4. Paleontology and Paleobiodiversity
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4.4 De Baets K., Klug C., Korn Dieter.: Early Emsian Ammonoidea: stratigraphy, intraspecific variability, and evolutionary trends.


4.6 Klug C., De Baets K., Monnet C.: Parallel evolution controlled by adaptation and covariation in ammonoid cephalopods.

4.7 Lavoyer T., Berger J.-P.: Stratigraphy and Paleogeography of the North-Middle Upper Rhine Graben (N-Middle URG) during the Paleogene.

4.8 Marty D., Paratte G., Lovis C., Jacquemet M., Meyer C.A.: Extraordinary sauropod trackways from the Late Jurassic Béchat Bovais tracksite (Canton Jura, NW Switzerland): implications for sauropod locomotor styles.


4.11 Pirkenseer C., Steurbaut E., Speijer R.: The evolution of Early Ypresian microfossil assemblages and stable isotopes during a distinct plankton peak in the Corbières (Aude, France) continental margin record.


4.13 Ware D., Bucher H., Brühwiler T., Goudemand N.: Dienerian (Early Triassic) ammonoid successions of the Tethys: preliminary results from Pakistan and India.
4.1

Stratigraphy and ecology of large benthic foraminifera during the Cenomanian-Turonian transition: new insights from the Morelos-Guerrero carbonate platform, southwestern Mexico.

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Contrary to the Central Atlantic and Western Tethys areas, the carbonate platform of Guerrero-Morelos, located in southwestern Mexico, persisted up to the basal Turonian. The Axaxacualco and Baranca el Cañon sections are located at the Guerrero-Morelos carbonate platform in southern Mexico and exhibit a typical and correlateable δ¹³C curve. In the distal part of the carbonate platform (Axaxacualco), the δ¹³C positive excursion coincides with oligotrophic carbonate platform environments, characterized by abundant and diversified benthic microfauna and rudists, confirmed by low concentrations in phosphorus. The impact of OAE appears more significant in the proximal part of the carbonate platform at Barranca, characterized by the deposition of thick laminated microbialites indicative of mesotrophic conditions. This carbonate platform characterized by oligotrophic to mesotrophic conditions, was therefore persistent throughout the entire OAE2 in Central Mexico despite the closeness to the Caribbean plateau. The definitive drowning, marked by the deposition of black shale and turbidites, occurs only in the lower Turonian (P. flexuosum), well above the end of the δ¹³C shift. This carbon isotope positive excursion, coinciding with the Oceanic Anoxic Event (OAE2), is therefore recorded in the upper part of platform carbonate deposits. That allows a better understanding of large benthic foraminifera distribution during the OAE2 event.

During the Late Cenomanian, microfauna is not extremely diversified, but some large benthic foraminifera as Pseudohapydolina chapianensis and dubia, Caneolina parva, Dicyclina sp., and Chrysalidina gradata are present. In the first part of the δ¹³C shift (peak 1) these foraminifera still keep going, but are less abundant. Some Caneolina excepted, they completely disappear in the second part of the positive excursion. These large benthic foraminifera probably linked to green symbiotic algae, are absent in uppermost part of the carbonate platform sediments. However, some endo-benthic foraminifera with thin shell and without symbiotic association persisted. They consist of trochospiralia species which belong to Nezzazata, Nezzazatinaella and Dobrogelina genera, suggesting significant biotic stress conditions. The demise of the Guerrero-Morelos carbonate platform is related to a regression and occurs only at the end of the δ¹³C shift, thus significantly after the OAE2. However, the last carbonate deposits are recorded at Axaxacualco, located in a more distal part of the platform, and correspond to a falling stage system tracks. No relevant microfauna is observed. The drowning of Guerrero-Morelos carbonate platform takes place in the early Turonian, characterized by deeper and anoxic environments, which preclude large benthic fauna reestablishment.

4.2

Upper Triassic reef biota from southwestern Japan: new data from a Panthalassan seamount

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Upper Triassic reefs are particularly important because they represent the renewal of metazoan reefs after the Permian crisis. A renewed diversification of metazoan reef builders and dwellers began in the Anisian and reached its maximal biodiversity only during the Late Triassic. As a result of a change from humid to arid climatic conditions that began during the Carnian and extended through the Norian, the Norian-Rhaetian interval was characterised by an extraordinary global latitudinal expansion of reefs across the northern and southern hemispheres between 33° N and 35° S (Kiessling et al., 1999; Flügel, 2002). During this time, large reef complexes developed worldwide both north and south of the Tethys Ocean and throughout the Panthalassic Ocean in displaced terranes and/or on seamounts.
Important works on Triassic reefs by several authors (Kiessling et al., 1999; Flügel, 2002; with bibliography) have thoroughly catalogued these numerous Upper Triassic reef localities throughout the world. However, most studies involve those in the Tethys realm, and few data are from Panthalassic reefs, generally corresponding to atoll-type shallow-marine carbonates accumulated over seamounts and/or oceanic plateaus in an open-ocean realm.

Because these reefs are pivotal in resolving sedimentological, paleontological and paleobiogeographic issues related to the Panthalassic Ocean and Late Triassic reefs during the Mesozoic, we intensely studied the reef limestones discovered near Inaba Cave on Shikoku Island, Japan, with respect to their microfacies, paleontology and paleoecology.

This Norian-Rhaetian reef limestone belongs to the Sambosan Accretionary Complex, a Late Jurassic to Early Cretaceous subduction-generated accretionary complex in southwestern Japan. This patch reef complex is inferred to have formed within an atoll-type carbonate system accumulated over a mid-oceanic seamount surrounded by deep-water radiolarian cherts in the Panthalassic Ocean during the Late Triassic (Chablais et al., 2010a).

Based on preserved depositional textures and biota, we described several microfacies and interpret its sedimentary environment. Due to the preservation state of the outcrop and the geological context of the Sambosan limestones (accretionary system), the sedimentological and paleontological analysis should be regarded as a characterisation of reef communities rather than of the total reef. Based on these constraints, three groups of facies can be identified: (1) boundstone reef facies, (2) interstitial reef facies, and (3) surrounding reef facies (Chablais et al., 2010b).

The reef boundstone facies is characterised by abundant coralline sponges that, in association with microbial crusts, constitute the main framebuilders. Some phaceloid and/or dendroid corals occur, but these groups are poorly represented, as are algae. Microproblematica and foraminifers exhibit rich associations, acting as secondary reef builders and/or reef dwellers. The surrounding setting comprises biotidal sponge-coral rudstone and well-preserved megalodont rudstone-floatstone. The sedimentary contact between reef and lagoon is observed for the first time within Inaba Cave, where an excellent exposure of megalodont floatstone occurs in association with a coral-sponge boundstone facies.

Finally, this Japanese Upper Triassic reef gives interesting assets for paleobiogeographic comparisons with the coeval Upper Triassic reefs of the southern Peri-Tethys area including the Northern Calcareous Alps, Sicily, and Oman. It appears that the Japanese and Peri-Gondwanian (Oman) seamount reefs resemble one another because of their similar depositional setting. Both types of reefs are characterised by a similar biodiversity of corals, sponges and foraminifers, but they exhibit significant differences in the rarity of calcareous algae and abundant endemic coral species in Japan. Nevertheless, the major similarities confirm a more southern-Hemisphere origin for Upper Triassic Japanese reefs than predicted by previous reef studies.

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4.3

**Triassic decapods: new data from the Arabian shelf of the northern United Arab Emirates**

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Knowledge about Triassic decapod crustaceans is very limited due to the paucity of Triassic fossils throughout the world. Around 65 species of Triassic shrimps and lobsters have been reported, mainly from Tethyan and Eurasian localities, as well as a few from North America and Madagascar (Amati et al., 2004; Feldmann and Schweitzer, 2006).

One reason for the relatively small number of fossil decapod crustaceans is the susceptibility of the carapace to be consumed by many predators and scavengers and to the post mortem fragmentation of organisms by wave action. As a result, the discovery of new fossil decapod crustaceans commonly marks a notable addition to the taxonomic and systematic knowledge of the group.

Thus, the discovery of a new specimen, *Platykotta akaina* n. gen. n. sp., identified as a Triassic anomuran, from the Arabian shelf of the northern United Arab Emirates, represents important contribution to the paleontological knowledge of the crustacean fossils (Chablais et al., 2010). The generic name is derived from the Greek *platys* = flat, and *kotta* = head, in reference to the flattened surface of the metagastric region. The trivial name is derived from the Greek *akaina* = thorn or spine, in reference to the spinose nature of the cephalic region.

This crustacean fossil has been collected from the Upper Triassic carbonates of the Ghalilah Formation in the Musandam Peninsula, United Arab Emirates. The Musandam Mountains offer spectacular exposures of Permian to Cretaceous shallow-marine carbonates which were deposited on the passive margin of the Arabian Plate bordering the southern Tethys during that time (Maurer et al., 2008). The fossil decapod was found in an extensively burrowed limestone level within the Ghalilah Formation (Norian-Rhaetian) of the Wadi Naqab.

The great abundance and high biodiversity of decapod crustaceans in the shallow-water environment of the Arabian shelf during the Triassic is suggested by the large number and variety of burrows on the exposures, including large *Spongeliomorpha* burrows.

Initially, only the ventral exposure of the new taxon was preserved. Using a rigorous chemical preparation by dilute organic acid (acetic) to dissolve limestone but leaving the carapace (chitin) intact, the dorsal view revealed a well-preserved, chitinous, granular carapace exhibiting characteristic carapace morphology and groove pattern of the Eocarcinoidea, the superfamily to which the new family is assigned.

The dorsal view together with the ventral surface, rarely seen in the fossil record, provides new insight into the morphology of representatives of the Eocarcinoidea. It brings new insight into the crustacean origins, dispersal, and radiation along the carbonate shelf of the Tethys during the Triassic. Until now, Triassic crustaceans known from the Southern Hemisphere only have been reported from Madagascar (Feldmann and Schweitzer 2006). This is the first known occurrence of anomurans from this part of the world. Furthermore, the new species represents the oldest occurrence of the Anomura MacLeay known to date.

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Ammonoids represent one of the most important groups of macro-invertebrates for dating Devonian to Cretaceous marine sediments. Ammonoids originated from bactritoids in the Early Devonian during a time of macroecological turnover in marine ecosystems (the so-called ‘Devonian Nekton revolution’). Several authors noticed an evolutionary increase in coiling in embryonic and post-embryonic whorls in the lineage from Orthocerida via Bactritoidea to plesiomorphic and derived Ammonoidea. This evolutionary trend was, however, never quantified. Progressive coiling has been interpreted as adaptation towards improved swimming capabilities, an r-strategy reproduction, and increasing predation pressure by jawed fish. The taxonomy is still poorly resolved due to often fragmentary or poorly preserved material, the low amount of characters (suture line rather simple), oversplitting because of little consideration for ontogenic changes and intraspecific variability, and correlation problems. We focused on the earliest ammonoids (early Emsian), the here called Anetoceras faunas, many of which are loosely coiled. Most authors agree that their evolution must have proceeded rapidly, but the quantification has never been attempted, mostly due to the low stratigraphical resolution. Additional problems lie in the correlation between the more pelagic (Bohemian) facies and the more neritic (Rhenish) facies in the Pragian and Emsian stages. In the Rhenish facies, the classical Emsian was defined. Ammonoids mostly occur in Bohemian facies, but occasionally also in Rhenish facies, thus representing a valuable source to correlate neritic facies with more pelagic facies (Klug et al. 2008; De Baets et al. 2009, 2010), improving stratigraphical schemes.

Based on new material from the Moroccan Anti-Atlas, the Uzbek Zeravshan-Gissar Range, and the Rhenish Slate Mountains (Klug et al. 2008; De Baets et al. 2009, 2010; Becker et al. 2010) as well as museum materials (Berlin, Bonn, Kitab, New York, Prague, Moscow), we can now draw several conclusions. Several new taxa could be introduced and other taxa could be synonymized, integrating ontogeny and intraspecific variability. These taxonomic revisions partially extended the paleogeographic distribution of some species and decreased the overall ammonoid diversity. Some of the earliest more loosely coiled ammonoids such as Anetoceras and Erbenoceras, show a large intraspecific variability, which is in part related with their loose coiling. We report some of the earliest well-dated ammonoids from the Hunsrück Slate, which is considered to be the cradle of early ammonoids by some. The Hunsrück material provided an important window enabling the examina-
tion of the ontogeny of earliest ammonoids. Some of these specimens display the most plesiomorphic character states among ammonoids. In contemporary Moroccan layers, comparable species are only preserved as fragments.

In addition to the knowledge of early ammonoid ontogeny from the Hunsrück, the embryonic and adult conchs of several additional taxa has been described from Morocco and Uzbekistan. Interestingly, several lineages such as the Mimosphinctidae, the Mimoceratidae, the Anarcestidae, and the Agoniatitidae convergently developed a trend towards increased coiling (e.g., decrease in umbilical window size).

We could produce diversity charts with a higher resolution as before. In the early Emsian of Morocco like in many other localities, however, often too little and different ammonoid taxa can be found pro section to allow for robust correlation between sections. This related with the fact, that many taxa are quite rare (e.g., Weyeroceras = 3 specimens have become known in 11 years time: see De Baets et al. 2010), while other taxa are quite abundant, but have long ranges (Erbenoceras). This supports the need to integrate several groups to augment stratigraphical resolution (ammonoids, conodonts, dacyroconarids) as has been partially attempted in the Hunsrück Slate by studying co-occurring dacyroconarids. New materials, new methods, and revisions of older materials have enabled us to study several aspects of the early evolution of ammonoids. This includes cases of parallel evolution, convergence, parasite-host-coevolution (Klug et al. in press) and several details of the links between evolution and development of early ammonoids. Of great interest is also the astonishingly rapid increase of morphologic disparity of ammonoids directly after their origin.

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4.5
Devonian pearls and ammonoid-endoparasite co-evolution

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Raised shell projections on the inner shell walls that form pits on the internal moulds of Devonian ammonoids have been known for several decades. New specimens from Morocco reveal novel details of these structures; most, if not all, of which consist of a capsule of ammonoid shell that covers tiny tubes attached to the outer (lateral or ventral) shell wall from the inside. In accordance with comparable Recent occurrences of similar structures in molluscs, we use the term “pearls” for these raised structures and the pits they form on the internal moulds. The nature of these encapsulated tubes is described and discussed. Because of the presence of these tubes inside the pearls, the arrangement and organization of the pearls, and their similarity to modern mollusc occurrences, the tubes are interpreted as traces of parasitoses. The pearls and pits were grouped into five types based on differences in morphology, size, and arrangement. Then, having used these traits to perform a simple cladistic analysis, the resulting cladogram was compared to the phylogeny of ammonoids. Based on this comparison, it appears likely that the parasites underwent a co-evolution with the ammonoids, which lasted 10 to 15 Ma. Patterns of evolutionary events that were detected include co-speciation, “drowning on arrival” (end of parasite lineage at base of a new host clade), and “missing the boat” (parasite lineage does not adapt to a new host clade, thus not evolving a new parasite clade). The condition of “swapping the boat” (parasites of another host clade evolving a new clade long after the emergence of a new host clade) probably did not occur. Because of the lack of fossilised soft tissue, only speculations can be made about the systematic affiliation of the parasites, their life-cycle, infection strategy and ecological framework. Some co-occurring bivalves also have pits reminiscent to structures caused by trematodes in recent forms. However, based on the available information, the tubes are interpreted as artefacts of trematode infestations, which if correct, would extend the fossil record of parasitic trematodes into the early Devonian.
4.6
Parallel evolution controlled by adaptation and covariation in ammonoid cephalopods

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A major goal in evolutionary biology is to understand what are the processes (and when, how, why, in which proportions, they occur) that shape the path of evolution and thus to explain evolutionary patterns documented in fossil and living organisms. Among evolutionary patterns, parallel evolution in extinct and extant lineages is a very common phenomenon, rarely studied in detail and over a time interval exceeding 1 myr. The repeated and similar large-scale morphological evolutionary trends of distinct lineages suggest that adaptation by means of natural selection (functional constraints) is the major cause of parallel evolution. However, some aspects of parallel evolution can result from other processes which are usually ignored or difficult to identify, such as developmental constraints. Hence, understanding the underlying processes of parallel evolution and ecological evolutionary feedbacks still require further research.

Herein, we present such a case study of two lineages of earliest ammonoids (extinct cephalopods with an external, chambered shell), which evolved in parallel several more or less independent shell characters. This case of parallel evolution concerns two ammonoid lineages (Auguritidae and Pinacitidae), which are of Emsian and Eifelian age (Early and Middle Devonian; ~ 405–395 Ma). Based on recent exceptional discoveries and a revised palaeobiological framework of both lineages (taxonomy, stratigraphy, phylogeny), the ammonoid shell is quantified by eight classical and biologically meaningful phenotypic characters.

This study highlights that both ammonoid lineages under consideration follow in time and through phylogenetic sequence the classical and common evolute to involute evolutionary trend throughout ontogeny (i.e. toward more tightly coiled whorls); they also show an increase of shell diameter (i.e. adult body size); they record an increasing complexity of their suture line (reflecting the complexity of the folded walls separating the gas-filled buoyancy-chambers); and they are characterized by the evolution of an umbilical lid in the most derived taxa (a shell feature unknown in any other ammonoid group). The trend of increasing involution toward shells with closed umbilicus has been widely demonstrated to reflect improving hydrodynamic properties of the shell (velocity, manoeuvrability, energy efficiency and perhaps buoyancy) and thus likely result from similar natural selection pressures. The appearance of the peculiar umbilical lid might have speculatively also added to the improvement of the hydrodynamic properties of the shell as reflected by experiments on shell models. Finally, the trend toward increasingly complex sutures likely results from covariation induced by the trends of increasing adult size and whorl overlap given the morphogenetic properties of the suture.

The morphological evolution of the two Devonian ammonoid lineages presented here follows a common parallel evolutionary path of some important shell characters during several million years through their phylogenetic sequence. Evolutionary transformations of ammonoid shell traits (e.g., increasing involution, umbilical lid) appear mainly driven by adaptation to improve the hydrodynamic properties of the shell as corroborated by earlier experiments on shell models. Most of the other characters evolving in parallel (e.g., sutural complexity) appear to be triggered by covariation of shell characters, which plays a central role in the morphogenesis of mollusc shells. This example provides evidence that parallel evolution can be driven simultaneously by different factors such as covariation (fabricational constraints) and adaptation (natural selection).
Stratigraphy and Paleogeography of the North- Middle Upper Rhine Graben (N-Middle URG) during the Paleogene.

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Located between Strasbourg (France) in the south and Landau (Germany) in the north, the North- Middle Upper Rhine Graben (N-Middle URG) can be subdivided from west to east into three parts.

In the western part, the “champ de fracture de Saverne” is largely composed by Mesozoic sediments. The Paleogene is almost absent. It is represented mainly by the Lutetian outcrop of Bouxwiller.

The Pechelbronn oil field presents the traditional stratigraphic succession of the URG is present. In stratigraphic order: the transition zone, in contact with the underlying Jurassic limestone, the dolomitic zone, the red bed, the Lower-, Middle- and Upper Pechelbronn Beds and the “Série Grise”. There are very few outcrops in this area, but many boreholes exist because of the oil industry. Two of them will be presented more in detail: GPK4 Soultz-sous-forêt, covering the whole series, and 01983X2854 Preuschdorf, which is a complete cored drilling corresponding to the Upper Pechelbronn Beds with a small part of the Middle Pechelbronn Beds at the base. A particular focus will be the discovery of marine elements (especially foraminifers) along the Upper Pechelbronn Beds, in the Preuschdorf profile. This confirms the different facies defined by Schnaebele (1948) for this formation.

In the Eastern part, the Central Graben and the foothill of the Black Forest don’t show any Paleogene outcrops. The data comes from drillings. The stratigraphic succession is the same than in the previous part, except that the Red Beds are not present, and the whole series is overlaid by the Niederroedern Formation. On the German side, some boreholes indicate the presence of “Süßwasserkalk” and “Lymnaenmergel”.

A geological map of the studied area will be presented, just as a stratigraphic profile from Bouxwiller to Karlsruhe (Fig 1). According to the recent compilation of Berger (2010), a stratigraphic correlation will be exposed and the previous paleogeographical reconstructions (Berger et al. 2005 a, Pirkenseer 2007) will be discussed.

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Figure 1. Location of the section and boreholes.
4.8

Extraordinary sauropod trackways from the Late Jurassic Béchat Bovais tracksite (Canton Jura, NW Switzerland): implications for sauropod locomotor styles

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In 2008 and 2009, the Béchat Bovais tracksite, located on the future course of the A16 highway (Canton Jura, NW Switzerland), was excavated over a surface of more than 4000 m². On level 515, 2100 dinosaur tracks were uncovered and 28 sauropod trackways identified and documented by means of classical ichnological techniques, laser scanning, and photogrammetry. Layer 515 is a 5-15 cm thick, calcareous marl and its bedding plane (level 515) is a palaeosurface characterized by the presence of a dense network of reddish Thallassinoides burrows and true tracks with a wide range of morphologies indicating that substrate properties were not uniform across the site. Generally, on the underlying, desiccation-cracked level 510, no or only very shallow and faint undertracks are visible, indicating that level 510 was already well indurated at the time of track formation on level 515. Level 510 only broke occasionally under the pressure of the sauropod feet, leading in some places to the formation of deep tracks with steeply inclined track walls.

Pes tracks are oval in shape, longer than wide, only rarely exhibit digit and never claw impressions, and their mean length and width vary from 35.8 to 59.3, and 27.4 to 45.4 cm, respectively. Manus track morphology varies from horseshoe-shaped over semi-circular to sub-circular without any evidence for pollex claw impressions. Manus imprints are always wider than long, and their mean length and width varies from 8.5 to 28, and 20.9 to 34.3 cm, respectively.

Many of the trackways show different patterns and configurations, and marked distinctions also occur along single trackways (e.g. changes: from pes/manus to pes-only, in relative position of pes and manus tracks, in trackway gauge, in track rotation). Two extraordinary long and parallel trackways (S18 with 115 m, S19 with 105 m) show several small turns. The mean ratio between the width of the angulation pattern and the pes length ([WAP/PL]-ratio) characterizes 10 trackways as narrow, 9 as intermediate, and 9 as wide gauge. However, along several trackways (e.g., S18, 19, 21) these values change between narrow and wide over a couple of steps and demonstrate that these two locomotor styles could have been used by one and the same sauropod trackmaker and over short distances (Figure 1). This evidence – together with the fact that the studied trackways equally divide between the three different gauge categories – suggests that trackway gauge is not an unambiguous characteristic to distinguish sauropod ichnotaxa and to identify sauropod trackmakers.

The long, continuous sauropod trackways of Béchat Bovais can be used for detailed studies on the environmental and phonomical controls of track geometry and morphology, and they may provide important new data on the habitual locomotor characteristics of sauropods such as unsteady locomotion and changes in locomotor behaviour. Locomotor variation within ichnospecies can be addressed statistically, and ontogenetic effects of size on locomotor function can be analyzed.

Figure 1. Variation of trackway gauge (as expressed by the [WAP/PL]-ratio) along the 115 m long sauropod trackway S18, Béchat Bovais tracksite, level 515. Even though the mean [WAP/PL]-ratio classifies the trackway as wide gauge, the ratio varies remarkably along the trackway course. Pronounced changes between narrow up to very wide gauge occur over a couple of steps and may also be associated with changes in the relative position of pes and manus tracks.
4.9

Swiss Amphitragulus and Dremotherium (Mammalia; Ruminantia): State of the art

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The ruminants are typical European post- «Grande-Coupure» migrants and are quiet common within the Oligo-Miocene deposits of the Swiss Molasse Basin. Nowadays, the appendages and cheek teeth allow easily differentiating the numerous extant ruminant families. However, only hornless animals with sabre teeth occurred until the Early Miocene and the tooth patterns of primitive ruminants exhibit also strong similarities. As result, the Swiss Oligocene and Early Miocene ruminants, as well the European ones, were for a long time mainly identified either as Dremotherium or Amphitragulus. At least 17 species of Amphitragulus had been described until the beginning of the 20th century (A. aurelianensis, A. boulangeri, A. communis, A. elegans, A. gracilis, A. feningrei, A. fluarentianum, A. lemanensis, A. major, A. medius, A. neminoides, A. nouletti, A. podelskicius, A. pomeli, A. primaevus, A. quercyi, A. query). But, recent discoveries and studies allowed underlining within most of material wrongly assigned to Dremotherium or Amphitragulus new genus attributions (Gelocus, Hydropotopsis, Micromeryx, Pomelomeryx), intraspecific variability and synonymies (today only A. elegans and A. quercyi are valid).

The higher Pecora only appeared during the latest Oligocene (MP28; ca. 24.5 Ma) with the first representatives of Dremotherium and Amphitragulus, whereas Tragulina or Gelocidae represented the mid-Oligocene primitive ruminants. This faunal change is probably linked to the Late Oligocene Warming, migrations, and global environmental changes. Dremotherium and Amphitragulus are recorded from MP28 to MN2 (latest Oligocene to Aquitanian). The reassessment of the Swiss specimens of these two genera permits to better understand their taxonomy and ecology, and to update faunal composition of the Swiss ruminants during the Oligo-Miocene transition.

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4.10

New biostratigraphic data from the Voirons Sandstones (Voirons massif, Haute-Savoie, France): implications for the paleogeographic origin of the Gurnigel Nappe

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New biostratigraphic data from the Voirons Sandstones (Voirons Massif, Gurnigel Nappe) demonstrate the importance of reworking in this turbiditic succession and suggest that it is younger than previously thought, thus raising questions about its inferred south-penninic origin.

The Voirons massif is situated in the Chablais Prealps (Haute-Savoie, France), at about 20 km to the East of Geneva. It belongs to the Gurnigel Nappe, which essentially consists of deep-water turbidites (i.e. flysch) supposedly derived from an ultrabriançois or south-penninic realm. This attribution, however, is controversial. In this area, the Gurnigel Nappe comprises three stratigraphic units of Paleogene age: the Voirons Sandstones, the Vouan Conglomerates and the Saxel Marls. The Voirons Sandstones consist of a monotonous alternation of shales and sandstones, locally including thin intercalations of conglomerates. Based on calcareous nannoplankton and dinoflagellate assemblages, the age of this formation has previously been constrained between the early Paleocene and the early middle Eocene.
We have logged new sections in the most important outcrops of the region and described new exposures. Sampling was performed mainly from the shaly intervals within the sandstone/shale turbidite succession. About 30 shale samples were washed with gasoline. Residues were picked and examined for foraminiferal content with a binocular microscope and a SEM. Small pieces of six out of these 30 samples were sent off for calcareous nannofossil analysis.

The obtained biostratigraphical results are controversial. Nannofossil data confirm previous research and constrain the age of the Voirons Sandstones between the early Paleocene and the early middle Eocene. In contrast, foraminiferal data suggest that, in many exposures, the Voirons Sandstones may be as young as the late Eocene.

These new results emphasize the importance of reworking phenomena in the fine fraction of turbiditic sediments and question the use of nannofossil analyses for dating these deposits. Furthermore, the youngest ages obtained by foraminiferal dating suggest that the sedimentation of the Voirons Sandstones took place in a more external basin than the Piemont Ocean, which became inverted during the middle Eocene.

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4.11
The evolution of Early Ypresian microfossil assemblages and stable isotopes during a distinct plankton peak in the Corbières (Aude, France) continental margin record

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The Corbières Foreland Basin represents the southeastern-most extension of the Aquitaine Basin. During the Ypresian a succession of marine carbonates, marine marls, brackish marls to sandstones and subsequent fluvio-lacustrine sediments were deposited in the Corbières (Aude, France) area in several sequences. The present study focuses on the middle and upper part of the neritic „Blue Marls” close to Pradelles-en-Val. Samples from the overview section contains nannofossils indicating the nannoplankton zone upper NP11 and a fully marine, nearshore depositional environment. The lower half of the section is characterized by a strongly variable (1-85% plankton), plankton/benthos-ratio. A last pronounced peak in plankton occurrence in association with the near disappearance of all larger faunal elements (except pteropods) and a change in the ostracod assemblage was chosen for a more detailed sample campaign.

The detailed section (46 samples in 15cm intervals) pinpoints the correlation between rising P/B-ratio and abundance and composition of the ostracod assemblage. Variations in the assemblages of the planktic and small benthic Foraminifera taxa suggest rapidly changing conditions, probably triggering the speciation event in the ostracod lineage Echinocythereis isabeni-ana-aragonensis (Reyment 1985). During the depleted interval ostracoda and foraminifera numbers decrease, Pseudouvgigerina wilcoxensis is nearly absent and buliminids, Pulsiphonina wilcoxensis as well as echinoderm spines peak. The depleted interval is slightly preceded by the first occurrence of the planktic taxa Subbotina hornibrooki and Globoturborotalites bassriverensis, the latter being considered a PETM Excursion taxon (Olsson et al. 2006). The subsequent interval is characterized by rapidly increasing P/B-ratio, a dominance of Globoturborotalites bassriverensis and Pseudohastigerina wilcoxensis as well as an altered ostracod assemblage composition. Sedimentation of clastic material larger than 63µm increases approximately 100%. Bulk δ13C values generally drop from around -1.0‰ to around 1.5‰ and then increase to -0.8‰ after the plankton peak. The influence of either local factors and/or diagenesis obscuring possible global events (H-K hyperthermals, Cramer et al. 2003) remains difficult to quantify due to the lack of data from comparable marginal marine Paleogene sections and the high resolution due to the short represented timespan (upper NP11).

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4.12

A Tooth Tale: the *Anthracotherium bumbachense* (Artiodactyla, Mammalia) from Beuchille (Delémont, Switzerland).

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The genus *Anthracotherium* (Artiodactyla, Mammalia) originated in Asia in the middle Eocene and migrated to Europe in the Early Oligocene. Its worldwide extinction is reported to the end of the Oligocene (Lihoreau and Ducrocq, 2007). Early descriptions (e.g., Kowalevsky, 1873; Stehlin, 1910) determined fossils of this genus in Europe, widely occurring in France, Germany, and Switzerland. No less than ten species were described throughout the Oligocene, and these species were generally only differentiated by biometrical comparisons.

The species *A. bumbachense* was established by Stehlin (1910) from the locality of Bumbach in Switzerland, which is the reference locality of the Mammal Biozone MP25 (early Late Oligocene, ca. 28 Ma). Stehlin (1910) based his observations on scarce postcranial remains such as a cuboid, a phalange, and two metapods. In his monography on the genus *Anthracotherium*, Kowalevsky (1873) had observed a morphological difference between the large specimens of the Late Oligocene (e.g., *A. magnum, A. vuldense*) that had four digits of similar size, and the specimens of the Early Oligocene that showed a reduction of the lateral digits. *A. bumbachense* belonged to this latter group, called “Anisodactyls”.

For ten years the section of paleontology of Porrentruy (Jura, NW Switzerland) excavates fossils along the Transjurane highway. In 2001, the locality of Beuchille, located in the Delémont Basin, displayed numerous remains of vertebrates such as reptiles and terrestrial mammals. Dental and postcranial remains of anthracotheriids were found and preliminarily determined as *Anthracotherium* sp. The upper molar of *Anthracotherium* discovered here was particularly difficult to deter-
mine at the specific level due to the fact that anthracotheres displayed highly monotonous morphological characters. This isolated tooth was not the only anthracotheriid remain found in this locality. It was also completed by a single metapod that allowed Becker et al. (2004) to assign this specimen to Anthracotherium cf. bumbachense thanks to its shape.

In 2007, an SNF-project (126420) began at the University of Fribourg on the large terrestrial mammals of the Swiss Molasse Basin from the Early Oligocene to the Early Miocene, employing two PhD students and two Master students. A review of the locality of Bumbach (old collection and new field work) was made by N’Guyen in 2008, but no molars of A. bumbachense were discovered. Later, a review of the material deposited in the University Claude Bernard in Lyon (France) showed two complete skulls and their mandibles from the locality of Bénisson-Dieu (France) assigned to A. bumbachense by Roman and Boucher (1936). It enabled a detailed description of the teeth, and especially of the upper molars. Thanks to a new method established by Boisserie et al. (2010) to describe the dental remains of bunodont artiodactyls (e.g., hippopotamuses), the European species of Anthracotherium could finally be systematically differentiated by the morphology of their cusps. The molar from Beuchille could be compared to the material from Bénissons-Dieu and it could be assigned without any doubt to the species A. bumbachense (Fig. 1). Furthermore, a new biostratigraphic and paleogeographic frame could be proposed.

Figure 1. Synthesis of the determination of A. bumbachense from Beuchille. A: M2II from Bumbach (drawing from Kowalevsky, 1873); B: M3 from Beuchille; C: M2II from Beuchille; D: skull from Bénisson-Dieu. Scale bars equal 5 cm.

REFERENCES
4.13

Dienerian (Early Triassic) ammonoid successions of the Tethys: preliminary results from Pakistan and India

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In the aftermath of the Permian/Triassic mass extinction, ammonoids are one of the two fastest animal marine clades to recover (Brayard et al. 2009). It is generally assumed that diversity remained low during the Griesbachian, increased slowly during the Dienerian, and then reached a first peak in middle Smithian times. However, Dienerian faunas are only poorly known, and most recent works deal with boreal faunas whose record is strongly affected by the paucity of carbonate rocks. Recent fieldwork conducted in the Lower Triassic of the Northern Indian Margin (Salt Range, Pakistan and Spiti Valley, NW Himalaya) allow us to reassess the hypothesis of a slowly increasing diversity during the Dienerian: late Griesbachian and Dienerian ammonoid taxonomy is being completely revised and a preliminary, high resolution biochronological scheme has been constructed.

This paper focuses on the Nammal section (Salt Range), which possesses the best stratigraphic record so far (17 ammonoid-bearing beds within this 12 m interval of the section; the duration of the Griesbachian, Dienerian and lowermost Smithian together being of ca. 1.4 My, Galfetti et al. 2007). This time interval can be divided here into 5 major ammonoid zones: the first one is late Griesbachian, characterised by ophiceratids, and the other five zones are Dienerian, characterised by a succession of five phylogenetically related gyronitid genera: *Gyronites, Ambites, gen. nov. C*, and *Prionolobus* (in stratigraphical order). Preliminary results from other sections in the Salt Range and Spiti show that these five Dienerian zones can be recognised easily in every of these.

Diversity in the latest Griesbachian and Dienerian stays rather low and constant, with 5 to 7 species per zone, but this time interval is characterised by very high turnover rates. The supposed low increase of diversity during the Dienerian is therefore not obvious, and may just be a consequence of the previous lower time resolution combined with high turnover rates. In the earliest Smithian zones, diversity remains low (6 to 8 species), and starts increasing only at the end of the lower Smithian (Brühwiler et al., accepted).

We also note a drop of the morphological disparity among Dienerian ammonoids. The most striking fact is the loss of ornamentation: ribbed forms are still known in the *Gyronites* zone, but they completely disappear in the *Ambites* zone, and reappear only in the earliest Smithian faunas. Cadiconic forms are also absent during this time interval.

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