The presence of the mastodon "*Mammut*" *borsoni* (Proboscidea, Mammalia) at Valea Deșului (Gorj County)

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Abstract. A fragment of the right upper jaw of a proboscidean with molars M_2 (fragmentary) and M_3, was collected by locals from the riverbed of the Valea Deșului, which flows through the village of the same name (Vladimir commune, Gorj County). This village is situated on the interfluve that separates the Gilort Valley to the west from the Amaradia Valley to the east. The area is predominantly hilly, with topography shaped by the erosion caused by tributaries of the Jiu River, which generally flow in a north-south and northwest-southeast direction. The lithological succession of the Pliocene fluvial system is characterized by sandstone and siltstone formations, specifically the Jiu-Motru and Cândești formations. Through ongoing fluvial erosion, the jaw fragment became detached from its original layer and was subsequently remobilized by the current watercourse. Although the exact source layer remains unidentified and consequently, the geological age unclear, it is evident that the jaw was embedded in medium-coarse sandstone. Based on the geological context of the area where the locality is situated, we have reason to believe that the fossil originates from the deposits of the Cândești Formation (Romanian). We have classified the fossil as belonging to the mastodon "*Mammut*" *borsoni*, a large-sized species commonly found in the Pliocene sedimentary deposits of Oltenia. The fossil's journey through the watercourse caused significant damage to the cheek teeth, obscuring several morphological and dimensional details. This jaw fragment is from a mature specimen that had severely worn molars, mainly M_2. This discovery demonstrates the paleontological value of the area, which includes a protected site in Valea Deșului specifically for this reason.
Key words: Proboscidea, Borson's mastodon, Late Pliocene, Oltenia, Romania.

Rezumat. Prezența mastodontului "*Mammut*" *borsoni* la Valea Deșului (Județul Gorj). Un fragment de maxilar superior drept de proboscidian care păstrează M_2

(fragmentat) și M_3 a fost colectat de localnici din albia Văii Deșului, care traversează satul cu același nume (comuna Vladimir, jud. Gorj). Satul menționat se află amplasat pe interfluviul care separă văile Gilort (la vest) și Amaradia (la est). În ansamblu este o zonă colinară, cu un relief controlat de eroziunea cursurilor de apă tributare Râului Jiu cu direcții de curgere orientate N-S – NV-SE. Din succesiunea litologică a sistemului fluvial pliocen dominat de roci arenitice si siltice care revin formațiunilor de Jiu-Motru și de Cândești, prin procesul actual de eroziune fluvială, fragmentul de maxilar a fost desprins din stratul de proveniență și remobilizat de către cursul de apă actual. Nivelul de proveniență rămâne așadar neprecizat și în consecință vârsta geologică imprecisă, însă rocă gazdă a fost o gresie mediu-grosieră. Judecând după contextul geologic al ariei in care se găsește amplasată localitatea, avem motive să presupunem că fosila provine din depozitele Formațiunii de Cândești (Romanian). Fosila este atribuită mastodontului "*Mammut*" *borsoni*, o specie de talie mare, comună în depozitele pliocene din Oltenia. Rularea fosilei de cursul de apă a avariat grav jugalii, astfel încât o serie de detalii morfologice și dimensionale sunt definitiv compromise. Fragmentul de maxilar provine de la un specimen matur, care uzase extrem M_2. Această descoperire evidențiază potențialul paleontologic al zonei specificate, la Valea Deșului aflându-se o arie protejată, obiectul protecției fiind bazat pe acest considerent.
Cuvinte cheie: Proboscidea, mastodontul lui Borson, Pliocen Superior, Oltenia, România.

Introduction

Proboscideans, which emerged as early as the Late Paleocene (Thanetian) and have a documented presence in Northwest Africa, represent a successful group of placental mammals with a geological history that continues to this day. The oldest known taxon within this group is *Eritherium azzouzorum* GHEERBRANT, 2009 (Gheerbrant, 2009). Following this, the African history of proboscideans persisted throughout the Eocene and Oligocene, marked by significant systematic diversification that showcases broad adaptive capabilities suited to various paleoenvironments. In response to ecological challenges, numerous fascinating taxa have emerged, exhibiting adaptations related to morphology, size, and behavior. For example, forms adapted to swampy environments include *Platybelodon* BORISSIAK, 1928, as noted in works by Osborn & Granger (1931), Wang et al. (2013), and Wang & Li (2022).

In the Early Miocene (around 18-19 My), the paleogeographic reorganization of continental masses due to plate tectonics led to Africa coming into contact with Eurasia. This contact provided a land bridge for proboscideans to migrate into Eurasian regions, known as the "Gomphotherium Landbridge" (Steininger et al., 1985; Harzhauser et al., 2007). Mastodons are particularly noteworthy for their diversity and adaptive capabilities. Among them, some are notable for their enormous waists. Certain authors suggest that, among

proboscideans, specific taxa, including some mastodons, rank among the largest terrestrial vertebrates ever known, surpassing giant rhinoceroses and indricotheres (Larramendi, 2016; Larramendi et al., 2020).

In Romania, the oldest known representatives date back to the Middle Miocene, with discoveries of the species *Gomphotherium angustidens* (CUVIER, 1817) found in the intra-Carpathian area, specifically at Minișu de Sus (Nicorici, 1976; Jurcsák, 1983; Codrea, 2008) and Viscri (Codrea & Ciobanu, 2008). Most mastodon findings in Romania, however, are linked to the Dacian Basin and the continental-lacustrine sedimentary sequences from the Pliocene (e.g., Athanasiu, 1908, 1909; Apostol, 1968; Terzea, 1983; Rădulescu & Samson, 1985; Petrescu et al., 1987a,b; Codrea & Diaconu, 2003, 2007, 2010, 2011, 2024; Rădulescu et al., 2003; Codrea et al., 2018; Codrea & Venczel, 2018; Codrea et al., 2021; Codrea & Popescu, 2023; Koenigswald et al., 2022). The stratigraphy of these localities are detailed by Andreescu et al. (2011, 2013).

This paper presents a cranial fragment of "*Mammut*" *borsoni* (HAYS, 1834) collected from Valea Deșului, Gorj County.

Geological setting and age

The village of Valea Deșului, part of the Vladimir commune, is located approximately four kilometers north of the commune center. It lies around 30 kilometers southeast of Târgu Jiu, the capital of the county. Geographically, this locality is positioned on the Getic Plateau, within the region of the Getic Subcarpathians. The relief of the area has been shaped by the erosion of the substrate caused by the hydrographic network.

From a geological perspective, the area in question serves as an excellent exposure for Pliocene deposits, specifically Romanian, covered by Quaternary rocks (Codarcea et al., 1967;).

Structurally, it belongs to the Carpathian Foredeep, where sedimentation commenced immediately after the end of the Cretaceous period (Săndulescu, 1985). The Pliocene (Dacian, Romanian) deposits are part of a monocline structure with dips oriented N-NW to S-SE, ranging from 2 to 6 degrees. Given that the locality of interest is situated north of the Pericarpatic fault, known as the Bibești-Tinosu fault in this sector, it can be stated that, at depth, the older Paleogene and Lower Miocene deposits are part of folded structures (Paraschiv, 1979). This tectonic activity is evidenced by wells that have crossed the Middle Miocene deposits at depth.

The deposits at the base of the Lower Pliocene (Dacian: Getian) form the Berbești Formation (Bosphorian-Getian). The lower boundary of this formation distinguishes it from the Turcești Formation (Late Miocene, i.e. latest Pontian: Bosphorian). In certain sections of the Carpathian Foredeep, this boundary can even be classified as intra-Bosphorian, exhibiting heterochronous characteristics throughout the Foredeep. The upper boundary, which separates the Berbești

Formation from the overlying Jiu-Motru Formation (Dacian: Parscovian-Siensian), is isochronous across all sectors.

The lithology of the Berbești Formation primarily consists of sands, fine gravels, silts, and silty clays, with occasional coal accumulations. These sediments originate from littoral depositional systems at the base, transitioning into deltaic and ultimately fluvial systems. In the outer zone, the depositional environments began as coastal, followed by fluvial plain environments, while in the inner zone, which is closer to the Carpathian orogen, the environments were characteristic of a deltaic plain.

The lower boundary of the following unit i.e., the Jiu-Motru Formation, is situated at the base of a deltaic system, which later transitions into a fluvial system. The upper boundary, separating it from the Cândești Formation (Upper Pliocene: Romanian), is heterochronous. In some areas, the Jiu-Motru Formation may also encompass the Upper Pliocene (Romanian). Thus, at the upper limit, the boundary between the Lower Pliocene (Dacian) and Upper Pliocene (Romanian) is typically found between coal seams III and IV. However, some interpretations suggest that this limit may be positioned higher, between lignite layers IV and V in the local context (Ion Andreescu, personal communication to V.A.C.).

From a lithological perspective, the Jiu-Motru Formation is primarily characterized by light-colored sands, clays, and silts, with lignite interbeds. These features are linked to deltaic depositional systems at the base and transition into fluvial and even alluvial systems in certain sections. The basal section reflects a deltaic plain environment. As one moves upward through the formation, it transitions to environments typical of a fluvial plain, exhibiting progradational characteristics in the outer sector and aggradational features in the inner zone. There are also influences from alluvial fans, which will become dominant in the overlying Cândești Formation.

Within the area of interest for this research, the final formation in the sequence is the Candești Formation (Romanian). According to current understanding, it dates back to the terminal Pliocene (Andreescu et al., 2011, 2013). The lithology is characterized by sands, fine gravels, silts, and clays; however, toward the crown, the clastic sedimentation becomes coarser, featuring boulders and gravel, referred to as the "Cândești Gravels" (Ionesi, 1994). The depositional system is predominantly alluvial, with some fluvial contributions at the base. The depositional environments are associated with an alluvial plain, which includes proximal and medial alluvial fans in the outer zone and medial and distal ones in the inner zone.

This succession bears a series of lumachellic levels populated by specific, endemic mollusks from brackish and freshwater environments, which serve as useful markers for local correlations (e.g., *Viviparus bifarcinatus* (BIELZ, 1864) above coal bed VI). The stratigraphic location of the mastodon jaw fragment cannot be established, as the fossil was found reworked within the deposits of the Deseșului Valley riverbed. Nevertheless, it is evident that the fossil originates from a lenticular layer or accumulation of medium-to-coarse sandstones. The local

context suggests that it likely comes from either the crown of the Jiu-Motru Formation or, more probably, from the upper Pliocene (Romanian) deposits, corresponding to the Cândești Formation.

Materials and methods

We had only a single fragment of the right upper jaw with M_2-M_3 available, with no other associated bones. This material is housed in the Natural Sciences collection of the "Alexandru Ștefulescu" Museum in Târgu Jiu. The fossil was embedded in a sandy concretion made up of medium-to-coarse quartz sands, which was extracted through mechanical preparation. The sandy matrix was removed using an air-scriber connected to an AIRBAG HP1 compressor at the Laboratory of Paleotheriology and Quaternary Geology of Babeș-Bolyai University in Cluj-Napoca. No interventions were necessary to consolidate the fossil with professional polymers. Measurements were taken using calipers (0.8 m and 0.45 m, respectively). Photographs were captured with a Sony® DSC-RX100M5 equipped with a Zeiss Vario-Sonnar T* 1.8-2.8/8.8-25.7 lens and were subsequently processed in Adobe® Photoshop® CS2 Version 9 to enhance certain details. Dental terminology follows Tobien (1975, 1996), and the measurement methodology adheres to Göhlich (1998).

Abbreviations

ASMTJ - "Al. Ștefulescu" Museum Tg. Jiu

M(x) = M - upper molar, x = 2, 3; L = length W (x, t) = W – maximum width of the transverse crests, x = I – IV, t = talon.

Systematic paleontology

Proboscidea ILLIGER, 1811
Elephantiformes TASSY, 1988
Elephantimorpha TASSY AND SHOSHANI, 1996
Mammutidae HAY, 1922
Mammut BLUMENBACH, 1799
"*Mammut*" *borsoni* (HAYS, 1834)

Material: fragment of the upper right jaw with M_2 (fragmentary) – M_3 (ASMTJ 35403)

Description. The jaw fragment exhibits visible signs of having been rolled by the current course of the Deșului Valley. Essentially, the fossil acted as a large boulder. The effects of this transportation are also evident on the two molars, with portions of their crowns severely damaged. Despite the poor preservation, the zygodont appearance of the crowns is still recognizable.

Only the posterior transverse loph of M_2 is preserved; the rest of the crown is broken, rendering any additional details indistinct. The last molar in the dental row features a crown structured with four transverse lophs and a talon. These lophs

are separated by completely open transverse valleys. The M_3 crown is largely broken, with the most severe damage observed on the apical portions of all four transverse lophs, as well as the lateral terminations on the palatal and labial sides; the breaks are particularly severe on the labial side. The sulcus separating the pretrite and posttrite lobes is distinct and evident on all transverse lophs. The protocone and hypocone are worn down, making it impossible to observe certain details; however, it can be inferred that both cusps were undergoing physiological wear. The hypocone and metacone are also experiencing wear, though it appears to be less advanced compared to the aforementioned cusps of the pretrite row. Conelets are generally challenging to distinguish, but they are defined, particularly on the pretrite row. Crescent-shaped structures are visible on the last three transverse lophs (II-IV), while they remain indistinct on the first loph. The anterior cingulum, although broken, is evident, but other cingula cannot be observed in the current state of the tooth.

Measurements (mm):

L M_2-M_3 = + 267

M_2: L = + 100; $W_{(3)}$ = 88.5

M_3: L = + 169; $W_{(1)}$ = 96.5; $W_{(2)}$ = + 102.7; $W_{(3)}$ = + 96.2; $W_{(4)}$ = + 92.5; $W_{(t)}$ = ca. 55

The measurements refer strictly to the dimensions of the cheek teeth actually associated with the maxillary fragment. The initial sizes of the molars were larger, in some cases significantly larger, judging by the fact that only the third transverse loph of the second molar was preserved, and only its base could be measured. Under these conditions, the calculation of certain ratios (W_{max}/L, L/W_{max}, H/L) cannot be performed.

Comparisons and Discussions

Unfortunately, the morphological details observable on the fossil from Valea Deșului are quite limited because of its post-depositional history. Significant portions of the crowns are damaged due to the recent torrential transport that occurred after they were released from the layer.

The existing published data for the area in question indicates that there are not fossils originating at Vladimir directly comparable to the two molars herein described. The only available reference is Athanasiu's report (Athanasiu, 1908), which pertains to mandibular teeth that apparently, like in our case, were not found *in situ* at Valea Deșului. Based on other descriptions provided by this paleontologist, we can estimate that M_2 may be comparable in size to the specimen described from Budești (Argeș County; pp. 166-168) or the one from Sălcuța (Dolj County; p. 168). The comparative table published by Athanasiu (1907, p. 168) presents widths similar to those observed at Simnic and Pestchana, but the accuracy of these comparisons is significantly hindered by the damage to the molar from Valea Deșului.

Regarding M_3, it seems to be slightly smaller than the molar described from Turburea (Gorj County; p. 169), but somewhat longer than the specimen from Bărbătești (Gorj County; pp. 170-171). Overall, the dimensional variation ranges reported from Oltenia suggest modest differences. This could be interpreted as a sign of dimensional conservatism throughout the Pliocene for this mastodon species. However, the limited number of cheek teeth over the past century is noteworthy; the increase in the number of described teeth has been so minimal that it has not revealed potential differentiations that might indicate different evolutionary stages based on the geological ages of the source deposits.

It is also important to note that the stratigraphic positions of the various cheek teeth described have not always been accurately determined. Many mastodon fossils found in Oltenia were discovered by locals rather than paleontologists, who often did not pay close attention to details such as the geological levels from which they originated. Additionally, in most cases, we lack available faunal associations that include this mastodon species. It is certain that this species frequently coexists with the mastodon *Anancus arvernensis* (CROIZET & JOBERT, 1828) as in Stoina (Popescu, 2016), and in the neighboring county of Dolj, at Cernătești, where the two mastodons are found alongside the oldest European mammoth, *Mammuthus rumanus* ȘTEFĂNESCU, 1924 (Schoverth et al., 1963; Radulescu et al., 2003). However, the age of the association from Cernătești (the Cândești Formation) is more recent than those from Stoina and Valea Deșului.

In northern Oltenia, in Gorj County, "*M.*" *borsoni* has been reported from a series of localities. These include: Vladimir (Athanasiu, 1908; Barbu, 1930—incorrectly referred to "Valea Dealului" instead of Valea Deșului; Macarovici, 1978); Petrești de Jos (Athanasiu, 1908; Macarovici, 1978); Vlăduleni (Athanasiu, 1908; Barbu, 1930); Bărbătești (Athanasiu, 1908; Macarovici, 1978); Turburea (Athanasiu, 1908; Macarovici, 1978); Săcel (Athanasiu, 1908; Macarovici, 1978); Frunza (= Tândălești; Athanasiu, 1908); Covrigi (Athanasiu, 1908; Popescu, 2016); Groșerea (Athanasiu, 1908; Popescu, 2016); Bălteni (Popescu, 2016); Stoina (Popescu, 2016); Hurezani (Popescu, 2016) and Urdea de Jos (Schowerth et al., 1963; Macarovici, 1978).

The association between the two mastodon species has also been reported from the easternmost sector of the Dacian Basin, at Tulucești (Dacian) and Măluțeni (Romanian) (Radulescu et al., 2003; Andreescu et al., 2011, 2013 and related references).

In the intracarpathian area, the same association has been reported from Căpeni-Sector I, where "*M.*" *borsoni* was found without *A. arvernensis*, at Fântâna Fagului and Iarăș, from deposits considered Romanian (Radulescu et al., 1965; Radulescu & Samson, 1985; Radulescu et al., 2003).

Mammut praetypicum (SCHLESINGER, 1919) from Păgaia (Codrea et al., 2005) was reported from the west-northwest area of Romania. As Göhlich (1999, 2004) pointed out, discussions regarding the synonymy versus non-synonymy of this mastodon species with "*M.*" *borsoni* have to be solved by additional research, based on more relevant discoveries that could resolve the dilemma. Despite the

definitive statements establishing the synonymy between the two species (e.g. Yaghoubi et al., 2023), we believe that a richer, more stratigraphically well-positioned sample, associated with various other vertebrate taxa, is necessary to reach a clear and well-supported conclusion. Currently, the outcrop at Păgaia has been compromised for an extremely long term by being covered with a landfill. The hope of recovering additional material from this vertebrate locality is therefore nil. This highlights the significant problem that our country inadequately protects fossil sites.

As the stratigraphic position of the mastodon remains in the Valea Deșului deposit sequence is rather uncertain, any interpretation regarding the paleoenvironment in which this proboscidean lived is currently not meaningful. For the Pliocene in Oltenia, adequate data for such reconstructions can be found in Petrescu (2003), but there are significant differences between the Dacian and Romanian interpretations regarding paleogeography and paleoclimate. For the "Lower Romanian" this paleobotanist suggests a "temperate-warm" climate characterized by an annual average temperature of 13-14°C and average annual precipitation ranging from 1000 to 1100 mm. At the time this text was written, the Quaternary/Pliocene boundary was thought to be at 1.75 million years ago, suggesting that the Romanian context should be understood more broadly than it is currently interpreted.

Finally, it is important to highlight that there is a protected fossil site at Valea Deșului that spans one hectare (Bleahu, 2004), established by local decisions (Decree 174/1974, HCJ 82/1994) and by Law 5 of March 6, 2000 (RONPA0468 Valea Deșului Fossil Site), classified as IUCN category IV, with the protection focus on the "Levantine fauna". This legislation raises several issues that remain unresolved at the national level, including the need to define areas for protection, such as fossil sites, through proper marking; the installation of explanatory panels to clarify the scientific significations of the protected sites; and the appointment of paid reserve custodians and rangers to manage these areas. The Valea Deșului fossil site requires these measures to ensure the effectiveness of the protection provided.

Conclusion

The Deșului Valley does not represent a new locality in Oltenia for "*M*". *borsoni*, as it was previously noted by Athanasiu (1907). Therefore, this study does not contribute to extend the list of already known localities. However, it serves as an additional rationale for the protection of the fossil site, which is already legally protected. Although the fossil recovered from the valley alluvium is of poor quality in terms of preserved details and stratigraphic positioning, it still supports the need to monitor the Pliocene sequences in that area. This finding highlights the fossil potential of the site, suggesting that we may soon discover a more extensive and suitable sample for systematic determinations.

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Anexe

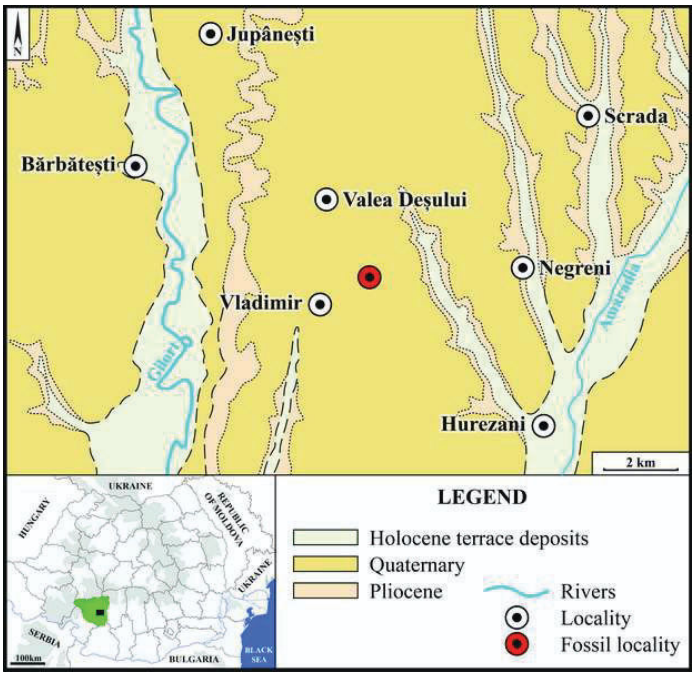

Fig. 1. Geological map of the Valea Deșului area, according to the geological map scale 1: 200000, folio 33 Tg. Jiu L-34-XXX (Codarcea et al., 1967).

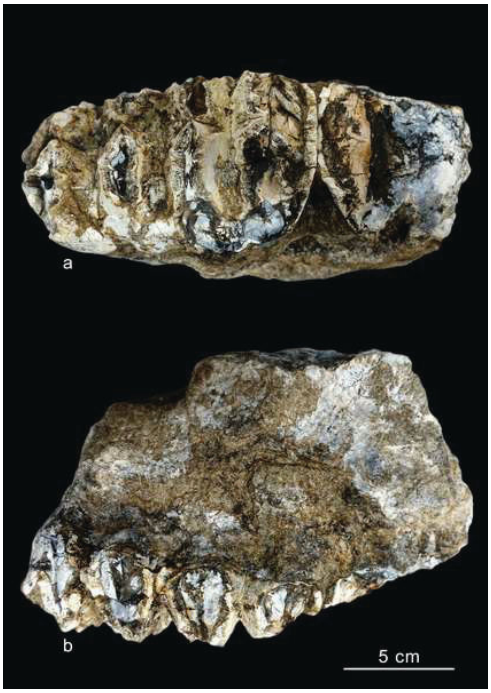

Fig. 2. "*Mammut*" *borsoni*, Valea Deșului, Gorj County (ASMTJ 35403). Upper right jaw fragment with M2-M3: a – occlusal view; b – lateral outer view.

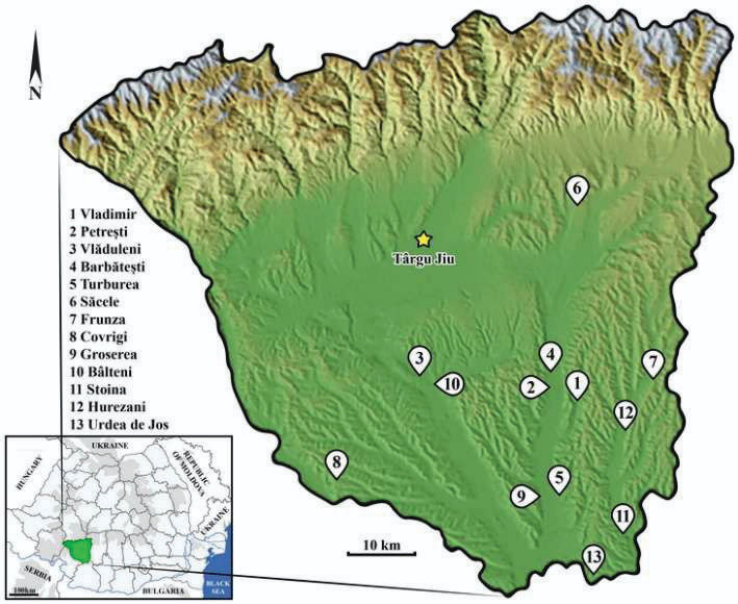

Fig. 3. Map of the Gorj County with "*Mammut*" *borsoni* localities.