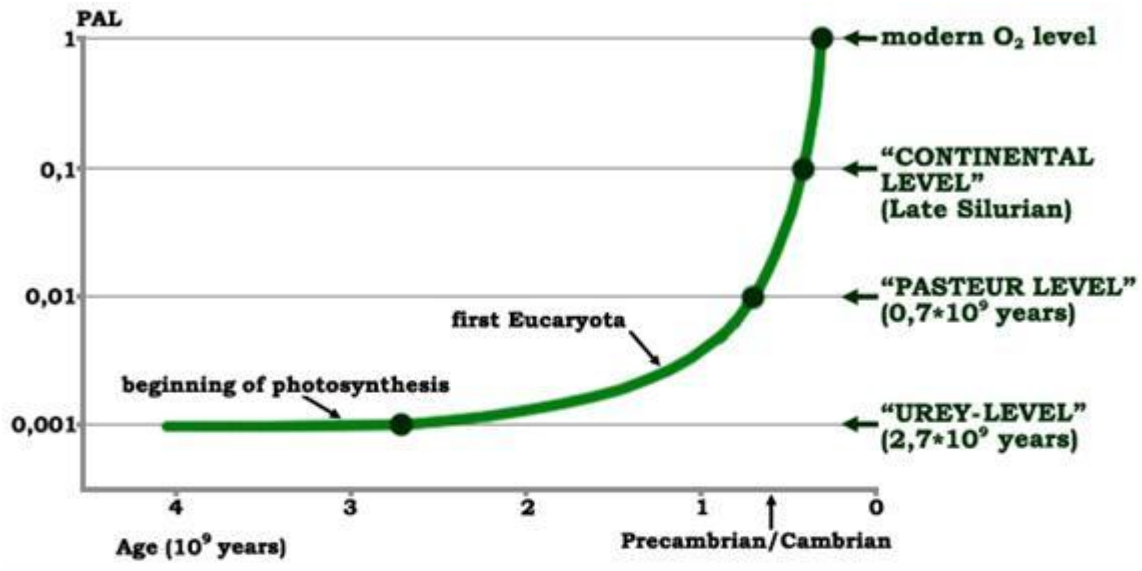


Fig.1.1. Growing of oxygen content of the atmosphere during the Earth's history

3.3. Palaeozoic Era

The Paleozoic (meaning "time of ancient life)" Era lasted from 544 to 245 million years ago, and is divided into six periods.

Cambrian (544 to 505 mya): Hard-shelled animals appeared in great numbers for the first time during the Cambrian, significantly because shallow seas flooded the continents. Gondwana formed near the South Pole.

The Cambrian truly is an astonishing period in evolution of life on earth. Most major groups of animals first appear in the fossil record, an event popularly and scientifically called the "Cambrian Explosion". The name largely derives from the hypothesized explosion of diversity of life that occurred very rapidly, but that this actually occurred is not a consensus among scientists.

Many marine metazoans having mineralized exoskeletons flourish in the Cambrian, including sponges, corals, molluscs, echinoderms, bryozoans, brachiopods and arthropods. It is commonly believed that there were no organisms at the very base of Cambrian that had hard parts, either as an external skeleton or simply spicules. This is, however, remains in dispute. The first shelled metazoans that are characteristic of the Cambrian occur well after the earliest complex trace fossils.

Trilobites dominate the Cambrian fossil record, and these arthropods actually attained their peak number of families near the end of the Cambrian. It is believed there were some 15,000 species that evolved during the Paleozoic. The first detailed record of vertebrates appears during the Cambrian as fossils of jawless fish. These bottom-dwellers, some of which had skeletons made of cartilage rather than bone, first appeared some 500 million years ago. Many were covered in plate-like armour.

3.4. Ordovician

Ordovician (505 to 440 mya):

Owing to continental separation, trilobites drifted apart genetically taking on new, location-dependent forms, some quite exotic. The first planktonic graptolites evolved, and other graptolite species became extinct. Most profound perhaps was the colonization of land. Terrestrial arthropod fossils occur in Ordovician strata, as do microfossils of the cells, cuticle, and spores of the early land-based plants.

Ordovician strata are characterized by numerous and diverse trilobites and conodonts (phosphatic fossils with a tooth-like appearance) found in sequences of shale, limestone, dolostone, and sandstone. In addition, blastoids, bryozoans, corals, crinoids, as well as many kinds of brachiopods, snails, clams, and cephalopods appeared for the first time in the geologic record in tropical Ordovician environments. Remains of Ostracoderms (jawless, armored fish) from Ordovician rocks comprise some of the oldest vertebrate fossils.

Despite the appearance of coral fossils during this time, reef ecosystems continued to be dominated by algae and sponges, and in some cases by bryozoans.

The Ordovician fossils are the oldest complete vertebrates. They were jawless, armored fish with large bony shields on the head, and small plate-like scales covering the tail.

The Ordovician ended with a major extinction event that caused the demise of some 60% of marine genera. A Late Ordovician glaciation contributed to profound ecological disruption and mass extinctions. Reef-building fauna were broadly decimated. Nearly all conodonts disappeared in the North Atlantic Realm. Many groups of echinoderms, brachiopods, bryozoans, graptolites, and chitinozoans also disappeared.

3.5. Silurian

Silurian (440 to 410 mya):

The Silurian realized additional marked changes for Earth that affected life significantly. Sea levels rose as the climate stabilized, at least compared to the prior millions of years. Coral reefs made their first appearance and expanded. Land plants evolved in the moist regions near the Equator. The Silurian was also a remarkable time in the evolution of fishes. Not only does this time period mark the wide and rapid spread of jawless fish, but also the highly significant appearances of both the first known freshwater fish as well as the first fish with jaws, which resulted from an adaptation of an anterior gill arch. The Silurian strata has fossils that are substantive evidence of life on land, particularly the arthropod groups. The fossils of the earliest of vascular plants are also prevalent. In the oceans, there was a widespread radiation of crinoids and a continuation of the expansion of the brachiopods.

Devonian (410 to 360 mya): The Devonian was a time of great change across the Tree of Life. Reef ecosystems saw new and more varied forms, including the ammonoids and fish. It was also a time when life achieved the critical event of adapting to land. Both the first tetrapods, or four legged land-living vertebrates, and the first arthropods colonized the land, including wingless insects and the earliest arachnids. In the sea, ammonoids and fish evolve and quickly diversify. Arthropods and ultimately tetrapods were plodding the lands. The first insects, spiders, and tetrapods evolve.

In the Lower Devonian, plants were very tiny and primitive, generally lacking the leaf, root and vascular systems that would soon appear. But plant radiation was already progressing rapidly and led to the ferns, horsetails and seed plants. By the late Devonian earth had forests of tall rooted trees covered with leaves. The lycopodes (Phylum Lycopodiophyta) are the oldest extant lineage of vascular plants. Sigillaria is an example of a lycopod tree. The seed-bearing Gymnosperms appeared near the end of the Devonian, an adaptation ultimately leading to propagation to dryer habitats.

The Devonian is often appropriately called the "Age of Fishes", since the fish took their place in complex reef systems containing nautiloids, corals, graptolites, blastods, echinoderms, trilobites, sponges, brachiopods and conodonts. With the many new forms of predators, trilobites continue to evolve their defensive strategies. During the Devonian, Placodermi (armored fish), Sarcopterygii (lobe-finned fish and lungfish) and Actinopterygii (conventional bony fish or ray-finned fish) evolved rapidly, many of which became huge and fierce predators. Until later in the Devonian the fishes were the only vertebrates, and gave rise to all other vertebrate lineages.

Arthropods radiated to become well-established on land in the Devonian, and in some cases attained impressive size. The increasing biomass of land plants and higher oxygen levels by the end of the Devonian faciliated the adaption to terrestrial life of herbivorous animals. The arthropods colonized the land, including wingless insects and the earliest arachnids. This adaptation was influenced by the Caledonian orogeny. This process began during the Cambrian – Silurian and resulted collision of the Iapetus Ocean. The final collision happened between Laurencia, Baltica and micro terrains at the end of Silurian period.

3.6. Carboniferous

Carboniferous (360 to 286 mya):

During the Carboniferous, the continents below the equator still formed the supercontinent Gondwana. Life flourished in the seas in the wake of the late Devonian Extinction. Ammonoids rediversified very quickly. It looks at the loba line which became very complicated during the evolution of this group (Fig. 1.2.).

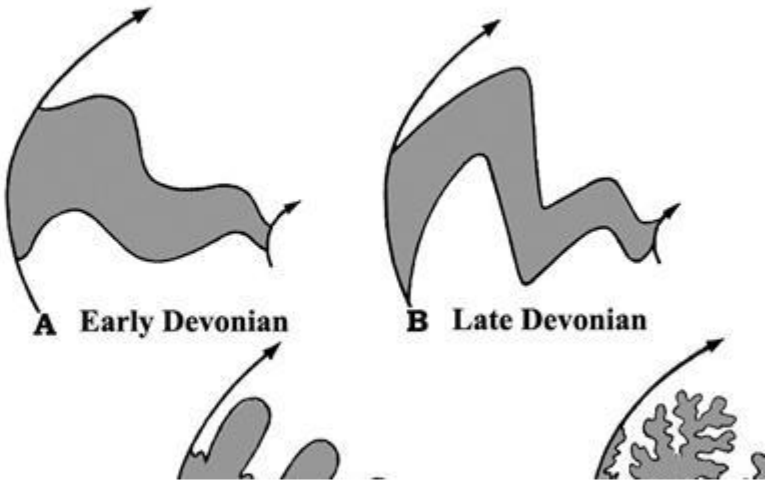


Fig. 1.2. Lobe alternations during the evolution of Ammonoidea

Crinoids, blastoids, brachiopods and bryozoans and single-celled Eukaryotes fusulinids known as fusulinids became abundant. The ray finned fishes radiate enormously. However, the age of the trilobite was drawing to a close.

Life on land really took root in the Carboniferous, setting the stage for huge coal deposits to be formed in low-laying swamps. Common in the coal producing swamps spore bearing lycopod trees that grew to more than 100 feet tall, Sigillaria and both spore-bearing and seed ferns. The early wingless insect forms that appeared in the Devonian acquire wings, and continue their radiation filling ever-expanding environmental niches. The burial of organically produced carbon is believed to have caused atmosphereic oxygen to increase to concentrations 80% higher than today, and may have, in turn, led to gigantism in some insects and amphibians whose limited respiratory systems would have otherwise constrained their size.

Despite the appearance of seeds, most Carboniferous plants continued to use spores from reproduction. The moist and swampy environments of the Carboniferous enabled the Lycophytes (i.e., scale trees and club mosses) that evolved during the late Silurian to early Devonian to continue to diversify and flourish throughout the Carboniferous. Similary, Calamites and ferns were other spore-bearing plants that appeared during the Devonian and thrived during the following Carboniferous period.

Reptiles first appear in the Carboniferous, following the appearance of amphibians in the Devonian. The amniote egg appears, an important evolutionary invent that set the stage for further colonization of the land by tetrapods. The ancestors of birds, mammals, and reptiles could then reproduce on land since the embryo no longer required an aqueous environment.

3.7. Pemian

Permian (286 to 245 mya):

The Permian Period extends from about 286 to 245 million years ago, and is the last geological period of the Palaeozoic Era. During the Late Palaeozoic there was the Variscan orogenic event. The collision of Euramerica and Gondwana produced a supercontinent, Pangea (Fig. 1.3.). It eventuated the change of the climate and the decrease of the self-area.

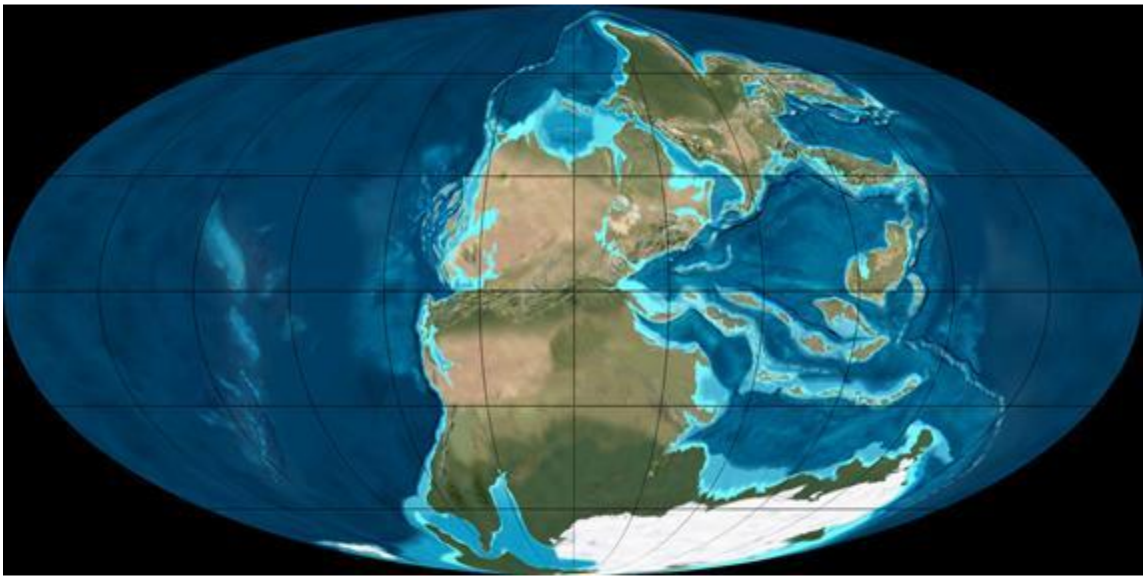


Fig. 1.3. Evolving of the Pangea during the Late Permian

Life on land included a diversity of plants, arthropods, amphibians and reptiles. The reptiles were mainly synapsids (Pelycosaurs and Therapsids) that appeared in the Upper Carboniferous, and were bulky, cold-blooded animals with small brains Towards the very end of the Permian the first archosaurs appear, the ancestors of the soon to follow Triassic dinosaurs. Permian marine environments were abundant in molluscs, echinoderms, and brachiopods.

The Permian ended with the most extensive extinction event recorded in palaeontology: the Permian-Triassic extinction event, where some 90% to 95% of marine organisms and 70% of all terrestrial organisms became extinct.

3.8. Mesozoic Era

One of the most striking events in the Mesozoic Era was the rise to dominance of dinosaurs in terrestrial ecosystems. The Mesozoic lasted from 245 to 65 million years ago, and is divided into three periods. The Mesozoic, which derives its name from the Greek with a rough meaning of middle animals, began after the Permian extinction and ended with the Cretaceous extinction. It comprises the Triassic, Jurassic and Cretaceous Periods. The Mesozoic is most famed for the Dinosaurs, and popular lexicon considers it the Age of the Dinosaurs (or Reptiles). The dinosaurs together with reptiles of all sizes ranging from the gigantic to the merely intimidating by human size standards, dominated the terrestrial environments. The flowering plants, or angiosperms, appeared in the Mesozoic.

Triassic (245 to 208 mya): The Permian-Triassic (P/T) Extinction Event marked the end of the Permian Period of the Paleozoic Era, and the start of the Triassic Period of the Mesozoic Era. The P/T extinction decimated the brachiopods, corals, echinoderms, mollusks, and other invertebrates. The last surviving trilobite order, the Proetids, also did not survive. The P/T event set the stage for adaptative radiation in both land and marine environments. Corals belonging to Hexacorallia appeared.

Among the Enchinodermata, the inadunate crinoids, which had barely survived the end-Permian extinction with one family, finally disappeared. While crinoids were the most abundant group of echinoderms from the early Ordovician to the late Paleozoic, they nearly went extinct during the Permian-Triassic extinction. All the post-Paleozoic crinoids, namely the Articulata, are presumed to be a monophyletic clade that originated from the inadunate Order Cladida. However there seems to be a great gap between the morphologies of articulates and Paleozoic crinoids. Thus, a single genus of crinoid is known from the early Triassic, and is ancestral to all "deep water" extant articulate crinoids.

Other invertebrates, notably the bivalves, ammonoids and brachiopods recovered to dominate the marine environment, and the squid-like Belemites appeared and became abundant. New groups of echinoderms appeared as well. Marine reptiles were highly diverse, including the Sauropterygia, nothosaurs, pachypleurosaurs, placodonts, and the first plesiosaurs. The ichthyosaurs appeared in the early Triassic, and radiated into huge, marine-dominating species. Seed plants dominated the land, especially conifers to the north and the Glossopteris, or seed ferns, to the south. The first flowering plants (the Angiosperms) probably evolved during the Triassic

The Triassic period closed with an extinction event that particularly affected marine life, including decimation of marine reptiles, except the surviving ichthyosaurs and plesiosaurs. A quarter of invertebrate families met extinction, as well as the conodonts. Actually, many extinction events punctuated the Triassic, which are believed to have provided additional selective pressures fostering the dinosaur radiation into emptied niches. Triassic land was predominately the supercontinent Pangea (meaning all the land) located near the equator. Sediments from the Dinosaurs would thus go on to be increasingly diverse and dominating in the subsequent Jurassic and Cretaceous Periods. Among other tetrapods, several reptilian orders also became extinct, including the protosaurs, nothosaurs, and placodonts.

Jurassic (208 to 146 mya): While the dinosaurs appeared in the Triassic, it was during the Jurassic that they prodigiously radiated and ascended to be the rulers of the land. Dinosaurs are a clade of reptiles defined by somewhat ambiguous criteria. Compared with other reptiles, the dinosaur hind limbs are beneath the body. The pelvis extends vertically so that the hip socket vertically carries the load, rather than on lateral loading other reptiles. In recent years dinosaurs have been viewed as transitional between ordinary reptiles (especially crocodiles) and the birds.

The immense plant-eating dinosaurs (the sauropods) were ubiquitous and were the prey of the large theropods, including ceratosaurs, megalosaurs, and allosaurs. Among plantae, Gymnosperms (especially conifers, Bennettitales and cycads) and ferns are common providing abundant food for the sauropods. Birds evolved during the late Jurassic. The pterosaurs, the flying reptiles, were common in the Jurassic. Fish and reptiles dominated marine environs. The ichthyosaurs, plesiosaurs, and marine crocodiles flourished, as did bivalves, belemnites, brachiopods, echinoids, starfish, sponges and ammonites among the invertebrates. Ammonites were very divergent during the Permian. There are special deep-marine limestones, so called ammonitico rosso (Pict. 1.9.), which contains remains of ammonites in high quantity. As a general rule, the mammals remained diminutive and backstage during the Jurassic.

Pict. 1.9. Polished surface of ammonitico rosso

Cretaceous (146 to 65 mya): During the Cretaceous, the rays, modern sharks and teleosts, or the ray-finned fish became widespread and diverse. The marine reptiles persisted, including the ichthyosaurs in the in the Lower and Middle of the Cretaceous, the plesiosaurs throughout the Cretaceous, and the mosasaurs that dominated the Upper Cretaceous. Baculites, a straight-shelled ammonite, flourished in the seas. The Cretaceous also saw the first radiation of marine diatoms in the oceans.

The archosaurian reptiles, particularly the dinosaurs, continue to dominate the land. Climate changes due to the breakup of Pangaea allowed flowers and grasses to appear for the first time. The most well-known dinosaurs, Tyrannosaurus rex, Triceratops, Velociraptor and Spinosaurus all lived in the Cretaceous. Pterosaurs remain common until the Upper Cretaceous when competition occurs from evolving birds. Mammals persist in their backstage existence among life on land. Insects became even more diverse as the first ants, termites and butterflies appeared, along with aphids, grasshoppers, and gall wasps. Another important Hymenopteran insect, the eusocial bee appeared, which was integral to and symbiotic with the appearance of flowering plants.

The Cretaceous ended at the so-called KT boundary, or the Cretaceous-Tertiary (K-T or KT) extinction event, that occurred some 65.5 million years ago (Fig. 1.4.). While the duration of this extinction remains unknown, half of all life’s genera disappeared; most famous was the extinction of the non-avian dinosaurs. Though many theories exist for the cause, the most widely-accepted is an impact on the Earth of an immense body from space.

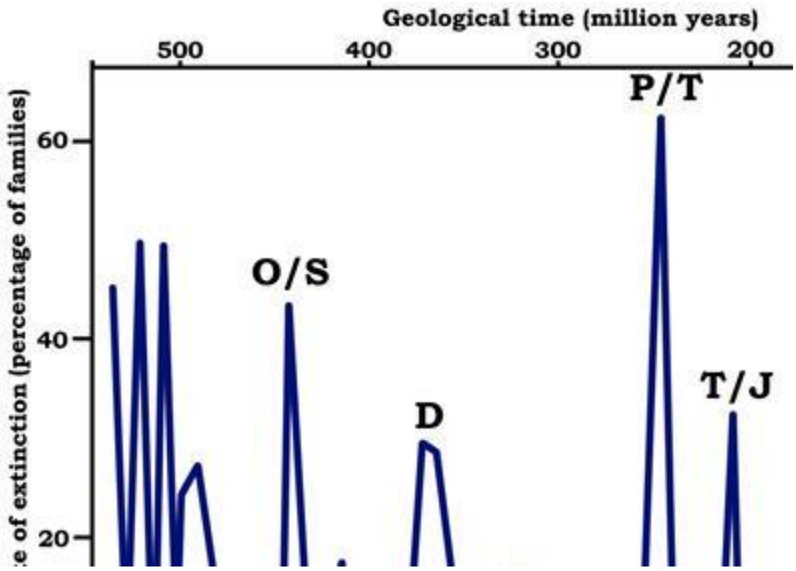


Fig. 1.4. Rate of extinctions during the evolution of biosphere on the base of extincted families

3.9. Cenozoic Era

The K/T Event set the stage for the Cenozoic Era Cenozoic Era that began 65 million years ago. As the dinosaurs perished at the end of the Cretaceous, the mammals took center stage. Even as mammals increased in numbers and diversity, so too did the birds, reptiles, fish, insects, trees, grasses, and other forms of life. Species changed as the epochs of the Cenozoic Era rolled by, with the mammals eventually becoming the largest land animals of the Era, as the dinosaurs had been during the Mesozoic. Flowering plants strongly influenced the evolution of both birds and herbivors throughout the Cenozoic era by providing a rich abundance of food. Those that could adapt to the changes in the environment survived; those that could not were doomed to extinction.

Invertebrates, fish and reptiles were similar to those of modern types, but mammals, birds, protozoa and flowering plants would undergo considerable evolutionary change.

Paleocene - The Paleocene Epoch began after the extinction of the dinosaurs. Mainly nocturnal mammals that had cowered in the shadows of dinosaurs for millions of years eventually evolved into a vast number of different forms to fill the newly vacant environmental niches. At the beginning of the Paleocene, most mammals were tiny and rodent-like. With time, mammals grew in size, number, and diversity. Many early mammal designs of this time would soon become extinct, but others would survive and then evolve into other forms. The diversity of birds, other animals, and plants increased, and species became more specialized. Although dinosaurs were gone, their reptile cousins lived on in the form of turtles, crocodiles, lizards, and snakes.

Eocene (54 to 37 mya) - The first grasses appeared in the Eocene Epoch with growth near the root as opposed to the tip, providing a vastly expanded and renewable food resource for the herbovores; this allowed adaptation to life on the savanna and prairie and the evolution of running animals such as the Equiidae (the horse family). The grazing mammals evolved the teeth enabling a diet of harsh grass. The Eocene Epoch was a period when flowering plants continued a massive radiation that began in the Paleocene Epoch. Plants thrived, and with that many animals as new environmental niches were filled. The first grasses also provided a refuge for many animals. Small mammals radiate. Many new species of shrubs, trees and small plants appeared. A variety of trees thrived in a warm Eocene climate, including beech, elm, chestnut, magnolia, redwood, birch, and cedar, and more. The evolution of plants was providing a powerful selective pressure across the entire animal Kingdom, and many new symbiotic systems appeared.

Oligocene (34 to 23 mya) - The Oligocene Epoch is in reference to the paucity of new mammalian animals after their radiation during the preceding Eocene Epic. The Oligocene is often considered as an important window of environmental transition from the tropical Eocene and the cooler Miocene. The start of the Oligocene is marked by a major extinction event that might have been caused by a meteor impact in Siberia or near the Chesapeake Bay. Angiosperms continued their expansion throughout the world, as did grasses. Temperate deciduous woodlands mostly replaced tropical and sub-tropical forests, while plains and deserts became more commonplace. Among the animals, mammals diversified markedly, and marine fauna evolved to forms closely resembling those extant today. Ancestors of modern elephants and rhinoceros grew to large size in Africa, where the first apes primate belonging to suborder Anthropoidea that includes monkeys, apes, and humans, also appeared.

Miocene (23 to 5 mya) - The Miocene is thus a very long 18 million years, and generally marks the transition from the far prehistoric world to a pseudo-modern world. A major expansion of grasslands occurred as forests declined in the cooler and dryer climate, driving selection and radiation of large herbivores, including the ruminants which are ancestors of modern cattle and deer. Mammals such as wolves, horses and deer as well as birds also generally evolved to closely resemble forms extant today.

Pliocene (5.3 to 1.8 mya) - The Pliocene climate was relative cool and dry as in modern times. These modern climates reduced tropical vegetation and shrank tropical forest to a band near the equator. Concurrently, deciduous and coniferous forests, tundra, grasslands, dry savannahs and deserts filled the space.

Continental drift would play a major role is how animals, and particularly terrestrial mammals were to distribute.

Both marine and terrestrial life was for the most part modern, though discernibly more primitive. Herbivores grew in size, as did their predators. The first recognizable human ancestors, the australopithecines, appeared in the Pliocene. Mammalian life evolved in continent-dependent ways, and some migration occurred between continents. In North America, rodents, mastodonts, elephant-like gomphotheres, and opossums were notably prolific, while hoofed animals generally declined. Africa’s hoofed animals and primates were notably successful, and the australopithecines (some of the first hominids) appeared late in the Pliocene The Pliocene seas were thrived with mammals such as seals and sea lions. Rudabánya is a fossil-rich famous Pliocene locality in Hungary. There were swamps at this area where fossilization rata was high. Mastodons, monkeys, small rodents and hominids are the most important fossils of this outcrop.

The Quaternary Period includes two geologic epochs: the Pleistocene and the Holocene. It began less than 2 million years ago. Pleistocene climate was marked by repeated glacial cycles where continental glaciers pushed to the 40th parallel in some places. It is estimated that, at maximum glacial extent, 30% of the Earth's surface was covered by ice. In addition, a zone of permafrost stretched southward from the edge of the glacial sheet, a few hundred kilometres in North America, and several hundred in Eurasia. The severe climatic changes during the ice age had major impacts on the fauna and flora. With each advance of the ice, large areas of the continents became totally depopulated, and plants and animals retreating southward in front of the advancing glacier faced tremendous stress. The most severe stress resulted from drastic climatic changes, reduced living space, and curtailed food supply. A major extinction event of large mammals (megafauna), which included mammoths, mastodons, saber-toothed cats, Irish elk, cave bears, and short-faced bears, began late in the Pleistocene and continued into the Holocene. Neanderthals also became extinct during this period. At the end of the last ice age, cold-blooded animals, smaller mammals like wood mice, migratory birds, and swifter animals like whitetail deer had replaced the megafauna and migrated north.

The most important event of Holocene is the evolution of the human and the human civilizations.

4. Trace fossils

Trace fossils are geological records of biological activity. Trace fossils may be impressions made on the substrate by an organism: for example, burrows, borings (bioerosion), urolites (erosion caused by evacuation of liquid wastes), footprints and feeding marks, and root cavities. The term in its broadest sense also includes the remains of other organic material produced by an organism — for example coprolites (fossilized droppings) or chemical markers — or sedimentological structures produced by biological means - for example, stromatolites. Trace fossils contrast with body fossils, which are the fossilized remains of parts of organisms' bodies, usually altered by later chemical activity or mineralization.

Sedimentary structures, for example those produced by empty shells rolling along the sea floor, are not produced through the behaviour of an organism and not considered trace fossils.

The study of traces is called ichnology, which is divided into paleoichnology, or the study of trace fossils, and neoichnology, the study of modern traces. This science is challenging, as most traces reflect the behaviour — not the biological affinity — of their makers. As such, trace fossils are categorised into form genera, based upon their appearance and the implied behaviour of their makers.

Trace fossils are generally difficult or impossible to assign to a specific maker. Only in very rare occasions are the makers found in association with their tracks. Further, entirely different organisms may produce identical tracks. Therefore conventional taxonomy is not applicable, and a comprehensive form taxonomy has been erected. At the highest level of the classification, five behavioral modes are recognized:

resting taces	resting traces
dwelling traces	
locomotion traces	crawling traces
walking traces	
runing traces	
jumping traces	
flying traces	
feeding traces	feeding traces
grazing traces	
predation traces	
other traces	

Owing to their nature, trace fossils can be considered as both paleontological and sedimentological entires, therby bridging the gap between two of the main subdivisions in sedimentary geology. Four major categories are recognized: (1) Bioerosion structure – a biogenic structure excavated mechanically or biochemically by an organism into a ridged substrate: includes borings, gnawings, scrapings, bitings and related traces (Pict. 1.10.).

Pict. 1.10. Bioerosion of boring bivalves and boring sponges in Early Miocene abrasion pebble

(2) Biostratification structures – a biogenic sedimentary structure consisting of stratification imparted by the activity of an organism: biogenic graded bedding, byssal mats, certain stromatolites and similar structures (Pict. 1.11.)

Pict. 1.11. Cross section of Cambrian stromatolite

(3) Bioturbation structures – a biogenic structure that reflects the disruption of biogenic and physical stratification features or sediment fabrics by the activity of an organism: includes tracks, trails, burrows and similar structure (Pict. 1.12.)

Pict. 1.12. Ophiomorpha nodosa – bioturbation of callianassid crab

(4) Biodepositional structures – a biogenic sedimentary structure that reflects the production or concentration of sediments by the activity of an organism: includes fecal pellets, pseudofeces, products of bioerosion and similar structures (Pict. 1.13.).

Pict. 1.13. Coprolite of dinosaur (www.nuggetsfactory.com)

4.1. The significance of trace fossils

Ichnofossils are very important in determining the ecology of extinct organism - although it is not always possible to link a single ichnofossil to the organism that made it.

Although individual traces can yield important information about the rocks within which they are found, e.g. U-shaped burrows make excellent geopetal indicators, generally, a single trace fossil alone is a poor indicator of the environment in which the trace maker lived. Trace fossil associations, however, can prove to be extremely useful tools in palaeoenvironmental interpretation. The two most powerful concepts in this regard are ichnocoenoses and ichnofacies, which are quite similar and might easily be confused with each other, so some initial definitions are perhaps in order. An ichnofacies is a rock sequence, the defining characteristics of which include its lithology and sedimentary structures (of which the only lebensspuren considered are specific trace fossils). An ichnocoenosis is an assembly of trace fossils that were all generated by members of the same community. They are used as components of ichnofacies, comprising less ichnodiversity than the broader range provided by the trace fossil signature of a full rock sequence.

5. Cenosoic formations of the Bükk Mountains

The Paleogene in the Bükk forms a homogeneous sedimentary cycle from the Upper Eocene to the top of the Oligocene. Formations overlie the metamorphosed and strongly-deformed Mesozoic structures with an angular unconformity everywhere. The Paleogene transgression commenced in the Middle Priabonian. A well-lit, shallow sea of normal-salinity water came into being on the carbonate shelf, which expanded from the SW. Rich, tropical biota settled down on the sea bottom. The rise of water level resulted in the development of a pelagic basin by the end of the Eocene. From the Early Oligocene onwards the Bükkian Paleogene Basin gradually became restricted from the world ocean. Due to its restricted position, a kind of endemism was developed in the biota. Opening of this connection, shallow-bathyal deposits arose at the southern part of the Bükk. In the Middle Oligocene the subsidence of the southern rim came to an end. The filling up of the basin resulted in the development of a shallow-marine environment. The Paleogene sedimentary cycle in the Bükk was closed by the Eger Formation, the latter being of a regressive character.

After the temporal regression that took place at the end of the Oligocene and at the beginning of the Miocene, the next transgression occurred in the Early Miocene. Rhyolite tuffs accumulated on the Bükkalja in several times. It’s because of the heavy volcanism of the Mátra and other areas. Carpathian stage was a calm period. Siliciclastic sediments deposited in shallow marine environment in this time. The vicinity of the Nagyvisnyó – Dédestapolcsány – Lénárddaróc line was an abrasion coat. Bioeroded abrasion pebbles and blocks deposited in high thickness.

At the end of the Miocene Bükk Mountains became terrestrial environment. The most important processes have been denudation and karstification.

Selected literatures

Báldi T. 2003: A történeti földtan alapjai. – Nemzeti Tankönyvkiadó, p. 312.

Baucon, A. 2010: Da Vinci’s Paleodictyon: the beauty of traces. – Acta Geologica Polonica 60(1), 3-17.

Boucot, A. J. 1990: Evolutionary Paleobiology of Behavior and Coevolution. – Elsevier, Amsterdam, p. 725

Buatois, L.A. 2010: Ichnology applied to facies analysis and sequence stratigraphy: a core workshop. – SLIC 2010 Latin American Symposium on Ichnology, p. 43.

Dávid Á. 1999: Predation by Naticid Gastropods on Late - Oligocene (Egerian) Molluscs Collected from Wind Brickyard, Eger, Hungary – Malakológiai Tájékoztató (Malacological Newsletter) 17, 11 – 19.

Dávid Á. 2003: Bioeróziós nyomok, patológiás elváltozások és epizoák a Mátra Múzeum Wind gyári puhatestűinek mészvázain. – Folia Historico Naturalia Musei Matraensis 27, 5-32.

Dávid Á. 2009: Bioeróziós és patológiás elváltozások az egerien Mollusca faunáján. – Disszertációk az Eszterházy Károly Főiskola Földrajz Tanszékéről 3., Eger, p. 230.

Dávid Á. - Fodor R. 2001: Activity of boring bivalves in Lower-Miocene (Karpatian) age abrasion pebbles of two localities – a comparison (Nagyvisnyó and Dédestapolcsány, Bükk Mountains, Hungary). – Wold Congress of Malacology, Vienna, Austria, Abstract Volume, 74.

Dávid Á. – Püspöki Z. – Kónya P. – Vincze L. – Kozák M. – McInthos R.W. 2006: Sedimentology, paleoichnology and sequence stratigraphy of a Karpatian sandy facies (Salgótarján Lignite Formation, N Hungary) – Geologica Carpathica 57(4), 279-294.

Dávid Á. – Püspöki Z. – Kozák M. – Demeter G. – Finta B. 2007: Terrestrial ichnoassemblages from the fluvial and lacustrine facies of the Quaternary formation in NE Hungary – a preliminary study. – International Ichnofabric Workshop 2007, Calgary, Canada /Abstracts/, 21-23.

Géczy B. 1993: Ősállattan. Invertebrata paleontologia. – Nemzeti Tankönyvkiadó, Budapest, p. 595.

Géczy B. 1993: Ősállattan. Vertebrata paleontologia. – Nemzeti Tankönyvkiadó, Budapest, p. 502.

Juhász Á. 1987: Évmilliók emlékei. – Gondolat Kiadó, Budapest, p. 562.

Pemberton, S. G. – Spila, M. – Pulham, A. J. – Saunders, T. – MacEachern, J. A. – Robbins, D. – Sinclair, I. K. 2001: Ichnology & Sedimentology of Shallow to Marginal Marine Systems: Ben Nevis & Avalon Reservoirs, Jeanne D'Arc Basin. – Geological Association of Canada Short Course, 15, p. 343.

Seilacher, A. 1964: Sedimentological classification and nomenclature of trace fossils. – Sedimentology, 3, 253-256.

Szónoky M. 1995: A Föld és az élet fejlődése. – JATEPress, Szeged, p. 212.

www.paleodb.org

http://www.fossilmuseum.net

http://research.eas.ualberta.ca/ichnology

http://www.ichnology.ca

Palaeonological exhibition of the Mátra Museum

6. Palaeobotanical exhibition

Fossil plants recorded from the rocks of the Carboniferous-Pleistocene in Northeaster Hungary are on view at the exhibitions. This part of our country is also notewortly from the point of view of paleobotany. Most of the fossils were yielded by Paleogene and Neogene deposits. Among Paleogene localities Eger-Kiseged is overriding importance, it dates back to the end of the Early Oligocene, thus its fossil plants are about 35 million years old. The remains of terrestrial plants, leaves, fruits and seeds had drifted into the former sea, then were burried by sediments and fossilized. Nowadays unknown, ancient plants were recorded here the most of which became extinct as early as the Late Oligocene. These plants were tropical-subtropical requiring warm climates, and their remote modern relatives are to be found in South-East Asia. This extremely exotic flora flourished during the Early Oligocene at much lower latitudes than the recent latitudinal position of Eger. The great variety of plants is manifested both in the high diversity and the morphological variability of species. The flora and vegetation were dominated by ancient species of beech, oak, walnut, laurel, leguminous plants, elm, buckthorn, however, numerous exotic, tropical plants appeared, such as Sloanea of the Elaeocarpaceae family. Among plants that have become extinct during Earth history Ráskya recorded also in Kiseged, is a quite peculiar one with its winged fruits.

From the younger Late Oligocene epoch the locality in the Eger-Wind brickyard is noted for plant remains. Fossils were collected from three levels which are referred to as „lower", „middle" and „upper level floras" representing different time slices. The „lower level flora" is the oldest one, some elements of which recall the thermophilous ancient flora of the Early Oligocene. The most diverse among the three levels is the youngest „upper level flora" which includes in the mass the remains of a riparian vegetation. This flora is much more modern with several new plant taxa resembling extant specie and requiring in part temperate climatic conditions. However, temperate elements appeared along the rivers and withdrew to catchment areas, whereas most of the plant forming the zonal vegetation were thermophilous. Due to the presence of swamps and inundated areas the number of riparian and paludal taxa is high. Plants, like a species of Acer (Acer trilobatum), alder, elm, laurel species, Myrica, „Rhamnus" warthae –a species known only from the Late Oligocene of the Carpathian Basin – swamp cypress, ferns and other plants dominated this flora.

After the uplift of the Carpathians significant volcanic events took place in more cycles during the Miocene. Owing to this, the formation of silicified woods was favoured by upwelling hydrothermal solutions, a quite nice example of which is exhibited from Mikófalva. Great number of localities are known from the Miocene of Northeastern Hungary (Felsőtárkány, Sály, Dédestapolcsány, Uppony, Mikófalva, Bánhorváti, Balaton-Dellő). Fossil plants indicate well warming and cooling cycles during the Miocene. Remains of woingnut (Pterocarya), maple (Acer), mediterranean species of oak (Quercus), laurel (Lauraceae), sweet gum (Liquidambar), leguminous plants (Leguminosae) and Zelkova were frequent in the floras. The occurrence of thermophilous plants, e.g. palms, serves as a proof of the fact that even as late as the younger Miocene subtropical climate periods that were much warmer than today, took place. In addition to changes of the zonal climate, the flora indicates well the coeval environment (swamps, wetlands, lowlands, uplands, etc.).

Leaf fossils of the Pleistocene epoch have been preserved first of all in freshwater limestones formed in the vicinity of thermal waters. Mainly species of ferns, alder, elm and hazel-nut were recorded. Since these plants represent the plant cover formed in the special environment of thermal waters they provide useful pieces of information on the microclimate of the hydrotermal area. Information of the remote palaeoenvironment can be obtained by the study of pollens (palynological studies).

Professor baron Gábor Andreánszky was an outstanding personality of palaeobotanical studies in Hungary. He studied among others the fossil floras of Northeastern Hungary and described numerous new fossil species based on the collections of the Mátra Museum.

7. Palaeozoological exhibition

Fossils are the remains of ancient life. These remnants or traces of organisms of past geologic ages help us learn about evolution and the development of ancient environments of the Earth. Fossils date back to thousands of years to many millions of years in age, and come in a variety of sizes, from minute traces to large skeletons. Trace fossils are clues to former life, they are resulted by the activities or presence of animals and plants.

The oldest rocks of Bükk Mountains were formed at the end of Palaeozoic Era during the Carboniferous and Permian periods reflecting marine environments. These rocks can be fined in the vicinity of Nagyvisnyó. The most famous Carboniferous locality is at cuts of Eger-Putnok Railway. Brachiopods, bryozoans, crinoids can be found here. While the most beautiful locality of Permian marine sediments is the Mihálovits quarry.

The Bükk Mountains are mainly built up of Triassic limestone which is relatively poor in fossils. Some green algae (Diplopora) and bivalves (Daonella) can be collected only. The Cretaceous ager fossils refer to the diversity of the ancient fauna of small biohermas. The most characteristic fossils are colonial corals and Rudist bivalves.

Cainozoic rocks of the Bükk Mountains are also marine deposits. During the Eocene, shallow marine environment were dominant at this area. The biggest locality of Eocene sediments is the Nagy-Eged Hill, near to Eger. Nummulites, sponge and coral colonies, molluscs are very common here.

During the Oligocene, Paratethys took place in the Carpathian Basin. Several world-famous Oligocene localities can be found at the vicinity of Eger. Kiseged is a well-known locality of Early Oligocene plant remains and fishes. While the outcrop of Wind Brickyard is the stratotype of Egerian. Leaves, solitary corals, molluscs, fish remains can be collected here. Rocky shoreface were characteristic near to Nagyvisnyó and Dédestapolcsány at the beginning of Miocene. Bioerosional traces are very common in the abrasion pebbles. These trace fossils are from several boring sponges, boring bivalves and worms mostly. At the end of Miocene, during the Pleistocene, characteristic climate change were determinate. Special megafauna leaved in the Carpathian Basin at this time: wholly mammoth, wholly rhino, cave bear, cave lion. This megafauna extincted 10.000 years ago, because of the climate change.

Selected literatures

Andreánszky G. 1966: On the Upper Oligocene Flora of Hungary. Analysis of the Site at the Wind Brickyard, Eger. – Studia Biologica Hungarica 5, p. 151.

Báldi T. 1973: Mollusc fauna of the Hungarian Upper Oligocene /Egerian/. - Akadémiai Kiadó, Budapest, p. 511.

Dávid Á. 2009: Bioeróziós és patológiás elváltozások az egerien Mollusca faunáján. – Disszertációk az Eszterházy Károly Főiskola Földrajz Tanszékéről 3., Eger, p. 230.

Főzy I. – Szente I. 2007: A Kárpát-medence ősmaradványai. – Gondolat Kiadó, Budapest, p. 456.

Fűköh L. 2010: Gerinctelen-ősmaradványok a Mátra térségében. – In: Baráz Cs. (szerk.) 2010. A Mátrai Tájvédelmi Körzet. Heves és Nógrád határán. – Eger, 81. - 83.

Géczy B. 1993: Ősállattan. Invertebrata paleontologia. – Nemzeti Tankönyvkiadó, Budapest, p. 595.

Géczy B. 1993: Ősállattan. Vertebrata paleontologia. – Nemzeti Tankönyvkiadó, Budapest, p. 502.

Hably L. 2010: Ősnövénymaradványok a Mátra térségében. – In: Baráz Cs. (szerk.) 2010. A Mátrai Tájvédelmi Körzet. Heves és Nógrád határán. – Eger, 79-80.

Hably L. – Erdei B. – Kvaček, Z. 2001: 19th century's palaeobotanical types and originals of the Hungarian Natural History Museum, p. 235.

Hír J. 2010: Miocén korú szárazföldi gerincesek maradványai a Mátra hegységben. – In: Baráz Cs. (szerk.) 2010. A Mátrai Tájvédelmi Körzet. Heves és Nógrád határán. – Eger, 85-90.

Vörös I. 2010: Fossilis Elephantidák a Mátra környékén. – In: Baráz Cs. (szerk.) 2010. A Mátrai Tájvédelmi Körzet. Heves és Nógrád határán. – Eger, 91-98.

PALAEONTOLOGICAL FIELD TRIP TO THE BÜKK MOUNTAINS

Route: Eger – Szarvaskő – Mónosbél – Bélapátfalva – Szilvásvárad – Nagyvisnyó – Dédestapolcsány – Nekézseny – Csernely – Bükkmogyorósd – Szilvásvárad – Bélapátfalva – Mónosbél – Szarvaskő – Eger (100 km) (Fig. 3.1.)

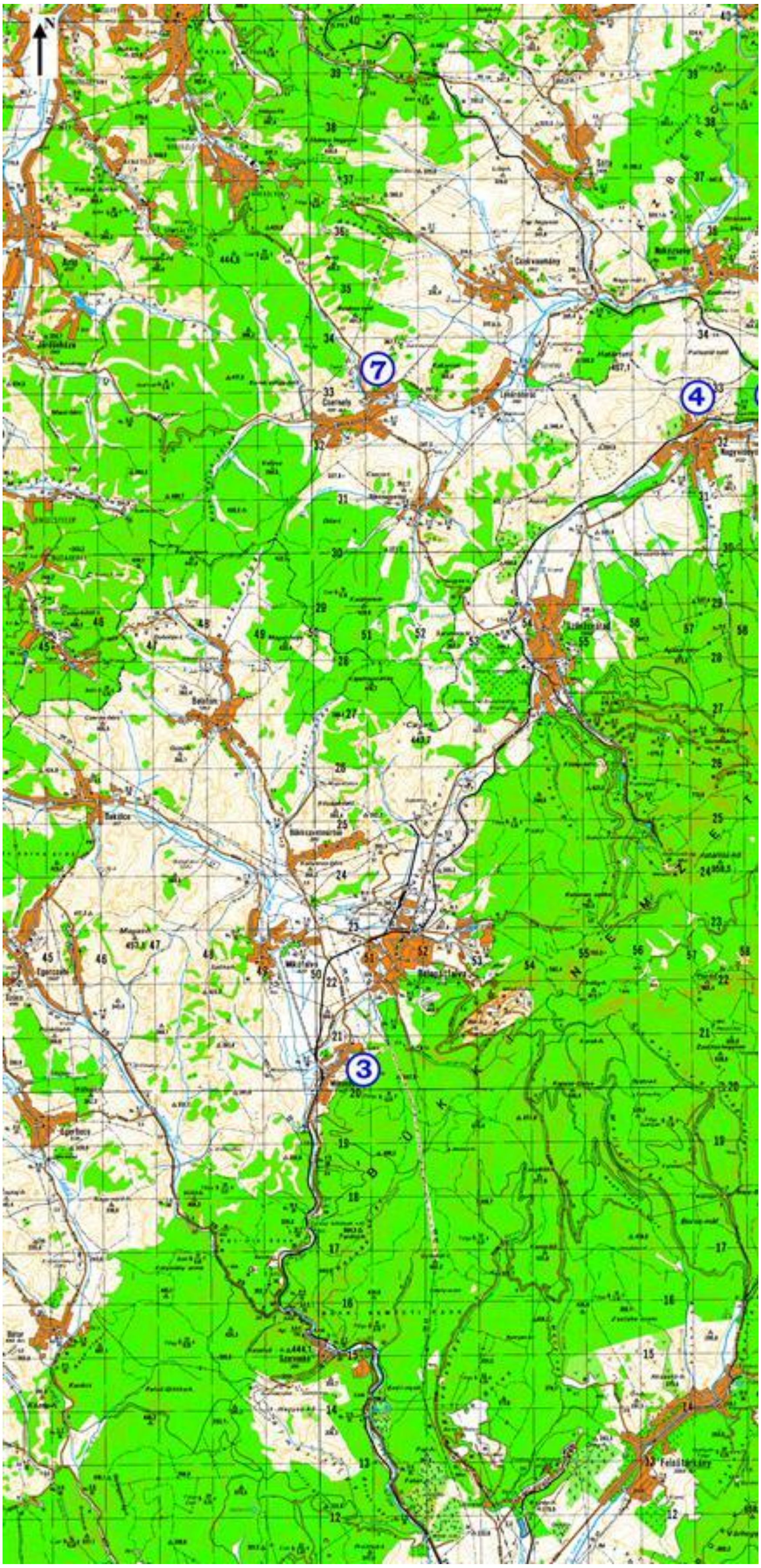


Fig. 3.1. Topographical map of the one-day field trip at Bükk Mountains

Aims: To get acquinted with the development of the Bükk Mountains on the basis of paleontological data. To know the most important fossil finding sites of the Bükk Mountains, and to collect fossils at the above mentioned localities.

It is important to take care of your and of the others' physical soundness during the field trip!

8. Geology of the Bükk Mountains

Bükk Mountains was built mostly such marine sediments which arose during the Late Paleozoic and the Early Mesozoic. These rocks are limestone, shale, radiolarite, dolomite and sandstone. These formations can be analogue with the South Apline and Dinarid formations.

The oldest section recorded in the Bükkian sedimentary cycle was deposited in a pelagic basin during the Carboniferous. The filling up of this flysch basin resulted in the development of a shallow marine environment. Sedimentation vas controlled mainly by a continuous siliciclastic influx. Shales and bioherma-limestones arose in this time.

Permian is featured by shallow-marine limestones. This formation evolved in anoxic sea. It's rich in benthic flora and fauna (alga, foraminifers, brachiopods). The mass extinction at the Permian-Triassic boundary was not followed by significant changes in the sedimentary patterns; the accumulation of sediments continued on a gently sloping shallow shelf.

During the Early Triassic the sedimentary basin became less restricted and a well-oxigenated, wave-agitated ramp came into being. In the high-energy environment of the inner ramp characteristic coatal or nearshore oolithic sand banks were formed. As in other parts of the Tethyan shelf, from the beginning of the Middle Triassic, a carbonate plateau also came into being in the Bükk Unit. A rich biota developed in the shallow water of the slowly but steadily sinking area, and the latter was separated from the distant continental terrain by sedimentary traps. Stromatolites, rip-up and redeposited algal mat laminae, and strata consisting of oncoids with a diameter of some centimetres, alternate with subtidal sediments. These latter are indicative of the well-oxygenated, well-circulated shallow water of the euphotic zone in the lagoonal environment of the platform. These facieses are dominant in the Bükk Mountains.

During the Early Jurassic special magmatic succession, so called ophiolitic series was formed at the area. The area of the Bükk may have been close to the rift zone of the Tethys in this time. Basalt lava flows, pillow-lava masses and radiolatites show these processes.

Cretaceous rocks are very rare in the Bükk Mountains. Near to Nekézseny and Dédestapolcsány can be found Late Cretaceous conglomerates which were deposited in shallow-marine environment. The age of this is Senonian on the base of fossils.

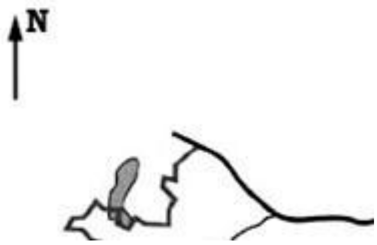
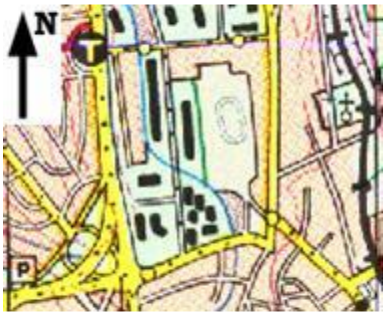
The Paleogene in the Bükk forms a homogeneous sedimentary cycle from the Upper Eocene to the top of the Oligocene. Formations overlie the metamorphosed and strongly-deformed Mesozoic structures with an angular unconformity everywhere. The Paleogene transgression commenced in the Middle Priabonian. A well-lit, shallow sea of normal-salinity water came into being on the carbonate shelf, which expanded from the SW. Rich, tropical biota settled down on the sea bottom. The rise of water level resulted in the development of a pelagic basin by the end of the Eocene. From the Early Oligocene onwards the Bükkian Paleogene Basin gradually became restricted from the world ocean. Due to its restricted position, a kind of endemism was developed in the biota. Opening of this connection, shallow-bathyal deposits arose at the southern part of the Bükk. In the Middle Oligocene the subsidence of the southern rim came to an end. The filling up of the basin resulted in the development of a shallow-marine environment. The Paleogene sedimentary cycle in the Bükk was closed by the Eger Formation, the latter being of a regressive character.

After the temporal regression that took place at the end of the Oligocene and at the beginning of the Miocene, the next transgression occurred in the Early Miocene. Rhyolite tuffs accumulated on the Bükkalja in several times. It's because of the heavy volcanism of the Mátra and other areas. Karpatian stage was a calm period. Siliciclastic sediments deposited in shallow marine environment in this time. The vicinity of the Nagyvisnyó – Dédestapolcsány – Lénárddaróc line was an abrasion coat. Bioeroded abrasion pebbles and blocks deposited in high thickness.

At the end of the Miocene Bükk Mountains became terrestrial environment. The most important processes have been denudation and karstification.

9. 1st stop: Eger, Wind Brickyard

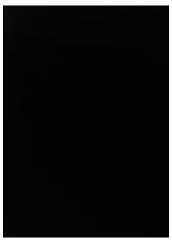
The Wind Brickyard's exposure is situated at the SE part of Eger (Fig. 3.2.1.). It's an active mine, which can be approach by car or on foot. Geographical coordinates of the locality are: 47°53'47.55"N, 20°23'52.20"E (Fig. 3.2.2.).

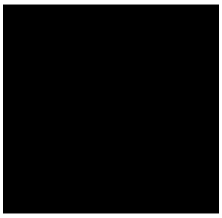
 Fig. 3.2.1. Geographical position of the Wind Brickyard	 Fig. 3.2.2. Topographical map of Eger and its environs	 Fig. 3.2.3. Geological map of Eger and its environs

This exposure is the stratotype of the Egerian stage. The stage is transition between Oligocene and Miocene. The succession of the outcrop belongs to the NP 25 nannoplankton and the Paragloborotalia opima opima foraminifer zones (Fig. 3.2.3.).

The succession of Wind Brickyard exposes the lower unit of the formation. Several marine facies (shallow batial, sublittoral, littoral, lagoonar) can be observed here with diverse flora and fauna. The layers of the Egerian Formation develop concordantly from Kiscellian Formation. Glauconitic tuffitic sandstone settles onto it. Characteristic fossils of it are the following: Flabellipecten burdigalensis Lamarck, Cerithium egerense Gábor, Babylonia eburnoides umbilikoziformis Telegdi-Roth, Dentalium apenninicum Sacco, corals and shark teeth.

Molluscan clay develops from the glauconitic sandstone in 35-40 m thickness. It has a rich and diverse micro-fauna with foraminifers, small molluscs and otoliths. 5-5,5 m thick sandy clay can be found on it. This layer contains the so called "middle flora". 2 m thick limonitic sandstone is the next layer. It contains variable, excellently preserved mollusc fauna. Because of the diverse fauna this layer called "k"-layer (k like fossiliferous /kövületes/ in Hungarian). The succession proceeds with brackish, shallow marine sand layers, which contain Anadara diluvii Lamarck, Mytilus aquitanicus Mayer, Ostrea cyathula Lamarck, and Tympanotonus margaritaceus Brocchi mostly. This is the "m"-layer (Mytilithic). Finally there is a 4-5 m thick limonitic sand on the top of the succession.

 Detail of the Wind Brickyard' exposure	 Turris sp. in molluscan clay	 Cinnamomum sp.; leaf remain	 Fragments of Balanophyllia desmophyllum Edwards - Haime	 Pitar polytropa Anderson
 Flabellipecten	 Aporrhais callosa (Telegdi-Roth)		 Dentalium sp.	

burdigalensis (Lamarck)		Hadriana egerensis (Gábor)		Lamna sp., shark tooth
 Osteichthyes indet., vertebra of bony fish	 Eroded Entobia cateniformis Bromley et D'Alessandro, in the test of Conus dujardini egerensis Noszky			

10. 2nd stop: Noszvaj, Kiseged, roadcut

The Kiseged Hill is about two kilometres distance to Eger. There are several road-cuts expose the formations of the hill along the road to Noszvaj (Fig. 3.3.1.). One of these contains the world-famous Oligocene flora. Geographical coordinates of the locality are: 47°54’57.49”N, 20°24’34.37”E (Fig. 3.3.2.).

 Fig. 3.3.1. Geographical position of Kiseged	 Fig. 3.3.2. Topographical map of Kiseged and its environs	 Fig. 3.3.3. Geological map of Kiseged and its environs

Silty marls which contains the plant remains belong into the Tard Clay Formation. The age of this formation is Upper Eocene – Lower Oligocene and belongs to the NP 23 nannoplankton zone (Fig. 3.3.3.).

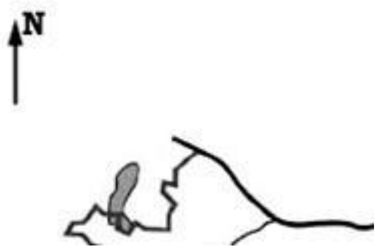
Flora of Kiseged was tropical-subtropical referring to warm climate, and their remote modern relatives now can be found in South-East Asia. This extremely exotic flora flourished during the Early Oligocene at much lower latitudes than the recent latitudinal position of Eger. The great variety of plants is manifested both in the high diversity and the morphological variability of species. The flora and vegetation were dominated by Zizyphus zizyphoides, Eotrigonobalanus furcinervis, Sloanea elliptica and Engelhardia orsbergensis. Wingeg fruits are also really important at the locality, like Raskya ventusta, Tetrapterys harpyiarum, Engelhardia brongniarti, Cedrelospermum aquense, Eotrigonobalanus andreanszkyi. There are a lot of leaves which conserved their cuticles. It made possible the determination of several Laurophyllum species.

 View of the locality at Kiseged Hill	 Early Oligocene laminated marl is exposed at the Kiseged Hill locality	 Pteridophyta indet.; ancient pteridopgyte	 Pinaceae indet., pine cone	 External mould of sea grass on the surface of laminated marl
				

External mould of sea grass on the surface of laminated marl (closer view)	Styrax sp.	Castanea sp.	Cinnamomum sp.; leaf remain	External mould of leafs on the surface of laminated marl
 External mould of crab on the surface of laminated marl	 Osteichthyes indet. external mould	 Osteichthyes indet. 2 external mould	 Osteichthyes indet. 3 external mould	 Osteichthyes indet.4 external mould
 Osteichthyes indet. 5external mould	 Fish scales in laminated marl			

11. 3rd stop: Mónosbél, Vízfő

At the eastern end of Mónosbél can be found one of the biggest travertine formation of Europe (Fig. 3.4.1.). Geographical coordinates of the locality are: 48°02’04.18”N, 20°20’21.20”E (Fig. 3.4.2.).

 Fig. 3.4.1. Geographical position of Vízfő at Mánosbél	 Fig. 3.4.2. Topographical map of Mónosbél and its environs	 Fig. 3.4.3. Geological map of Mónosbél and its environs

Travertine is an interesting but not frequent rock type of carbonate mountains (Fig. 3.4.3.).

Developing of this formation started during the Pleistocene. Springs of Vízfő built the small benches and stairs. Benches are 30-40cm in width and 5–10 cm in high. Streams are not persistent today because of an underground reservoir.

The travertine covers 15 hectares on the surface.. There is an abandoned travertine quarry conquered by the vegetation. There are small cavities in the limestone, where dropstones and peastones can be found. Fossils are very rare in this limestone. Mostly imprints of leaves and freshwater snails can be found here.

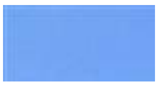
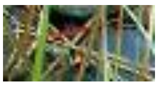
View of the locality at Vízfő, Mónosbél	 Abandoned limestone quarry at Vízfő	 Travertine-cliffs at Vízfő	 High-porosity travertine	 Travertine contains plant remains and external moulds
 External mould of leaf	 External moulds of plants			

12. 4th stop: Nagyvisnyó, Határ Hill

There is an abandoned limestone quarry in the vicinity of railway station at Nagyvisnyó-Dédes (Fig. 3.5.1.). Geographical coordinates of the locality are: 48°08'43.65"N, 20°25'32.68"E (Fig. 3.5.2.).

 Fig. 3.5.1. Geographical position of Határ Hill at Nagyvisnyó	 Fig. 3.5.2. Topographical map of Nagyvisnyó and its environs	 Fig. 3.5.3. Geological map of Nagyvisnyó and its environs

There were shallow marine, black coloured Permian age limestone mined here, which formed during anoxic circumstances Abandoned quarry of Határ Hill exposes abrasion pebbles of Permian black limestone. These pebbles formed in littoral, shallow marine environment, during the Early Miocene, Karpatian stage. At that time along the Nagyvisnyó – Dédestapolcsány – Lénárddaróc line an abrasion shoreline developed. Thick pebbly formation evolved close to the coast line. These pebbles are heavily bioeroded by marine organisms. Boring sponges (Clionaidae), boring bivalves (Lithophagidae) and marine worms (Sipunculidae, Polychaete) left their traces in the pebbles and steep cliffs dominantly (Fig. 3.5.3.).

 View of the strip pit at Határ-tető quarry, Nagyvisnyó	 The eastern wall of the quarry covered by Early Miocene age abrasion pebbles	 Bioeroded abrasion pebbles in the quarry	 Bioeroded surface of a limestone block at the Határ-tető quarry	 Trace fossils of boring bivalves in a limestone block at the Határ-tető quarry
				

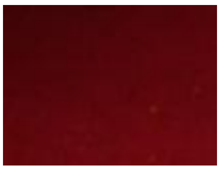
Trace fossils of boring bivalves in a limestone block at the Határ-tető quarry (closer view)	Entobia isp. in an abrasion pebble at the Határ-tető quarry	Gastrochaenolites lapidicus Kelly - Bromley	Gastrochaenolites isp. in an abrasion pebble at the Határ-tető quarry	Epoxy cast of Caulosrtepsis contorta Bromley - D'Alessandro
 Epoxy cast of Maeandropolydora elegans Bromley - D'Alessandro				

13. 5th stop: Nagyvisnyó, 416th railway section

The railway between Eger and Putnok has been constructed at the beginning of the 20th. century (Fig. 3.6.1.). During the construction several railroad cuts exposed the oldest formations of the Bükk Mountains. These were the Late Carboniferous – Permian shales and limestones. Fossil-rich Carboniferous shale can be found at the 416th railway section. Geographical coordinates of this outcrop are: 48°08'48.94"N, 20°26'54.66"E (Fig. 3.6.2.).

 Fig. 3.6.1. Geographical position of 416th railway section at Nagyvisnyó	 Fig. 3.6.2. Topographical map of Nagyvisnyó and its environs	 Fig. 3.6.3. Geological map of Nagyvisnyó and its environs

The most common fossils are Brachiopods, Bryozoans (Fenestella, Penniretepora, Septopora), Trilobites and plant remains (Calamites). On the basis of the fossils, the material of the shale has been formed among shallow marine, tropical circumstances, under the swash zone. Close to the above mentioned outcrop, limestone blocks can be observed, which contain fusulinid foraminifers, rugos corals, Scaphopods, bivalves, gastropods, and rarely trilobites (Fig. 3.6.3.).

 The railway leading to the 416th railroad section situated between Nagyvisnyó and Nekézseny	 View of the 416th railroad section	 The locality at the 416th railroad section situated between Nagyvisnyó and Nekézseny	 Carboniferous shale at the locality of 416th railroad section	 Fragmented, laminated, metamorphic shale
				

Shale debris at the 416th railroad section	The Carboniferous shale contains fossils abundantly	Bryozoa, Fenestella sp. in Carboniferous shale	Bryozoa; Fenestella sp. in Carboniferous shale	Bryozoa; Fenestella sp. Carboniferous shale
 Bryozoa; Fenestella sp. in Carboniferous shale (closer view)	 Bryozoa; Septopora sp. in Carboniferous shalev	 Crinoid stem fragment in Carboniferous shale	 Crinoid stem fragment in Carboniferous shale	 Crinoid stem fragment in Carboniferous shale
 Crinoid stem fragments in Carboniferous shale	 Crinoid stem fragments from the locality of 416th railroad section			

14. 6th stop: Dédestapolcsány, Malom Hill

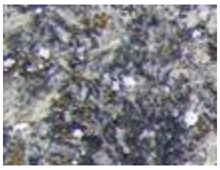
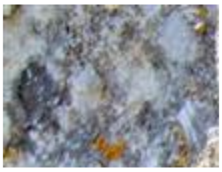
At the territory of the North Hungarian Mountain Ranges the only place where Cretaceous age rocks occur is a narrow stripe in the vicinity of Bükk Mountains and Uppony Hills, between Csokvaomány and Dédestapolcsány (Fig. 3.7.1.). This is a conglomerate-sandstone succession, which belongs into the Nekézseny Conglomerate Formation. The age of this formation is Late Cretaceous, Senonian (75-80 million years old).

 Fig. 3.7.1. Geographical map of the locality at Dédestapolcsány	 Fig. 3.7.2. Topographical map of Dédestapolcsány and its environs	 Fig. 3.7.3. Geological map of Dédestapolcsány and its environs

The material of this conglomerate is not from the Bükk Mountains. Around 60 percent of the pebbles is originated from the Aggtelek and Rudabánya Mountains, but there are paleozoic rocks from the Uppony Mountains, too. The conglomerate was formed in shallow marine environment, as underwater fans.

NW of Dédestapolcsány some light-grey, coral-rudist limestone boulders are known within the conglomerate. Geographical coordinates of this outcrop are: 48°11’28.14”N, 20°28’29.25”E (Fig. 3.7.2.). These limestone blocks are lenticular in their structure. The most common fossils are colonial corals and rudist bivalves in them (Fig. 3.7.3.).

 View of the locality at Malom Hill, Dédestapolcsány	 Limestone blocks at the abandoned limestone quarry at	 Limestone blocks are situated in Cretaceous age	 Conglomerate and sandstone layers at the locality	 Limestone fragments among the pebbles in the

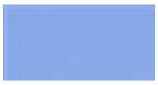
	Malom Hill, Dédestapolcsány	conglomerate	debris	
 The debris of the Cretaceous age limestone contain fossils abundantly	 Surface of a biogenic limestone block at Malom Hill, Dédestapolcsány	 Laminated – lenticular limestone at Malom Hill, Dédestapolcsány	 Coral- and bivalve fragments in the Cretaceous age limestone	 Stylina tubulifera; colonial coral from the Malom Hill, Dédestapolcsány
 Cross section of a colonial coral; Stylina tubulifera (Philips)	 Colony fragment of Microsolena sp. from the Malom Hill, Dédestapolcsány	 Colony fragment of Fungiastraea sp. from the Malom Hill, Dédestapolcsány	 Surface of Fungiastraea sp. from the Malom Hill, Dédestapolcsány	 Cross section of rudist in limestone from the Malom Hill, Dédestapolcsány
 Rudist fragment in limestone from the Malom Hill, Dédestapolcsány	 Rudist valve from the locality	 Thin section of rudist fragments		

15. 7th stop: Csernely, sandpit

One kilometre from Csernely to north there is a hundred metres long abandoned sandpit, close to the road (Fig. 3.8.1.). Geographical coordinates of the outcrop are: 48°09'12.44"N, 20°20'24.13"E (Fig. 3.8.2.).

 Fig. 3.8.1. Geographical position of Csernely, sandpit	 Fig. 3.8.2. Topographical map of Csernely and its environs	 Fig. 3.8.3. Geological map of Csernely and its environs

The sandpit at Csernely exposes fine- and middle grain size limonitic sand succession. The age of this formation is Early Miocene, Karpatian and it belongs into to the Egyházasgerge Formation (Fig. 3.8.3.). The lower part of the succession is unbedded sand. Coquinas and sandstone beds can be found in it. Coquinas are full with scaphopods. Venerid bivalves, Pecten, Corbula and scaphopods occur on and in the sandstone blocks regularly. In the case of some sandstone blocks sedimentation patterns like ripple marks can be observed. Trace fossils (bioturbation) are also characteristic at certain levels of the exposure. While alternation of sand and marl can be observe at the upper part of the succession. This alternation shows the oscillation of sea water.

 Detail of the Csernely sandpit	 Arduous wall of the Csernely sandpit	 Fossils can be collected from the debris at the bottom of the quarry’s wall	 Fossils occur on the surface of sandstone layers, too	 Underwater ripple marks on the surface of a sandstone block
 Fossil-rich levels in unstratified sandstone	 Coquinas are common in the sand pit	 Scaphopod coquina in sandstone	 Scaphopod coquina on the surface of a sandstone block	 Poorly preserved Scaphopod fragments in sandstone
 Oriented Scaphopod fragments on the surface of a sandstone block	 Scaphopoda indet. on the surface of a sandstone block	 Scaphopoda indet. on the surface of a sandstone layer (closer view)	 Bivalves are also common fossils at the locality	 Pecten sp. on the surface of a sandstone block
 Alternation of sand and marl layers at the upper part of the succession	 Alternation of sand and marl layers refers to the oscillation of sea level			

Selected literatures

Báldi T. 1973. Mollusc fauna of the hungarian Upper Oligocene (Egerian). Studies in stratigraphy, palaeoecology, palaeogeography and systematics. – Akadémiai Kiadó, Budapet, p. 511.

Báldi T. 1998: Magyarország epikkontinentális oligovén képződményeinek rétegtana. – In: Bérczi I. – Jámbor Á. 1998: Magyarország geológiai képződményeinek rétegtana. –Budapest, 419-435.

Dávid Á. 2007: Eger, Wind-féle téglagyár agyagbányája. – In: Pálfy J. – Pazonyi P. (szerk.) 2007: Őslénytani Kirándulások Magyarországon és Erdélyben. – Hantken Kiadó, Budapest, 204-207.

Dávid Á. 2009: Bioeróziós és patológiás elváltozások az egerien Mollusca faunáján. – Disszertációk az Eszterházy Károly Főiskola Földrajz Tanszékéről 3., p. 230.

Dunai M. 2007: Nagyvisnyó, vasúti bevágások (I-V.). – In: Pálfy J. – Pazonyi P. (szerk.) 2007: Őslénytani Kirándulások Magyarországon és Erdélyben. – Hantken Kiadó, Budapest, 207-209.

Főzy I. – Szente I. 2007: A Kárpát-medence ősmaradványai. – Gondolat Kiadó, p. 456.

Fűköh L. 2007: Mónosbél, Darázskő-bánya. – In: Pálfy J. – Pazonyi P. (szerk.) 2007: Őslénytani Kirándulások Magyarországon és Erdélyben. – Hantken Kiadó, Budapest, 214-217.

Fülöp J. 1994: Magyarország geológiája. paleozoikum II. – Akadémiai Kiadó, Budapest, 122-168., 183-229.

Hably L. – Báldi T. – Nagymarosy A. 2007: Noszvaj, Kiseged. – In: Pálfy J. – Pazonyi P. (szerk.) 2007: Őslénytani Kirándulások Magyarországon és Erdélyben. – Hantken Kiadó, Budapest, 199-203.

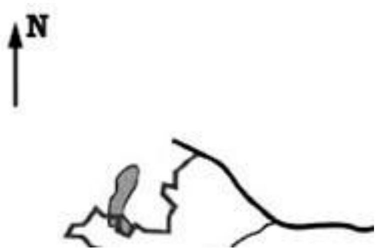
Kovács S. – Hips K. 1998: A Bükk- és az Aggtelek–Rudabányai-hegység újpaleozóos képződményeinek rétegtana. – In: Bérczi I. – Jámbor Á. (szerk.) 1998: Magyarország geológiai képződményeinek rétegtana. – Budapest, 149-153.

Pelikán P. (szerk.) 2005: A Bükk hegység földtana. – Magyarázó a Bükk-hegység földtani térképéhez (1:50 000). – Budapest, 23-132.

Fossil collecting field trips in Hungary

16. Dunavarsány, gravel quarry

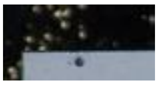
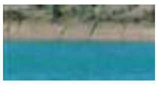
South to Budapest until the northern boundary of Nemesnádudvar, in the vicinity of river Danube there are large areas covered with Pleistocene age gravels. Several quarries expose this gravel succession (Fig. 4.1.1.). The examined locality is situated one kilometre to Dunavarsány to the east. The geographical coordinates of that are: 47°16'22.39"N, 19°02'42.32"E (Fig. 4.1.2.).

 Fig. 4.1.1. Geographical position of the Dunavarsány, gravel quarry	 Fig. 4.1.2. Topographical map of Dunavarsány and its environs	 Fig. 4.1.3. Geological map of Dunavarsány and its environs

The basal formation of it is Late Miocene age clay, aleurolite and sand. Thickness of gravel beds is 6-7 m at Taksony – Dunavarsány – Délegyháza but 10-40 m at other parts of the Danube Valley (Fig. 4.1.3.).

The material of gravels is mostly quartzite, but other rock can be occur from the nearest mountains (e.g. andesite from the Visegrád Mountains, or sandstone, limestone and dolomite from the Buda Mountains). There are rocks among the pebbles, which cannot fin din Hungary. These are eclogite, granulite, and other metamorphic rocks. Fossils can be occur among the pebbles also. The most common are the rounded oyster valves and the petrified wood fragments. Sometimes it can be found Pleistocene age mammal remains, like teeth of horses, molars of mammoths, bones of herbivorous terrestrial mammals.

The grain size of the gravels is variable. Small (2-5 mm) and fine grained (5-20 mm) pebbels are dominant at the surface, while bigger grans are common near to the base.

 The gravel quarrys at Dunavarsány are the property of AQUA Kft.	Area of the gravel quarry is closed by gates. You need permission to enter.	 One of the lakes at Dunavarsány, gravel quarry	 The gravel beds at Dunavarsány are from the terraces of river Danube	 The pebbles are moderately – well rounded, poorly sorted

 Fossils are common among the pebbles	 Lithothamnium sp.	 Gramineae indet.	 Gramineae indet. (closer view)	 Fragment of a siliciferous wood
 Bivalve internal casts in a Miocene limestone block	 Pecten coquina	 Lucina sp. external mould	 Cardium sp. internal cast with shell fragments in Miocene limestone	 Pecten aduncus Eichwald on the surface of a Middle Miocene limestone block
 Internal casts of bivalves in Miocene age limestone	 Bivalvia indet. internal cast	 Ammonite internal cast in limestone	 Cerithium sp.	 Tympanotonus sp. external moulds
 Ocenebra sp. external moulds	 Gyraulus sp.	 Gastropoda indet. external moulds	 Brachiopod cross sections in limestone	 Shark tooth in Miocene sandstone
 Horse tooth fragment from the gravel quarry at Dunavarsány	 Mammuthus primigenius (Blumenbach) molar fragment	 Bone fragment of a Pleistocene age terrestrial mammal	 Entobia isp. in oyster shell	 Gastrochaenolites torpedo Kelly – Bromley in oyster shell
 Caulostrepsis taeniola Bromley – D'Alessandro in oyster shell				

Selected literatures

Budai T. – Gyalog L. 2009: Magyarország földtani atlasza országjáróknak (1:200 000). – Budapest, 202.

Juhász Á. 1987: Évmilliók emlékei. – Gondolat Kiadó, Budapest, 123-128., 263-267.

Nagy K. 2009: Őslénytani megfigyelések Dunavarsány környéki kavicsbányákban. – Szakdolgozat, Eszterházy Károly Főiskola Földrajz Tanszék, p. 90.

http://macgyver.web.elte.hu/elte/2-foldtan/foldtan_terepgyak

http://fold1.ftt.uni-miskolc.hu/~foldshe/mof04

17. Eger, Wind Brichyard

The Wind Brickyard’s exposure is situated at the SE part of Eger (Fig. 4.2.1.). It’s an active mine, which can be approach by car or on foot. Geographical coordinates of the quarry are: 47°53’47.55”N, 20°23’52.20”E (Fig. 4.2.2.).

This outcrop is the stratotype of the Egerian stage. This stage is a transition between Oligocene and Miocene. The succession of the outcrop belongs to the NP 25 nannoplankton and the Paragloborotalia opima opima foraminifer zones.

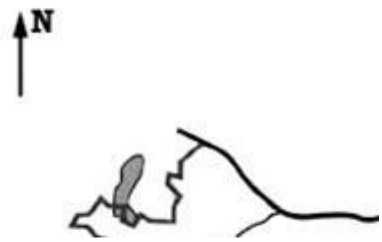
<table>
<tr>
<td>

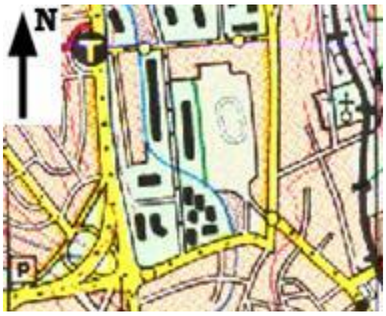
Fig. 4.2.1. Geographical position of the Wind Brickyard</td>
<td>

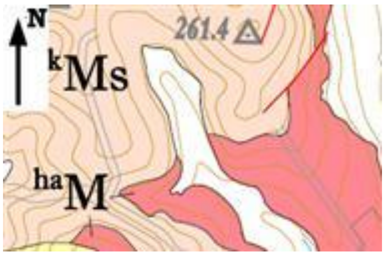
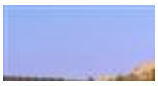
Fig. 4.2.2. Topographical map of Eger and its environs</td>
<td>

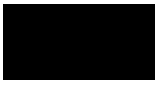
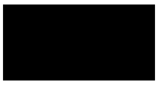
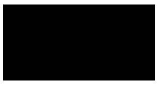
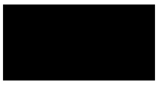
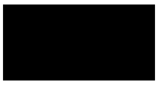
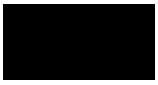
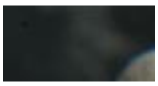
Fig. 4.2.3. Geological map of Eger and its environs</td>
</tr>
</table>

The succession of Wind Brickyard exposes the lower unit of the formation (Fig. 4.2.3.). Several marine sediments can be seen here with diverse flora and fauna. Egerian Formation develops concordantly from Kiscellian Formation. Glauconitic sandstone can be found on it, which contains Flabellipecten burdigalensis Lamarck, Cerithium egerense Gábor, Babylonia eburnoides umbilikoziformis Telegdi-Roth, Dentalium apenninicum Sacco, corals and shark teeth.

Molluscan clay develops from the glauconitic sandstone with 35-40 m thickness. It has a rich and diverse micro-fauna with foraminifers, small molluscs and otoliths. Here can be found x1 and x2 aleuritic intercalations which are rich in plant fossils (“lower flora”). Fine-grained aleurithic sandstone can be found at the upper part of this layer (“x”-layer). It is a transition between molluscan clay and the next layer. 5-5,5 m thick sandy clay can be found on it. This layer contains the so called “middle flora”. 2 m thick limonitic sandstone is the next layer. It contains variable, good preserved mollusc fauna. Because of the diverse fauna this layer called “k”-layer (k like fossiliferous /kövületes/ in Hungarian). 10-12 m thick grey coloured clayey marl is the next layer. It is poor in fossils. Micaceous, aleuritic clay develops from the previous layer with 5-7 m in thickness. It is followed by a 20 m thick cross-bedded sandstone. The succession proceeds with brackish, shallow marine sand layers, which contain Anadara diluvii Lamarck, Mytilus aquitanicus Mayer, Ostrea cyathula Lamarck, and Tympanotonus margaritaceus Brocchi mostly. This is the “m”-layer (Mytilithic). Finally there is a 4-5 m thick limonitic sand on the top of the succession.

Fossil associations can be refer into the paleocenoses produced by Tamás Báldi. According it molluscan clay deposited in deep sublittoral – shallow bathyal environment. Fossils belong to the Hinia-Cadulus association. The upper layers are deposited in shallow sublittoral (Pitar polytropa) and coastal (Tympanotonus-Pirenella és Mytilus aquitanicus) paleocenoses.

<table>
<tr>
<td>
Panoramic view of the Wind Brickyard’s exposure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</table>

The northern entrance of the Wind Brickyard’s exposure	Concordant marine succession at the Wind Brickyard’s exposure	Slump at the middle part of the exposure	Turris sp. in molluscan clay	Flabellipecten burdigalensis (Lamarck) in molluscan clay
				
Myrica sp. 1, a fossil leaf	Myrica sp. 2, a fossil leaf	Daphnogene sp.; a fossil leaf	Cinnamomum sp.; a fossil leaf	Nodosaria sp.
				
Balanophyllia desmophyllum Edwards - Haime	Anadara diluvii Lamarck	Flabellipecten burdigalensis (Lamarck)	Arctica islandica (Braun in Agassiz)	. Laevicardium sp.
				
Pitar polytropa Anderson	Architectonica sp.	Aporrhais pespelicani (Linnaeus)	Strombus coronatus Defrance	Galeodea nodosa (Solander in Brander)
				
Hadriana egerensis (Gábor)	Typhis pungens (Solander in Brander)	Galeodes basilica (Bellardi)	Athleta rarispina (Lamarck)	Turris coronata (Münster in Goldfuss)
				
Turricula legányii Báldi	Dentalium sp.	Fragment of Decapod crab claw	Schizaster sp.	Synodontaspis sp.
				
Carcharias sp.	Lamna sp.	Osteichthyes indet.; vertebra of bony fish	Osteichthyes indet., skull fragment	Eroded Entobia cateniformis Bromley - D'Alessandro in shell of Conus dujardini egerensis Noszky
				

Maeandropolydora elegans Bromley - D'Alessandro in shell of Ampullina crassatina (Lamarck)	Teredolites longissimus Kelly – Bromley in molluscan clay	Teredolites longissimus Kelly – Bromley in molluscan clay	Conservated Teredo valves on natural casts of Teredolites longissimus Kelly – Bromley	Arenicolites isp. in limonitic sandstone
 Lockeia isp. in limonitic sandstone	 Planolites montanus (Pemberton - Frey) in limonitic sandstone	 Ptichoplasma isp. in limonitic sandstone	 Teichichnus rectus Seilacher in glauconitic sandstone	 Thalassinoides paradoxicus Woodward in limonitic sandstone
 Trichichnus linearis Frey in molluscan clay	 Trichichnus isp. in glauconitic sandstone			

Selected literatures

Báldi T. 1973. Mollusc fauna of the hungarian Upper Oligocene (Egerian). Studies in stratigraphy, palaeoecology, palaeogeography and systematics. – Akadémiai Kiadó, Budapet, p. 511.

Báldi T. 1998: Magyarország epikkontinentális oligovén képződményeinek rétegtana. – In: Bérczi I. – Jámbor Á. 1998: Magyarország geológiai képződményeinek rétegtana. –Budapest, 419-435.

Dávid Á. 1990: Újabb paleoökológiai megfigyelések felső-oligocén korú puhatestűeken (Eger, volt Wind-féle téglagyár). - Malakológiai Tájékoztató 9., 12-14.

Dávid Á. 2007: Eger, Wind-féle téglagyár agyagbányája. – In: Pálfy J. – Pazonyi P. (szerk.) 2007: Őslénytani Kirándulások Magyarországon és Erdélyben. – Hantken Kiadó, Budapest, 204-207.

Dávid Á. 2009: Bioeróziós és patológiás elváltozások az egerien Mollusca faunáján. – Disszertációk az Eszterházy Károly Főiskola Földrajz Tanszékéről 3., p. 230.

Fodor R. 2001a: Bioeróziós nyomok felső-oligocén korallokon (Wind-féle téglagyár, Eger). – Földtani Közlöny 130/1-2, 179-196.

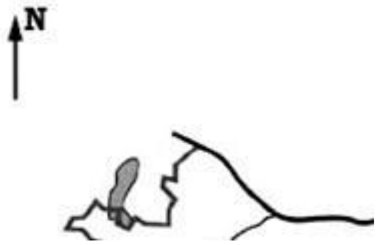
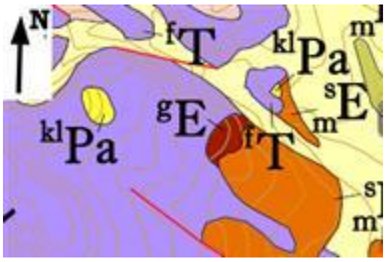
Főzy I. – Szente I. 2007: A Kárpát-medence ősmaradványai. – Gondolat Kiadó, 258-259.

Hegedűs Gy. 1962: Magyarországi oligocén korallok. – A MÁFI Évi Jelentése az 1959. évről, Budapest, 231-261.

Pelikán P. (szerk.) 2005: A Bükk hegység földtana. – Magyarázó a Bükk-hegység földtani térképéhez (1:50 000). – Budapest, 107-108.

18. Gánt, Bagoly Hill, bauxite quarry

The centre of bauxite mining had been in the vicinity of Gánt during the 1980' years. There were five quarries close to the village. The Bagoly Hill was the biggest one among them (Fig. 4.3.1.). The geographical coordintes of this quarry are: 47°22'01.06"N, 18°23'02.43"E (Fig. 4.3.2.).

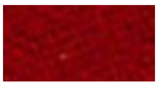
 Fig. 4.3.1. Geographical position of the Gánt, Bagoly Hill	 Fig. 4.3.2. Topographical map of Gánt and its environs	 Fig. 4.3.3. Geological map of Gánt and its environs

The quarry exposes a Middle Eocene succession (Forna Formation, Kincses Formation) in 20-25 m thickness (Fig. 4.3.3.). Sediments had been deposited among freshwaterc circumstances first than it changed to brackish lagoon environment. After that normal marine circumstances had developed. The thickness of this succession is approximately 200 m.

Late Lutetian – Early Bartonian Forna Formation had been settled onto the top of the bauxites. It is a greyish aleuritic clay, which is rich in fossils at its upper part.

Most characteristic fossils of the marine sediments are the molluscs. Brotia distincta, Tympanotonus hungaricus, T. calcaratus, Cerithium subcorvinum, Pyrazus focillatus, Ampullina perusta, Cantharus brongniarti, Arca vértesensis, Brachyodontes corrugatus, Anomia gregaria, Pteria trigonata, Ostrea roncana and Dreissena eocaena are the most common forms. Other fossils are the miliolinids, spores, pollens, Charophytes, foraminifers and ostracods. This formation can be studied at the NNE-SSW and the NW-SE walls of the quarry.

Kincses Formation is a succession of shallow marine limestones, sandy marls, sandstones and tuffitic limestones. It is more poor in fossils, mostly miliolinids, alveolinids, corals, Nummulites striatus and Perna urkutika are dominant.

 Fossil-rich layers in the bauxite mine at Gánt	 Gray, shallow marine sandy marl with significant fossil content	 Fossils are situated in separate levels within the layer	 Fragmented molluscan shells in marl	 Mollusc coquina in the gray marl layer
 Gastropods are the most frequent macrofossils at the locality	 Tympanotonus bicalcaratus (Brongniart) in the sediment	 Cerithium subcorvinum Oppenheim	 Ampullina perusta Defrance	 Cantharus brongniartianus (d'Orbigny)
 Tympanotonus bicalcaratus (Brongniart)	 Tympanotonus calcaratus (Grateloup)	 Tympanotonus diaboli (Brongniart)	 Tympanotonus hantkeni (Munier-Chalmas)	 Tympanotonus hungaricus (Zittel)
				

Pyrazus pentagonatus (Schlotheim)	Bayania melaniaeformis (Schlotheim)	Globularia incompleta (Zittel)	Melanopsis dorechensis

Selected literatures

Budai T. – Fodor L. 2008: A Vértes hegység földtana. Magyarázó a Vértes hegység földtani térképéhez (1:50 000). – Budapest, 61-69.

Kecskeméti T. 1998: Magyarország epikontinentális eocén képződményeinek rétegtana. – In: Bérczi I. – Jámbor Á. (szerk.) 1998: Magyarország geológiai képződményeinek rétegtana. –Budapest, 403-417.

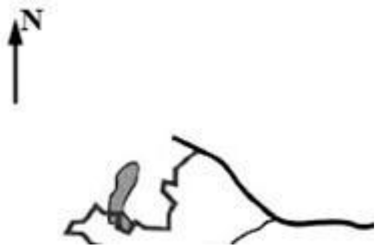
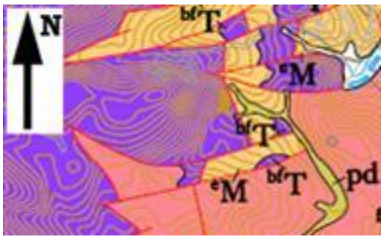
Kecskeméti T. – Mindszenty A. 2010: Bagoly-hegyi felhagyott bauxit-külfejtés, Gánt, Vétres. – In: Haas J. (szerk.): A múlt ösvényein. Szemelvények Magyarország földjének történetéből. – Budapest, 109-112.

Mihály S. 1975: Paleoökológiai megfigyelések a gánti középsőeocénből. – Földtani Közlöny 105(1), 75-81.

Mihály S. – Vincze P. 1984: Újabb paleoökológiai megfigyelések a gánti középsőeocénból. – Földtani Közlöny 114(3), 263-283.

19. Mályi, brickyard’s exposure

Sediments of Pannon Lake can be studied at Sály, Borsodgeszt, Harsány, Bükkaranyos and Mályi (Fig. 4.4.1.). Their characteristic fossils are Lymnocardium soproniense, Congeria hoernesi (= C. ungulacaprae?), Congeria czjzeki, and Melanopsis. The succession proceeds near to Alsódobsza with Melanopsis fossilis, M vindobonensis, Congeria subglobosa, C. czjzeki, Lymnocardium soproniense and L. brunnense. The outcrop of the Brickyard at Mályi is the best locality among these. Geographical coordinates of the quarry are: 48°00’45.97”N, 20°48’24.53”E (Fig. 4.4.2.).

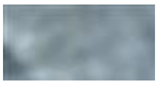
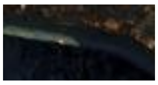
 Fig. 4.4.1. Geographical position of the Mályi Brickyard	 Fig. 4.4.2. Topographical map of Mályi and its environs	 Fig. 4.4.3. Geological map of Mályi and its environs

This clay-pit exposes 10 m’s of this formation, which is an unbedded clayey marl. Aleurite contents increases to the top of the succession. The top formation is a white or yellow coloured, cross-bedded sand (Fig. 4.4.3.).

Clayey marl deposited in the sublittoral zone, below to the wave base. Bivalve shells were fossilized in life position dominantly.

Fauna of these marls are less diverse. Mostly bivalve can be found in the sediment. The most common fossils are the Congeria czjzeki M. HÖRNES, Congeria hörnesi BRUSINA. Congeria partschi CZJZEK shows the transition to the top layers. Lymnocardium soproniense (VITÁLIS) is a very common species here, but it’s very rare at the other pannonian localities. The size of this can be 5-8 cm here. Further fossils are "Pontalmyra " otiophora (BRUSINA), Caladacna steindachneri (BRUSINA), Lymnocardium brunnense (ANDRUSOV), Pisidium krambergeri (BRUSINA), Melanopsis vindobonensis FUCHS and Gyraulus sp. in this locality.

The outcrop of Mályi belongs to the Congeria czjzeki zone, Lymnocardium soproniense subzone according to the presence of Lymnocardium soproniense (VITÁLIS). The age of this can be 9,5-10 million years.

 View of the clay pit at Mályi	 Strip pit of the clay pit	 Detail of the upper strip pit	 Pannonian clay is excavated in the clay pit	 Fossiliferous clay at he upper strip pit
 Bivalves are the most common macrofossils at the locality	 Bivalve coquinas in the Pannonian clay (closer view)	 Poorly preserved, fragmented bivalve shells	 Congeria-coquina in Pannonian clay	 Congeria partschi Czjzek
 Congeria partschi Czjzek	 Congeria hörnesi Brusina	 Lymnocardium brunnense (Andrusov)	 Lymnocardium soproniense (Vitális)	 Lymnocardium soproniense (Vitális)
 Lymnocardium soproniense (Vitális) internal cast	 Lymnocardium soproniense (Vitális) internal cast	 Bivalvia indet. internal cast in concretion	 Otolith indet.	

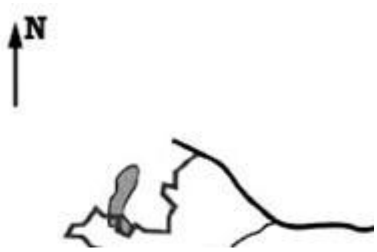
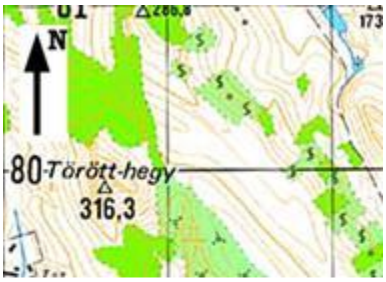
Selected literatures

Juhász Á. 1987: Évmilliók emlékei. – Gondolat Kiadó, Budapest, 102-110.

Korpásné Hódi M. 1998: A medenceperemi pannóniai s.l. üledékes formációk rétegtana. – In: Bérczi I. – Jámbor Á. (szerk.) 1998: Magyarország geológiai képződményeinek rétegtana. – Budapest, 453-468.

20. Máriahalom, sandpit

At the NE part of the Transdanubian Mountains a unique sandpit can be found where Late-Oligocene (Egerian) age sediments are exposed (Fig. 4.5.1.). The sandpit is situated close to Máriahalom village. The geographical coordinates of the quarry are: 47°37’56.39”N, 18°43’29.51”E (Fig. 4.5.2.).

 Fig. 4.5.1. Geographical position of the Máriahalom, sandpit	 Fig. 4.5.2. Topographical map of Máriahalom and its environs	 Fig. 4.5.3. Geological map of Máriahalom and its environs

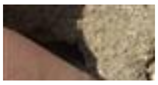
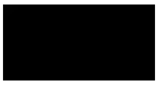
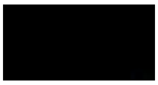
The succession of this outcrop belongs into the Mány Formation. It is a transgressional succession with alternation of brackish and fully marine facieses. Limonitic coarse-grained sand and sandstone are excavated in this sandpit. The thickness of the succession is 6-10 m (Fig. 4.5.3.). Fossils and concretion beds show the stratification of the sands. Fossils are allochtonuous, and often appears in coquinas. The formation belongs to the Tympanotonus-Pirenella paleocenoses.

70 mollusc taxa are known from the sandpit of Máriahalom. The distribution of these is the following: 20 bivalves (Bivalvia), 40 snails (Gastropoda) and 5 scaphopods (Scaphopoda). The most common bivalves are the Angulus nysty and oysters. While Tympanotonus margaritaceus, Potamides lamarcki and Pirenella plicata are dominant gastropod species. While among the scaphopods Dentalium is the most significant.

Among the remains of vertebrates shark and ray teeth, bony fish teeth, and bone fragments of Reptilia (snake, turtle, and crocodile) have to be mentioned.

Plant remains also occur in the huge limonitic concretions all around in the sandpit.

Trace fossils are represented by Teredolites isp. (traces of wood boring bivalves) and Thalassinoides isp. (dwelling traces of marine crabs).

 View of Máriahalom sand pit	 Detail of the Máriahalom sand pit	 Thick mollusc coquina in the sand	 Non-directed gastropod shells in the sand	 Gastropod coquina in the sand pit
 Cross-stratified molluscan coquina	 Cross section of gastropods in sand	 Plant remains are common on the surface of sandstone blocks	 Ostrea sp.	 Angulus sp.
 Emarginella sp.	 Jujubinus sp.	 Nerita plutonis (Basterotti)	 Nerita plutonis (Basterotti)	 Tympanotonus coquina
 Tympanotonus margarithaceus (Brocchi)	 Pirenella plicata (Bruguiere)	 Polinices catena helicina (Brocchi)	 Bittium sp.	 Teredolites longissimus Kelly - Bromley
 Thalassinoides isp. 1 on the surface of a sandstone block	 Thalassinoides isp. 2 on the surface of a sandstone block			

Selected literatures

Báldi T. 1967: A Mány-Zsábméki-medence felsőoligocén makrofaunája. – Földtani Közlöny, 97, 437-446.

Dávid Á. 2009: Bioeróziós és patológiás elváltozások az egerien Mollusca faunáján. – Disszertációk az Eszterházy Károly Főiskola Földrajz Tanszékéről 3., p. 230.

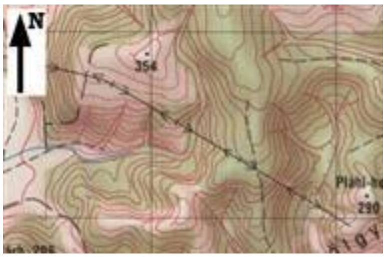
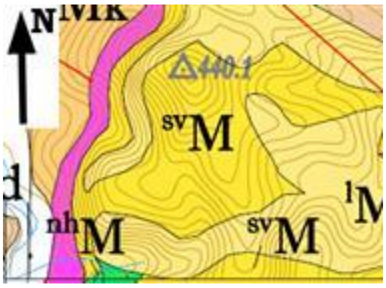
Főzy I. – Szente I. 2007: A Kárpát-medence ősmaradványai. – Gondolat Kiadó, 259.

Janssen, A. W. 1984: Late Oligocene molluscs from a sand-pit near Máriahalom (Hungary): A preliminary study. - Annales Universitates Scientarium Budapestiensis de Rolando Eötvös Nominate, Tomus XXV., Sectio Geologica, pp. 109-149.

Ollé R. 1998: Életnyomok és patológiás elváltozások az unyi homokbányában gyűjtött puhatestűek mészvázain. - Malakológiai Tájékoztató, 15, pp. 11-27.

21. Mátraverebély, Szentkút

The locality is near to Mátraverebély. It can be approach across Kányáspuszta (Fig. 4.6.1.). Geographical coordinates of the area are: 47°59’10.63”N, 19°47’48.27”E (Fig. 4.6.2.).

 Fig. 4.6.1. Geographical position of the Mátraverebély, Szentkút	 Fig. 4.6.2. Topographical map of Mátraverebély and its environs	 Fig. 4.6.3. Geological map of Mátraverebély and its environs

The vicinity of Mátraverebély, was famous for coal mining. Remains of mine dumps can be recognise around the village. The age of these coal-bearing formations are Early Miocene, (Ottnangian).

Near to the cloister can be found so called „Szent László layers”, wich contain a shallow marine succession (Sámsonháza Formation). These layers settle discordantly on Middle Miocene andesites (Mátra Volcanite Formation) (Fig. 4.6.3.). The rocks of Sámsonháza Formation are sandstone, calciferous limestone and conglomerate. Fossils are poorly preserved in these layers. Calciferous sandstone settles on andesites at the cloister in 20-25 m thickness. It has a rich fauna, while several levels of this are full with shallow marine trace fossils (Macaronichnus isp.).

Molluscs are the most common fossil in the „Szent László layers”. The most important bivalve taxa are the following: Arca, Anadara, Barbatia, Glycymeris, Modiolus, Pecten, Chlamys, Ostrea, Cardita, Lucina, Cardium, Callista, Chama, Dosinia, Venus, Tapes, Mactra, Corbula, Ensis, Tellina and Panopea. While the most important gastropods are: Fissurella, Gibbula, Nerita, Turritella, Cerithium, Natica, Trivia, Cassis, Pyrula, Murex, Columbella, Nassa, Ancilla, Mitra, Conus, Terebra and Ringicula. Remains of decapods occure also in the sediments, like Callianassa, Diogenes, ?”Phylopagurus”, ?Pagurites, Calappa, Maja, Parthenope, Portunudarum, Liocarcinus and Pilumnus.

Upper sand layers are rich in small fragments of bryozoans and crinoids. The most important Bryozoa taxa are: Adeonella polystomella, Metrarabdotus maleckii, Smittina cervicornis, Celleporaria palmata and Cellaria salicornioides. According these fossils, depth of the sea water could be around 80 m.

 Shallow marine tuffitic sediments at Mátraverebély- Szentkút	 Greenish gray tuffitic sandstone at the locality	 Branched red algae colony in tuffitic sandstone	 Pecten sp.	 Bivalvia indet. internal cast

 Conus sp. internal cast	 Gastropoda indet. internal cast	 Bryozoa indet.; colony fragment	 Macaronichnus isp. in friable sandstone	 Macaronichnus isp. in friable sandstone (closer view)

Selected literatures

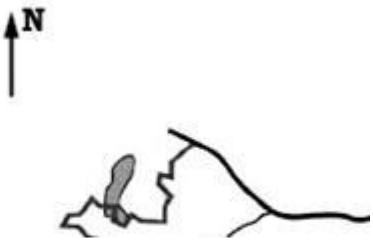
Dulai A. – Moissette, P. 2007: Mátraverebély, Szentkút. – In: Pálfy J. – Pazonyi P. (szerk.) 2007: Őslénytani kirándulások Magyarországon és Erdélyben. – Hantken Kiadó, Budapest, 190-193.

Fűköh L. 2010: Gerinctelen ősmaradványok a Mátra térségében. – In: Baráz Cs. (szerk.) 2010: A Mátrai Tájvédelmi Körzet. Heves és Nógrád határán. – Eger, 81-83.

Kéri J. 1966: A mátraverebélyi kutatás eredményei. – Földtani kutatás: földtani szakmai folyóirat, 9(4)

22. Pécs, Danitz-puszta, sand pit

This sand pit can be found at the eastern end of Pécs (Fig. 4.7.1.). The geographical coordinates of the locality are: 46°06’03.37”N, 18°17’05.39”E (Fig. 4.7.2.).

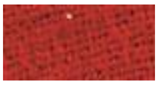
 Fig. 4.7.1. Geographical position of the Danitz-puszta sandpit	 Fig. 4.7.2. Topographical map of Pécs and its environs	 Fig. 4.7.3. Geological map of Pécs and its environs

Shore of Pannon lake drags at the foreland of Western Mecsek. Limonitic sand deposited here in 30-50m thickness. Danitz-puszta is a classical, well-known outcrop of these formations. The succession is limonitic, yellow and grey coloured, middle- and coarse-grained sand with small-size pebbles (Fig. 4.7.3.). Fossils can be found in the succession in great quantities. These sands have been deposited by rivers. The material of the sand is limestone, quartzite, granite and metamorphic rocks. Lower part of the succession is rich in internal casts of Congeria balatonica and Lymnocardium schmidti. The top of the succession is white coloured marl with Congeria balatonica, ostracods, Lymnocardium and Melanopsis. The age of this is Early Pannonian.

This sand pit is rich in vertebrata fossils. Fossils can be grouped into two parts on the basis of their age: 1, marine fossils, which are older, than the sediment; 2, terrestrial and freshwater fossils, which are contemporaneous with the sand.

Turtles of this locality belong to the freshwater Trionyx and the terrestrial Testudo forms. First one is Early and Middle Miocene in age, while Testudo was common during the Late Miocene. The remains of big size vertebrates are common, like Korynochoerus, Dorcatherium, Hippotherium primigenium, Aceratherium, Deinotherium cf. giganteum and Tetralophodon. Shark teeth and bony fish remains are also have to be taken into consideration. But the most important fossils of this locality are the remains of miocene marine vertebrates, like Sirenia, seal, dolphins and whales.

View of the sand pit at Danitz-puszta	Strip pit of the quarry	Corse-grained sand in the sand pit of Danitz-puszta	Vertebrata remains in sand	Colonial coral fragment from the overlying bed
 Oyster valve fragments	 Synodontaspis sp.	 Lamna sp.	 Sparus umbonatus (Münster) molars	 Sparus sp. incisor
 Sparus sp. incisor	 Sparus sp. molar	 Dentex sp. incisor	 Diplodus sp. incisor	 Diplodus sp. molar
 Sparidae indet. tooth	 Osteichthyes indet.; vertebra of bony fish	 Fragment of a turtle's shell	 Fossil bird bones	 Dolphin vertebra
 Dolphin vertebra	 Dolphin vertebra	 Dolphin vertebra	 Perioticum, from the ear of a dolphin	 Phalanx of terrestrial mammal
 Bone fragment of terrestrial mammal	 Undetermined bone fragment	 Undetermined bone fragments		

Selected literatures

Főzy I. – Szente I. 2007: A Kárpát-medence ősmaradványai. – Gondolat Kiadó, 315, 334.

Juhász T.J. 2006: A danitz-pusztai homokbánya porcoshal maradványainak vizsgálata. – Folia Historico Naturalia Musei Matraensis, 30, 9-24.

Kazár E. 2003: Miocén fogascet-leletek (Cetacea: Odontoceti) a Kárpát-medencében. – Doktori értekezés, p. 344.

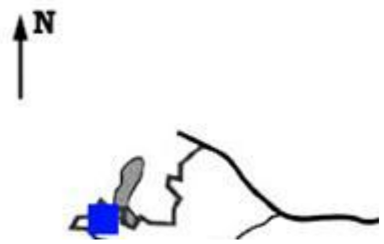
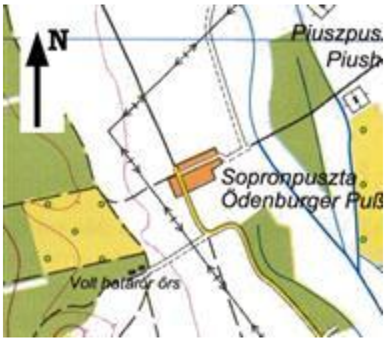
Kazár E. – Kordos L. – Szónoky M. 2007: Danitz-puszta homokbánya. – In: Pálfy J. – Pazonyi P. (szerk.) 2007: Őslénytani Kirándulások Magyarországon és Erdélyben. – Hantken Kiadó, Budapest, 131-132.

Konrád Gy. – Kordos L. – Sebe K. 2010: Danitz-pusztai homokbánya, Pécs, Mecsek. – In: Haas J. (szerk.): A múlt ösvényein. Szemelvények Magyarország földjének történetéből. – Budapest, 160-164.

http://foldrajz.ttk.pte.hu/foldtan/kirandulasvezetok/Danitz

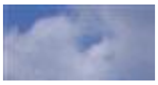
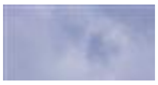
23. Sopronkőhida, Réti-forrás („Réti Spring”)

There is an abandoned gravel quarry at Réti Spring, between Sopronkőhida and the Boundary of Hungary (Fig. 4.8.1.). It exposes Lower Sarmatian formations, which builds up from gravels, sand, conglomerate and sandstone. The materials of these pebbles are mesozoic limestone, dolomite and sandstone dominantly. The geographical coordinates of this quarry are: 47°45’10.93”N, 16°37’06.38”E (Figs. 4.8.2, 4.8.3.).

 Fig. 4.8.1. Geographical position of the Sopronkőhida, Réti-forrás	 Fig. 4.8.2. Topographical map of Sopronkőhida and its environs	 Fig. 4.8.3. Geological map of Sopronkőhida and its environs

The succession of the quarry can be share out seven facieses. The first one will be coarser to the top. The sediment is well-sorted, the layers are graded. This shows nearshore environment. The second facies is built up by coquina-like layers with small-size pebbles. Fossils of this are dominantly bivalve fragments and in situ bivalve shells. Better preserved bivalves and gastropods will be dominant to the top of this facies. Ervilia dissita, Granulolabium bicinctum and Cerithids are common here. It shows a shallower marine environment. The 3rd facies deposited in shallower water. It is built up by small, well-rounded and well-sorted flat gravels. The layers are cross-bedded, while the pebbles are oriented. It shows a high-energy coastal environment. The further units touch tectonically with these. The 4th facies is poorly stratified limonitic sand. Pebble bed can be observed at the mid of this unit, which is a storm-deposit. This sediment deposited under the wave-base. The 5th facies is an unbedded sandy gravel layer with imbricated pebbles. The 6th facies is light-grey sand, which contains gastropod coquinas. And the 7th facies is calciferous, laminated sandstone with gravel levels. Gravels are well-sorted and imbricated.

According these, there was a N-S directional coastline during the Sarmatian at the area. Depth of the sea water were fluctuated because of the rate of sedimentation and the tectonically movements.

 View of the abandoned sand pit at Réti-forrás	 Northern wall of the sand pit	Detail of the strip pit	 Sandstone concretions in the wall of the quarry	 Cross-stratified fossiliferous sand
 Fossils show cross-stratification	 Forsets are built by gastropods	 Lentil shale gastropod coquina in the sand	 Gravel layers are characteristic to the quarry	 Bivalve fragments among the pebbles
 Bivalve coquina	 Mactra sp. in sandstone concretion	 Gastropod remains are abundant in the quarry	 Mactra sp.	 Irus gregarius Partsch

 Granulolabium bicinctum (Brocchi)	 Duplicata duplicata		

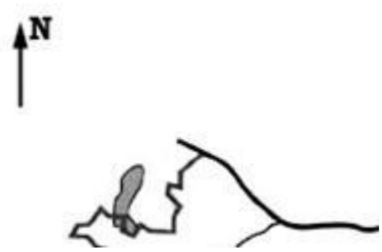
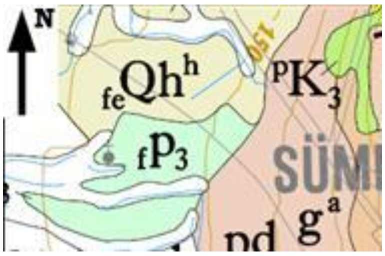
Selected literatures

Rosta É. 1993: Gilbert-típusú delta a Sopron-környéki szarmata-pannóniai üledékekben. – Földtani Közlöny, 123(2), 167-193.

Harzhauser, M. – Kowalke, T.H. 2002: Sarmatian (Late Middle Miocene) Gastropod Assemblages of the Central Paratethys. – Facies, 46, 57-82.

24. Sümeg, limestone quarry at Mogyorós Hill

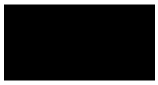
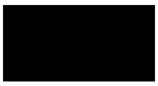
This outcrop can be found at the southern end of Sümeg (Fig. 4.9.1.). It excavates Cretaceous age limestones and flintstone. The geographical coordinates of the quarry are: 46°57’59.33”N, 17°17’07.69”E (Fig. 4.9.2.).

 Fig. 4.9.1. Geographical position of the Sümeg, Mogyorós Hill	 Fig. 4.9.2. Topographical map of Sümeg and its environs	 Fig. 4.9.3. Geological map of Sümeg and its environs

The Cretaceous limestones belong into the Tata Limestone Formation at the western part of the quarry. The age of the formation is Early Cretaceous (115 million years old). While Early and Late Cretaceous age limestones can be observed at the southern and eastern part of the exposure. The lower unit is crinoidal limestone. While the upper unit is a shallow marine limestone (Ugod Limestone Formation, 75 million years old), which significant fossils are the thick-shelled Hippurites-type bivalves (Fig. 4.9.3.).

The two limestone units settle discordantly.

Beside this characteristic ancient bivalves (Rudists) plant remains (Algae) corals (Cyclolites), gastropods (Nerinea, Acteonella) can be recognized easily at the locality.

 View of the limestone quarry at Mogyorós-domb, Sümeg	 Lower strip pit of the limestone quarry	 Cretaceous limestone blocks in the lower strip pit	 Colony of calciferous algae in Cretaceous limestone	 Cyclolites elliptica Lamarck
 Right valve of Hippurites sp.	 Cross section of Hippurites sp.	 Right valve of Hippurites sp.	 Right valve of Hippurites sp.	 Cross-section of calcitizated rudist

 Longitudinal section of a rudist fragment	 Cross-section of Acteonella sp.		

Selected literatures

Czabalay L. 1964: A sümegi felső-kréta malakológiai vizsgálata. – A MÁFI Évi Jelentése 1961-ről, 265-289.

Czabalay L. 1982: A Sümeg környéki Rudista fauna. – Geologica Hungarica Series Palaeontologica 41, p. 221.

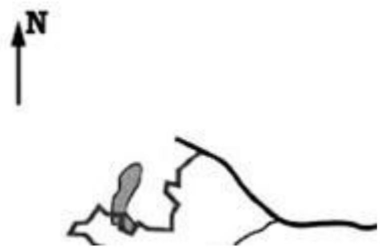
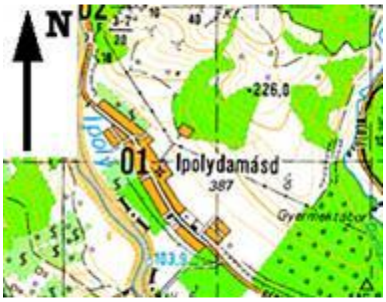
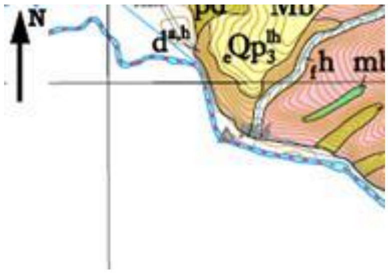
Főzy I. – Szente I. 2007: A Kárpát-medence ősmaradványai. – Gondolat Kiadó, 151.

Géczy B. 1954: Cyclolithes (Anth.) tanulmányok. – Geologica Hungarica Series Palaeontologica 24, p. 158.

Haas J. 1979: A felsőkréta Ugodi Mészkő Formáció a Bakonyban. – A Magyar állami Földtani Intézet Évkönyve, 61, p. 191.

25. Szob, road cutting behind the Malom kert (”Malom Garden”)

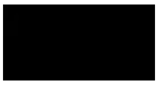
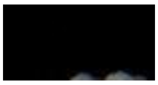
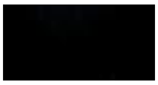
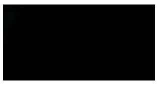
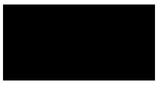
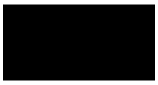
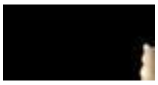
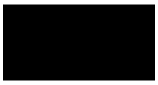
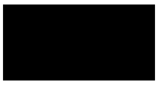
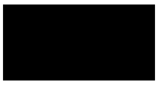
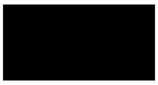
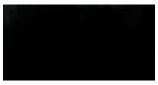
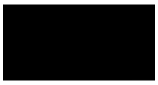
Sedimentary rocks formed after the Middle-Miocene volcanism can be found at the western and southern edge of Börzsöny Mountains. One of the best localities of these outcrop is in the Malom Kert and behind of it at a road cut close to Szob (Fig. 4.10.1.). Geographical coordinates of this outcrop are: 47°49’55.31”N, 18°51’06.97”E (Fig. 4.10.2.).

 Fig. 4.10.1. Geographical position of the Szob, Malom-kert	 Fig. 4.10.2. Topographical map of Szob and its environs	 Fig. 4.10.3. Geological map of Szob and its environs

The outcrop of Malom Kert is rich in well preserved marine fossils. For example 267 gastropod and 74 bivalve species are known from here. Fossils are mostly small in size (Fig. 4.10.3.). The most common bivalves are Corbula carinata, Corbula gibba, Nucula nucleus, Nuculana fragilis, Anadara diluvii, Chlamys scabrella, Glycymeris pilosa deshayesi and Venus multilamella. Most of these bivalves are inbenthic, suspension feeder animals. The next important group is the gastropods. Turritella badensis, Turritella erronea, Turritella vermicularis, Conus (Rhizoconus) ponderosus, Polinices redempta, Natica millepunctata, Natica catena helicina, Murex partschi, Murex michelottii, Murex aquitanicus and Murex spinicosta are common species. Feeding traces of muricids and naticids are common on the valve of corbulids and turritellids mostly. Bioerosion of boring sponges (Cliona) are also common traces in the tests of molluscs.

A quarter of fossils belong into other groups, like bryozoans (Cupuladria vindobonensis, Reussirella haidingeri, Celleporaria foraminosa, Crisia denticulata, Crisia haueri), fish teeth and otoliths (Gobius, Lesueurigobius, Deltenosteus), Scaphopods (Dentalium badense, D. korytnicense) and decapods (Callianassa szobensis, C. cf. chalmasii, Calappa praelata, Cancer sp.).

According to the bryozoans the depth of sea water could have been 30 meters.

 View of the road cut at Szob	 Fossil-bearing layer in the succession of the locality	 Dark colored, sand layer with coal marks	 Cardium sp.	 Aequipecten seniensis (Lamarck)
 Pitar sp.	 Solarium (Nipteraxis) marthae (Boettger)	 Theodoxus sp.	 Tritia rosthorni Partsch	 Ancilla glandiformis (Lamarck)
 Bittium spina Partsch	 Natica catena helicina (Brocchi)	 Murex (Tubicauda) spinicosta Bronn	 Clavatula granulatocincta Münster	 Ringicula auriculata (Ménard de la Groye)
 Turritella turris badensis Basterot	 Oliva inflata Lamarck	 Cymatium sp.	 Erato laevis auctorum	 Erato laevis auctorum
 Tudicla sp.	 Fragment of Decapod crab claw	 Selachoidei indet.; shark tooth	 Selachoidei indet.; shark tooth	 Otolith indet.
 Osteichthyes indet.; vertebra of bony fosh	 Oichnus paraboloides Bromley, complete naticid feeding trace			

Selected literatures

Bosnakoff M. 2001: Két középső-miocén feltárás otolithjainak összehasonlító vizsgálata (Ipolydamásd, Börzsöny hegység, Bükkmogyorósd, Bükk hegység). – Földtani Közlöny 131(1-2), 197-220.

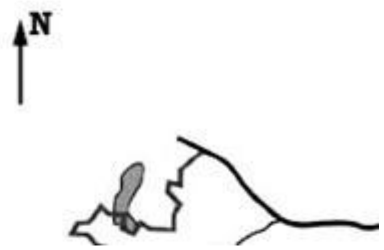
Bosnakoff M. 2006: a szobi középső-miocén lelőhely otolith-faunája és őskörnyezeti viszonyai. – Szakdolgozat, ELTE TTK Őslénytani Tanszék, Budapest, p. 63.

Dudás G. 1999: Naticidae fúrásnyomok középső-miocén puhatestűek mészvázain (Ipolydamásd, Börzsöny-hegység) – Malakológiai tájékoztató, 17, 21-36.

Dulai A. 2007: Szob, Malom-kert. – In: Pálfy J. – Pazonyi P. (szerk.) 2007: Őslénytani kirándulások Magyarországon és Erdélyben. – Hantken Kiadó, Budapest, 34-37.

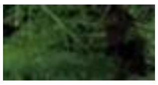
26. Szurdokpüspöki, diatomite quarry

The locality is situated at the border of Nógrád County, between Szurdokpüspöki and Gyöngyöspata villages. There is a special white coloured rock, which has very low specific weight. This rock is the laminated diatomite (Fig. 4.11.1.). Geographical coordinates of the abandoned quarry are: 47°50’34.38”N, 19°43’49.91”E (Fig. 4.11.2.).

 Fig. 4.11.1. Geographical position of the Szurdokpüspöki, diatomite quarry	 Fig. 4.11.2. Topographical map of Szurdokpüspöki and its environs	 Fig. 4.11.3. Geological map of Szurdokpüspöki and its environs

Diatomic mud settled during the Middle Miocene (Sarmatian). There had been shallow marine lagunal environment at that time. Marine water had a special composition because of the hydrothermal processes took place at the Mátra Mountains. The water had significant silica content which favoured for siliceous algae. Millions of microscopic shells of Diatomaceae alga compose the diatomite. The maximal thickness of diatomite succession is 100 m in the vicinity of Szurdokpüspöki and Gyöngyöspata. The lower 40 m thick unit deposited in freshwater, while the upper unit settled down among marine circumstances. Abandoned quarry at Szurdokpüspöki excavates the both units.

The lower, freshwater unit is rich in small fossils. Hydrobia is very common gastropod genus in marly layers. While diatomite laminae are rich in imprints of leaves, insects (larvae of dragonflies, flys) and fishes (Fig. 4.11.3.).

 Small road leads to the diatomite quarry	 The entrance of the quarry	View of the diatomite quarry at Szurdokpüspöki	 Fossils are most common at the eastern wall	 Diantomaceous layers are at the eastern wall
 Fossils are common on the surfaces of shale fragments	 Cinnamomum sp., leaf of laurum	 External mould of scribble	 Hydrobia-bearing marl	 Hydrobia sp. in marl
 Gastropoda indet. on surface of marl	 Osteichthyes indet.; external mould of bony fish	 Osteichthyes indet.; external mould of bony fish	 Planolites isp. 1. in siliciferous diatomite shale	 Planolites isp. 2. in siliciferous diatomite shale

Selected literatures

Fűköh L. 2010: Gerinctelen ősmaradványok a Mátra térségében. – In: Baráz Cs. (szerk.) 2010: A Mátrai Tájvédelmi Körzet. Heves és Nógrád határán. – Eger, 81-83.

Hajós M. 1956: Előzetes jelentés a szurdokpüspöki nagy kovaföldbánya kovaföldüledékeinek anyagvizsgálatáról. –A Magyar Állami Földtani Intézet évi jelentése 1954-ről, 63-67.

Hajós M. 1959: A szurdokpüspöki kovaföldrétegek algái. – Földtani Közlöny, 89(2), 155-169.

Juhász Á. 1987: Évmilliók emlékei. – Gondolat Kiadó, Budapest, 91-93., 249-250.

Kiss Kocsis I. 1954: A szurdokpüspöki diatomás pala faunája. – A Magyar Állami Földtani Intézet évi jelentése 1952-ről, 33-35.

Pelikán P. 2010: A Mátra és közvetlen környezetének földtana. – In: Baráz Cs. (szerk.) 2010: A mátrai Tájvédelmi Körzet. Heves és Nógrád határán. – Eger, 17-26.

27. Tardos, Bánya Hill

Bánya Hill, near to Tardos village gives place a huge limestone quarry (Fig. 4.12.1.). The excavated rock is reddish, fossiliferous jurassic limestone. The geographical coordinates of this quarry are: 47°39’32.51”N, 18°28’26.91”E (Fig. 4.12.2.).

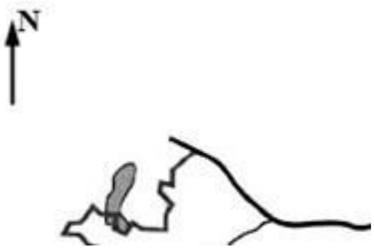
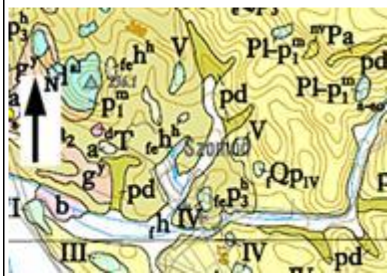
		

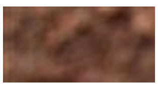
Fig. 4.12.1. Geographical position of the Tardos, limestone quarry	Fig. 4.12.2. Topographical map of Tardos and its environs	Fig. 4.12.3. Geological map of Tardos and its environs

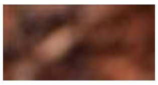
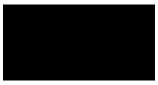
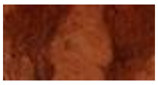
Area between Lábatlan and Tatabánya is built up from Triassic age limestone mostly. But there are small spots near to the mountaintops which are Jurassic age reddish, lenticular limestone called “ammonitico rosso” (Fig. 4.12.3.). It deposited in offshore environment. Oxided iron gives reddish colour to this sedimentary rock. Calcareous mud formed from skeleton of planktonic organisms. Bigger fossils, like ammonites, nautiloids and belemnites segregated on the bottom of sea, because of the very slow sedimentation.

The most common ammonites of the locality are belong into the Phylloceras, Lytoceras, and Mercaticeras genera.

Lenticular structure of this limestone is because of bioturbation. There are levels in the succession, which are rich in burrows of callianassid crabs (Thalassinoides isp.) and worms.

This limestone called “red marble of Gerecse” or “red marble of Piszke” because of the internal structure of this rock. It is a very beloved building and sheathing stone today.

				
Limestone quarry at Tardos is the property of Dekor – Stein Kft.	View of the main strip pit of the limestone quarry	Jurassic red clay is above the limestone	It’s easy to collect ammonite from the red clay	Laminated – lenticular red clay
				

Fossils in the debris	Stylolite is aspecial structure of jurassic limestone	Harpoceras radians (Reinecke)	Phylloceras sp.	Hildoceras sp.
 Parkinsonia sp.	 Parkinsonia sp.	 Juraphyllites sp.	 Calliphylloceras sp.	 Fargment of Calliphylloceras sp.
 Fragment of Calliphylloceras sp.	 Gregoryceras sp.	 Ammonites indet.	 Thalassinoides isp. 1.	 Thalassinoides isp. 1.

Selceted literatures

Főzy I. – Szente I. 2007: A Kárpát-medence ősmaradványai. – Gondolat Kiadó, 96-97.

Hála J. 1995: Kőbányászat és kőfaragás a Gerecse hegységben, különös tekintettel a tardosbányai kőfejtők barlanglakásaira. In: Hála J. (szerk.) 1995: Ásványok, kőzetek hagyományok. Életmód és tradició 7. Budapest, MTA Néprajzi Kutatóintézet, 308-334.

Juhász Á. 1987: Évmilliók emlékei. – Gondolat Kiadó, Budapest, 61-65, 271-272, 376-382.

Vörös A. 1998: A Dunántúli-középhegység jura képződményeinek rétegtana. – In: Bérczi I. – Jámbor Á. (szerk.) 1998: Magyarország geológiai képződményeinek rétegtana. –Budapest, 299-308.

Fájlok

1_1_fossil_plants.ppt

2_1_4_miocene_fossil_plants.ppt

2_2_1_paleozoic_fossil_animals.ppt

2_1_2_wind_brickyard_lower_llora.ppt

1_2_fossil_animals.ppt

2_2_2_mesozoic_fossil_animals.ppt

2_1_1_kiseged_hill.ppt

1_3_trace_fossil.ppt

2_1_3_wind_brickyard_upper_flora.ppt

2_2_3_cenozoic_fossil_animals.ppt