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A STRATIGRAPHIC, TAPHONOMIC AND PALEOECOLOGIC APPROACH TO A "FORGOTTEN LAND": THE DINOSAUR-BEARING DEPOSITS FROM THE HAŢEG BASIN (TRANSYLVANIA — ROMANIA)

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This paper represents a general review of the stratigraphy, sedimentology, taphonomy and paleoecology of the dinosaur deposits (Sînpetru beds) from Haţeg Basin, based on new field investigations in Sînpetru region — the classical area studied by F. Nopcsa. The age of these deposits, previously assigned to Danian, is proved to be Maastrichtian, through their geometric position, above the Campanian marine deposits, and the palynologic content ("Normapolles" association). The Sînpetru beds represent the deposits of a braided river system on the slope of a mountain piedmont apparently grading distally to deltaic conditions.

K e y w o r d s: stratigraphy, sedimentology, taphonomy, paleoecology, Maastrichtian, Romania.

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INTRODUCTION

The Haţeg Basin [1] has been known to vertebrate paleontologists for more that three quarters of a century for its uppermost Cretaceous reptilian fauna. This fauna, mostly including dinosaurs, was described in several papers between 1898 and 1929 by Francis von Nopcsa, and led to the inclusion of the Haţeg region among the important dinosaur localities in Europe.

During the last five decades no further papers on this fauna have been published, except that of Harrison and Walker (1975) on a few remains they considered to belong to birds.

[1] Since December 1, 1918, the Haţeg region and the entire Transylvanian province are united with Romania (fig. 1). However, in several papers by foreign authors, some of them very recent ones, this region continues to be mentioned as part of Hungary.

In order to add new data on the paleontology, stratigraphy, sedimentology and paleoecology of the uppermost Cretaceous continental deposits from Haţeg Basin, in 1978 I started systematic studies, an acitivity considered absolutely essential and complementary to that of the taxonomic revision of the bone material from these deposits located in the museums to which Nopcsa gave his collections.

During the last three years, the excavations I carried out in the Sînpetru and the Vălioara localities, with the substantial help of some geology students from the University of Bucharest, gave evidence of more than 120 bones and bone-fragments belonging to dinosaurs, chelonians, crocodiles, birds and micromammals; most of these materials are still under determination. I also carried out lithologic and lithostratigraphic studies as well as sedimentological and taphonomic observations that may contribute to a better understanding of the paleoenvironment of the vertebrate fauna from the Sînpetru beds.

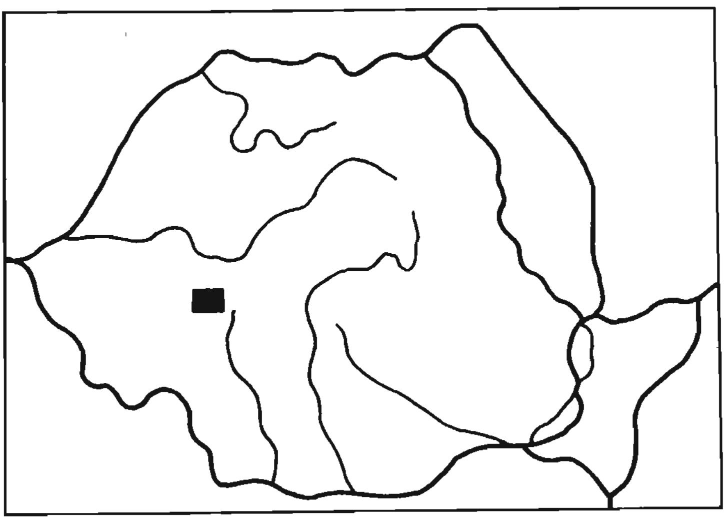

Fig. 1. Geographic situation of the Haţeg Basin.

Geographical setting

The Haţeg Basin is situated in the northwestern part of the southern Carpathians, being encircled by mountain ranges. These are the Sureanu Mts. in the east and northeast, Poiana Ruscă Mts. in the west and northwest, the Retezat and Ţarcu Mts. in the south (fig. 2). The Haţeg Basin covers an area of ca 600 km^2, its maximum width being 50 km WNW-ESE and 18 km from south to north. It is also well defined from the borders of the encircling mountains by altitudinal differences of hundreds of meters (up to 600 m in the southern part), which creates a clear geographic individuality.

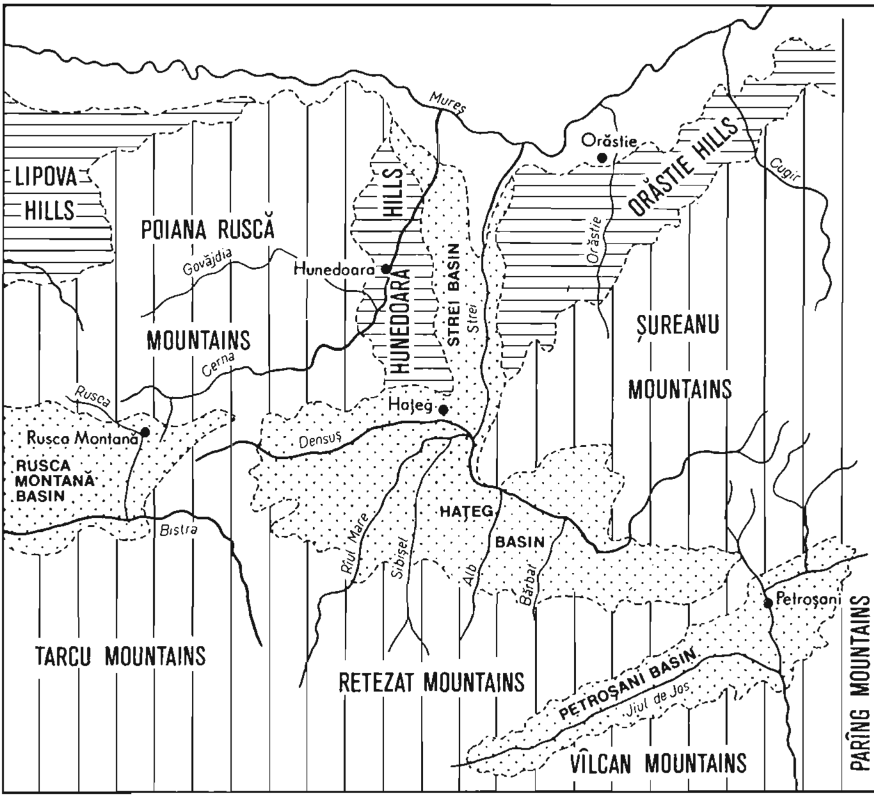

Fig. 2. Geographic setting of the Haţeg Basin and surrounding regions.

The central part of the basin contains a high alluvial plain, drained by the Strei river and its principal tributaries: the rivers Bărbat, Alb, Sibişel, Rîul Mare, Densuş and Răchitova; the altitude of the alluvial plain varies from 300 m to 400 m in its northen part, and between 400 m and 500 m in the south. Around it there are several hills and small mountains representing erosional piedmonts, with altitudes generally ranging from 500 m to 800 m that make the transition to the mountainous regions.

The Haţeg Basin is connected by narrow passes to the other post-tectonic basins: the Petroşani Basin (in the east and southeast), the Strei Basin (in the northeast) through which the Haţeg Basin is connected, like a "bay" to the great Transylvanian Basin, and the Rusca Montană Basin (in west).

REGIONAL STRATIGRAPHY

The Haţeg Basin has a tectonic origin, being formed by the downward thrusting of the pre-Upper Cretaceous basement rocks along faults, following mid-Cretaceous diastrophic movements. A slow subsidence of the central part of the basin is still taking place.

1. *Pre-Upper Cretaceous rocks*

The basement of the Haţeg Basin consists of epi- and mesometamorphic schists (Upper Proterozoic — pre-Upper Carboniferous), that in the southern part, near Retezat Mts., include important granitic and granodioritic intrusions.

The unmetamorphosed sedimentary deposits begin with the Permian (in a terrigenous — Verrucano-type lithofacies), unconformably overlain by transgressive Jurassic rocks, predominantly sands and clays in the lower and middle part (Liassic and Dogger), and with reef-limestones in the upper part (Malm). The development of bioclastic limestones continues in the Lower Cretaceous up to the Aptian (Urgonian facies). The epeirogenic movements prior to the mid-Cretaceous orogenesis led to the uplift of the sea floor, followed by lateritic alternation under terrestrial conditions and the formation of bauxite deposits.

2. *Upper Cretaceous and Cenozoic sedimentary rocks*

The post-diastrophic sedimentary rocks are represented by Upper Cretaceous (Vraconian-Cenomanian, Turonian-Campanian and Maastrichtian), Paleogene, Neogene (Upper Miocene and Lower Pliocene) and Quaternary.

Vraconian-Cenomanian sediments include conglomerates, calcareous sandstones deposited in shallow water with marine gastropods (*Nerinea*) and pachyodont pelecypods (*Itruvia, Praeradiolites, Durania*). These sediments grade to argillaceous sandstones and marls with *Mantelliceras mantelli* and *Acanthoceras rothomagense*.

Turonian-Campanian sediments are developed as a flysch-like facies consisting of a rhythmic alternation of fine sandstones and silts with shales containing *Inoceramus labiatus, I. inconstans, Nowakites karezi* and a Globotruncanidae microfauna, on the basis of which several biozones have been recognized. The final part of these deposits includes tuffs and volcanic agglomerates connected with the pre-Laramian movements. With the Campanian, Upper Cretaceous marine deposition in the Haţeg Basin ends.

The Maastrichtian is represented by the "Sînpetru beds", continental red beds with dinosaurs, unconformably overlying Turonian and Senonian marine deposits. The lithology, stratigraphy, paleontology, taphonomy and paleoecology of the Sînpetru beds are presented in detail below.

The Paleogene disconformably or slightly unconformably overlies the older deposits; it includes mostly coarse terrestrial deposits (conglomerates, gravels, coarse sandstones) with a red or greenish matrix, intercalated with sandy claystones and small lens-shaped coal beds. The lack of a diagnostic fauna makes it difficult to separate it into chronostratigraphic subdivisions.

The Upper Miocene is represented by a pelagic lithofacies (globigerinid marls passing laterally to bioclastic limestones with red algae and numerous mollusk shells) of Badenian age, and by Sarmatian entirely formed of sands, torrential gravels and sandy claystones with small coal lenses.

The Lower Pliocene is represented by Pannonian brackish and freshwater lacustrine facies, including gravels, sands, mollusk-bearing silty marls and thin coal intercalations.

The Quaternary is mainly formed by alluvial (terraces along the valley-rivers), proluvial and fossil soils deposits.

SÎNPETRU BEDS

In his first papers on the continental dinosaur strata from Haţeg Basin, Nopcsa named the fossiliferous rocks "Sînpetru sandstone" ("Szentpéterfalva sandstein") (Nopcsa 1902: 34). Afterwards Mamulea (1953) understood this as a formation name for the "fluviolacustrine facies" of the uppermost Cretaceous in this basin, and converted Nopcsa's lithologic term into a lithostratigraphic one: "Sînpetru beds".

Although these "beds" are characterized by their sedimentological characters as a real lithostratigraphic unit, the name did not enjoy much popularity among geologists, who preferred to keep the general term "continental red dinosaur beds" or "continental dinosaur deposits" (i.e. Dincă *et al.* 1972) in order to avoid further confusions with other red deposits in the region.

In the following pages the name of "Sînpetru Beds" will be used in its lithostratigraphic meaning, for the uppermost Cretaceous continental deposits with reptile fauna from Haţeg basin.

The Sînpetru Beds are exposed in the southern region of the Haţeg Basin, along the tributary valleys of the Rîul Mare, near the villages of Valea Dîljei, Sînpetru, Săcel and Bărăşti up to the vicinity of Sîntămaria-Orlea, as well as in the northern region, near the villages of Răchitova, Ciula Mare and Vălioara (fig. 3).

The principal area for the study of the Sînpetru Beds is located in the Sibişel valley, from 3.5 km away of Sînpetru up to this village. The deposits here outcrop continuously on both sides of the valley under a Pleistocene terrace. The exposures are restricted to near the valley and on the short terrestrial tributaries; the height of the exposures ranges from 30 to 60 m. In this region, the Sînpetru Beds reach their maximum thickness of 2500 m, on the southern slope of a large anticline. The angle of dip of the beds varies from 22° S to 45° S.

Lithologically, the Sînpetru Beds are made up of repeated upward fining sequences. These sequences vary in their total thickness, in the

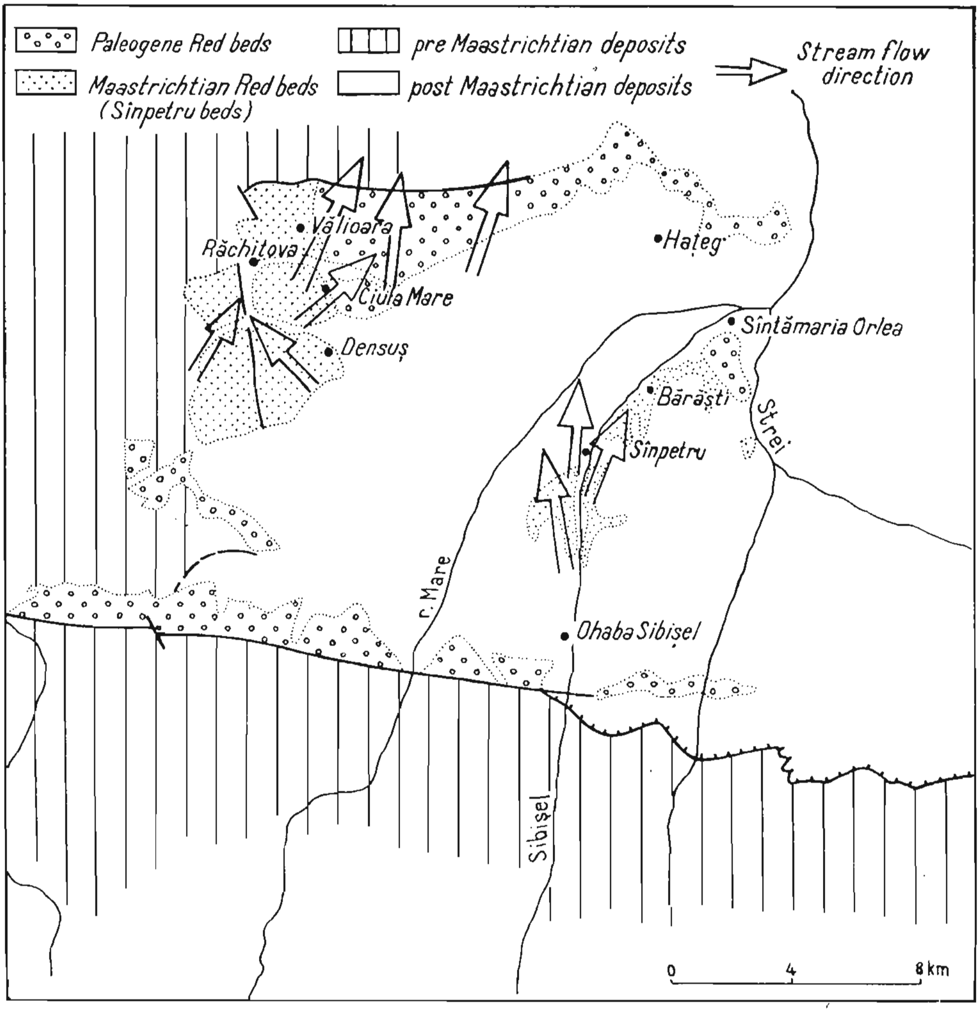

Fig. 3. Exposures of Maastrichtian (Sînpetru beds) and Paleogene red conglomerates in the Hațeg Basin.

ratio between the coarse and fine members as well as in the lithologic composition of the fine argillaceous components.

The lower parts of the sequences are always represented by sandstone beds, scoured at their bases, with small erosional channels and load casts, their thicknesses ranging from one or two decimeters up to one meter, rarely more. The beds are chiefly lens-shaped, frequently passing laterally into silty mudstones and usually do not extend more than several tens of meter laterally. The degree of cementation varies from well cemented to friable.

The sandstones are massive and generally lack cross or parallel laminations. They are coarse to medium sized, showing small granulo-

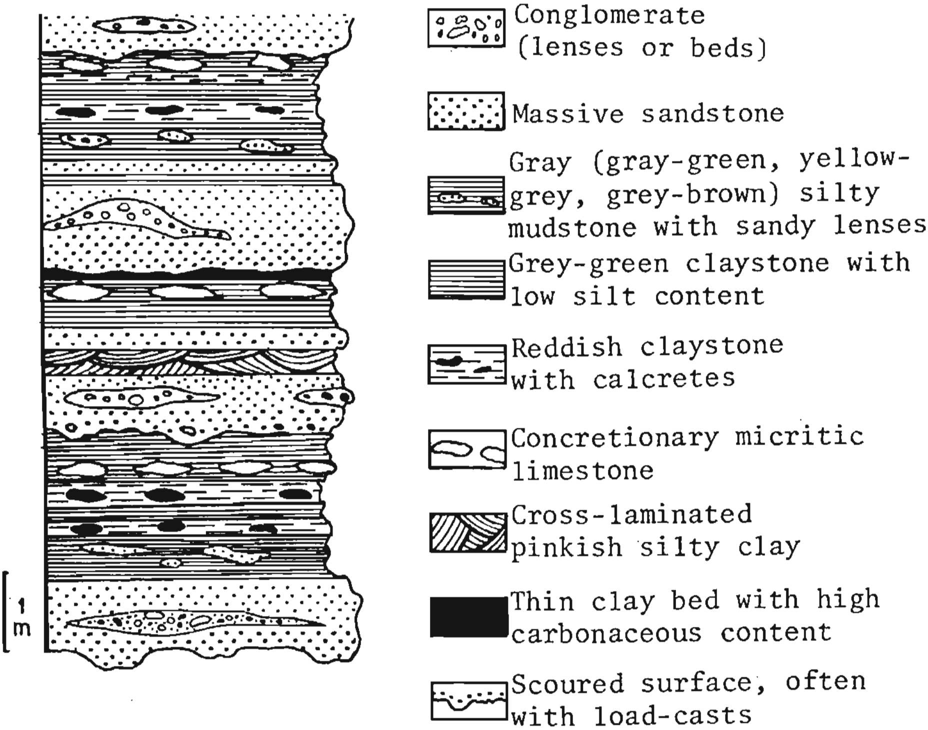

Fig. 4. Four successive repetitive sequences at the lower part of the Sînpetru beds (Sibișel valley).

metric differences from the base to the top of the bed. The clastic constituents of the sandstones are: mono- and polycrystalline quartz grains, rock fragments (micaschists, gneisses, quartz-feldspar rocks), muscovite and chlorite, feldspar (most of them acid plagioclase grains, usually fresh or slightly weathered), along with larger argillaceous clasts and small coal fragments, all of which are cemented in a silica-argillaceous matrix. A sparse volcanic component is represented as glass shards. The relative amount of rock fragments and feldspar grains in the rocks indicate that these sandstones are lithic subgraywackes and subarkoses. The detrital clasts have angular or rarely subangular outlines. The clasts are well to moderately sorted, the sorting degree being poorer in the coarser levels. The colour of sandstones is gray-yellow to gray-green, the latter seemingly due to larger amounts of volcanic ash and glass.

Frequently, inside the massive sandstones there are lens-shaped fine conglomerates, with very short lateral development (a few meters or less), no more than two decimeters thick. Their pebbles include metamorphic rocks (quartzites, micaschists, gneisses, granitoid rocks), argillaceous clasts, coal fragments and small fragments of bones. The maximum diameter of pebbles is usually less than 10 cm; they are moderately sorted.

In the upper part of the Sînpetru beds, the conglomerates increase in importance, and form strata up to two meters thick consisting of poorly sorted pebbles, some of them more than 50 cm in diameter. The conglomerates have a sligthly sandy-argillaceous matrix.

The coarse lower members of the lithological sequences are usually followed by silty mudstones and red claystones that quite often alternate with green-gray claystones. Occasionally, the sequences include grayish claystones with spheroidal limestone concretions and thin dark-gray laminae rich in carbonaceous debris.

The mudstones include a considerable amount of silt and fine sand material, even small pebbles, with an argillaceous coating, that become obvious during washing and screening activities. The rock has a gray-greenish or gray-yellowish colour, spotted with red-violet iron oxides. Calcareous nodules are often found near local concentrations of bones. The rock lacks well-defined macrobedding, being also devoid of internal microtextures, except finger-like burrows that will be discussed separately.

The silty mudstones contain the majority of fossil remains (both vertebrates and invertebrates) of the Sînpetru beds: thin, flattened shells of small freshwater gastropods including *Anastomopsis rostellaris* (Matheron), *Bauxia bulimoides* (Matheron), *Strophostomella reussi* (Stoliczka), *Helix* (*Archelix*) sp., *Vidadiella darderi* (Vidal), *Gastrobulimus munieri* (Hantken), *Lynchus* sp., *Paludinopsis* sp., along with rare small unionid pelecypods (identification by Denisa Lupu). Few characean gyrogonites and small carbonized wood fragments are also to be found in these rocks. Fish remains are absent from the silty mudstones and any other rock of the Sînpetru Beds.

The red claystones are very characteristic of the lower part of the Sînpetru Beds, where they often represent the thickest members of the sequences. Their colours vary from dark red to purple and red-yellowish. They also contain a large amount of sand and silt sized material, and lack internal lamination. Mollusk shells are very rare and carbonaceous fragments totally absent, due to strongly oxidizing syngenetic conditions.

Carbonate nodules (calcretes), irregular in shape and size (not more than 30 cm long, however) are very characteristic for the red claystone. In thin sections they show a homogenous micritic mass, practically devoid of coarse clasts, and irregular void spaces filled with calcisparite.

Usually the red claystone layers, a few decimeters thick, alternate with gray-greenish mudstones and claystones with carbonaceous debris and suggest seasonal variations in temperature and humidity. The red claystones with nodular calcretes are distinct from the cross-laminated pinkish claystones, a few decimeters thick, that are infrequently found above the sandstone beds (fig. 4).

The red claystones are much rarer in the upper half of the Sînpetru Beds; their rarity, correlated with the coarser, frequently torrential character of the lower members of the repetitive sequences gives sedimentologic and lithostratigraphic distinctiveness to this half. The bone remains are also very rare in this upper part. The fine laminated gray-greenish claystones with relatively low silt content are usually developed at the top of the sequences. Their paleontologic content consists mostly of small coal fragments and broken pieces of bone. The ellipsoidal limestone concretions up to 30 cm maximum diameter, are characteristic of these rocks. They consist of a micritic mass including few coarser terrigenous clasts (quartz, feldspars, rock fragments of the same type as those from the sandstones), carbonaceous fragments and fragments of small gastropods.

Trace fossils. Finger-like tabular burrows, a few centimeters long and several millimeters wide, filled with silt are common in the gray-greenish mudstones and gray-greenish fine laminated claystones, below the scoured surface of the sandstone beds. Longer and wider tubes (up to 30 cm long and 2—3 cm wide), slightly sinuous in shape, also occur on the basal surfaces of sandstones. They do not show any preferred orientation.

The Sînpetru Beds change lithology and stratigraphic characters to the northern part of the Haţeg Basin (Vălioara region). The deposits here do not display obvious sequences of sandstone, mudstone and claystone, being mostly formed by dark red friable sandstones and sandy claystones, lacking macrobedding or internal textures, and with large intercalated lenses of poorly sorted gravels in a friable sandy matrix.

Sedimentologic conclusions

The lithology corroborated by the stratigraphic features of the Sînpetru beds is best explained by a braided river system on the slope of a mountain piedmont source area.

The conglomerates are the bottom lag deposits of the temporary, laterally migrating channels, while the sandstones and silty mudstones are overbank sediments deposited on the bars and islands between the channels during seasonal floods, when the rivers burst their banks and spread over the surrounding land.

The rarity of cross bedding and cross laminations, the angular shape of the terrigenous clasts, the abundance and the freshness of the feldspar grains suggest transport a short distance from the source area followed by a rapid burial of the sediments.

The source area indicated by the paleocurrent measurements of pebble orientation (fig. 5) as well as by the petrographic similarity of the sedimentary clasts with rocks of the Retezat Mts. was situated to the south. From there the streams flowed northward, or slightly northeastward or northwestward.

A secondary source for the sedimentation of Sînpetru Beds was

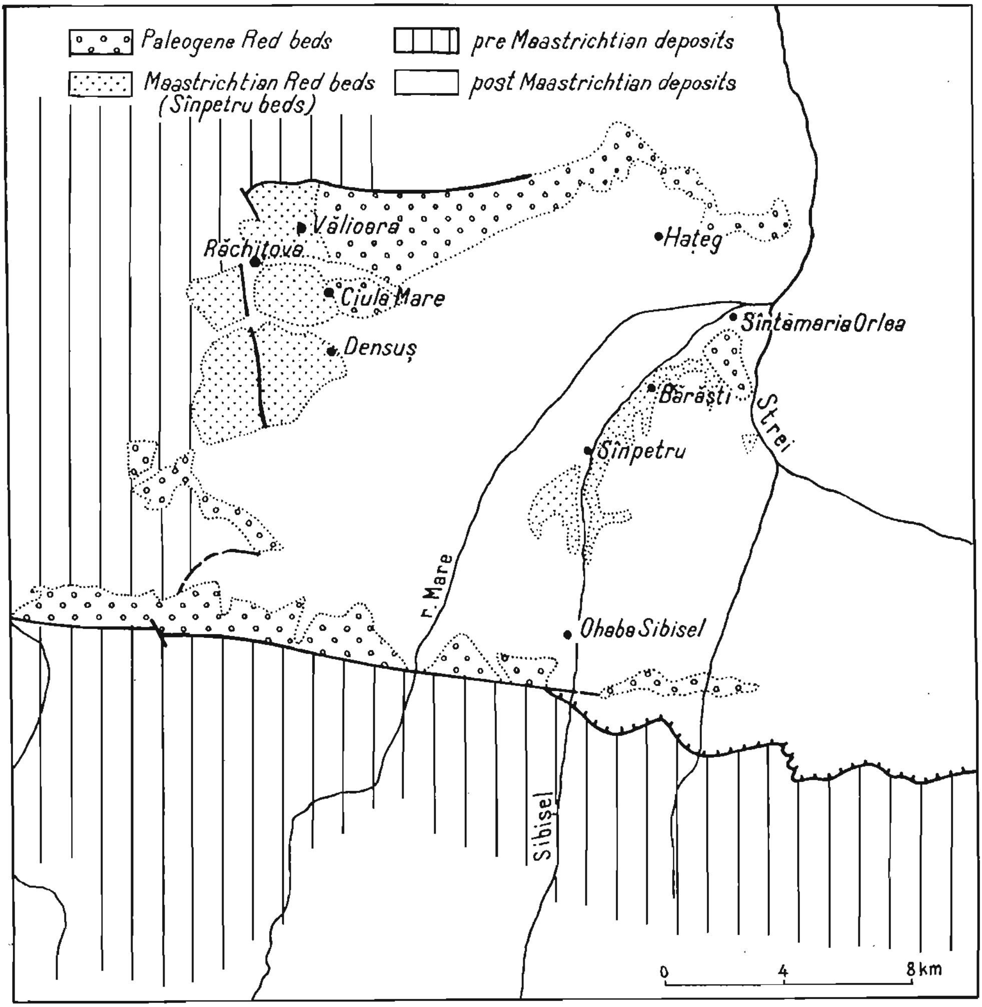

Fig. 5. Paleocurrent directions in Sînpetru beds and Paleogene conglomerates (after N. Mihăilescu).

provided by the volcanic explosions which took place in the northern part of the Hațeg Basin (tuff beds and agglomerates are intercalated in the Sînpetru Beds near the Densuș and Răchitova localities). The finer volcanic products are diluted by the predominant terrigenous material, but their contribution to the sedimentation of the Sînpetru Beds is obvious from the fine glass fragments in sandstones. Future studies on the clay mineralogy of these deposits will certainly lead to more elaborate data on this subject.

The red claystones with nodular carbonate concretions (calcretes) are generally considered fossil soils formed during the drier periods, when the alluvial plain was raised above the average water table (Dodson *et al.* 1980).

Finally, the thin gray-green claystones with fine internal microbedding, signs of bioturbations, ellipsoidal limestone concretions, and intercalated layers rich in carbonaceous material, indicate shallow ephemeral lacustrine conditions.

As regards the northern (Vălioara) region, its poorly sorted sediments, chaotic in appearance, seem to represent deltaic sediments laid down by high density currents, passing downslope into a lake region, a presumption that requires further investigation.

Summarizing the lithologic and sedimentologic data presented here, the Sînpetru Beds are the fluviatile (and possibly deltaic) sediments of the Laramian orogeny, formed in a braided river system, sloping south to north in an alluvial plain; hydrodynamic energy increased from the base to the top of the formation, leading to the development of the poorly sorted, coarser conglomerates of the upper Sînpetru Beds.

The age of the Sînpetru Beds

The major development in the Haţeg Basin of continental deposits of red bed type at different stratigraphic levels, the general scarcity of the continental faunas, the lack of palynological analysis, led to the controversial opinions concerning the age of the Sînpetru Beds.

Before Nopcsa's papers on the dinosaur content of the red beds from Sînpetru and Vălioara, the general opinion was that all the red continental deposits from the Haţeg Basin are of a Tertiary age. Inkey (1891) considered that they belong to Oligocene, while Halaváts (1896) referred them to Aquitanian.

The reptilian fauna of the Sînpetru Beds includes several genera and species common with the "Danian" of southern France, as well with other uppermost Cretaceous deposits from Spain, Belgium, Austria. Especially the close similarity of the Haţeg dinosaurs with those from France led Nopcsa (1905) to conclude a Danian age. But Nopcsa also assigned to the Danian the red deposits from Transylvania (that afterwards were documented to belong to Lower Eocene, or Lower Miocene) on the basis of bone fragments presumed to belong to dinosaurs, discovered near Sebeş, at Vurpăr (northeast of Sibiu), Someş-Odorhei (northwest of Cluj-Napoca). Other Romanian and foreign geologists agreed with Danian age of the red deposits from the Haţeg Basin: Schafarzik (1908), Laufer (1925), Mamulea (1953).

However, the Tertiary age was not totally abandoned. Recently Iliescu *et al.* (1972, unpublished report) on the basis of the freshwater gastropods gave an Ypressian-Ruppelian age to all of the red continental deposits from Haţeg Basin, suggesting that the dinosaur and other reptile bones were uncovered for a long time and reworked into the Paleogene deposits. But the taphonomic features of the bones presented below, obviate this possibility.

After the 1960 Copenhagen Geological Congress on the Cretaceous/ /Paleogene boundary, the Danian was removed to the base of the Paleogene and the Maastrichtian substage became the terminal division of the Cretaceous. During this Congress, Jeletzky assigned the Transylvania dinosaur-bearing beds to the Campanian, considering their fauna equivalent to that of Austrian Gossau beds, that are surely dated by the ammonites and rudists from the marine intercalations.

The microbiostratigraphic studies carried out by Maria Tocorjescu (in Dincă *et al.* 1972) on the Senonian marine deposits from Haţeg and Rusca Montană basins, demonstrates that Cretaceous marine sedimentation of these regions ended in the Campanian; continental sedimentation commenced in both basins with the Maastrichtian, under different facies: red beds with dinosaurs in Haţeg Basin, pyroclastic-terrigenous deposits with coal beds and flora in Rusca Montană Basin.

Palynological samples collected from a fossiliferous pocket with dinosaur remains near Sînpetru gave evidence of the presence of some palynomorphs of the "Normapolles" Pflug, 1953 — association: *Pseudopapilopollis praesubhercynicus* Gócsán, 1967, *Convexipollis convexigerminalis* Krutzsch, 1965, *Oculopollis* cf. *baculotrudens* (Pflug) Zaklinskaia, 1963, *Interporopollenites proporus* Weyland et Krieger, 1953, *Pseudoplicapollis* cf. *palaeocenicus* Krutzsch, 1967 (E. Antonescu, personal communication). This palynologic assemblage endorses the Maastrichtian age of the Sînpetru Beds.

A similar microfloral assemblage was recognized by E. Antonescu in the intercalated carbonaceous strata from Ciula Mare (where *Convexipollis convexigeminalis* is missing, however), as well as in the "Upper coal Complex" from Rusca Montană Basin. In both these regions the "Normapolles" association also includes *Interporopollenites* cf. *gracilis* Krutzsch, 1960, *Plicapollis* cf. *serta* Pflug, 1953, *P.* cf. *excelsus* (Pflug) Krutzsch, 1967, *Suemeghipollis triangularis* Góczán, 1964, as well as some palynomorphs of the "Postnormapolles" Pflug, 1953 association: *Subtriporopollenites* aff. *constans* Pflug, 1953, *Tricolpites* sp., *Rhoipites* sp., *Liliacidites* sp.

Two taxa from the microfloral assemblage of the stratotypic Sînpetru Beds are highly significant. *Pseudopapilopollis praesubhercynicus* is known elsewhere only in the Campanian and Maastrichtian of Europe (i.e. Maastrichtian of Bakony, Hungary, the Fouvelian of Southern France, as well as in the *Hoplitoplacenticeras* beds from Pîclişa, Romania) and *Convexipollis convexigerminalis*, very common at Sînpetru, is known exclusively from Maastrichtian deposits. Common forms of the "Normapolles" and "Postnormapolles" association from the Haţeg Basin were also listed in the continental dinosaurian-bearing remains from Southern France and from Lerida, Spain.

Paleontology

The described reptilian fauna was exclusively the result of Nopcsa's studies (table 1). The remains of three genera are more numerous by far. These are: *Rhabdodon, Orthomerus*, known from both skulls and cranial fragments; teeth, limb and girdle bones, ribs, vertebrae, being reported; *Titanosaurus*, known especially from limb and girdle bones, ribs and vertebrae. The three genera were discovered at both Sînpetru and Vălioara, and according to Nopcsa (1914), they represent 70% of the total bones from Sînpetru. Chelonian remains are also numerous (20%): skulls, limb bones, vertebrae and especially parts of carapace and plastron. Nopcsa described a single taxon of chelonian: *Kallokibotion bajazidi*. The remaining 10% of the fauna is represented by the ankylosaurid *Struthiosaurus*, megalosaurids, crocodiles, pterosaurs and birds; the last two groups are very rare.

Table 1

Class REPTILIA
  Subclass ANAPSIDA
    Order CHELONIA
      Suborder AMPHICHELYDIA
        Family PLEUROSTERNIDAE
          Kallokibotion bajazidi Nopcsa, 1923

  Subclass ARCHOSAURIA
    Order SAURISCHIA
      Suborder THEROPODA
      Infraorder CARNOSAURIA
        Family MEGALOSAURIDAE
          Megalosaurus hungaricus Nopcsa, 1915

      Suborder SAUROPODOMORPHA
        Family TITANOSAURIDAE
          Titanosaurus dacus Nopcsa, 1915

    Order ORNITHISCHIA
      Suborder ORNITHOPODA
        Family IGUANODONTIDAE
          Rhabdodon priscum Matheron, 1869
          (synonyms[1]: *Mochlodon suessi* Seeley, 1881; *Ornithomerus gracilis* Seeley, 1881; *Mochlodon suessi robustum* Nopcsa, 1901)

        Family HADROSAURIDAE
          Orthomerus transylvanicus Nopcsa, 1915
          (synonyms: *Limnosaurus* Nopcsa, 1901; *Hecatosaurus* Brown, 1910; *Telmatosaurus* Nopcsa, 1903)

[1] after Nopcsa (1923).

Suborder ANKYLOSAURIA
Family ACANTHOPHOLIDIDAE
Struthiosaurus transylvanicus Nopcsa, 1915
(synonyms: *Crataeomus* Seeley, 1881; *Pleuropeltus* Seeley, 1881; *Rhodanosaurus* Nopcsa, 1929; *Danubiosaurus* Bunzel, 1871; *Leipsanosaurus* Nopcsa, 1917).

Order PTEROSAURIA
Suborder PTERODACTYLOIDEA
Family ORNITHOCHEIRIDAE
cf. *Ornithodesmus* Seeley, 1887

Order CROCODILIA
Suborder EUSUCHIA
Family CROCODYLIDAE
Allodaposuchus precedens Nopcsa, 1928
(synonym: *Crocodylus* (? = *Allodaposuchus*) *affuvelensis* Matheron, 1869)

Class AVES
Subclass NEORNITHES
Order PELECANIFORMES
Elopteryx nopcsai Andrews, 1913

There are no bone remains from Nopcsa's collection in Romania: several in the British Museum of Natural History (P. J. Whybrow personal communication), most of them seem to be in the Museum of the Hungarian Geological Institute, Budapest (information from T. Jurcsák).

The recent discoveries at Sînpetru and Vălioara though just beginning, generally confirm Nopcsa's conclusions regarding the frequency of taxa from the Sînpetru fauna: the most numerous are ornithopod bones and bone fragments (due to the difficulties in distinguishing iguanodontids from hadrosaurids on the basis of postcranial bones, as well as lack of comparative osteologic material, for the moment I prefer to treat all the ornithopod bones together), followed in order by the chelonians, sauropods, carnosaurs, crocodiles and ankylosaurs. We have no pterosaur remains in our collection and only one avian bone fragment, a distal part of femur, of the pelecaniform bird *Elopteryx nopcsai* Andrews (Grigorescu and Kessler 1980).

We have several teeth and vertebrae of coelurosaurid along with a few fragments of limb bones that may have the same origin, too.

Through washing and screening the softer argillaceous sediments we found, after looking at only some 80 kg of the screened material, a micromammal tooth, an upper incisor probably belonging to a multituberculate.

Taphonomy

A major taphonomic feature of the Sînpetru Beds is that osteological material is highly disarticulated, articulated skeletal remains being rare.

The bone material was found as isolated bones or bone fragments, or as small concentrations of several bones or bone fragments; but the majority of bones occur as accumulations in large fossiliferous pockets.

Nopcsa (1901, 1902) mentioned several such fossiliferous pockets. One such is situated on the left slope of Sibişel valley, opposite Tămăşel hill (2.5 km south of Sînpetru). From a gray-greenish sandy claystone placed between a yellowish sandstone bed and red claystones he obtained more than 85 bones, from 7 reptilian species and several individuals, inclusing skull fragments of *Limnosaurus* (= *Orthomerus*) and *Mochlodon* (= *Rhabdodon*). The fossiliferous pocket was excavated to a depth of 3 m and for a length of ca 18 m.

A similar large fossiliferous pocket (1.5 m depth and 8 m length) was also dicovered in the gray-greenish mudstones, on the right slope of Sibişel valley, near Sînpetru, at a place named "După rîu". There we found 48 bones (limb and girdle bones, vertebrae, ribs), most of them complete, and 26 teeth. These bones are also from 7 taxa: ornithopods (both iguanodontids and hadrosaurids), sauropods, carnosaurs, coelurosaurs, crocodiles and turtles, from individuals of different ages and sizes, many of the from young individuals. Thus, among the ornithopods that represent more than 50% of the total number of bones and teeth in this pocket, the remains of at least three individuals can be recognized on the basis of the limb bones.

The bone material is unsorted, small teeth being found together with bones up to 50 cm long, and long bones together with flat girdle bones and vertebrae.

The bones are well cemented in a silty argillaceous matrix hardened by calcitization at the contact points. The original dense bone material has been generally replaced by amorphous collophane; the internal portion is more or less calcitized. Large calcite crystals fill the bone marrow cavities. The removal of bones from the matrix and further preparation usually caused serious difficulties. The bone material seemed to accumulate in primary depressions of the bottom land; bones lay one above the other.

Isolated bones or bone fragments are also found in sandstones and red claystones, without forming important concentrations. Usually the isolated bones from red claystones are preserved complete.

The colour of bones varies from pinkish, gray-yellowish to reddish, red-brown and dark-brown. Generally, in the gray-green and gray-yellowish mudstones the pinkish and gray-yellowish bones are predominant, but the teeth have invariably a red-brown or dark-brown colour. Dark brown bones are also common in the more greenish silty claystones. The reddish and red-brown bones are specific to red claystones, while the darkest brown ones were found in the red sandy claystones from Vălioara. On the weathered surfaces of the gray-yellowish sandstones were found dark-gray bone fragments, probably due to the presence of manganese oxides. The bones that were exposed for longer periods have a yellowish to light-gray (whitish) colour.

As regards the state of preservation, most bones and bone fragments, either isolated or found in fossiliferous pockets, are well preserved, with shiny surfaces, without deep cracks or splintered marks. However, only a few of the long and flat bones do not show any sign of weathering. Usually they are superficially cracked, parallel to the longitudinal fiber structure in long bones. The limb bones especially have eroded articular ends, seemingly due to the bottom impact during transportation. This can also explain the broken surfaces, where the external layers of bone tissue were removed, although the rest of bone is almost unweathered. Some of the very flat bones, like the scapula, show no significant sign of transportation; such bones were probably floating in a swift stream. Rarely the long or flat bones display different weathered surfaces: one side being much more weathered, with a rough texture, while the other side has a fresh appearance.

The main deformations and deep fractures on the complete bones enclosed in a silty-argillaceous matrix seem to be related to postburial compaction of the sediments. This conclusion is strengthened by the presence of highly compressed small vertebrae of theropods and ornithopods.

The bone fragments from sandstones show a higher degree of weathering, deep cracks, splinters and broken parts. The smaller fragments completely lack the surface layers and have a rough aspect. The bones do not display obvious signs of action by carnivores.

Comparing the state of preservation among different taxonomic groups it is obvious that the ornithopods are the best preserved, followed by the carnosaurs (but which are mostly present in the bone assemblages as long bones and vertebrae, more resistant to the weathering processes), chelonians and sauropods. The most weathered are the small, presumably coelurosaurid limb bones. The paucity of crocodile remains (teeth excepted) and ankylosaurs prevents me from making any statements on their taphonomy.

In conclusion, the taphonomic characters displayed by the bone remains of the Sînpetru Beds indicate that most of them were buried after a short transportation from the places of death and desarticulation by muddy flows within the river drainage system. It seems that the main disaticulation processes took place before transportation. The moisture and shade of swampy areas, where probably most of the dinosaurs died, prevented the bones from being more weathered (cf. Behrensmeyer 1978).

Paleoecologic conclusions

The combined sedimentologic and taphonomic features of the lower part of the Sînpetru Beds lead to the following paleoenvironmental model:

a gentle northward sloping alluvial plain, well drained by a braided river system, with periodically wandering channels, alluvial islands or braid bars, swamps, ephemeral shallow lakes, laterally bordered by the drier regions (i.e. flood plains).

The climate was warm and humid with seasonal fluactuations in rainfall that is well documented by the common occurrence of red claystones with calcretes (deposited during the drier periods) alternating with gray claystones (formed in the more humid seasons).

The state of preservation of bone material indicates that dinosaurs, crocodiles and turtles lived and died within the river drainage system. General considerations of dinosaur ecology and the taphonomic characters of the Sînpetru fauna suggest four, closely connected, biotopes:

a. alluvial islands where the crocodiles lived (the scarcity of crocodile remains is probably due to their original low abundance);

b. swampy areas inhabited by iguanodonts, hadrosaurs and turtles;

c. flood plains, further from the source of water but still relatively moist regions, where sauropods and ankylosaurs lived;

d. upland areas, close to c, but drier, the original habitat for both carnosaurs and coelurosaurs.

Nopcsa (1923) considered that the three principal genera of the Sînpetru Beds fauna, *Rhabdodon, Orthomerus, Titanosaurus*, as well as the crocodiles, turtles and birds, lived in swamps and lakes where their remains were buried, while the ankylosaurs, megalosaurs and pterosaurs lived further, in drier areas, being accidentally buried in the same place with the bone remains of the members of the first paleocommunity.

As it was shown above in the chapters on lithology and sedimentology of the Sînpetru Beds, there is no good evidence for large, perennial lakes in the region. It is also more probable that the sauropods, whose bones were found in the same fossiliferous pockets with the ornithopod ones but are more weathered, did not compete for the same ecologic niche with the iguanodonts and hadrosaurs. The association of bones from distinct ecologic assemblages can be explained through the stream accumulation.

The plant productivity must have been high enough to sustain the trophic relationships in the ecosystem. We have very little direct information about the flora of the Sînpetru Beds, except for some leaf impressions of palms (*Palmophyllum*) and from the palynologic analysis. Most of the palynomorphs listed above (p. 114) come from swamp vegetation. The scarcity of flora in the Sînpetru Beds is a consequence of general oxidizing conditions of this formation.

Fortunately, the rich fossil flora from the synchronous beds of the Rusca Montană Basin gives us good idea about the vegetation the herbivorous dinosaurs ate. This flora is dominated by palms, especially *Pandanus* represented by several species, and ferns (*Gleichenia, Asplenium*).

From different lithostratigraphic levels various dicotyledones were collected, mostly Platanaceae, Lauriaceae and Araliaceae, while gymnosperms are quite rare (Petrescu and Duşa 1980). This flora is characteristic of tropical and subtropical regions with abundant rainfall. *Pandanus*, a most characteristic component of this flora, lives today in tropical regions of Africa, Asia, Polynesian islands, Hawaii, near the shores and on the swampy terrains.

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