Geoconservation Research

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From Scientific Research to Geoconservation and Geopark

Dan Alexandru Grigorescu
Institute for Advanced Studies in Levant Culture and Civilization, Bucharest, 2A Mareşal Constantin Prezan Bd., Romania

Abstract

The Haţeg region of Transylvania-Romania, known as the "Haţeg Country", due to its specific character as a region wholly encircled by mountains, has been renowned for over a century for its palaeontological geosites from which dinosaur bones of several species, dinosaur eggs and hatchlings, were unearthed along with numerous other taxa representative of all the major vertebrate groups: fishes, amphibians, reptiles, birds and mammals. The region illustrates the phenomenon of "insular dwarfism", linked to the lengthy persistence of animals in isolated habitats. Palaeontological research in the region took place across two periods, separated by a 50-year gap in which no systematic studies were carried out. The first, closely associated with Franz Nopcsa, spanned between 1897 and 1929; the second period, begun in 1977, continues to this day. The main achievements of these two periods are briefly presented. After 1990, the region also became a center for geoconservation, incorporating a complex activity of research, protection and valorisation of existing dinosaur sites, under the tutelage of geologists from the University of Bucharest. These efforts led to UNESCO recognizing the region as the "Haţeg Country Dinosaurs Geopark" in 2005. Afterwards, it became a leading centre for geoeducation and geotourism in Romania. Here, we discuss the roles played in this achievement by enduring scientific research in the fields of geology and palaeontology across the region, the efforts for the geoconservation of the fossiliferous sites and not least local authorities' involvement and cooperation.

Corresponding Author:
Dan Alexandru Grigorescu
Institute for Advanced Studies in Levant Culture and Civilization, Bucharest, 2A Mareşal Constantin Prezan Bd., Romania
https://orcid.org/0000-0002-4811-9698
Email: danalgrigorescu@gmail.com

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Introduction

In his excellent book on geodiversity, Gray (2013) shows that the term 'geodiversity' was first proposed in 1993 by Wiedenbein (1993), in counterpoint to the established term 'biodiversity', and this generated a paradigm shift in geology from which new terms emerged, such as geosite (geotope), geoconservation, geoeducation, geotourism and geopark. By virtue of its practical nature as an action designed to conserve and prevent the destruction of geosites, selected in accordance to their respective importance and levels of risk, geoconservation is the essential, defining feature of the paradigm, from which stem the applied efforts to capitalize upon geodiversity: geoeducation, geotourism and the geopark.

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The geopark is the corollary to the geodiversity paradigm, bringing together its constitutive components in an interconnected nexus aimed at conserving and capitalizing upon natural and cultural heritage sites through tourism and education, and therefore supporting the socio-economic development of a region, with beneficial effects on local communities.

The concept of the geopark emerged in the late 1980s as a consequence of the ProGEO movement in Europe, whose efforts in highlighting the urgent need for geological protection led to the idea that only through practical demonstration in a coherent system could these values and needs be understood and understood by a broader segment of the population. This idea was supported by UNESCO, which launched the concept of a geopark in 1997, based on a series of principles and recommendations (Patzak & Eder 1998).

Soon after UNESCO announced the principles and the main guidelines governing the creation of geoparks, the first four were created in Europe; by June 2020, their number on the Old Continent has increased to 76, across 26 different countries (www.europeangeoparks.org*)*. From 1995 onwards, geoparks were also established on other continents: primarily in Asia (61), but also in North America (5), South and Central America (3) and Africa (2). The new UNESCO Geoscience and Geopark Program, the International Geoscience and Geoparks Programme (IGGP), established in 2015, provides more robust support in advising the creation of new geoparks, which have proved to represent a proper organizational framework for the development of integrative approaches, coupled with geodiversity and biodiversity in natural research on the one hand, and natural and cultural heritage management on the other, while altogether supporting and furthering the sustainable development of the regions.

There is no perfect recipe for the creation of geoparks, across any region that meets the established UNESCO criteria. In some cases, the initiative lies with local stakeholder groups, building upon a sound knowledge of the region with regard to UNESCO requirements, which affords them a realistic estimate of the advantages and risks associated with the endeavor, once the necessary funding pathways have been secured. In other cases, when the regional potential is insufficiently apparent to the local actors (due, in most part, to insufficient scientific research having been carried out to attest the natural and cultural potential of the region in comparison to other candidates), the initiative to create a geopark falls to a group of researchers who, although hailing from outside the region, have been made aware of its geopark potential by way of research; in this case, a significant part of the endeavour to create a geopark will see this group of outsiders carrying out popularization and information activities to raise awareness among local stakeholders, in order to broaden the pool of potential available partners. Such was the case with the Haţeg Country Dinosaurs Geopark, where extensive research carried out over the years, and the continuous highlighting of its natural and cultural values, coupled with a growing concern for geoconservation, are presented below (Fig. 1).

Haţeg Country

The Haţeg Country covers a 1024 sq. km depression in the south-westernmost corner of Transylvania, its average altitude of 450 m is guarded on all sides by the mountain ranges of the Southern Carpathians which rise to heights of up to 2500 m (2509 m at Peleaga Peak). This gives it the character of a vast organic citadel, with natural portcullises dug athwart valleys leading to Romania's various regions: northwards to Transylvania; south-eastwards to Oltenia; and south-westwards to the Banat. The almost entirely enclosed nature of the region lent it the term of "country", used in Romanian geographical topology – similar to the French word "pays" – to denote such regions (Fig. 1).

The relatively small territory of the Haţeg Country nevertheless testifies to a lengthy human history spanning over 100,000 years, with the earliest evi-

Figure 1. Map of Romania with geographical regions and Haţeg Basin location in South-Western Transylvania.

dence dating to the Middle Palaeolithic. The Dacian period, understood as the crucible from which the Romanian people emerged, saw the earliest battles fought between the Dacians and the Romans, in 101-102 AD, near the Iron Gates of Transylvania (ancient *Tapae*), towards the western edge of the depression. The victorious Romans then erected a military garrison (*castrum*) at this location, which soon became the capital of the Roman province of Dacia under the name of Sarmizegetusa Ulpia Traiana. The Mediaeval period (12^{th}–16^{th} centuries) is particularly well represented by stone churches (unique in Romania), the ruins of stone-walled citadels dating to the early feudal Romanian voivodeships (*cnezate* in Romanian) in the region – later incorporated into the Kingdom of Hungary – and through stone watchtowers, built atop heights in order to keep watch over invaders. The sheer density of historically and culturally relevant sites in the Haţeg Country is unmatched anywhere else in Romania, a country itself known for its particularly rich cultural heritage (Fig. 2).

This extensive historical and cultural record is integrated in a wondrous natural tableau, featuring many rare and endemic species of plants and animals (of which some fall under the protection of the European Commission Natura 2000 reservations), breath-taking vistas towards the neighbouring mountain peaks (with particular deference to the summits of the Retezat Mountains, mostly contained within Retezat National Park), numerous glacial lakes, forests of oak, beech, fir and pine (including the European cedar, *Pinus cembra*), chamois herds and marmot colonies. Moreover, the Haţeg Country also boasts a heightened ethnographic specificity, expressed through traditional dress (still worn by the older generations on festive occasions), local songs and dances, wooden and woolen

Figure 2. Haţeg Country cultural monuments. Sarmizegetusa Ulpia Traiana, the capital of the Roman province Dacia (II-III century AD): A) Amphitheatre. B) The Great temple, Middle Age stone churches. C) Densuş: XIII century, Orthodox, Romanic style. D) Suseni: XIV century, Orthodox, Late Romanic style. E) Sântămaria Orlea: XIII century, Reformed Calvin, formerly Catholic, Late Romanic style. F) Răchitova watch tower, XIV century. G) Mălăiesti Fortress, XIV century. Ruins and recent reconstruction. H) Kendeffi castle, XVIII century.

craftsmanship and culinary traditions (Fig. 2).

Lastly, geology serves to enhance the Haţeg Country's specificity and scientific value: the geological strata of the hills which surround the lowlands bear vestiges of some of the last dinosaurs ever to walk the Earth before their extinction 66 million years ago (Ma). The dinosaur remains together with several other contemporary animals, mainly crocodiles, turtles, pterosaurs, and mammals, are found in fluvio-lacustrine deposits, corresponding to the Maastrichtian, the last Cretaceous stage (72–66 Ma). The deposits correspond to the uplift phase of the Southern Carpathians following an almost complete series of Mesozoic marine strata, from Lower Jurassic to upper Cretaceous (Campanian). The tectonic uplift that interrupted the marine evolution of the region was associated with powerful volcanic eruptions whose products are interbedded through the sedimentary sequences. Compared to related species uncovered in other regions, the Haţeg dinosaurs reveal a chronic dwarfism; little wonder, then, that palaeontologists have popularized them as "Tran-

Figure 3. Representatives of the Late Cretaceous fauna of the Haţeg Basin, reconstructed by Jakub Kowalski (by the permission of the Transylvanian Museum Society): A) Paralatonia transylvanica (Anura, Discoglossidae). B) Bicuspidon hatzegiensis (Squamata, Borioteiioidea). C) Nidophis insularis (Serpentes, Madtsoiidae). D) Kallokibotion bajazidi (Chelonia-cryptodirae). E) Allodaposuchus precedens (Crocodilia, Allodaposuchidae). F) Theriosuchus sympiestodon (Mesoeucrocodilia, Atoposauridae). G) Magyarosaurus dacus (Sauropoda, Titanosauridae). H) Paludititan nalatzensis (Sauropoda, Titanosauridae). I) Balaur bondoc (Theropoda, Velociraptorinae). J) Richardoestesia sp. (Theropoda, Dromaeosauridae). K) Elopteryx sp. (Theropda, Troodontidae). L) Zalmoxes squiperorum (Euornithopoda, Rhabdodontidae). M) Zalmoxes robustus (Euornithopoda, Rhabdodontidae). N) Telmatosaurus transsylvanicus (Ornithopoda, Hadrosauroidea). O) Struthiosaurus transylvanicus (Ankylosauria. Nodosauridae). P) Hatzegopteryx thambema (Pterosauria, Azhdarchidae). Q) Euenantiornithine birds. R) Kogaionon ungureanui (Multituberculat mammal-Kogaionidae).

sylvanian dwarf dinosaurs” (Fig. 3).

The Scientific Treasure Unveils Its Secrets: The “Giants” Were Dwarf Dinosaurs

It is fortunate that the first dinosaur fossils found in the Haţeg Country were on the lands belonging to the lands of Baron Franz Nopcsa (1877–1933). His younger sister, Ilona, found them when she was only 12. However, the shepherds driving their flocks along the Sibişel Valley, between Săcel (the site of the Nopcsa family manor) and Sânpetru had long known of such strange bones, which were washed out by mountain torrents which followed the spring thaws. The shepherds treated these bones with great apprehension and avoided even touching them, as in popular belief these were the bones of “giants” that had once called these lands home, bringing ill fortune to whoever laid hands on them. This account comes from a certain Doenel Vulc, whom I had the great fortune of having guide my earliest forays into the region (1977–1980), and who in turn had heard it from one of the village elders who had personally met Franz Nopcsa and had assisted him in retrieving dinosaur bones.

Ilona’s discovery irreversibly altered the course of Franz Nopcsa’s life, irresistibly luring him to the study of reptile palaeontology. In the area his sister indicated, Nopcsa uncovered several bones, including a greatly fragmented skull which would later be identified as from a hadrosaur (*Telmatosaurus*). After graduating from secondary education, Nopcsa’s discoveries informed his decision to enrol in the Faculty of Science at the University of Vienna, where he studied under the renowned geologist Eduard Suess (1831–1914). Franz Nopcsa eagerly awaited his introduction to Professor Suess, thinking it would prove a good opportunity to show the scholar several of the bones he had collected; yet their meeting proved a disappointment to the aspiring palaeontologist. Neither Suess nor the other university professors were able to offer any advice, other than that he would have to rely on his own faculties: “then, learn it” he was told (Weishampel & Jianu 2011). This was perhaps unsurprising, since at the time there were few people across Europe who might have been able to offer any input, even though the term “dinosaur” had entered academic parlance some 50 years earlier, a combination of the Ancient Greek *deinos* (“terrible”) and *sauros* (“lizard”, “reptile”). And, indeed, Nopcsa did succeed on his own, guided only by the tomes contained in the University library, among them the works of two American pioneers in dinosaur research: Othniel Marsh and Edwin Cope as well as the writings of Louis Dollo, famous for his excavations in southern Belgium which unearthed several nearly complete *Iguanodon* skeletons, restored and displayed in the Brussels Royal Museum (Fig. 4).

Figure 4. A) Franz von Nopcsa (1877-1933). B) Outcrop in the dinosaur-bearing strata on the Sibişel valley, south of Sânpetru village. The outcrops on the Sibişel River banks, provided most of the fossil-remains studied by F. Nopcsa.

With great ambition, tenacity and above all natural talent, Nopcsa embarked upon his laborious self-study from the early years of his time in Vienna, acquiring an extensive knowledge of osteology, comparative anatomy and functional morphology. His research on the Sânpetru skull, initially presented as *Limnosaurus transsylvanicus* and later renamed as *Telmatosaurus transsylvanicus* in 1903 (having realized that Marsh had already coined the earlier name for a crocodile) was presented to the Hungarian Geological Society in Budapest in 1899 (Nopcsa 1900). That same year, he gave the same presentation at the Vienna Academy of Science, where his former mentor Eduard Suess expressed his pleasant surprise at how quickly Nopcsa had managed to complete his complicated inquiry (Fig. 4).

Stimulated by the abundance of fossils in the hills around his Săcel manor, not only did Franz Nopcsa publish numerous articles, but he also penned ample monographs on several of the representative examples of this palaeofauna, such as the ornithopod *Rhabdodon* (renamed *Zamolxes*: Weishampel et al. 1993), the stem-turtle *Kallokobotion*, and the ankylosaurid *Struthiosaurus transylvanicus*. Many other articles feature reviews of fossil reptile specimens found in the collections of the great European Natural History Museums he visited. These sojourns also allowed him to make the acquaintance of many renowned palaeontologists such as Otto Jaeckel, Ferdinand Broili, Carl Wiman, Friederich von Huene, Albert Gaudry, Luis Dollo, Arthur Smith Woodward and Richard Lydekker, among others. At a remarkable pace, Nopcsa soon made a name for himself as a leading scientific scholar in the fields of palaeontology and the paleobiology of Mesozoic reptiles, a reputation undimmed to the present day. Following his dramatic death in 1933, Luis Dollo evoked his life and work as follows: “A comet racing across our paleontological skies spreading but a diffuse sort of light” (Weishampel & Jianu 2011).

Franz Nopcsa’s primary contributions to documenting the Haţeg Basin and to the palaeontology of the dinosaur fossil layers found in this region can be summarized as follows:

1. In the field of geological cartography, he created the geological map of the region between Alba Iulia-Deva and Rusca Montană, which comprises the Haţeg Basin, for his doctoral thesis which he defended in Vienna in 1903 and published in 1905 (Nopcsa 1905). On this map, he dated the continental strata rich in dinosaur fossils to the Danian, which at the time was considered to be the uppermost stage of the Cretaceous period. The broader area of these deposits extends far outside the Haţeg Basin into greater Transylvania.

2. Nopcsa also showed that the underlying continental deposits, where they can be observed, are Campanian-aged marine sediments, with the contact between the two facies characterised by a continuous transition, interspersed in places by a brackish sequence. The Danian strata are termed the Sânpetru (*Szentpéterfalva*) sandstone, named after the village in the Sibişel Valley where the majority of fossils were found. The Sânpentru sandstone is interpreted as being of riverine or wetland origin, with the sedimentary layers interspersed with remnants of volcanic eruptions (tuff and other volcanic rocks) towards the western and north-western parts of the basin.

3. In the field of systematic palaeontology, Nopcsa described nine species of dinosaurs and other coeval reptiles, of which five still retain their original taxonomic status: *Kallokibotion bajazidi* Nopcsa, 1923, a primitive turtle; *Allodaposuchus precedens* Nopcsa, 1928, a crocodilian; *Magyarosaurus dacus* Nopcsa, 1915 (emend Huene, 1932), a sauropod dinosaur; *Telmatosaurus transsylvanicus* Nopcsa, 1903, a basal hadrosaurid dinosaur; and *Struthiosaurus transylvanicus* Nopcsa, 1915, a basal nodosaurid (Nopcsa 1929). The ornithopod *Rhabdodon robustum* (Nopcsa, 1915), previously *Mochlodon robustum* (Nopcsa 1902,1904) was revised as the new genus *Zalmoxes* with two species: *Z. shqiperorum* and *Z. robustus* (Weishampel et al. 2003). Two other taxa, *Megalosaurus hungaricus* (theropod) and *Ornithidesmus* sp. (pterosaur) are invalid due to the loss of the specimens (Fig. 5).

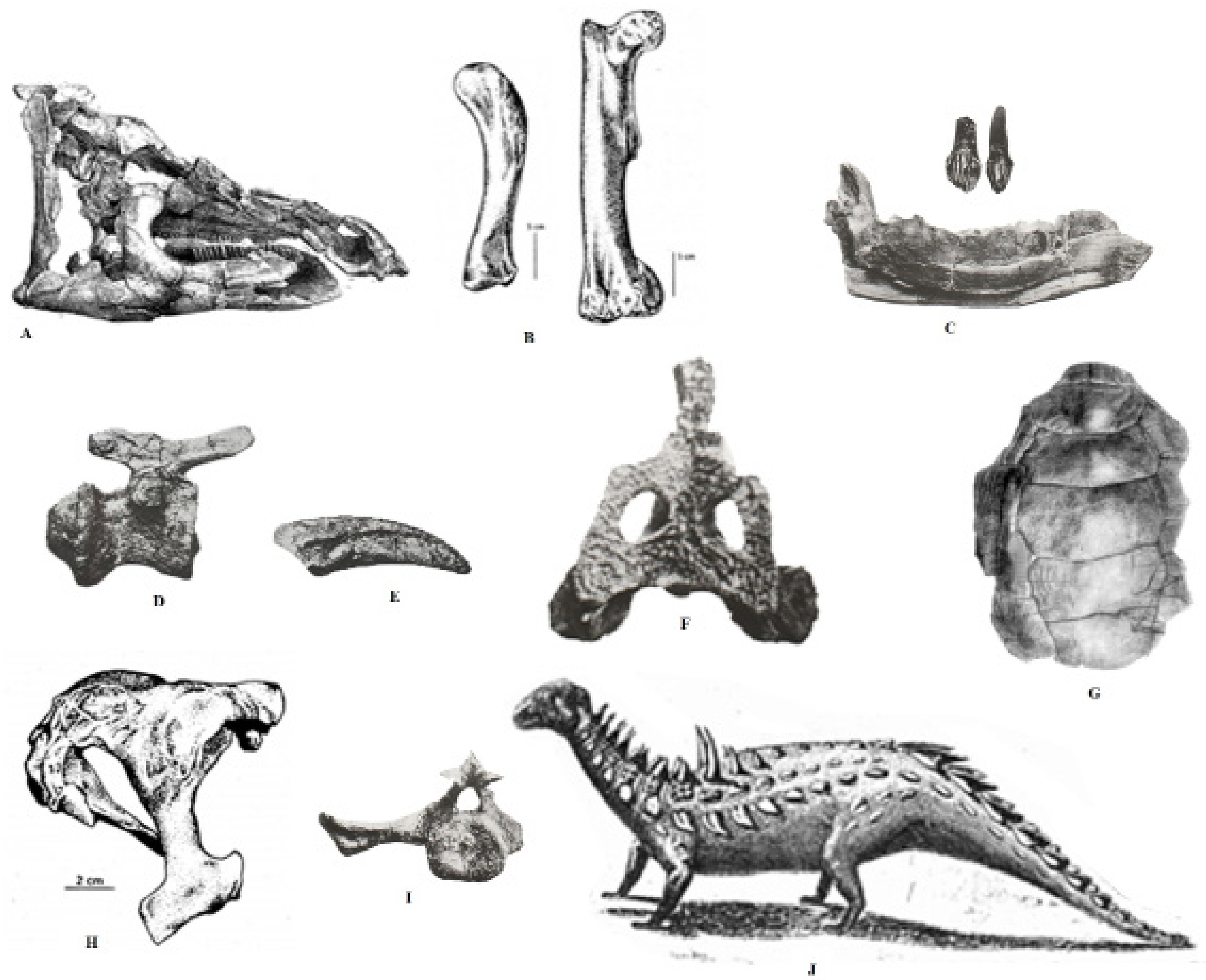

Figure 5. Dinosaurs and other contemporary reptiles described by F) Nopcsa in the 'Hațeg Country' region. The hadrosauroid Telmatosaurus transsylvanicus (described initially as Limnosaurus and Orthomerus): A) Skull (BMNH R 3386). B) Humerus (MAFI 3126) and femur (MAFI 10338). The ornithopod Rhabdodon robustum var. suessi (now Zalmoxes robustus Weishampel et al. 2003). C) Dentary and maxillary teeth. The titanosaurid sauropod Magyarosaurus dacus (described as Titanosaurus dacus, corrected by F. Huene, (1932)). D) Caudal vertebra. E) Claw. The crocodile Crocodylus affulevensis (later Allodaposuchus precedens Nopcsa, 1928). F) Skull roof. The turtle Kallokibotion bajazidi. G) Carapace. The ankylosaurid dinosaur Struthiosaurus transylvanicus. H) Lateral view of the skull (BMNH R 4966). I) Caudal vertebra. J) Nopcsa's reconstruction of Struthiosaurus transylvanicus.

Abbreviation: BMNH R -British Museum Natural History, London. Reptile collection. MAFI – Magyar Allami Foldtani Intezet Budapest.

4. Regarding the evolution of species, Nopcsa highlighted dwarfism as a primary characteristic of the faunal assemblage, with most of the uncovered species much smaller than their closest relatives from other regions of Europe. Moreover, Nopcsa also noted the primitiveness and endemism of the taxa which, despite their Late Cretaceous age, appear to be much more closely related to Late Jurassic and Early Cretaceous forms. He interpreted both aspects as deriving from the isolated nature of the regional ecosystem, situated on an island inhabited by the dinosaurs and coeval animals over a long period of time; before Nopcsa, similar conditions had been highlighted in the fossil record of several Mediterranean islands, where dwarf mammals (elephants, deer etc.) were found to have lived during the Pliocene and Quaternary periods.

5. In the field of paleobiology, Franz Nopcsa documented the effects of sexual dimorphism on the bone morphology and morphometry in dinosaurs and other fossil reptiles. Nopcsa is also recognized as an early proponent of the theory of avian evolution from dinosaurs, which was then far from the general view and yet is seen as correct today, as well as the theory of the cursorial origin of bird flight.

6. Finally, Franz Nopcsa carried out extensive research, over 15 years (1903–1918) in northern Albania, across a broad array of disciplines such as geology (his geological map of the region is still current), geography, archaeology and ethnography. Numbering over 40 scientific treatises, Nopcsa's collected works on the region constitute an extremely valuable scientific and historical record.

His qualities as a researcher of various broad fields, yet one capable of attaining the pinnacle of achievement in each, are interwoven throughout the tapestry of Nopcsa's life with his military and political spirit, his insidious interference in the Balkan conflicts around the time of the Great War, and not least with his adventurous life – seemingly inspired by the novels of Karl May (some of his favourite early reading) or from the local myths romanticizing the brigandism of his own grandfather, Baron Vasile Nopcsa, the supposed "Blackface" in the Jókay Mór novel "The poor plutocrats", with a first Magyar edition in 1860.

An Unwanted Interruption to the Continuity of Nopcsa's Studies

Due to their taxonomic abundance and diversity as well as their specific evolutionary patterns, the discoveries from the Hațeg Country, the majority of which Nopcsa published in German and Hungarian, seemed to foreshadow a region of great interest for palaeontologists specializing in dinosaurs and other coeval animals. These early expectations were never fulfilled, however, due to a series of overlapping factors: the World War I that involved him in both military and political affairs; his research in Albania, which restricted his available time for some 15 years; his pronounced streak of individualism, which prevented him from developing close collaborations and fostering a new generation of palaeontological research in the region; and, not least, the estrangement of his extensive collection contributed to a suspension of systematic research into the dinosaur fossil deposits of the Hațeg Basin which lasted well over half a century.

During these 50 years, some regional stratigraphic research facilitated the discovery of several isolated bones, which were entrusted to the palaeontological collection of the University of Bucharest (Mamulea 1953a, b; Dincă et al. 1972). In this period, a floristic association made up of leaf impressions of fern and angiosperm plants was uncovered from tuffite deposits in the Densuș area (Mărgarit & Mărgarit, 1967). The Geological Institute of Bucharest commissioned a cartographic study of the Haţeg region, carried out by Laufer (1925). These studies confirmed the Danian age of the local deposits and delineated two distinct and stratigraphically superimposed lithofacies. The lower, predominantly lacustrine layer saw significant interspersions of volcanic material, while the upper, riverine-lacustrine layer, had no volcanic inputs. The Danian age of the continental deposits was supported by later research and was only revised to the Maastrichtian once the International Stratigraphy Commission in 1970 had reclassified the Danian as the oldest stage of the Palaeocene.

Picking up the Thread

Even though no systematic research into the continental fossil-bearing deposits of the region had been undertaken after Nopcsa left the region, following Transylvania's political and administrative reorganization occasioned by its post-war incorporation into the Romanian state, the issue was far from forgotten: it would not only be discussed by the few Romanian palaeontologists during national scientific colloquiums, but it would also routinely be brought up by foreign palaeontologists during meetings, occasioned by international conferences and symposia. One such reunion was the one I attended in the summer of 1975 in Corvallis, Oregon, on "Advances in the systematics of marine mammals" symposium to which the Smithsonian Institute had invited me to present the discovery of seals in Southern Dobrogea. For the six weeks of my American sojourn, I met a great many dinosaur scholars at the Museums of Natural History in New York, Washington DC and Los Angeles, who continuously asked me why no studies were forthcoming on the Transylvanian dinosaurs. The question put me in an awkward position, as I was loath to confess that, over half a century, Romania had failed to produce a single specialist in that field, or that international collaborations, which would have been one solution, were actively discouraged by the Communist regime.

I returned from America determined to do my utmost to resume the Haţeg research. I was somewhat familiar with the region, from day trips to Sânpetru that I led for my 2nd-year students as part of their summer field training, beginning in 1973. I was aware that much more would need to be done, especially the creation of a small team of students who would agree to accompany me, as volunteers, over their summer holidays.

As luck would have it, it was not difficult to assemble this team, as the discussions I had with my students during laboratory classes and in particular the lectures I gave at the university following my visit to the United States proved successful in sparking much greater interest than I had anticipated. Now, the problem became securing the funds for travel, as Haţeg lies 400 km from Bucharest, as well as the accommodation and meals for the students during the ten days I had estimated the research would take. It was impossible to draw these funds from either the faculty or university budget, as our endeavour was, to many eyes, more recreational than educational. I managed to persuade the leaders of the National Association of Communist Students that our research was motivated by patriotism, and that the new discoveries would reinstate the region's international prestige and rebuild a valuable scientific collection that had long been estranged. In this manner, for nine years (1977–-1985), we managed to secure a small sum each summer, which we stretched to cover our field expenses; at the end of each research campaign, we would compile reports on the scientific finds we had made. For the first few years, our primary objective was to identify fossil-bearing sites along the Sibişel Valley, south of Sânpetru, from where most of the fossils Nopcsa studied were sourced. We were greatly aided by one local person in particular, Doenel Vulc, whose unbounded appreciation of his native land encouraged him to accompany us in the field and allowed us the use his own much-needed digging implements.

Throughout the early years of our research, we collaborated closely with Ion Groza of the Deva Museum, a fresh graduate of the Faculty of Geography in Bucharest, housed in the same building with Geology. While a student, Ion, a native of a commune (Boşorod) that neighboured Haţeg, would sometimes visit me to inquire about my plans for Haţeg Country. I suggested that he join the Deva Museum, which at the time was seeking staff specializing in the natural sciences, and that he join my team, and in return, I would aid him in creating a palaeontological collection for the Deva Museum, since Ion lacked geological, and much more, palaeontological training. Both his native village and the Deva museum were relatively close to the fossil deposits (20 and 60 km, respectively), which allowed Ion to continue digs on potential fossiliferous sites after we had to leave.

A significant number of bones were discovered in sites lying on either bank of the Sibişel Valley, while the ongoing research afforded me the knowledge of the sedimentological and taphonomic characteristics of the uncovered deposits. It was much harder to assign the fossils to dinosaurian taxa, since this required extensive knowledge of osteology and comparative anatomy which can only be gained through hard work on rich materials in large museums. My expertise at the time lay in the osteology of marine mammals (pinnipeds, cetaceans), an entirely different field from dinosaur osteology.

Assistance would come from several foreign specialists who, having heard of the resumption of research in the Haţeg Basin, popularized through Nopcsa's work, were eager to learn more, and initiated inter-academic exchanges. The first such visit was by a Polish team led by Zofia Kielan-Jaworowska alongside Teresa Maryańska and Halszka Osmólska, who at the beginning of the 1960s had taken part in three joint Polish-Mongolian palaeontological research expeditions to the Gobi Desert, which made many new discoveries of dinosaurs and mammals in Upper Cretaceous deposits. Zofia provided us with a powerful impetus to seek out mammal remains via the micropaleontological method, given that the size of mammals during the dinosaur age did not exceed that of modern rats. From among the remains we uncovered, Teresa and Halszka, specializing in ankylosaurid and ornithopod dinosaurs respectively, highlighted the osteological characteristics of each of the two groups, both well represented in our growing collection.

In response to the Polish palaeontologists' visit, in September 1981 I took part in the Second International Symposium on Mesozoic Terrestrial Ecosystems, held in Jadwisin in Southern Poland. There, I presented the results of our early years of research, with particular focus on the sedimentological and taphonomic aspects and only incorporating some palaeoecological deductions, since the dinosaur systematics was difficult to approach, mainly from lack of comparative material. The paper was published in 1983, alongside the other proceedings of the symposium, in *Acta Palaeontologica Polonica* (Grigorescu 1983). The reunion in Jadwisin marked my entry into the world of dinosaur specialists, where I met Eric Buffetaut and Philippe Taquet from Paris, José Luis Sanz from Madrid, Philip Currie of Drumheller Museum, Canada, David Archibald of the University of San Diego, California, as well as many other renowned specialists.

A series of visits to Haţeg by French, British and American scientists followed that event, which I returned by attending some international symposia such as the Third International Symposium on Mesozoic Terrestrial Ecosystems (Tübingen, 1984), meetings of the International Geological Correlation program on Nonmarine Cretaceous of the World (IGCP 245) in which I was catalyst for Eastern Europe, in Urumqi (China 1988) and Alma Ata (Kazahstan 1990), also visits to Montpellier University (1984), to the London Natural History Museum and the Sedgwick Museum of Earth Sciences in Cambridge (1987), in exchange with the visits by French and English colleagues to Haţeg (Fig. 6).

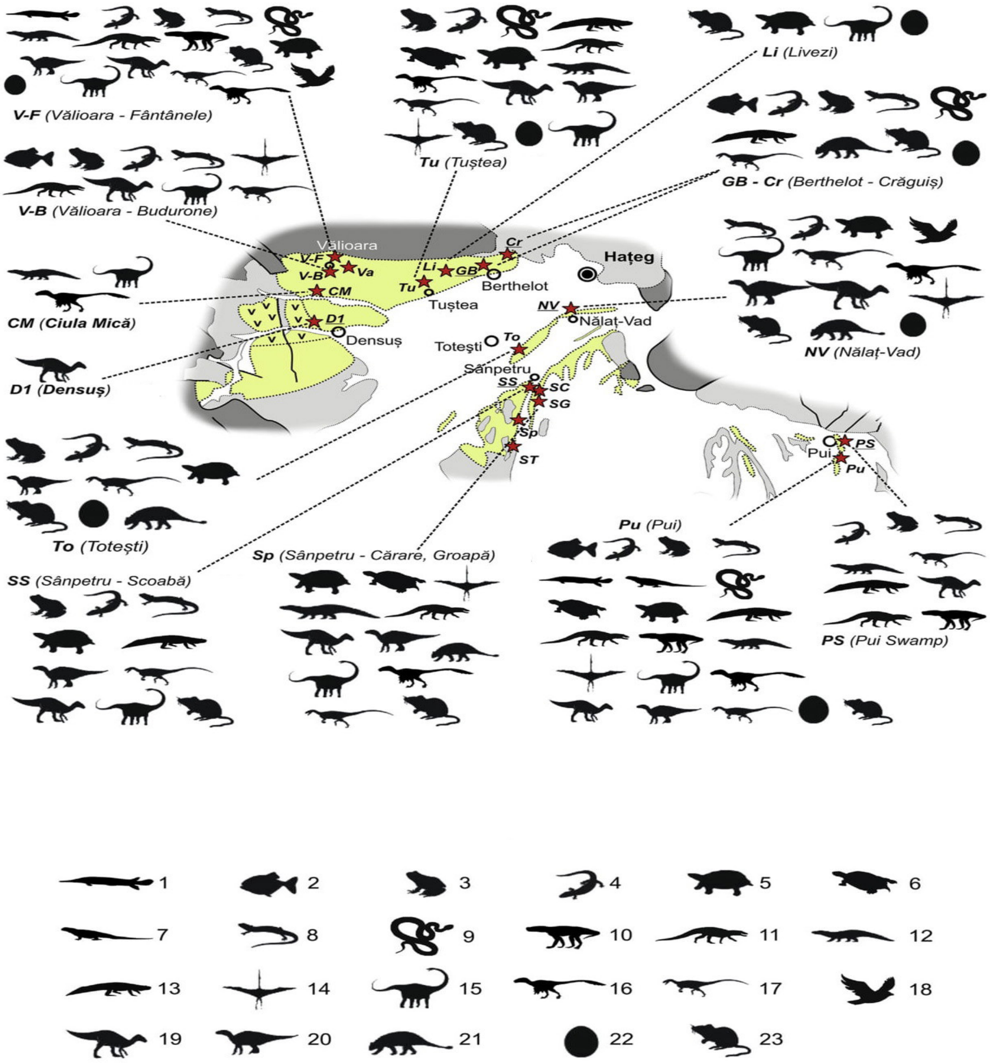

Figure 6. Main Upper Cretaceous geosites that provided vertebrate assemblages in the Haţeg Basin.
A) Lepidosteid fish. B) Other fishes. C) Frogs D) Albanerpetontids. E) Turtle (Kallokibotion) F) Dortokid turtles. G) Borioteiioid lizards. H) Other lizards. I) Madtsoiid snakes. J) Doratodon crocodilian. K) Theriosuchus crocodyliform. L) Allodaposuchus. M) Acynodon crocodile. N) Azhdarchoid pterosaurs. O) Titanosaurian sauropods. P) Dromeosaurid theropods. Q) Other non-avian theropods. R) Birds S) Rhabdodontids ornithopods. T) Hadrosauroids. U) Nodosaurid ankylosaurs. V) Dinosaur megaloolithid eggs. W) Kogaionid multituberculates. (From Csiki-Sava Z. et al. 2015).

Throughout, our research continued, summer after summer, and new fossiliferous sites were added to the known ones (Fig. 6). Intensive use of the screen-washing method led to a spectacular increase in the number of taxa of fishes, frogs, lizards, and snakes, but mostly crocodiles and crocodyliforms, theropods and multituberculate mammals, whose small teeth were frequently found in the micropaleontological samples. No fewer than 70 taxa are known today, some of them only classifiable to higher ranks (family, order), including representatives of all the major groups of vertebrates, from fishes to mammals, which gives a complex insight into the Latest Cretaceous biodiversity of the region (Fig. 7). New large vertebrates were also discovered, among them the sauropod *Paludititan* (Csiki et al. 2010), the giant pterosaur *Hatzegopteryx* (Buffetaut et al. 2003), ornithuran and enantiornithine birds (Wang X et al. 2011a & Wang X et al. 2011b). As noted before, the revision of Nopcsa's iguanodontid *Rhabdodon* revealed two species of the new euornithopod genus *Zalmoxes* (Weishampel et al. 2003) (Fig. 8).

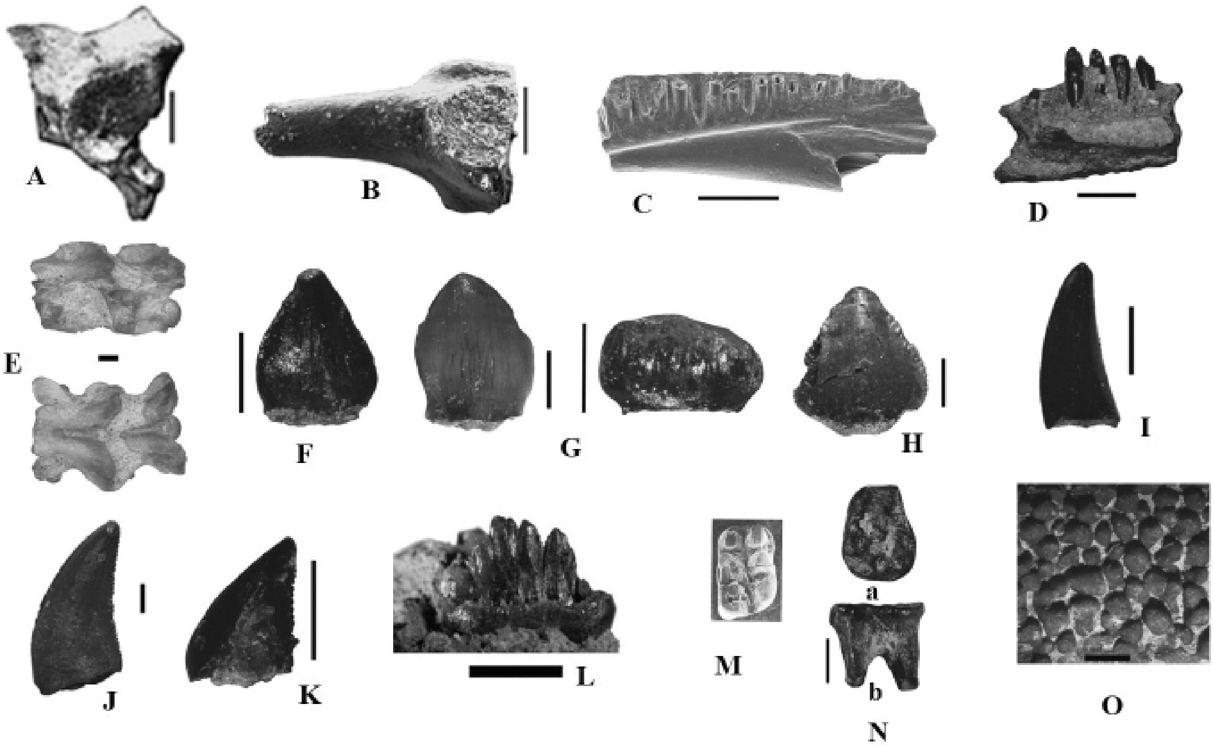

Figure 7. Discoveries after 1977. Microvertebtates. Amphibians: A) Paralatonia transylvanica -ilium (FGGUBv 455). B) Hatzegobatrachus grigorescui-ilium (FGGUBv 433). C) Albanerpetontid lissamphibian- partial dentary (FGGUBv 842). D) Scinomorph lizard Becklesius nopcsai – partial dentary (FGGUBv 809). E) Madtsoiid snake, Nidophis insularis -articulated vertebrae (FGGUBv 547) F) Ataposaurid crocodyliform Theriosuchus sympiestodon -anterior tooth (FGGUBv 825). G) Eusuchian crocodyliform cf. Acynodon anterior tooth (FGGUBv 804) and posterior tooth (FGGUBv 829). H) Ziphosuchian crocodyliform Doratodon sp. anterior tooth (FGGUBv 859). Theropod teeth: I) Richardoestesia (FGGUB R 2287). J) Troodontid (FGGUB R 2286). K) Dromaeosaurid (FGGUB R 2289). L) Indeterminate nodosaurid ankylosaur (FGGUB R 2182). Multituberculate teeth: M) The first Cretaceous mammal in Romania: Multituberculate lower molar (occlusal view) assigned to Paracimexomys ? dacicus (Grigorescu & Hahn,1987). N) Indeterminate kogaionid multituberculate: upper molar (FGGUB M 1672) in occlusal (a) and labial (b) views. O) Dinosaur megaloolithid eggshell.
Abbreviation: FGGUB R – Faculty of Geology and Geophysics University of Bucharest. Reptile collection. FGGUB M – Faculty of Geology and Geophysics University of Bucharest. Mammal collection. Scale bar 1mm.

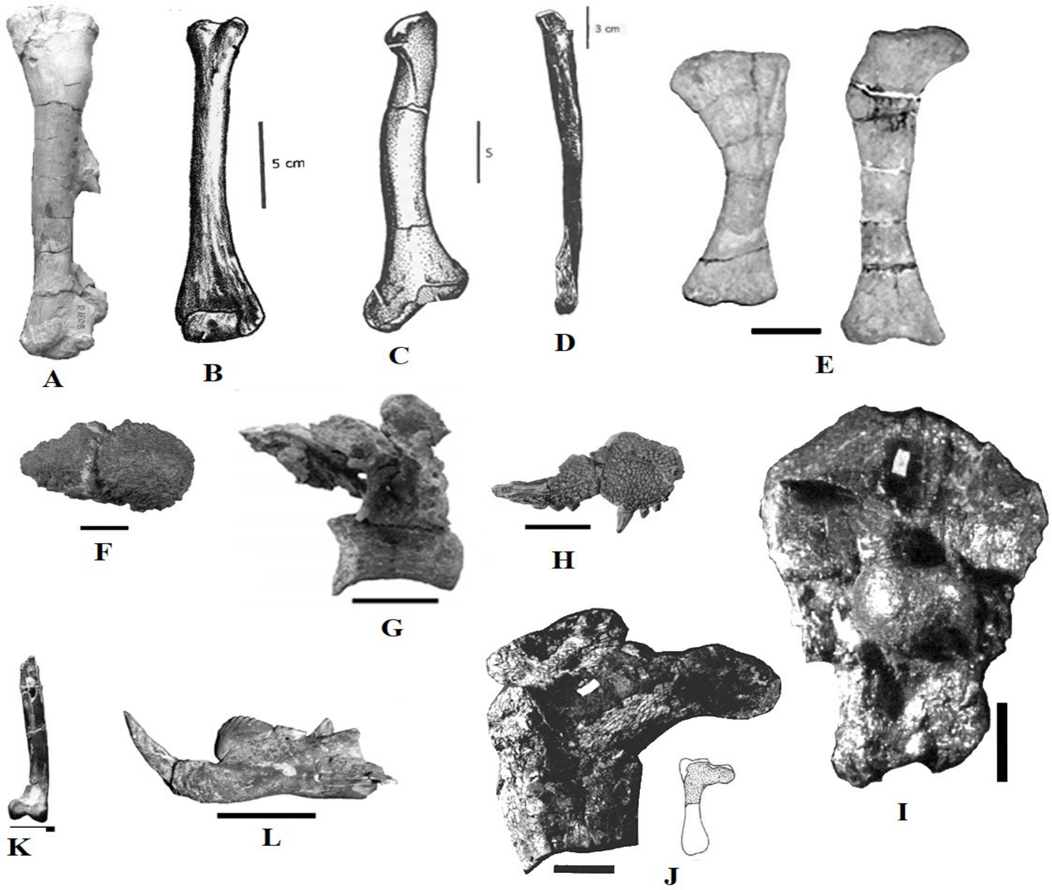

Figure 8. Discoveries in the Hateg basin after 1977. Macrovertebrates. The euornithopod Zalmoxes shqiperorum: A) Femur (FGUB R 1608). B) Tibia (FGUB R 1087). Zalmoxes robustus: C) Tibia (FGUB R 0008). D) Fibula (FGUB R 1365). The titanosaurid Magyarosaurus dacus: E) Femur (FGUB R 1046) and humerus (FGUB R 1047). F) Isolated osteoderm (FGUB R 1410). The titanosaurid Paludititan nalatzensis: G) Dorsal vertebra (UBB NVM1-43). The ataposaurid crocodyliform Theriosuchus sympiestodom: H) Maxilla (MCDRD 793). The azhdarchid pterosaur Hatzegopteryx thambema: I) Occipital (FGGUB R 1083). J) Humerus -proximal part (FGGUB R 1082). Indeterminate ornithuran bird: K) Tibiotars fragment (FGGUB R 1902). Multituberculate mammal Barbatodon transylvanicus. L) Maxilla (FGGUB M 1635). Scale bars: A, B, C, D, F, I, J - 5 cm. E, G - 10 cm. H – 2 cm. K, L – 1 cm.

Abbreviation: FGGUB R – Faculty of Geology and Geophysics University of Bucharest. Reptile collection. FGGUB M – Faculty of Geology and Geophysics University of Bucharest. Mammal collection. MCDRD - Museum of Dacian-Roman Civilization Deva. UBB NVM – University Babes-Bolyai Cluj-Napoca Vertebrate Paleontology collection.

A new chapter in the history of research at Haţeg was opened in 1988 by the discovery of dinosaur eggs in a gully near Tuştea village in the northern part of the basin, since then not known in any other part of Romania. The report was accepted for publication in Nature (Grigorescu et al. 1990). Soon after the eggs, neonate remains of the hadrosauroid *Telmatosaurus* were found near the egg clutches; this initiated a dispute around the "Tuştea puzzle", the megaloolithid type of egg discovered there being almost unanimously attributed to sauropod dinosaurs (Grigorescu 2010a) (Fig. 9).

After Tuştea, dinosaur eggs were found in five other places in the Haţeg Basin, but also in different regions of Southern Transylvania, and in some cases the geosites proved to represent the incubation places used repeatedly by dinosaurs. Of all of these, the Tuștea site is unique, beyond the primacy of the discovery itself, in being the only location in Europe, including the abundant dinosaur incubation areas of southern France and northern Spain, to feature dinosaur hatchling bones alongside the more common fossils of dinosaur nests. Not only are scientists interested in the dinosaur eggs from Transylvania, but also thieves, euphemistically called "fossil hunters" (Fig. 9K).

The new systematic discoveries allowed a comprehensive reconstruction of the great biodiversity at the end of the Cretaceous in Transylvania, which stimulated phylogenetic and palaeobiological analysis on the faunas and paleoenvironmental reconstructions based on the stable isotope distribution in fossil soils (Bojar et al. 2010). Further, it has been established that the latest Cretaceous Haţeg and Transylvanian fauna is a point of reference in analysing palaeobiogeographic aspects at a global scale (Weishampel et al. 2010) or the Cretaceous-Paleogene Boundary (K-Pg) event (Csiki-Sava et al. 2015).

A special issue of the journal *Palaeogeography, Palaeoclimatology, Palaeoecology*, under the title "European island faunas of the Late Cretaceous -The Haţeg island" (Z. Csiki and M. J. Benton Eds.), was published in 2010. The 15 articles in the volume covered multidisciplinary investigations on the Haţeg fauna and flora, and palaeoenvironmental and evolutionary aspects. Some papers endorsed the insular condition of Transylvania (Haţeg Island) during the Late Cretaceous; palaeomagnetic studies indicated its palaeolatitude as 22.6 ± 5.9º N within the Mediterranean sector of the Tethys (Panaiotu & Panaiotu 2010). The evolutionary effects of the insularity were analysed through phylogeny and bone histology by Benton et al. (2010), and at least a few taxa (*Magyarosaurus, Telmatosaurus,* and possibly *Zalmoxes)* were confirmed as dwarf dinosaurs. A historical overview of studies on the latest Cretaceous fauna in the Haţeg Basin is included in the volume (Grigorescu 2010b). That issue also suggested a number of aspects that should be further considered, among these clarification on the temporal and spatial distribution of the taxa, interrelationships within the biota, and the paleobiogeographic origin of some forms.

Above these scientific aspects, there is a practical need for geoconservation to be more professionally approached and sustained by local communities, aware of the positive consequences that the geosites, well preserved and presented to visitors, might have on their lives. The creation of the Haţeg Country Dinosaur Geopark, that followed a long period of studies and approaches to the local people, created a good foundation for this endeavour.

The Need for Geoconservation

From my earliest years of study, I noticed that the sites our professors would choose for field trips or summer practical sessions in order to explain different geological phenomena were the most direct and the most attractive way to both gain a practical understanding of geology and to familiarize oneself with the field. This initial impression has crystallised over the course of my studies and would later inform my approach to teaching the subject. I would provide concrete examples of the phenomena described, either from those sites the students had

Figure 9. Dinosaur eggs and neonate remains. A, B) Dinosaur megaloolithid egg clutches from Tuştea, presumably representing original nests. Maximum 13 eggs were found in a clutch. C) Megaloolithid dinosaur egg, apparently unhatched. D) Eggshell with rounded nodes, 2.0-2.5 mm thick. E) Eggshell radial thin section. Neonate skeletal remains found in Tuştea, associated with the egg clutches: F) dentary fragment with teeth (FGGUB R 1850). G) Limb bones: homers (FGGUB R 1851) and tibia (FGGUB R 1853). H) Articulated partial skeleton of a neonate Telmatosaurus transsylvanicus (FGGUB R 2087). I, J) Discovery and preparation of dinosaur egg clutches in field. K) Dinosaur eggs stolen in the Haţeg Basin, recuperated by the Italian carabinieri and returned to Romania, now in the University of Bucharest collection.

Abbreviation: hu- humerus sc-scapula dv-dorsal vertebrae.

already visited or were about to, in the course of their practical fieldwork. Outside class, we would discuss the importance of geological reservations already known at the time; my students stressed that many other sites deserved the same status and that they, as young geologists, could play an important role in the creation of new geological reservations.

Such talks eventually led to the creation of the Student Association for the Protection of the Geological Environment in the autumn of 1977, within the Faculty of Geology of the University of Bucharest. The group's stated aim of protection stemmed from youthful ambition, as the students themselves lacked the means of practically implementing such measures. I chose not to temper their enthusiasm, knowing that, were they allowed to proceed, they would naturally implement the essential prerequisite step to effective protection, namely to apply scientific inquiry through fieldwork and to the scientific justification of studied sites' geological importance. Over the course of the seven years of the Association's activity, our students indeed drafted many studies; groups of students would voluntarily travel to sites of geological significance over their summer holidays: to sites relevant for volcanism and its associated mineral accretions (in the Banat, around Deva and in Maramureș), to stratigraphy and palaeontology (the Jurassic reefs of Dobrogea, the continental Cretaceous dinosaur-bearing deposits in Hațeg) or to geological phenomena (the mud volcanoes of the Buzău Valley). During the academic year, monthly communication sessions were held, and the studies were periodically published in the Association's collected volumes. After the Romanian Revolution of December 1989, geoconservation activities were amplified through the Society for the Protection of the Geological Environment, a non-governmental organization established in 1990 and open to a broader range of interested parties than to just university professors and their students as the prior Association had been.

In 1990, I published an article on geoconservation in Romania, co-authored by David Norman, in the Earth Science Conservation journal of the British Nature Conservancy Council. Soon after, in June 1991, I attended the first International Symposium on the protection of geological heritage, held in Digne-les-Bains, France.

On that occasion, representatives from over 30 countries in attendance signed the Declaration of the Rights of the Memory of the Earth, which provided a powerful stimulus to the European ProGEO movement for the study of geological heritage, the protection of geological sites and their capitalization through education and tourism. As a consequence of the activities of ProGEO, six years later UNESCO launched the concept of the "geopark", which saw a flurry of geoparks created worldwide, at first in Europe, and then across the world's other continents. In order to make their activity more efficient, a number of regional ProGEO work groups were created throughout Europe, among them, the Balkan Group, which brought together the countries of south-eastern Europe (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, North Macedonia, Montenegro, Romania, Serbia, Slovenia, Hungary and, more recently, Kosovo) and Turkey. International symposia were periodically organized in one of these countries, which facilitated both a better mutual understanding, the launch of regional projects and elaboration of joint studies, whose effects positively contributed to the knowledge, protection and capitalization of notable geological sites (Grigorescu 1996; Maran & Grigorescu 2006). The number of scientific articles dedicated to geoconservation has continuously increased across all Balkan countries, and special volumes on the topic have been published in the majority of these (for example, *Geologica Balcanica*, Sofia 1996; *Revue Roumaine de Géologie*, 2018). Moreover, from their 1995 session in Athens onwards, all Congresses of the Carpathian Balkan Geological Association have featured dedicated sections on geodiversity and geoconservation, as well as an increasing number of contributions. One overarching synthesis of the state of geoconservation in Europe is provided by the ProGEO volume entitled "Geoheritage in Europe and its Conservation" (Wimbledon & Smith-Meyer eds. 2012). Further, the vast number of research publications tackling geoconservation, steadily increasing after 1995, had impacts on public authorities who began to allot more funds to the geoheritage protection projects – far less than the optimal levels of funding required, however.

In this encouraging atmosphere for geoconservation, UNESCO drafted a document, disseminated to a select circle of groups, that outlined the criteria and conditions for geopark creation (Patzak & Eder 1998). In reading them, I had the impression that in drafting, UNESCO took inspiration from the realities of Hațeg Country; such was the overlap between the requirements and the realities of the region. In the list of three UNESCO requisites, I note how the Hațeg Country fits:

1. A geographically well-defined territory, of a size sufficient to allow activities related to economic development – a territory of 1020 sq. km., surrounded by mountain ranges which impart the region a definite individuality (hence the term "country" attributed it).

2. The existence of geological sites of particular scientific and aesthetic value – besides the numerous palaeontological sites found within the continental Cretaceous deposits, over 30 other geosites in deposits of different ages.

3. The existence of sites representative of local fauna and flora, as well as of the history of the region, in addition to sites of geological importance – numerous species of rare and endemic plants and animals, archaeological sites of the late Roman period, Mediaeval stone churches under UNESCO protection.

As shown above, UNESCO's requirements had already been met: the first through the nature of the region, and the other two through the region's natural and cultural significance, documented through extensive scientific research and inquiry. The requirements merely had to be reorganized in accordance with the administrative recommendations for natural and cultural sites; these are approached holistically as intertwined elements of regional heritage in conservation initiatives, and capitalized upon through education and tourism, with a view to the sustainable development of the region.

A geopark represents a special setting to promote scientific research in the fields of geoscience and life sciences, to develop new methods for geoconservation, and to innovate in the fields of geoeducation and geotourism.

Of particular importance among UNESCO's recommendations was the issue of the geopark's administration: "The Geopark is run by a designated local authority or several authorities having an adequate management of infrastructure, qualified personnel and adequate financial support."

To achieve this criterion, so distinct from all others, required us to embark on an intense campaign to, first, persuade local authorities, through discussions and practical demonstrations, of the potential benefits of a geopark; and then, to tackle the practical and organizational challenges inherent in creating the management scheme and securing the necessary funding for planned activities and required personnel.

The 25 years of consistent research into the palaeontology and geology of the region proved decisive factors in convincing locals that the initiative of creating a geopark, albeit coming from outside the local community, would realistically improve the welfare of the region and of its inhabitants. The lengthy periods spent with students and researchers, Romanian and foreign alike, meant that I was a known quantity in the region; in turn, I attempted to resolve some of the locals' own pressing issues, especially those related to the creation of rural schools.

Ultimately, I succeeded in persuading local and regional authorities of the geopark's usefulness in developing the region, and of the need for local authorities to be invested in the management and leadership of the reservation. To this end, I initiated the Hațeg Country Inter-Communal Association, a non-governmental organization with legal status which brings together the mayors and representatives of the region's 12 settlements, one city (Hațeg, population 10,000) and 11 communes (around 30,000 inhabitants total), alongside delegates from two universities: the University of Bucharest, where I was active at the time, and the University of Petroșani (geographically close to the region, only 20 km from its eastern boundary). The leadership of the University of Bucharest, through the good will of its chancellor, agreed to sponsor the salaries of five essential staff, while the local councils agreed to allot a pooled annual budget for the geopark's activities.

Thus, the region saw the creation of a new type of partnership, in which the usefulness of the academic partner had to be showcased to locals both quickly and efficiently. To this end, qualification courses were organized, open to locals on behalf of the geopark's two partner universities, which were joined by the University of Agriculture and Zootechnics in Timișoara, also geographically close to Hațeg. The preparatory courses in agriculture and zootechnics this university offered (which were novel fields in Romania at the time, given that over the 45 years of Communist rule up to the December 1989 Revolution, farmers had only had the experience of collectivization and state-run agricultural enterprises) would prove to be the most sought-after, and their attendees awarded diplomas from the University of Timișoara following a year-long course of week-end learning and practical activities in the field.

On the basis of its portfolio, compiled in accordance with UNESCO requirements, the Hațeg Country Dinosaur Geopark, thus named in order to highlight its primary scientific relevance, was recognised as a UNESCO geopark in March 2005, only the 18th geopark to be consecrated as such and the first in any former Communist country in Eastern Europe. Prior to the award, the geopark had already received national recognition in November 2004.

Among the primary objectives outlined upon the geopark's creation were to elaborate the park's management plan, with a focus on protecting valuable natural and cultural sites; to consolidate its relationship with local authorities and local communities and aim to promote local specificity and enterprise; to revitalise local folkloric and artisanal traditions; to create educational and touristic information locations, to be made available both online and in situ; to strengthen the geopark's strategic partnerships and secure its financing pathways (Fig.10).

Over the course of its 15 years of operation, the Hațeg Country Dinosaur Geopark has experienced successes and failures, a careful analysis of which, alongside an account of the valuable experience gained for future sustainable development initiatives, is forthcoming.

Although not quite achieving our most optimistic expectations, the creation of the Hațeg Country Dinosaur Geopark has had far-reaching consequences of utmost importance both for the region itself and the academic environment that initiated and guided the effort. For the Hațeg Country region, notable is the fostering of social cohesion through the establishment of the Inter-Communal Association, as the region's twelve mayors periodically assemble to discuss joint projects and organize folklore festivals specific to the Hațeg Country. The numbers of visitors to the region from Romania and abroad, attracted by local dinosaur sites, archaeological monuments or by the region's natural beauty has increased substantially, primarily through promotion on the geopark's sizeable IT footprint. As a direct consequence of the increased flow of visitors, the numbers of restaurants and available accommodation have also increased, as has the impetus the geopark provided to the craftsmanship of regionally specific items and objects, highly sought-after by tourists.

Figure 10. A) The Geopark Educational center in the General Berthelot commune. B) Magyarosaurus dacus in the Educational center garden. Reconstruction by Brian Cooley (Canada). C) “House of the dwarf dinosaurs” in Sânpetru village. D) “Volcanoes house” in Densuş village. E, F) Images from the Geopark Information center in Haţeg town (Source www.hateggeoparc.ro)

For the academic environment, the benefits of the geopark are particularly resonant at the Faculty of Geology and Geophysics at the University of Bucharest, where it has provided a great impulse to the applied facet of geological training, focusing on field research, which has been reinforced by the creation of a research center for Life and Earth Sciences within the geopark itself, on the initiative of the Romanian Academy in partnership with the University of Bucharest (Fig. 11).

Figure 11. A) The Research centre in Life and Earth Sciences of the Romanian Academy in the General Berthelot commune. The centre is open to the scientific researches in the Geopark. B) The Haţeg Country village museum in Peşteana village. C-F) The tradition of weaving artisanal clothes is kept by the women in Santa Maria-Orlea commune (Source: www.hateggeoparc.ro).

A new Masters' degree course in geology, Applied Biology for the Conservation of Natural and Cultural Heritage was created in the Department of Geology of the University of Bucharest. The course stimulates interdisciplinary research, while also aiming to consecrate the new career path of geoconservationist.

The establishment of the Haţeg Country Dinosaur Geopark has also had far-reaching international effects, both within the European Geopark Network and the Global Geopark Network. Across both bodies, the geopark's representatives actively contribute to discussions in the ProGEO Balkans and Turkey Working Group, offering to share their experiences with other partner countries that may wish to create a UNESCO geopark.

Conclusions

The history of the more than 100 years between the first documented record of dinosaur fossils in Haţeg Country and the creation of the Haţeg Country Dinosaur Geopark, briefly summarised in this article, illustrates a series of systematic approaches and strategies that led to the creation of this new structure:

- In-depth and applied research carried out throughout the geographical extent of the region, thematically diversified and holistically approached.
- The familiarization of students with field research methods, on a voluntary basis, and the continued guidance of laboratory activities of those most interested.
- The dissemination of discoveries and their scientific significance to local communities, alongside actions to raise awareness of the need to safeguard natural and cultural sites.
- The creation of partnerships between different groups within academia with diverse interests in researching the region and local authorities, and the involvement of as many local stakeholders as possible in projects aiming to conserve and capitalise upon the natural and cultural heritage of the region by way of education and tourism.

Through the geopark's creation, the Haţeg region of Transylvania saw the establishment of a unitary framework for experimentation and innovation in geoconservation strategies and methodologies, the results of which could easily be extended to other regions as examples of good practice.

Conflict of Interest

The author declares that he has no competing interest.

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