Rediscovery of a "forgotten land". The last three decades of research on the dinosaur-bearing deposits from the Haţeg Basin

Article · January 2005

CITATIONS
29

READS
222

1 author:

Dan Grigorescu
University of Bucharest
129 PUBLICATIONS **2,464** CITATIONS

SEE PROFILE

ACTA PALAEONTOLOGICA ROMANIAE V. 5 (2005), P. 191-204

REDISCOVERY OF A "FORGOTTEN LAND": THE LAST THREE DECADES OF RESEARCH ON THE DINOSAUR-BEARING DEPOSITS FROM THE HAȚEG BASIN

Dan GRIGORESCU[1]

Abstract: Cercetările asupra depozitelor continentale cu resturi ale unor dinozauri de la sfârşitul perioadei cretacice din cadrul Bazinului Hațeg au o istorie de peste o sută de ani. Primele cercetări asupra faunei cu dinozauri din Bazinul Hațeg sunt datorate lui Franz von Nopcsa (1877-1933), contribuțiile sale în domeniul paleontologiei sistematice, a evoluției şi paleobiologiei dinosaurilor îşi păstrează şi în prezent actualitatea.

După Nopcsa cercetarea sistematică a acestor depozite s-a întrerupt pentru multe decenii, fiind reluată în vara anului 1977 când D. Grigorescu însoțit de un mic grup de studenți geologi a început excavarea unor situri fosilifere identificate pe valea râului Sibişel, în apropierea satului Sânpetru, localitate renumită prin cercetările lui Nopcsa. An de an, fără intrerupere cercetările au continuat într-un cadru multidisciplinar, domeniile abordate fiind paleontologia sistematică, stratigrafia, sedimentologia, tafonomia; în timp acestor domenii li s-au adaugat cercetările asupra mineralelor argiloase, izotopilor stabili şi paleomagnetismului. Rezultatele acestor cercetări, care au antrenat în timp câteva sute de studenți, dar şi mulți cercetători profesionişti din țară şi din străinătate, sunt sintetizate în cadrul prezentei lucrări.

Intre aceste rezultate sunt cuprinse descoperirea a numeroşi taxoni (90% din fauna maastrichtiană a Hațegului cunoscută în prezent este rodul cercetărilor de după 1977), descoperirea cuiburilor cu ouă şi a puilor de dinozauri, descoperirea mamiferelor şi a uriaşului pterozaur *Hatzegoperyx*. Cadrul stratigrafic al depozitelor cu dinozauri atât în privința structurii litostratigrafice cât şi a vârstei depozitelor, acceptată în prezent ca acoperind întreaga durată a Maastrichtianului, a dobândit clarificări care permit pe de o parte o mai bună interpretare a evoluției sedimentologice, iar prin aceasta a condițiilor ecologice din cadrul regiunii, iar pe de altă parte corelarea mai precisă a depozitelor continentale cu vestigii ale dinozaurilor cu depozite similare de la sfârşitul Mezozoicului din alte regiuni ale lumii.

Pornind de la importanța ştiințifică a faunei cu dinozauri, evidențiată în mod special prin cercetările din ultimele trei decenii, un proiect de dezvoltare durabilă a Țării Hațegului a fost inițiat: "Geoparcul Dinozaurilor Tara Hațegului".

Key-words: Paleontology. Dinosaurs. Vertebrates. Microvertebrates. Maastrichtian. Hațeg Basin.

This year (2005) when the Centennial of the Laboratory of Paleontology of the University of Bucharest is celebrated, 108 years have passed since the issue of the first scientific paper dedicated to the dinosaur remains from the Uppermost Cretaceous continental deposits of the Hațeg Basin (Nopcsa, 1897). Franz Nopcsa (1877-1933) was at that time a student in Geology at the University of Vienna where he had among his professors well-known scientists such as Eduard Suess and Othenio Abel.

Nopcsa's paleontological field research on the dinosaur-bearing deposits of the Hațeg Basin continued till the first world-war, several papers dedicated to the Hațeg dinosaurs being published after he left the region and sold most of his collection to the British Museum of Natural History. In Nopcsa's scientific career, studies on the Hațeg dinosaurs and their cohabitants can be only compared with his geological mapping of Albania, a work in which he proved again his exceptional qualities as a researcher, both in the field and laboratory.

The main contributions of Franz Nopcsa to the knowledge of the dinosaur fauna from the Hațeg Basin can be synthesized in particular areas as follows:

- **Systematic Paleontology**: description of 10 species of dinosaurs and other fossil reptiles, out of which 6 were confirmed by the subsequent revisions;
- **Chronostratigraphy and Geologic mapping**: dating the continental fossiliferous deposits as Danian, at that time the upper-most stage of the Cretaceous; first detailed geological map of the Hațeg Basin and the neighbouring regions on which the Upper Cretaceous marine deposits are clearly delimited from the overlaid continental deposits with dinosaur remains described under the generic name of "Sânpetru sandstone";
- **Evolution**: recognition of the primitiveness of most of the taxa from the Hațeg paleofauna, stressing that in spite of their stratigraphic position the dinosaurs and other fossil reptiles preserved characters of their Upper Jurassic and Lower Cretaceous ancestors ;
- **Paleobiology**: besides their primitiveness, most of the fossil species from the Hațeg paleofauna were much smaller than their closest relatives from other regions of Europe. Both the primitiveness and the small size were explained by Nopcsa by their isolation on an island in which the dinosaurs and the other co-habitants lived for a long span of time; this biologic phenomenon, common for large animals living in small and medium-sized islands is known as "island dwarfism".

During the First World War Nopcsa left the family castle and estate and never came back. He continued to publish papers on the Hațeg dinosaur fauna till the end of his life, four syntheses on this

[1] *University of Bucharest, Faculty of Geology & Geophysics, Laboratory of Paleontology, dangrig@geo.edu.ro*

fauna being published after he left Haţeg. Nopcsa studied also the new collection of dinosaur remains from the north-western region of the Haţeg Basin made by Otto Kadic, a geologist from Budapest.

After Nopcsa no systematic studies on the reptile fossil fauna from Haţeg were done for about 65 years.

During this time the "Danian" continental deposits of the Haţeg Basin were touched on by a few individual geologists or teams, whose general aims were geological mapping or mineral prospecting. Among these researches should be mentioned those of Laufer (1925), Mamulea (1953 a, b) and G. Iliescu *et al.* (1972, unpublished report).

While the first two authors generally confirm, more or less, Nopcsa's areal distribution of the "Danian" deposits and make some corrections to the age of the "coarse red deposits" at the southern and northern border of the Basin, the map elaborated by G. Iliescu *et al.* (op.cit.) very much restricts the surface occupied by the "Danian". On that map the "Danian" occurs only in the "classical" Sânpetru region of Nopcsa and in a small outcrop in the north-western part of the Basin, east of Rachitova and west of Densuş. Thus important fossiliferous localities that provided dinosaur remains to Nopcsa and Kadic, like Ciula and Vălioara were included within the Lower and Middle Paleogene in a fluvio-lacustrine facies. This conclusion was based on fresh-water gastropods, apparently of a Paleogene type, while the more age-indicative dinosaur bones were considered as reworked into younger beds. This point of view was also expressed on the Geologic Map of Romania 1:200.000 (Deva sheet) published in 1968.

The researches on regional geology made after the First World War and up to 1977, when systematic studies on the dinosaur-bearing deposits of the Haţeg Basin began again, did not create new collections. The only important remains consisting of few vertebrae and limb bones, most of them of the sauropod *Magyarosaurus* (cf. Csiki, 2005), were collected by Mamulea from the Sânpetru zone and offered to the Laboratory of Paleontology of the University of Bucharest.

Other important fossils mentioned in the same period are plants (ferns and angiosperms); they were described by G. Mărgărit & M. Mărgărit (1967) from the tuffitic rocks outcropping in the Densuş valley.

Related to the same "post-Nopcsa" period is the change of the age of the Uppermost Cretaceous deposits of the two neighbouring post-tectonic basins in south-western Transylvania, Rusca Montana and Haţeg, from Danian to Maastrichtian. The correction is due to Dinca *et al.* (1972), who, based on foraminifera from the underlying marine deposits developed in both basins in a similar flysch-like facies, assigned their age to the Campanian, and so the overlying continental deposits, bearing a rich flora and the coal beds in Rusca Montana Basin, as well as the dinosaur remains in the Haţeg Basin got a Maastrichtian age. In doing this age correction Dinca *et al.* (op. cit.) followed the conclusion of the International Congress in Copenhagen (1970), that, in accordance with the micro- and macro faunal content of several key-sections in Europe, the Danian should be regarded as the first stage of the Tertiary in marine facies, and so the Maastrichtian became the final stage of the Cretaceous.

The decision I took in the mid 1970s to start new studies on the dinosaur beds of Haţeg had several reasons. At that time I was responsible for organizing and coordinating the summer practical field work in sedimentary deposits for the students in Geology at the end of their 2nd grade. Among the geological sections selected to be visited by students we included outcrops on the Sibişel valley south of Sânpetru village, the type–section of Nopcsa's "Sânpetru sandstone". During these one day visits students always found bone remains: isolated vertebrae, limb bone fragments, teeth, plates from turtle carapaces. All were naturally unearthed at the end of winters when the snow melted, being scattered close to the beds in which they were buried. After a few summers a small collection of bone remains from Sânpetru was made and deposited in the Laboratory of Paleontology in Bucharest. The new collection was added to the few vertebrae and limb bones, some of them remarkably preserved, donated to the Laboratory by A. Mamulea at the end of his work in Haţeg. In that time I received letters and even visits to the Laboratory from foreign scientists interested in getting new information on the Haţeg dinosaurs. My main scientific interest at that time was the fossil seals from the Middle Miocene of South Dobrogea that I started studying intensively after I got my PhD (in 1971) on the microfacies of the Cretaceous flysch deposits in the Eastern Carpathians and after a nine months post-doc fellowship in the Paleontological Division of the Geological Survey of India (GSI), in Calcutta. There I became familiar with Tertiary mammals (primates and proboscideans) from the Siwalik Hills, examining the large collection of the GSI Museum. I also participated in several field trips in the Siwaliks (for two weeks together with Bev Halstead), but also in the Deccan Plateau for the "inter-trappean frog beds" and in southern India for Mesozoic marine beds. In 1975 I was invited to the U.S.A. by the organizers of the paleontological symposium "Advances in Systematics of Marine Mammals" held in Corvallis, Oregon (in August 1975) to attend this meeting and to present a paper on the Paratethyan seals (published afterwards in Systematic Zoology, 1976). The six weeks visit to America sponsored by the Smithsonian Institution and the National Museum of Natural History in Washington D.C., allowed me to see the paleontological collections of the large museums in Washington D.C., New York, Los Angeles, Berkeley, but also other smaller museums. During my visits to museums I was

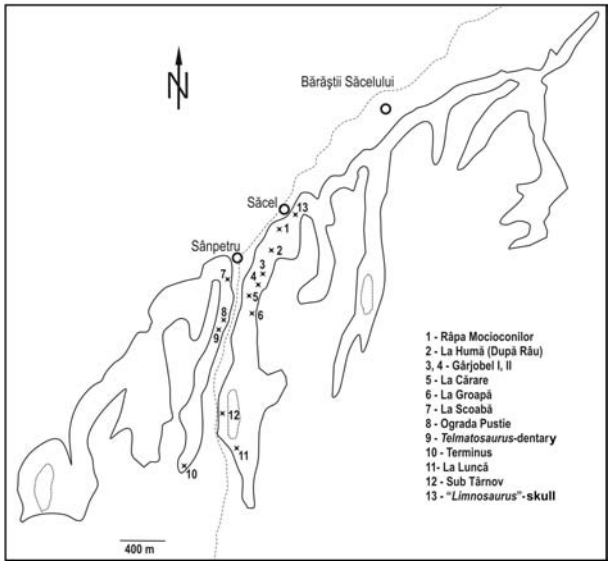

Fig. 1. Main fossiliferous sites of the Sibişel Valley, Sînpetru, Haţeg Basin (the contour shows the distribution of the Maastrichtian deposits)

approached by students interested in dinosaurs, asking me about the Haţeg dinosaurs, about which they knew especially from Nopcsa's papers in American or British publications. In the United States, where the fascination with dinosaurs was reaching a climax, museums, large and small, exhibit life reconstructions of American dinosaurs, and films and books depicting dinosaurs' features and their behaviours are abundant everywhere, I felt a sort of pressure from the scientific community to restart systematic researches on the Haţeg dinosaurs, in order to complete the gap created after Nopcsa. In comparison with the United States, in Europe and in Romania especially, professional vertebrate paleontologists are very few and the existing ones can not cover the variety of fossil groups encountered, from fishes to mammals, even as regards their taxonomic identification.

After coming back from America I started planning resarch at Haţeg for the next summers. The fossil seals were not totally abandoned but progressively they became secondary in my scientific preoccupations. To make our students more aware of dinosaurs in general, and the Haţeg ones in particular, I started presenting lectures to the newly created "Student Scientific Circle for the protection of the Geologic Monuments". The lectures attracted the students' interests, and beside the students in Geology, they were attended by students in Geography and Biology.

The first field campaign in Haţeg was organized in 1977, when a group of 7 volunteer students joined me at the beginning of the new research. Among them was Costin Ungureanu, a student in the final (5^{th}) grade who as an undergraduate student visited the region with me during the summer practical field work, and is now doing his own research under my supervision for the Graduation Diploma.

The first years searches in Haţeg were concentrated on the outcrops along both banks of the Sibişel valley, south of Sânpetru. Here we benefited very much in planning the excavations from the information provided by a native of Sânpetru village, Mr. Vulc Doinel, a nature lover and an extraordinary self-educated man. Every day he walked with his goats and cattle along the narrow paths traversing the fossiliferous continental beds, and he knew exactly where new bone remains occurred following erosion by the stream, and he told us. He knew the local names for all the places on the Sibişel valley where concentrations of bones in so–called "fossiliferous pockets" were identified (fig. 1). Mr. Vulc helped us not only with information, but he often joined us in digging and his house became our camp-base, where we used to store over the winters the tools and materials for fossil preparation in the field.

A close cooperation was established during those years with Mr. Ion Groza, who graduated in Geography from Bucharest, a few years before we started research in the Haţeg Basin. After graduation he was employed by the Deva Museum – the Section of Natural History. As a student in the same Faculty with me and only a few years younger, Groza used to come occasionally to me in the laboratory to get more information on fossils than what he was taught in the regular courses of Geology provided for the students in Geography. A native of the Călan region, close to Haţeg, Groza was interested to return home after graduation and to follow a career as a school teacher. In this respect, I always advised him, to survey constantly the fossiliferous sites mentioned by Nopcsa, from the Sibişel valley, not very far from his house in Boşorod village, and from Vălioara, in the northern part of the Haţeg Basin.

When we started researches near Sânpetru village, Groza joined us, a mutual understanding being established between us for digging and collecting together, the resulting material to be shared out between the University of Bucharest and Deva Museum, in a logical way, avoiding the division of isolated bones of the same individual in two places. The understanding worked for about six years, during which a new permanent paleontological exhibition, concentrated on fossils from Hunedoara County, was created within the Deva Museum, under my guidance. The dinosaur bones, that had not existed before in the Museum of Deva became real attractions for visitors and thus the Museum increased its reputation. Working in the field together with us, Groza became more familiar with dinosaur osteology and taphonomy and learned where and how to dig, and he also become aware of the methods for bone preparation in field and in laboratory. We also benefited from this collaboration; living not far from the fossiliferous sites, Groza could continue digging after we left the region at the end of the summer campaigns; thus the number of discovered specimens has considerably increased.

The good cooperation with Deva Museum ended after Groza left for a new job in the Council for Culture of Hunedoara County.

News of the resumption of the research on the Haţeg dinosaur beds quickly reached scientists from abroad interested in Late Cretaceous dinosaurs and associated faunas. After 1977, the first foreign scientists who came to Haţeg to visit the fossiliferous outcrops and to examine the bone collections were Dr. Zofia Kielan-Javorowska, Member of the Polish Academy of Sciences, together with Drs. Halszka Osmolska and Teresa Maryanska from Warsaw, all of them participants in the Polish-Mongolian expedition in the 1970s searching for dinosaurs and mammals in the Upper Cretaceous of the Gobi desert. They came to Romania in the summer of 1980 and spent a week at Haţeg and in Bihor County where concentrations of dinosaur bone fragments, mostly from ornithopods, had been found recently within Lower Cretaceous bauxite deposits.

Zofia Kielan-Jaworowska became and remains today a valuable adviser for us on multituberculate micromammals, whose remains and taxa increased during the time, from the first sign of an undetermined incisor found in 1981 - to at least six species known today from Haţeg, based on dentition, skull fragments and postcranial skeleton.

During her visit to Haţeg Zofia invited me to come next year to Warsaw to attend the 2nd Symposium on Mesozoic Terrestrial ecosystems. It took place in September 1981 in Jadwisin, a small locality, about 100 km from Warsaw. The "Solidarność" social movement against communism was growing in the country and a few month latter, in December the" state of necessity" was declared in Poland.

The Symposium in Jadwisin was attended by many reputed scientists and especially by young researchers who became later personalities in Vertebrate Paleontology, among them David Archibald, Eric Buffetaut, Bob Carroll, Philip Currie, Peter Dodson, Andrzej Elzanowski, David Martill, Jean-Michel Mazin, Gregory Paul, Paul Sereno, Philippe Taquet.

At the Symposium I presented the paper "A stratigraphic, taphonomic and paleoecologic approach to a "forgotten land": the dinosaur-bearing deposits from the Haţeg Basin (Transylvania, Romania)". The "forgotten land" metaphor in the title of the paper was intended to emphasize the long gap after Nopcsa in the study of the continental deposits from Haţeg. The paper synthesizes the results of our first four year's searches in the Haţeg Basin. The lithology, sedimentary structures and characters of the sedimentary sequences were indicative of a braided river system as the general environmental framework in the deposition of the "Sânpetru beds" from the central part of the basin, while deltaic sedimentation was suggested for the northern part –the Vălioara region. The braided river system was confirmed subsequently by new sedimentological research (e.g. Therrien, 2005), but the deltaic conditions in the northern part of the basin were refuted. New evidence, after Nopcsa, was added for the concentration of disarticulated bones from different taxa and individuals in "fossiliferous pockets", a taphonomic feature of the dinosaur-bearing deposits from Haţeg. The list of taxa presented in the paper was quoted from Nopcsa, without updating the names. (The Systematics of dinosaurs was my weak point for many years due to the lack in our laboratory and in the country in general of osteologic material for comparisons, and attempts at taxonomic identification were exclusively based on books and papers. Only in 1987, 10 years after starting research at Haţeg I had the opportunity to examine in the British Museum of Natural History, for a week Nopcsa's collection from the "Sânpetru beds"). However the paper presented in Jadwisin included the first mention of two new groups in the Cretaceous fauna of Haţeg: small theropods (coelurosaurs) and multituberculate micromammals, both based on teeth found in micropaleontological samples. (The description of these new groups was made three years after Jadwisin during the Third Symposium on Mesozoic Terrestrial Ecosystems that took place in 1984 in Tübingen.). Based on the data on the dinosaur and other contemporaneous reptile paleoecology, corroborated by sedimentologic and taphonomic characters of the deposits, four primary biotopes were recognized for the Maastrichtian of the Haţeg Basin: alluvial islands, swampy zones in poorly drained flood plains, well drained flood plains and upland, drier areas.

The research at Haţeg continued in a few themes, distinct by their specific methods, but closely interrelated in the reconstruction of the paleoenvironment: **a**. **Paleontologic** researches on both macro- and microfossils; new discoveries resulted by the extension of the searched area to the Ciula Mica-Vălioara region, in the northern part of the basin, in parallel with continued digging in the Sibişel valley; the main results of this geographic extension were: - the discovery of a few sites near Vălioara yielding concentrations of microvertebrates (fishes, frogs, lizards, small theropods, micromammals), -the discovery in 1988 of dinosaur eggs near Tuştea, -the discovery of the skull and limb bone fragments of what proved to be the remains of the huge pterosaur *Hatzegopteryx*.

b. Lithostatigraphic and Chronostratigraphic research that led to the recognition within the dinosaur-bearing continental deposits of the Haţeg Basin two distinct formations: the Sânpetru Formation and the Densuş-Ciula Formation, the last divided into three members; palynological studies indicated a Late Maastrichtian age for the fossiliferous deposits with dinosaurs.

c. Sedimentologic studies on the better exposed geological sections (Sibişel and Densuş valleys where the outcrops are exposed continuously for more than a thousand metres

thickness); these studies allowed the reconstruction of the sedimentological evolution of the basin based on sequence analysis.

The synthesis of this multidisciplinary approach to the Uppermost Cretaceous was presented in August 1990 during the International Symposium organized in Bucharest in the frame of the World Geological Correlation Program (IGCP 245), that included a three-day field trip to the Haţeg Basin. Following this meeting a number of foreign paleontologists visited the region, among them Philip Currie from Drumheller, Canada, Dave Norman from Cambridge, Dave Weishampell from Baltimore, Eric Buffetaut, Jean-Michel Mazin and Sevket Sen from Paris, Mike Benton from Bristol, Jack Horner from Bozeman, Montana. Some of these visits were followed by agreements of collaboration, with the main purpose of taxonomic revision of the dinosaurs from Haţeg. Grants from the National Science Foundation of U.S.A. and of the Romanian Academy of Science allowed Dave Weishampel to work in the field with us for five years (1991- 95) and Dan Grigorescu to participate in digs in 1991 and 1996 in Montana.

From the students who participated in field work at Haţeg a few chose afterwards vertebrate paleontology as the subject for their Graduation Diploma. Among these students, Zoltan Csiki has distinguished himself by his passion for dinosaur studies and the qualities of a hard-worker in the field as well as in the laboratory. He joined the team in the field from his first grade in Geology at the University of Bucharest, he became Assistant Professor after graduation from the Faculty, starting a scientific career on the Haţeg Maastrichtian fauna. A first major achievement in this career was his PhD on 'Saurischian dinosaurs and microvertebrates' from this fauna, that he defended very successfully, recently (September 2005).

The main purpose of this paper is to summarize the results of research on the dinosaur deposits from Haţeg after these studies were resumed in 1977. The results are grouped into thematic topics.

A. SYSTEMATIC PALEONTOLOGY

The nearly three decades that have elapsed since research on the Uppermost Cretaceous continental deposits of the Haţeg Basin were resumed, have led to a tremendous increase in the number of taxa, both plant and animal, which together represent the biodiversity at the end of Cretaceous in this region and, on a larger scale, in the whole Transylvanian land.

To give an impression of this increase we may mention that no **plant remains** were known before 1925 when Laufer described *Sabal mayor* from the tuff layers near Densuş. From the same deposits Margarit & Margarit mentioned in 1967 an association of leaf impressions of ferns (*Asplenium forsteri, Phyllites* sp*., Palmophyllum longirachis*) and angiosperms (*Myrica primigenia, Proteophyllum decorum).* The diversity of the flora is better illustrated by the palynological studies of Antonescu *et al.* (1983) and recentely of Van Itterbeeck *et al.* (2005). The floral list from these two studies includes more than 100 genera of spores of ferns and other cryptogams and pollen of gymnosperms and angiosperms, an assemblage that indicates a subtropical climate. Charophytes were also identified in the grey-greenish siltstone facies of the renamed Sânpetru Formation in the Sibişel valley (Grigorescu & Anastasiu, 1990).

As regards the **animals** more than 90% of the total number of taxa (invertebrates and vertebrates together) known today from the Maastrichtian of Haţeg and ca. 85% of the vertebrates were reported in the last decades.

Practically no **invertebrate** taxa had been described from Haţeg before 1983, except the general mention made by different authors of "fresh water molluscs". In a paper of Antonescu *et al.* (1983), D. Lupu presented a taxonomic list of freshwater gastropods that includes eight genera of snails belonging to five families. More recently a larger and more elaborate list was presented by Pană *et al.* (2001). It includes 30 species of freshwater gastropods in 26 genera and 14 families.

Further invertebrates that are well represented are the ostracods, tiny crustaceans (Grigorescu, 1992); a list of ostracod species from Haţeg was presented by Stoica (unpublished report, 1994).

A spectacular increase in the number of taxa in the last two decades has been recorded among **Vertebrates.** In addition to the ten vertebrate taxa, all reptiles, known from Nopcsa's studies, of which six have been confirmed afterwards, more than 60 taxa were listed recently in a synthesis by Csiki (2005) (Table 1). All the classes of vertebrates are present in this list, from fishes to mammals, including birds, and these latter were always controversial because of their close similarity with small theropods, especially as regards the limb bone characters.

Very spectacular are the discoveries of theropods, practically unknown in Nopcsa's time. The caudal vertebrae which Nopcsa described in 1915 as the carnosaur *Megalosaurus* sp. Have proved to belong to the sauropod *Magyarosaurus* (Csiki, 2005). The first real theropods, represented by isolated teeth of "coelurosaurians" were mentioned by Grigorescu (1984). Before this, Andrews (1913) and Harrison & Walker (1975) have studied some tibiotarsi from Nopcsa's collection, assigning them to different types of birds: cormorant-like by Andrews, and giant owls by Harrison & Walker. Almost unanimously, subsequent research led to the conclusions that this material does not belong to birds, but to theropods, probably to an undetermined troodontid.

The last ten years led to the discovery of several taxa of true theropods, possibly nine (cf. Csiki, op. cit), unfortunately most of them

represented only by isolated teeth which makes assignment below the genus or even subfamily level difficult.

The pterosaurs represent another group of archosaurs that have become better known among the Haţeg paleofauna. To the ornithocheirid *Ornithodesmus* mentioned by Nopcsa (1915), pteranodontids (Jianu *et al.*, 1997) and azhdarchids (Buffetaut *et al.*, 2002) have been added. The azhdarchid *Hatzegopteryx thambema* (a new genus and species) is particularly important, with its 12 m wing-span and the 3 m long skull, probably one of the largest, if not the largest, flying animal that ever lived.

The spectacular rise in the number of taxa in the Haţeg paleofauna is mainly the consequence of research on the microscopic content of the finer sediments; the micropaleontological method was introduced in the late 1970s, soon after we started the new research at Haţeg, but the wash and screen method was intensively used only during the last ten years. Through this method, the remains of fishes, amphibians, lizards, small theropods and mammals were for the first time recorded in the Maastrichtian of the Haţeg Basin.

Many of the taxa included in this list are based on very scarce and fragmentary material found in micropaleontological samples and thus their taxonomy could not be detailed below the family level. However the list of taxa gives a general view of the diversity of the vertebrates that composed the Maastrichtian fauna in this region. It is expected that future studies will clarify and detail the taxonomic aspects that are not completely resolved at the present stage. The increasing interest of a small group of researchers, both from Romania (Márton Venczel, Zoltán Csiki) and from abroad (Annelise Folie from Belgium) in the microvertebrates from the Haţeg paleofauna might be regarded as a guarantee in this respect.

Some of the taxa listed by Nopcsa were revised and redescribed after 1992 on the basis of old and new bone collections. These taxa are the non-crested hadrosaurid *Telmatosaurus* (Weishampel *et al.*,1993), the euornithopod *Rhabdodon* (Weishampel *et al.*, 2003) and the sauropod *Magyarosaurus* (Csiki, Ph. D thesis, 2005). These revisions included cladistic analysis as a basis for phylogenetic conclusions. Thus *Telmatosaurus* (*T. transsylvanicus*) is considered as the most basal hadrosaurid; the *Rhabdodon* specimens from Haţeg are regarded as a new genus – *Zalmoxes* - (with two species), being united with the *Rhabdodon* species from France and Spain in a new clade of basal euornithopods, Rhabdodontidae; the titanosaur sauropods, previously considered as represented at Haţeg by only one taxon (*Magyarosaurus dacus*), probably include one or, possibly, two more taxa; the possibility of another titanosaur genus in the Maastrichtian of Haţeg has also been considered.

B. DINOSAUR EGGS AND HATCHLINGS

The discovery of clutches with dinosaur eggs represents one of the most important paleontological discoveries of the last years in the Haţeg Basin, not only for this region but for the entire world map of Upper Cretaceous sites with dinosaur eggs and hatchlings, expecially because of questions on dinosaur ootaxonomy that were raised by this discovery. In spite of many years of research on the dinosaur deposits from Haţeg, dinosaur eggs were not known till 1988 when a few clutches with dinosaur eggs were found by Şeclăman and Ghinescu in a vertical escarpment on the Oltoane hill near Tuştea village (Grigorescu *et al.*,1990).

The eggs were encased in a red mudstone with small calcareous irregular structures (calcretes), below a conglomerate bed with large volcaniclasts that dominate the lithologic section through its 5 m thickness. The vertical escarpment of the Oltoane hill in which the first clutches with eggs were exposed, was leveled by a bulldozer during the next years, and on the horizontal platform that was created a dozen new clutches were found, each of them containing 3 to 6 eggs, rarely more, but also a few isolated eggs (Fig. 2). The eggs are subspherical, 15-17 cm in diameter, and the internal microstructure and the external ornamentation of the eggshell (2.3-2.4 mm thick) correspond to the Megaloolithidae oofamily.

Megaloolithid eggs have been recorded from different regions of Europe, Asia, and North and South America; they are particularly abundant and diverse in southern France where no fewer than eight megaloolithid oospecies have been described (Garcia & Vianey-Liaud, 2001). Traditionally, the subspherical dinosaur eggs from southern France were assigned to the sauropod genus *Hypselosaurus,* based on some occasional co-occurrences of adult bones and eggs in the same deposits. So far, no embryonic or hatchling remains associated with dinosaur eggs or eggshells have been found in France. The close similarities of the Tuştea eggs with the southern French ones in both macroscopic and microscopic aspects, made us assume at the beginning that the Romanian eggs were laid by *Magyarosaurus*, at that time the only known sauropod in the assemblage of dinosaurs from the Haţeg Basin, but noring also that other larger species of dinosaurs from Haţeg, including the hadrosaur *Telmatosaurus*, might also be the producers (Grigorescu *et al.*, 1990).

The correspondence of the megaloolithid type of eggs with sauropod dinosaurs was demonstrated more recently in southern Argentina, where numerous megaloolithid eggs containing embryonic remains were found (Chiappe *et al.*, 1998). However the important discovery from Argentina does not answer the question of whether sauropods were the only dinosaurs that laid megaloolithid eggs. The question was raised in Tuştea, two years after the discovery of dinosaur

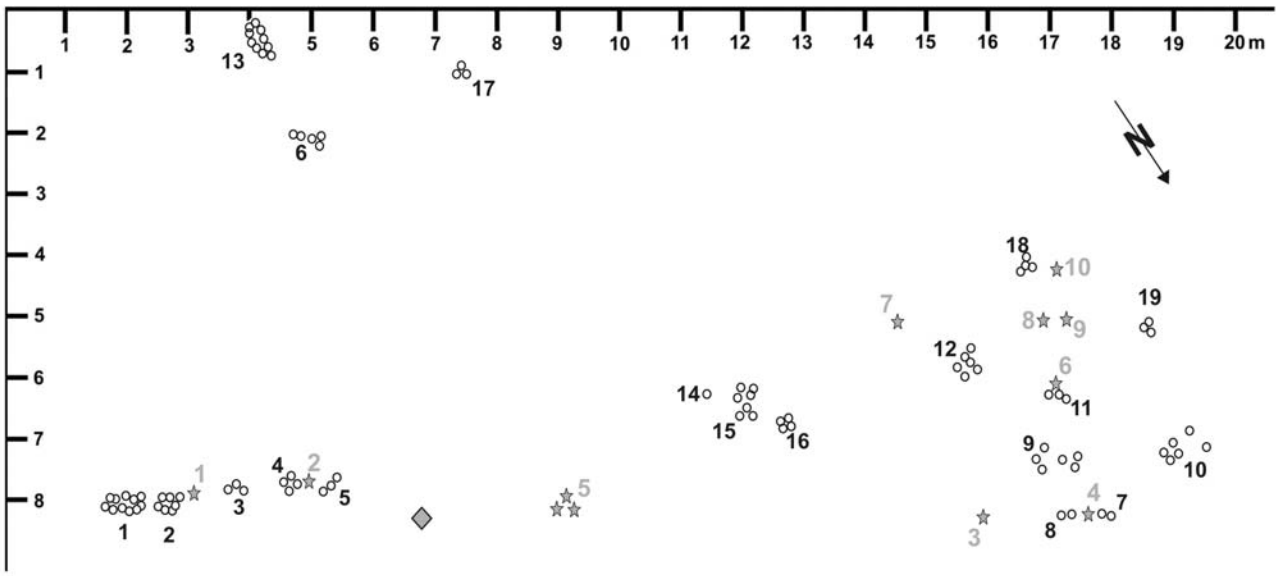

Fig. 2. Map of the nesting horizon, Tuştea nesting site (1, 2, ...17 – nests; stars – hatchling remains)

eggs, by the find of a few tiny limb bones of early hatchlings, very close to the egg clutches, the site from Tuştea becoming then the first in Europe with an association of dinosaur eggs and babies. The bones pertain clearly to the hadrosaur *Telmatosaurus transsylvanicus* (Grigorescu *et al.*, 1994). This unusual coincidence, presented at the 2nd Symposium on “Dinosaur eggs and babies “in Montpellier, France (August 2003) under the title “The Tuştea Puzzle” (Grigorescu, 2003) opens a scientific debate on the criteria for assignment of eggs and eggshells to specific dinosaur species, when the associated embryonic or nestling remains are missing. More recently, new incubation sites have been discovered by an international team from the Royal Museum of Natural History in Brussels and the Department of Geology from the University Babeş-Bolyai in Cluj in the Râul Mare valley, at Toteşti and Nălaţ-Vad. Several clusters of eggs of the same megaloolithid morphotype, and a very similar eggshell microstructure to the eggs from Tuştea, were collected from the two sites (Codrea *et al.*, 2002). The eggs were assigned to *Megaloolithus* cf. *siruguei*, a morphotype from Southern France (Smith *et al.*, 2002, Garcia *et al.*, 2003). No hatchlings were reported from these new egg sites. This time, the encasing sediments were dark-gray silty mudstone with calcretes, indicating immature paleosols in a poorly drained floodplain.

C. RECONSTRUCTION OF THE PHYSICAL AND BIOTIC PALEOENVIRONMENTS

Generally speaking, the reconstruction of physical and biotic paleoenvironments represents a major chapter in studies on fossil communities, attempting a holistic approach to the biodiversity from the past in relation to their surrounding geodiversity.

As for the particular case of the Maastrichtian of the Haţeg Basin, the last three decades led to a rather complex picture from the various aspects involved in paleoenvironmental studies, but it still remains a far from clear image.

The various fields of investigation involved in paleoenvironmental reconstruction became an essential preoccupation in the Haţeg researches, in parallel with and inseparably from the systematic paleontological studies. The approach is multidisciplinary, involving taphonomy, sedimentology, clay-mineralogy, stable isotope analysis, igneous petrology, and tectonic and paleomagnetic studies, and the general synthesis is based on data from all these fields, together with those from all the components of the paleontological studies (micro- and macroflora, invertebrates, micro- and macrovertebrates, trace fossils).

The reconstruction of the physical and biotic paleoenvironments includes on the one hand the geographic setting of the area (a continental one in the case of the Haţeg Basin), its relief and climate, the sedimentary environments and the dynamics of deposition in relation to tectonic evolution, and, on the other hand the reconstruction of the biotic and ecological aspects: the composition of flora and fauna, the biotopes and their biocenoses, based on autecological (concerning individuals and populations of a species) and synecological (relations and interactions among different species of a community) studies.

A large number of authors contributed by their specific specialties to current knowledge of the paleoenvironments of the Haţeg Basin. The names of these scientific contributors are mentioned with their contributions.

Geographic setting: After Nopcsa (1923), who concluded that the small size of most species from the “Danian” fauna of the Haţeg Basin, in comparison with their closest relatives from other

regions and also their primitiveness, can only be explained by the isolated conditions of an island in which they lived for a long while, no studies directed at a detailed reconstruction of the configuration of the "Haţeg island" were made till the last years of the 20th century. The reality of the "Haţeg island", also named "Haţeg land" or "Transylvanian land" is now unanimously admitted. The suggestion by Jianu and Boekschoten (1999) that the Haţeg Basin was a peninsula connected to a major landmass has not been sustained by tectonic studies on the Carpathians and surrounding regions in the frame of Northern Tethys evolution (Săndulescu, 1990), and incorporated in the tectonic synthesis figured in the Atlases of the Tethys and Peri-Tethys paleogeographical maps (Dercourt *et al.*,1993, 2000). The estimated surface area of the "Haţeg island" differs from 7500 sq. km (Weishampel *et al.*, 1991) to around 200,000 sq. km (Dercourt *et al.*,1993, 2000). It is obvious from all the paleogeographic reconstructions of Northern Tethys based on recent tectonic studies that the "Haţeg island" was not limited to the Haţeg Basin, but included a large part of the Transylvanian Depression and the Western Carpathians. According to the paleogeographic reconstructions of Dercourt *et al.* (op.cit.), the Haţeg island was situated at distances of around 2-300 km from major land areas in all directions: the Franco-Iberian land to the west, the Bohemian Massif ito the north, the Dinaric Carbonatic Platform to the south and the Balkan-Rhodope Massif to the south–east. The paleolatitude of the island, according to paleomagnetic studies, was about 27°N (Panaiotu & Panaiotu, 2002).

Relief and climate: Information on the fossil relief of a region is provided by the granofacies of the clastic rocks, the directions of transportation marked on coarser sediments and by stable isotope analysis. All these three categories of data were collected during the new study period on the Maastrichtian of the Haţeg Basin. The types of granofacies, together with the textures, structures and organization of the vertical sequences of the clastic sediments allow the recognition of all dominant depositional settings (proximal, medial and distal) of typical alluvial systems. In particular, the coarse, unsorted debris flows passing laterally into channel and sieve deposits indicate regions with rather high slopes, characteristic of mountainous regions. Paleocurrent measurements, made and synthesized by Mihăilescu (in Grigorescu, 1983) indicate that the current mountain chains that surround the Haţeg Basin, the Retezat Mountains and Poiana Ruscă, were the main source areas for the Maastrichtian sediments. Local indications on the paleoaltitude of the Haţeg zones were also given based on stable isotope analysis by Klárik (1999, unpublished data), according to whom the altitude of the Tuştea-Oltoane nesting site was around 600 m.

The reconstruction of the Maastrichtian climate of the region is based on qualitative evidence from the paleovegetation and the finer clastic sediments (mudstones and calcretic paleosols) and on quantitative evidence from stable isotopes.

The fossil plant assemblage from Haţeg, known especially from palynological data (Antonescu *et al.*,1983; van Itterbeeck, 2005) and to a lesser degree from macroplant remains and wood-tissue, was dominated by ferns and grassy and bushy angiosperms from the *Normapolles* - *Postnormapolles* group, with a reduced participation of gymnosperms and bryophytes.

The $\delta^{13}C$ analysis made on organic carbonates (from bones and eggshells) and inorganic carbonates (paleosol calcretes) by Bojar *et al.* (2001) indicate a vegetation assemblage of "dry woodland", poor in arborescent gymnosperms and angiosperms. The $\delta^{18}O$ analysis on the same organic and inorganic carbonates suggests a yearly average temperature of the Haţeg region during the Maastrichtian of ca. 17°C (Bojar *et.al*, 2003, unpublished report).

All the data, qualitative and quantitative, support a subtropical climate for the "Haţeg island" during the Maastrichtian, a semi-arid season alternating during the year with a rainy one, rich in precipitation. The proposal of this type of subtropical climate is confirmed by paleosol analysis (van Itterbeeck *et al.*, 2004; Bojar *et al.*, 2005; Therrien, 2005) as well as by the estimated paleolatitude of ca. 27°N (Panaiotu & Panaiotu, 2002).

Sedimentary-depositional environments: Sedimentological studies (Grigorescu, 1983; Grigorescu & Anastasiu, 1990; van Itterbeeck *et al.*, 2004; Therrien, 2005) unanimously indicate a sedimentary-depositional setting dominated by alluvial processes in braided-river systems and less commonly, in meandering types. The alluvial deposits include gravel and sandy channel infills, gravel and sandy bars, sandy and silty levee and crevasse splays, silty and clayey overbank deposits of both types: well drained floodplain and poorly drained floodplain, the first characterized by calcretic paleosols, the second by hydromorphic paleosols.

The main source-areas of sediments were the crystalline massifs of the Retezat Mountains for the Sânpetru Formation, and the Poiana Ruscă Mountains for the Densuş-Ciula Formation, both activated by the Laramiide tectonic movements. Important additional sources in the lower and middle members of the Densuş-Ciula Formation were the volcanic centres located in the present north-western part of the Haţeg Basin that supplied large quantities of bombs, lapilli and ashes connected with the Banatitic eruptions that took place at the same time as the deposition of these two lithostratigraphic units.

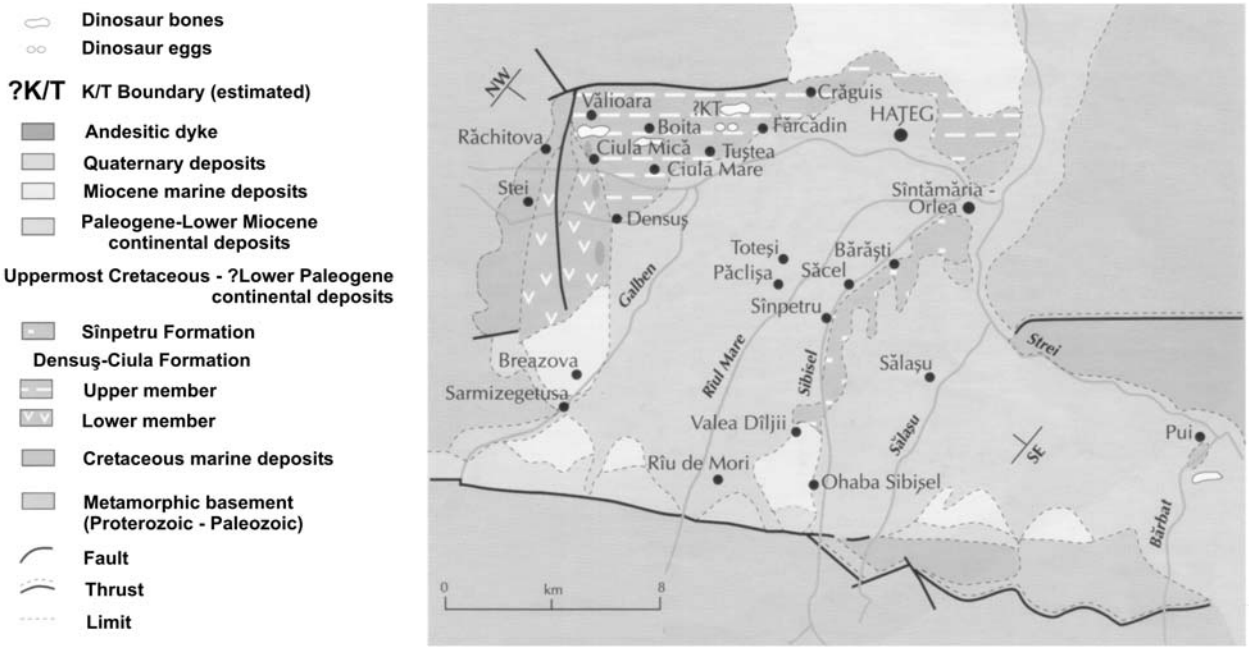

Fig. 3. Simplified geological map of the Hațeg Basin (after Grigorescu, in Weishampel *et al.,* 1991)

The various sedimentary paleoenvironments of the alluvial systems in the region represented microhabitats for the organisms grouped in biocenoses, all together these plants and animals constituting the biodiversity of the "Hațeg island".

Tectonic structure and evolution of the Hațeg Basin: The Hațeg Basin is a syn-orogenic basin, located in the Getic Domain, whose formation took place during the Middle and Late Cretaceous in connection with the emplacement of the Getic and Supragetic nappes on the Danubian Domain. During the Middle-Latest Cretaceous span of time, the Hațeg Basin evolved as a "piggy-back" basin, under the control of successive compressional movements related to the Austrian and Laramian orogenesis in Northern Tethys. The post-Campanian release of compressional stress was followed by a new phase of active subsidence during Maastrichtian- (?Early) Paleogene; during this time the Hațeg Basin evolved under sub-aerial conditions, as an intramontane basin in which a few thousands of meters of clastic, molasse-type deposits were accumulated by the erosion of the young mountain chains surrounding the basin. On the transverse faults that delimited the basin, explosive volcanism took place at the same time as the molasse sedimentation (Grigorescu *et al.*, 1990).

Paleoecology and other aspects related to the Maastrichtian fauna of the Hațeg Basin: The paleoecological studies, as well as the sedimentological and taphonomic ones, represent subjects not tackled before 1977 in the research on the dinosaur-bearing deposits from the Hațeg Basin.

The tremendous increase in the number of taxa during the new period of studies, especially the vertebrate groups as shown in the Systematic Paleontology section of this paper, provides a consistent data base for the biodiversity of the Maastrichtian of the Hațeg Basin on which paleoecological conclusions can be correctly drawn. The taphonomic and sedimentological data, together with the recent research on the ecology of living and fossil animals, especially those on some similar fossil faunas from other regions of the world, play an important role in the reconstruction of the fossil community of the "Hațeg island".

The first attempt to differentiate the biotopes inhabited by the dinosaurs, crocodiles and turtles made by Grigorescu (1983) based on the paleontological list of Nopcsa was followed after more than ten years by more detailed studies, based on a much larger data base (Csiki, 1997, Csiki & Grigorescu, 1998, 2002) and, recently, by Csiki (2005).

In his Doctorate thesis defended in 2005, Csiki mentioned 69 taxa of vertebrates that include all classes, from fishes to mammals. The individual taxa were analyzed in connection with their biotopes, relative frequency in taphonomic assemblages and interactions among the individual groups of the animal community. Here are some of the paleoecological conclusions drawn by Csiki in his thesis:

1. The paleoecological analysis reveals a rich and diverse paleocommunity, one of the richest in the Late Cretaceous of Europe, well structured in trophic guilds.
2. All the terrestrial habitats are represented in the Maastrichtian fauna of Hațeg: aquatic (fishes), semi-aquatic (frogs, albanerpetontids, turtles, crocodilians), aerial (pterosaurs and birds), terrestrial (lizards, snakes, all the dinosaurs and mammals).

3. The presence of several taxa in different types of lithofacies suggests that they were able to exploit the resources of different habitats. These include almost all the dinosaurs (ornithopods, titanosaurs, most of the theropods).

4. An interesting aspect related to the composition of the dinosaur fauna of Haţeg is the relatively small number of herbivorous taxa in comparison with the carnivores. There were possibly no fewer than nine species of theropods and only seven taxa of herbivorous dinosaurs; usually the taxonomic diversity of the plant-eating dinosaurs surpasses that of meat-eaters. The facts that can explain this reverse proportion were the diversity and abundance of the small tetrapods (lizards, micromammals) that probably represented an important food resource for the small theropods and, also, the absence of a large top-predator in the Haţeg fauna.

5. Another interesting paleoecological aspect for the Haţeg paleofauna is the presence of several dwarf taxa, a fact remarked by Nopcsa (1923) and explained by the insular environment in which the dinosaurs lived; the "island dwarfism" represents an evolutionary phenomenon encountered among large mammals (elephants, hippos) living in islands of smaller size. The pressure of the reduced space in such cases, implicitly the limited food resources, as well as the absence of large predators and thus, of the predator/ prey competition are common arguments for explaining insular dwarfism. According to recent views (Gould & MacFadden, 2004), two modalities of island dwarfism exist: autapomorphic nanism, when a single taxon has experimented with reduction in size and, phyletic nanism, when more taxa (species of the same genus) from different regions are affected. Three dinosaurs from Haţeg seem to illustrate autapomorphic nanism: *Telmatosaurus* (Weishampel *et al.*, 1993), *Magyarosaurus* (Jianu & Weishampel, 1999) and *Zalmoxes* (Weishampel *et al.*, 2003), while *Struthiosaurus* might be regarded as a case of phyletic nanism.

The origin of the Maastrichtian fauna is also discussed by Csiki (op. cit.) based on a large and recent bibliography. He concluded that the faunal assemblage was created during the first part of the Late Cretaceous, originating in a generalized Euramerican fauna of the Early Cretaceous. During the entire span of the Late Cretaceous (ca. 95-65 M.y.) this fauna evolved in isolation till the end of Mesozoic on the "Haţeg island". This can explain the "collection of endemic forms" in the Haţeg fauna that preserve the generalized characters of their ancestors. To the relicts of the original Euramerican fauna some immigrants from North America, Africa and Asia were added. Possibly most of the immigrants of American and African origin entered "Haţeg island" through dispersal from the "Franco-Iberian" continent using paleogeographic opportunities created in Northern Tethys during the second part of the Campanian.

D. LITHOSTRATIGRAPHY AND CHRONOSTRATIGRAPHY

The new phase of research has added important data in the felds of the stratigraphical frame of the dinosaur–bearing deposits of the Haţeg Basin. This involves the lithostratigraphic structure and the age of the Laramian continental deposits. Two distinct formations were recognized (Grigorescu, 1990, 1992): the *Sânpetru Formation* which includes the central part of the outcropping area of these deposits, restricted to the western part of the Basin, and the *Densuş-Ciula Formation* including the deposits from the north-western part (Fig. 3).

The *Sânpetru Formation* outcrops along the Sibişel valley , upstream of Sântămăria Orlea up to 2 km south of Sânpetru village also on the banks of the Râul Mare river, between the Toteşti dam and Nălaţ-Vad village (this section proved to represent a new important fossiliferous site with microvertebrates, dinosaur eggs and bones (Codrea *et al.*, 2002). It is generally agreed, in spite of the lack of clear criteria of correlation, that the thin and lacunar sequence of Pui, which outcrops on the Bărbat river banks (maximum 100 m thickness, at the lowest water level of the river) also belongs to the Sânpetru Formation, representing its most eastern occurrence and of the Maastrichtian continental deposits in general.

The *Densuş-Ciula Formation* (DCF), previously interpreted as two distinct formations: Densuş Formation and Ciula Formation (M. Lupu in Antonescu *et al.*, 1983), is developed along the northern margin of the basin, from east of Haţeg town to west of the Vălioara-Ciula Mica alignment. The outcrops are scarce and discontinuous, especially in the area between Crăguiş and Haţeg, and relatively better exposed around the Livezi, Tuştea, Vălioara and Ciula Mică localities; a good exposure of the lower part of the DCF is offered by the Densuş River, upstream of Densuş commune up to Ştei village. The main criteria for the distinction of the two formations that, globally, have a very similar paleontological content (as concerns the palynological association, fresh water gastropods, dinosaur taxa and the other vertebrates) are linked with the depositional environments of the two lithostratigraphic units. While the sedimentary evolution of the DCF took place under the influence of two main source-areas: the crystalline rocks of the Poiana Ruscă Mts. and the volcanic centres from the north-western part of the basin, the sedimentation of the Sânpetru Formation took place in more calm conditions, further from the volcanic centres (this explains the absence of large volcaniclasts within this formation), in a braided river system, with frequent shifts in the direction of the channels, the overbank deposits, including fossil soils being much more frequent than in the case of the DCF where the coarser sediments (channel-lag, debris flows) prevail over the finer (lacustrine and

overbank) deposits in the entire stratigraphic column of this formation**.**

According to their common palynological content, but without detailed biostratigraphic control, the two formations are considered as roughly time-equivalent; also the correlation among the sequences of the two formations is difficult in the absence of reliable criteria. A solution for future correlations between the two formations might be stable isotope measurements on the carbonates from fossil teeth and bones as well as from pedogenic calcretes.

The age of the dinosaur beds from the Haţeg Basin was a matter of controversy after Nopcsa, who correctly assigned them to the Danian, at that time the last stage of the Cretaceous. Different ages, from Danian to Aquitanian were given between 1953 and 1976 by different authors, to all or only to some of the occurrences of these deposits. Dinca *et al.* (1972) updated the age of the dinosaur beds from the Haţeg and Rusca Montană basins to Maastrichtian, following the resolution of the International Geological Congress in Copenhagen in 1970, which placed the Danian, according to its fauna, at the base of Tertiary, its previous position as final stage of Cretaceous being taken by the Maastrichtian. The first who argued this age based on more detailed biostratigraphic data was Antonescu (Antonescu *et al.*, 1983) who collected and analyzed palynological samples from the coaly silty clays of the middle member of the DCF at Ciula Mică and from the same facies in the upper part of the Sânpetru Formation on the Sibişel valley section. The samples from both formations showed a similar palynological content with *Pseudopapilopollis praesubhercynicus,* as an index species, considered as indicative of the Upper Maastrichtian. This opinion was criticized afterwards based on palynological assemblages from southern France including the same species but in deposits of Middle Campanian age.

The new data, based on the biostratigraphy of the Upper Cretaceous marine deposits, combined with paleomagnetic polarity data, suggests that continental sedimentation started earlier than Late Maastrichtian, probably during the Early Maastrichtian. Thus the calcareous nannofossil content of the youngest Cretaceous marine formation from the north-western part of the Basin (Răchitova Formation) that is unconformably overlaid by the continental deposits of the DCF, indicate an Uppermost Santonian - Uppermost Campanian age (CC18-CC19 up to CC22 Nanozones) (Grigorescu & Melinte, 2002).

Paleomagnetic data from the Sânpetru Formation in the section of the Sibişel river indicate an interval of reverse polarity covering most of the section, that in the context of paleomagnetic data from other Laramian deposits from the western part of Romania, including the Banatitic igneous rocks, corresponds probably to the magnetic chron 31r of the Lower Maastrichtian (68.7-71 My.) (Panaiotu & Panaiotu, 2002). On the other hand, paleomagnetic data on volcanic and sedimentary "red beds" of the Middle member of the DCF indicate a normal polarity chron (Pătraşcu *et al.*, 1993). In the absence of radiometric data, it is difficult to assign this normal polarity to the 30n magnetic chron corresponding to Middle-Upper Maastrichtian, but the paleontological content and the geometric position of this unit towards the lower and the upper member of the DCF makes this very plausible. The upper member of the DCF that outcrops east of General Berthelot commune (previously named Unirea) was tentatively assigned to a post-Upper Maastrichtian age, because of the lack of regional elements indicative of latest Cretaceous age: the dinosaur remains and the products of the volcanic eruptions (Grigorescu & Anastasiu, 1990). Considering the high rate of deposition of the conglomerates that prevail in this upper unit of the DCF, its presumed age was restricted only to Early Paleocene.

INSTEAD OF CONCLUSIONS: "The Haţeg Country Dinosaur Geopark"- a pilot project with multiple aims: development of studies on the fauna with dinosaurs and their environment from the end of Cretaceous, protection of the fossiliferous sites, enhancement through scientific tourism and education of these sites in an integrated system of management of all the important sites of nature and cultural heritage of the "Haţeg Country ".

The core of this project, which started four years ago, is the scientific attraction of the "Haţeg dwarf dinosaurs" that has surpassed specialist interest and has been widely disseminated by the media, including the "Discovery" TV channel.

Geoparks are a new type of structures for the protection of the environment with all its components - nature, society, and history - that was initiated by UNESCO in 1999 with the final goal of ensuring sustainable development of the regions. To be admitted as an UNESCO Geopark several criteria should be fulfilled. These include the importance of sites of different types from a region, and the way in which these sites are managed in order to ensure the rise of the economic and social situation of the region.

The "Haţeg Country Dinosaur Geopark" (HCDG) has fulfilled the preliminary conditions and recently received the UNESCO Diploma as a World Geopark. Also, the HCDG was recently admitted as a member in the European Geoparks Network which now has 25 members in 11 countries.

REFERENCES

Andrews, C. W., 1913. On some bird remains from the Upper Cretaceous of Transylvania. *Geological Magazine*, 10, 193-196.

Antonescu, E., Lupu, D. & Lupu, M., 1983. Correlation palinologique du Crétacé terminal du sud-est des Monts Metaliferi et des Depressions de Haţeg et de

Rusca Montană. *Annales de l' Institut de Géologie et Géophysique*, 59, 71-77.

Bojar, A. V., Grigorescu, D. & Csiki, Z., 2001. Preliminary data on continental Late Maastrichtian environment, South Carpathians. Abstracts volume, 3rd Viennese Workshop Stable Isotopes in Biological and Environmental Sciences, Vienna, Austria.

Buffetaut, E., Grigorescu, D. & Csiki, Z., 2002. A new giant pterosaur with a robust skull from the latest Cretaceous of Romania. *Naturwissenschaften*, 89, 180-184.

Codrea, V., Smith, T., Dica, P., Folie, A., Garcia, G., Godefroit, P. & Van Itterbeeck, J., 2002. Dinosaur egg nests, mammals and other vertebrates from a new Maastrichtian site of the Haţeg Basin (Romania). *Comptes Rendus Palévol*, 1, 3, 173-180.

Csiki, Z., 1997. Legături paleobiogeografice ale faunei de vertebrate continentale Maastrichtian superioare din Bazinul Haţeg. *Nymphaea*, 23-25, 45-68

Csiki, Z., 2005. Systematics, taphonomy and paleoecology of the Maastrichtian microvertebrates and saurischian dinosaurs from the Haţeg Basin. Unpubl. Ph.D. thesis, University of Bucharest, 541 pp.

Csiki, Z. & Grigorescu, D., 1998. Small theropods of the Late Cretaceous of the Haţeg Basin (Western Romania) – an unexpected diversity at the top of the food chain. *Oryctos*, 1, 87-104.

Csiki, Z. & Grigorescu, D., 2002. Animal-animal interactions in the Latest Cretaceous vertebrate faunas of Romania Abstracts volume, 7th European Workshop on Vertebrate Palaeontology, Sibiu, România, 14.

Dercourt, J., Ricou, L. E. & Vrielynck, B. (eds.), 1993. Atlas Tethys Paleoenvironmental Maps. Gauthier-Villars, Paris,

Dercourt, J., Gaetani, M., Vrielynck, B., Barrier, E., Biju-Duval, B., Brunet, M., Cadet, J. P., Crasquin, S. & Săndulescu, M. (eds.), 2000. Atlas Peri-Tethys, Palaeogeographical Maps. CCGM/CGMW, Paris, 269 pp., 24 hărţi.

Dincă, A., Tocorjescu, M. & Stilla, A., 1972. Despre vîrsta depozitelor continentale cu dinozaurieni din Bazinele Haţeg şi Rusca Montană. *D. S. Inst. Geol.*, 58, 83-94

Garcia, G. & Vianey-Liaud, M., 2001. Dinosaur eggshells as new biochronological markers in Late Cretaceous continental deposits. *Palaeogeography, Palaeoclimatology, Palaeoecolo*gy, 169, 153–164.

Garcia, G., Codrea, V., Smith, T. & Godefroit, P., 2003. Megaloolithid eggs from Romania. Abstracts volume, Fourth National Symposium of Paleontology, Cluj-Napoca, 19-21.

Gould, G. C. & MacFadden, B. J., 2004. Gigantism, dwarfism, and Cope's Rule: ''Nothing in evolution makes sense without a phylogeny''. *Bulletin of the American Museum of Natural History*, 285, 219-237.

Grigorescu, D., 1983. A Stratigraphic, Taphonomic and Palaeoecologic approach to a "forgotten land": the dinosaur-bearing deposits from Haţeg Basin (Transylvania- Romania). *In* Kielan- Jaworowska, Z. & Osmolska, H. (eds.) *Second Symposium on Mesozoic Terrestrial Ecosystems, Acta Palaeontologica Polonica*, 28 (1-2) Warsawa, 103-121.

Grigorescu, D., 1984. New tetrapod groups in the Maastrichtian of the Haţeg Basin: Coelurosaurians and multituberculates. In Reif, W-E. & Westphal, F. (eds.) *Short Papers, Third Symposium on Mesozoic Terrestrial Ecosystems*. Attempo Verlag, Tübingen, 99-104.

Grigorescu, D., 1990. Non-marine formations connected with the Laramian tectogenesis (post-Early Maastrichtian formations in the Haţeg and Rusca Montană basins). *In* Grigorescu, D., Avram, E., Pop, G., Lupu, M., Anastasiu, N. & Rădan, S. (eds.), Field Guide of the IGCP Projects 245 (Non-marine Cretaceous correlation) and 262 (Tethyan Cretaceous correlation) International Symposium, Bucharest, 18-24.

Grigorescu, D., Anastasiu, N., 1990. Densuş-Ciula and Sînpetru formations (Late Maastrichtian-?Early Paleocene). *In* Grigorescu, D., Avram, E., Pop, G., Lupu, M., Anastasiu, N. & Radan, S. (eds.), Field Guide of the IGCP Projects 245 (Non-marine Cretaceous correlation) and 262 (Tethyan Cretaceous correlation) International Symposium, Bucharest, 42-54.

Grigorescu, D., 1992. Nonmarine Cretaceous Formations of Romania. *In* Matter, N.J. & Pei-Ji, C. (eds.) *Aspects of Nonmarine Cretaceous Geology*. China Ocean Press, Beijing, 142-164

Grigorescu, D., Şeclăman, M., Norman, D.B. & Weishampel, D.B., 1990. Dinosaur eggs from Romania. *Nature*, 346, 417.

Grigorescu, D., Weishampel, D.B., Norman, D.B., Şeclăman, M., Rusu, M., Baltreş, A. & Teodorescu, V., 1994. Late Maastrichtian dinosaur eggs from the Haţeg Basin (Romania). *In* Carpenter, K., Hirsch, K.F. & Horner, J.R. (eds.) *Dinosaur Eggs and Babies*. Cambridge University Press, Cambridge, 75-87.

Grigorescu, D. & Melinte, M. C., 2002. The stratigraphy of the Upper Cretaceous marine sediments from the NW Haţeg area (South Carpathians, Romania). *Acta Pal. Romaniae*, 3, 153-160

Grigorescu, D., 2003. The Tuştea puzzle: Megaloolithidae type of eggs together with hadrosaur hatchlings and nestlings. How might it be explained? 2nd Symposium on Dinosaur Eggs and Babies, Montpellier.

Harrison, C.J.O. & Walker, C.A., 1975. The Bradycnemidae, a new family of owls from the Upper Cretaceous of Romania. *Palaeontology*, 18, 3, 563-570.

Jianu, C.-M., Weishampel, D,B, & Ştiucă, E. 1997. Old and new pterosaur material from the Haţeg Basin (Late Cretaceous) of western Romania and comments about pterosaur diversity in the Late Cretaceous of Europe. *Second European workshop on vertebrate palaeontology (Espéraza – Quillan), Abstracts*. Musée des Dinosaures, Espéraza, France

Jianu, C.-M. & Boekschoten, G.J. 1999. The Haţeg area: island or outpost? *In* Reumer, J.W.F. & de Vos, J. (eds.), *Elephants Have a Snorkel*. pp. 195-199. Deinsea Special Volume.

Laufer, F., 1925. Contribuţiuni la studiul geologic al împrejurimilor oraşului Haţeg. *An. Inst. Geol. Rom.*, 10, 301-333

Mamulea, M. A., 1953a. Cercetări geologice în partea de Vest a Bazinului Haţeg (Regiunea Sarmisegetuza-Răchitova). *D.S. Com. Geol. Rom.*, 37, 142-148.

Mamulea, M. A., 1953b. Studii geologice în regiunea Sânpetru-Pui (Bazinul Haţegului). *An. Com. Geol. Rom.*, 25, 211-274.

Mărgărit, G. & Mărgărit, M., 1967. Asupra prezenţei unor resturi de plante fosile în împrejurimile localităţii Demsuş (Bazinul Haţeg). *St. cerc. geol. geofiz. geogr., Geologie*, 12, 2, 471-476.

Nopcsa, F., 1897. Vorläufiger Bericht über d. Auftreten von oberer Kreide im Hátszeger Thale in Siebenbürgen. *Verhandlung. d.k.k. geolog. Reichsanstalt*

Nopcsa, F., 1915. Die Dinosaurier der siebenbürgischen Landesteile Ungarns. *Mitteilungen aus dem Jahrbuche der königlich ungarsichen geologischen Reichsanstalt, Budapest*, 1-24

Nopcsa, F. 1923. On the geological importance of the primitive reptilian fauna of the uppermost Cretaceous of Hungary; with a description of a new tortoise (*Kallokibotium*). *Quarterly Journal of the Geological Society of London*, 79, 100-116.

Panaiotu, C. & Panaiotu, C., 2002. Paleomagnetic studies. In Grigorescu, D. & Csiki, Z. (eds.), 7th European Workshop on Vertebrate Palaeontology, Abstracts volume and excursions field guide, 59, Sibiu.

Pană, I., Grigorescu, D., Csiki, Z., & Costea, C., 2002. Paleo-ecological significance of the continental gastropod assemblages from the Maastrichtian dinosaur beds of the Haţeg Basin. *Acta. Pal. Romaniae*, 3, 337-343.

Pătraşcu, Ş., Şeclăman, M. & Panaiotu, C., 1993. Tectonic implications of paleomagnetism in Upper Cretaceous deposits in the Haţeg and Rusca Montană basins (South Carpathians, Romania). *Cret. Res*., 14, 255-264.

Săndulescu, M., 1990. Structure and tectonic history of the northern margin of the Tethys betwee the Alps and the Caucasus. In Rakus, M., Dercourt, J. & Nairn, A. E. M. (eds.), *Evolution of the northern margin of the Tethys: The results of the IGCP Project 198*, 3 (Memoires de la Societe Geologique de la France, 154, 3 - Occasional Publications of the ESRI, 5), 3-14.

Smith, T., Codrea, V., Săsăran, E., Van Itterbeck, J., Bultynck, P., Csiki, Z., Dica, P., Fărcaş, C., Folie, A., Garcia, G. & Godefroit, P., 2002. A new exceptional vertebrate site from the Late Cretaceous of the Haţeg Basin (Romania). *Studia Universitatis Babeş-Bolyai, Geologia*, Special issue 1, 321-330.

Therrien, F., 2005. Paleoenvironments of the Late Cretaceous (Maastrichtian) dinosaurs of Romania: insights from fluvial deposits and paleosols of the Transylvanian and Haţeg basins. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 218, 1-2, 15-56.

Van Itterbeeck, J., Săsăran, E., Codrea, V., Săsăran, L. & Bultynck, P., 2004. Sedimentology of the Upper Cretaceous mammal- and dinosaur-bearing sites along the Râul Mare and Bărbat rivers, Haţeg Basin, Romania. *Cretaceous Research*, 25, 3, 517-530.

Weishampel, D.B., Grigorescu, D. & Norman, D.B. 1991. The Dinosaurs of Transylvania. *National Geographic Research & Exploration* 7, 2, 196- 215.

Weishampel, D.B., Norman, D.B. & Grigorescu, D. 1993. *Telmatosaurus transsylvanicus* from the Late Cretaceous of Romania: the most basal hadrosaurid dinosaur. *Palaeontology*, 36, 2, 361- 385.

Weishampel, D.B., Jianu, C.-M., Csiki, Z., and Norman, D.B. 2003. Osteology and phylogeny of *Zalmoxes* (n.g.), an unusual euornithopod dinosaur from the latest Cretaceous of Romania. *Journal of Systematic Palaeontology*, 1, 2, 65-123.

Table 1. The vertebrate taxa, valid or problematic, mentioned from the Maastrichtian of the Haţeg Basin (from Csiki, 2005, with changes)

Pisces
Acipenseriformes indet. (Grigorescu *et al.*, 1985)
Characidae indet. (Grigorescu *et al.*, 1985)
Lepisosteus sp. (Grigorescu *et al.*, 1999)
Atractosteus sp.

Amphibia

Albanerpetontidae
Albanerpeton sp. (Grigorescu *et al.*, 1999) possibly a new species of *Albanerpeton*;
Albanerpeton cf. *inexpectatum* (Folie *et al.*, 2003); possibly a new species of *Albanerpeton*;

Anura
Discoglossidae indet. (Folie *et al.*, 2003)
Eodiscoglossus sp. (Folie & Codrea, 2005)
Paradiscoglossus sp. (Folie & Codrea, 2005), possibly synonimus with *Paralatonia*;
Hatzegobatrachus grigorescui (Venczel & Csiki, 2003)
Paralatonia transylvanica (Venczel & Csiki, 2002)

Reptilia

Chelonia
**Kallokibotion bajazidi* (Nopcsa, 1923) ;
Pleurosternon sp. (Nopcsa, 1915) – possibly a second chelonian in the Hateg fauna but its appartenance to the genus *Pleurosternon* is problematic;

Lepidosauromorpha
Sauria
Anguimorpha indet. (Grigorescu *et al.*, 1999);
Beckesius aff. *B. hoffstetteri* (Folie *et al.*, 2003);
Bicuspidon hatzegiensis (Folie & Codrea, 2005);
Lacertilia genus et sp. indet. (Codrea *et al.*, 2005);
Paraglyphanodon sp. nov. (Folie *et al.*, 2003);
Scincomorpha indet. 1. (Grigorescu *et al.*, 1999);
Scincomorpha indet. 2. (Codrea *et al.*, 2002);

Serpentes
Madtsoiidae indet. (Folie & Codrea, 2005);

Archosauromorpha
Crocodylia
Doratodon sp. (Grigorescu *et al.*, 1999)
Crocodyliformes
**Allodaposuchus precedens* (Nopcsa, 1928)
Acynodon sp. (Jianu & Boekschoeten, 1999)
Musturzabalsuchus sp. (Jianu & Boekschoeten, 1999)

Pterosauria
Ornithodesmus sp. (Nopcsa, 1923)
Pteranodontidae indet. (Jianu *et al.*, 1997)
Hatzegopteryx thambema (Buffetaut *et al.*, 2002)

Dinosauria
Theropoda
**Elopteryx nopcsai* (Andrews, 1913)
Heptasteronis andrewsi (Harrison & Walker, 1975)
Bradycneme draculae (Harrison & Walker, 1975)
Euronychodon sp. (Csiki & Grigorescu, 1998)
Paronychdon sp. (Codrea *et al.*, 2002)
Ri*chardoestesia* sp. (Codrea *et al.*, 2002)
cf. *Saurornitholestes* sp. (Weishampel & Jianu, 1996)
aff. *Troodon* sp. (Csiki & Grigorescu, 1998; Codrea *et al.*, 2002; Smith *et al.*, 2002)
Velociraptorinae indet. (Csiki & Grigorescu, 1998)
Oviraptorosauria indet.
Alvarezsauridae indet. (*Heptasteronis andrewsi*, Naish & Dyke, 2004)

Aves
Enantiornithes (?)
Enantiornithies indet.

Sauropoda
Titanosaurus dacus (Nopcsa, 1915)
**Magyarosaurus dacus* (Huene, 1932)
Magyarosaurus transsylvanicus (Huene, 1932)
"Magyarosaurus" hungaricus (Huene, 1932)
Magyarosaurus sp. (Huene, 1932)
Titanosauria indet.

Ornitischia
Ornithopoda
Zalmoxes robustus (Weishampel *et al.*, 2003);
Zalmoxes shqiperorum (Weishampel *et al.*, 2003);
**Telmatosaurus transsylvanicus* (Nopcsa, 1903; emend. Weishampel *et al.*, 1993);

Ankylosauria
Ndosauridae
**Struthiosaurus transylvanicus* (Nopcsa,1915)

Mammalia
Multituberculata
Barbatodon transylvanicus (Rădulescu & Samson, 1986);
Barbatodon sp. nov. (Smith *et al.*, 2002);
Hainina sp. A (Csiki & Grigorescu, 2000);
Kogaionon ungureanui (Rădulescu & Samson, 1996);
Kogaionon sp. nov. 1 - Pui (Smith & Codrea, 2003);
Kogaionon sp. nov. 2 – Toteşti (Codrea *et al.*, 2002);
Kogaionidae gen et sp. nov. (Csiki & Grigorescu, 2002);

Theria
Theria indet. (Csiki & Grigorescu, 2002).

* Valid taxon described before 1977.