The Upper Palaeolithic site of Bistricioara-*Lutărie III* (Ceahlău Basin, Northeastern Romania): raw materials and possible supply sources

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Abstract: *This paper brings to light new results regarding the petroarchaeological investigations of the lithic raw materials used at the multi-layered site of Bistricioara-*Lutărie III*. These investigations include a series of field surveys for the identification and sampling of geological deposits with archaeologically relevant siliceous rocks, but also a comparative petrographic analysis of archaeological and geological samples. Seven categories of knappable siliceous rocks, covering a diversity of geological settings and ages, were characterized based on samples collected from the study area (between Târgu Neamț, Borlești, Lacu Roșu, and Toplița). The analysis of 25 thin sections from Bistricioara-*Lutărie III *allowed distinguishing seven raw material categories. Four of them originate from geological occurrences in the study area, within a radius of 50 km from Bistricioara-*Lutărie III *(the Audia detrital siliceous rocks, Eocene chert, Hăghimaș syncline cherts, Toplița chert). Three others originate from the Prut-Dniester (the Prut-Dniester spiculite flint, Dniester Globotruncanidae flint) and Întorsura Buzăului (the Sita Buzăului chert) areas, located at >130 km NE and 155 km S.*

Rezumat: *Acest articol supune atenției noi rezultate privind investigațiile petroarheologice ale materiilor prime litice utilizate în situl pluristratificat de la Bistricioara-*Lutărie III*. Aceste investigații includ o serie de periegheze pentru identificarea și eșantionarea depozitelor geologice cu roci silicioase de importanță arheologică, dar și un studiu petrografic comparativ realizat pe probe arheologice și geologice. Șapte categorii de roci silicioase prelucrabile prin cioplire, care acoperă o diversitate de contexte și vârste geologice, au fost caracterizate pe baza eșantioanelor colectate din zona de studiu (între Târgu Neamț, Borlești, Lacu Roșu și Toplița). Analiza a 25 de secțiuni subțiri de la Bistricioara-*Lutărie III *a permis diferențierea a șapte categorii de materii prime. Patru dintre ele provin din ocurențe geologice din cadrul zonei de studiu, pe o rază de 50 km față de Bistricioara-*Lutărie III *(rocile silicioase detritice de Audia, silicolitul eocen, silicolitele din sinclinalul Hăghimaș, silicolitul de Toplița). Alte trei provin din zona Prut-Nistru (silexul spiculitic de Prut-Nistru, silexul de Nistru cu Globotruncanidae) și Întorsura Buzăului (silicolitul de Sita Buzăului), localizate la >130 km NE și 155 km S.*

Keywords: *petroarchaeology; microfacies analysis; chert; Middle Bistrița Valley.*
Cuvinte cheie: *petroarheologie; analiza de microfacies; silicolit; Valea Bistriței mijlocii.*

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◈ 1. Introduction

Many papers dealing with the Palaeolithic archaeology start with a remark regarding *lithics* as the most abundant or the only preserved archaeological remains. In subsequent lines we find out that the *lithics* convey various amounts of information regarding the past hunter-gatherers economic organization, raw material procurement patterns, scale of mobility, social and exchange networks. Therefore, the accurate characterization and sourcing of the lithic raw materials, reliable estimates on their natural availability, size and quality, but also their frequency, mode of introduction and exploitation in the assemblage, are all vital in securing solid inferences on any of the above topics.

For reasons largely discussed elsewhere (A. Doboș 2017; M. Anghelinu 2018) and despite recent reassessments and a growing corpus of data, the Romanian Palaeolithic research is still far from reaching a coherent image on the above-mentioned issues, even on a regional basis. The limits of our current knowledge are particularly evident in the case of the dense network of Upper Palaeolithic (UP) sites found along the Middle Bistriţa Valley (in Ceahlău Basin), which has otherwise been the focus of many published papers and reports since the mid 1950's onwards (C.S. Nicolăescu-Plopşor *et alii* 1966; Al. Păunescu 1998; L. Steguweit *et alii* 2009; A. Tuffreau *et alii* 2018; M. Anghelinu *et alii* 2018, 2021a, 2021b, and references therein).

Even with some notable progress in the provenience studies recorded in the last decades (for a brief research summary, see Al. Ciornei 2015, p. 44-45; L. Moreau *et alii* 2019, p. 522), the description of the lithic raw materials used during the UP in the Eastern Carpathians still lingers on some generic categories defined more than half a century ago. Four basic raw materials were recognised in the UP assemblages from Ceahlău Basin (C.S. Nicolăescu-Plopşor *et alii* 1966, p. 20, 23-24): the "Audia black schist" and the "glauconitic siliceous sandstone" from the Lower Cretaceous Audia Beds opened on Hangu Valley; the "menilite" from the Lower Oligocene deposits found between Bicaz and Piatra Neamţ (Bisericani area); and the "Prut flint" from the Middle Prut Valley.

The Eastern Carpathians Flysch raw materials were identified based on archaeological samples (with the petrographic bulletins partially published by Al. Păunescu 1970, p. 217-219; 1998, p. 46-48) and their supposed origin was acknowledged by Th. Joja (C.S. Nicolăescu-Plopşor *et alii* 1966, p. 20, note 17). So far, except this expedient verdict, there is no published comparative petrographic and/or geochemical analysis of archaeological and geological samples confirming the supposed provenience of the Eastern Carpathians Flysch raw materials.

Beside these well-known raw materials, pointing towards local Eastern/Southeastern supply sources, the archaeological literature also referrers to other siliceous rocks less frequently used (or recognised) in the UP sites from the Middle and Lower Bistriţa Valley.

Florea Mogoșanu mentioned a hydrothermal silex (hornstein) from the Baia Mare area (Bicsad and Boinești) at Ceahlău-*Bofu* and Ceahlău-*Scaune* (Fl. Mogoșanu 1960, p. 127). Maria Bitiri-Ciortescu remarked the presence at Lespezi-*Lutărie* of (red and yellow) jaspers and (greyish, reddish, and yellowish) hydrothermal opals (presumably originating) from Oaș-Maramureș area (M. Bitiri-Ciortescu *et alii* 1989, p. 14), but also a few isolated obsidian pieces at Buda-*Dealul Viilor* (M. Bitiri-Ciortescu *et alii* 1989, p. 22). Contrary to these views, Constantin Nicolăescu-Plopşor considered the dark or light grey vitreous hydrothermal silex from Ceahlău-*Scaune* as originating, based on determinations made by the geologist Mircea Ilie, from the Harghita-Călimani volcanic mountains (C.S. Nicolăescu-Plopşor 1958, p. 10; C.S. Nicolăescu-Plopşor *et alii* 1966, p. 103). The two alternative origins of the "opals" indicate remote Western and distant Northwestern supply sources.

Another raw material observed in the UP assemblages from Ceahlău Basin, but especially in the swiderian assemblage from Ceahlău-*Scaune* (C.S. Nicolăescu-Plopşor *et alii* 1961, p. 40; 1966, p. 103; Al. Păunescu 1970, p. 84), was considered to be supplied from a place called "Polița Cremenișului", a massive reef limestone on Ceahlău Mountain located at an absolute altitude of >1500 m. Alexandru Păunescu noted the presence in all the sites from Ceahlău Basin, in small quantities, of radiolarites/jaspers, probably from the Mesozoic deposits in the Hăghimaș syncline (Al. Păunescu 1970, p. 84, 219; 1998, p. 56). Other researchers remarked the use of opal and radiolarites/jaspers, but no specific origin was attached to those materials (L. Steguweit *et alii* 2009, p. 144, 149, 150). These mentions largely point towards close-by Southwestern/Southern supply sources.

The "Prut flint" was recognised by C.S. Nicolăescu-Plopşor, based on his experience and familiarity with this raw material (C.S. Nicolăescu-Plopşor *et alii* 1966, p. 23-24). Only later, the "Prut flint" was characterized from the supposed source (the Middle Prut Valley, between Rădăuţi and Liveni) and its presence in the UP sites from the Middle and Lower Bistriţa Valley echoed without a direct petrographic comparison between the source materials and the archaeological ones (A. Muraru 1990, p. 151-153). The results of the most recent research cast serious doubt on its reiterated supposed provenience (L. Moreau *et alii* 2019, p. 530; Al. Ciornei, I. Mariș 2020, p. 53, tab. 4). Whatever the exact sources of the Upper Cretaceous flints bundled under the "Prut flint" label, their presence in the UP sites from Ceahlău Basin indicate a distant Northeastern supply trajectory.

The so-called "Balkan flint" is another raw material less frequently used (and/or recognised by previous research) in the UP assemblages from the Middle and Lower Bistriţa Valley (Al. Ciornei 2015, p. 59, and references therein; A. Tuffreau *et alii* 2018, p. 149; L. Moreau *et alii* 2019, p. 523-526, and references therein). While a recent geochemical analysis (L. Moreau *et alii* 2019, p. 532) has partially failed in certifying its provenience, a newer study (Al. Ciornei, I. Mariș 2020, p. 52-53, tab. 4) confirmed the presence in several regional UP contexts of two Lower Danube Valley chert identical to samples from the gravels around the UP site of Giurgiu-*Malu Roşu*. The presence of the Sita Buzăului chert (from the Upper Buzău Valley) in several UP sites from the Middle and Lower Bistriţa Valley (Al. Ciornei, I. Mariș 2020, p. 53, tab. 4), together with the Lower Danube Valley cherts, corroborates a Southern direction of raw materials transferred over great distances from, otherwise ignored, chronologically and presumably culturally equivalent UP sites.

From this brief and incomplete overview emerges an image of the UP procurement in the Middle Bistriţa Valley in which the different raw materials originate from geologically distinct sources and transported over short and long distances from almost all cardinal points. However, this image is also overprinted by research biases and the unverified terminology used to name and label the siliceous rocks exploited during the UP in Ceahlău Basin.

As showed above, several issues regarding the raw materials characterization and provenience still need to be addressed without losing sight of the terminological inconsistencies. The ongoing archaeological research at Bistricioara-*Lutărie III* (hereafter BL III) provides an excellent opportunity to reopen the petroarchaeological investigations and take advantage of the well segregated and directly dated UP lithic assemblages. The present study focuses mostly on the Eastern Carpathians Flysch raw materials and the ones less well known or less frequently used (opals, radiolarites/jaspers). The results of the ongoing investigations on the Upper Cretaceous flint sources will be presented in detail in a subsequent paper.

◈ 2. Setting of Bistricioara-*Lutărie III*

The BL III site is located near Bistricioara village (Ceahlău commune, Neamţ County), on the right side of Bistriţa River (pl. I), at 500 m absolute altitude. The archaeological investigations (2008-2019) explored a total surface of 36 m² (trenches T0/2008, T1 and T2/2015, T3/2018, T4/2019) and identified six archaeological horizons (AH) attributed to the Late Gravettian and to Epigravettian occupations spread between ca. 27 ka cal BP and 20-15 ka BP (for an expanded discussion on the archaeological contexts, see M. Anghelinu *et alii* 2021a). The size of the lithic assemblages recovered so far at BL III varies markedly between the archaeological layers: 2 lithics (AH 3.1, Gravettian); 2217 and 3 lithics, respectively (AH 2.5 and AH 2.4, both Late Gravettian); 1402 and 5902, respectively (AH 2.3 and AH 2.2, Early Epigravettian); 2802 and 1958 lithics, respectively (AH 2.1 and AH 1.1) for the youngest Epigravettian layers (M. Anghelinu *et alii* 2021a).

In the site's wider physiographic setting the absolute altitudes range from 900-1000 m to 1200-1400 m, with Ceahlău Mountain (Toaca Peak - 1904 m; Ocolașu Mare - 1907 m) dominating this mountainous landscape. The main watercourse draining the area is Bistriţa River, with Largu, Bistricioara, Hangu, Bicaz, and Tarcău as the most important tributaries.

From south of Boroșteni to Piatra Neamţ, Bistriţa River runs through Cretaceous and Paleogene flysch deposits pertaining to Teleajen, Ceahlău, Audia, Tarcău, and Marginal Folds nappes (I. Băncilă 1955, 1958; T. Joja *et alii* 1968; Gr. Alexandrescu 1968; M. Săndulescu 1990; M. Amadori *et alii* 2012; F. Guerrera *et alii* 2012; M. Melinte-Dobrinescu, R. Roban 2011; R. Roban, M. Melinte-Dobrinescu 2012). Further to the West, Bistricioara and Bicaz rivers open, beside the flysch deposits of Teleajen and Ceahlău nappes (sandstones, shales, conglomerates), the Proterozoic-Palaeozoic metamorphic rocks, the Triassic-Jurassic sedimentary deposits, and the Lower Cretaceous wildflysch deposits (I. Băncilă 1958; L. Contescu 1968; Gr. Alexandrescu *et alii* 1968; C. Grasu 1971; M. Săndulescu 1975; I.I. Bucur *et alii* 2011). On the left side of Bistriţa River, Largu creek opens the flysch deposits of Teleajen (sandstones, shales), Audia (black shales), and Tarcău nappes (limestones, shales, sandstones), while Hangu the ones of Audia and Tarcău nappes. On the right side of Bistriţa River, Tarcău and Izvorul Muntelui cut through the Paleogene flysch deposits (sandstones, shales, marlstones, bituminous shales and dysodiles) of Tarcău Nappe, while Schitu creek exposes the Cretaceous flysch deposits of Teleajen and Ceahlău nappes.

On its middle course, Bistriţa River has narrower valley segments (between Secu and Cârnu, Izvorul Muntelui and Straja) or wider ones (between Hangu and Buhalniţa, Poiana Cârnului, Stejaru and Piatra Neamţ), influenced by the background geological composition, and up to 10 terrace levels, of which two are alluvial plain terraces (I. Donisă 1960, p. 390; 1961, p. 445-447).

The site is located in one of the widest segments of Bistriţa Valley known as Ceahlău (Răpciuni) Basin (C.S. Nicolăescu-Plopşor *et alii* 1966, p. 8), on a lower terrace (15-18 m relative altitude) composed of loess-derivate deposits, sandy and gravelly loam (5-9 m thick), and alluvial terrace gravels (O. Trandafir *et alii* 2015; M. Anghelinu *et alii* 2021a). The area immediately surrounding the site is composed of polymictic calcareous-micaceous sandstones, calcarenites, and silty micaceous shales (Piscu cu Brazi flysch, Barremian-Aptian, Ceahlău Nappe; M. Săndulescu 1990, p. 34). Slightly to the East of Schitu creek, the geology is dominated by convolute sandstones and shales (Curbicortical flysch, Lower Cretaceous, Teleajen Nappe; M. Săndulescu 1990, p. 39).

◈ 3. Materials and methods

The petroarchaeological investigation regarding the raw materials from BL III comprised several overlapping stages:

1) preliminary macroscopic analysis and sampling of the archaeological materials;

2) pre-field documentation and preparation;

3) field surveys for locating and sampling the geological deposits supposed to be the sources for the local raw materials ("Audia black schist", "glauconitic siliceous sandstone", "menilite", Hăghimaș syncline Mesozoic radiolarite/jasper);

4) petrographic analysis of the geological samples, origin control samples, and archaeological samples;

5) review regarding the geological occurrence of knappable lithic raw materials in the study area.

3.1. Field surveys for raw materials sources

The general goal of the field surveys was to locate and sample the geological deposits supposed to be the sources for the archaeological materials. A substantial part of this effort relied on the pre-field preparation and documentation: (1) the preliminary review of the petroarchaeological, archaeological, and geological bibliography regarding the raw materials used at the UP sites from Ceahlău Basin and their supposed area of provenience; (2) the correlation of the geological and topographic maps of the area with the reviewed information in order to determine physical locations to be checked during the field surveys.

The study area considered for the field surveys (pl. I), adjacent to the site and dictated by the supposed geological occurrences of the archaeological raw materials, extends between Galu, Petru Vodă, Straja, Tarcău, Dămuc, Lacu Roșu and Tulgheș localities, covering some 1300 km^2. The preliminary review allowed confining the survey area and delineating five research perimeters:

A) Audia - Petru Vodă (Cretaceous Flysch with "black schists" and siliceous sandstones), an area of 66 km^2;

B) Ceahlău Mountain (Ceahlău conglomerates with jaspers/radiolarites and greyish cherts), an area of 58 km^2;

C) Izvorul Alb - Tarcău (Paleogene Flysch with menilite), an area of 101 km^2;

D1) Tulgheș - Toșorog (the Crystalline-Mesozoic area with Hăghimaș syncline Mesozoic radiolarites/jaspers), an area of 100 km^2;

D2) Cheile Bicazului - Lacu Roșu (the Crystalline-Mesozoic area with Hăghimaș syncline Mesozoic radiolarites/jaspers), an area of 147 km^2.

The field surveys (2018-2019, 2021) were carried out as walks with broadly predetermined paths and objectives based on the pre-field documentation. All stops (observation and/or sampling locations) and field survey routes were recorded with a handheld GPS (Garmin eTrex 35, accuracy of 3 m). Due to logistical reasons, the last research perimeter (D2) was not surveyed.

3.2. Lithic raw materials characterization

The method employed for the lithic raw material characterization and sourcing is the petrographic analysis: a) the macroscopic examination (naked eye, hand lens) of all geological hand samples collected during the field surveys and of the artefacts from BL III; b) the microscopic analysis (thin sections) of representative geological and archaeological samples.

A batch of 350 artefacts from BL III were macroscopically analysed and sampled for thin sections in 2018. The analysed samples came from three excavation campaigns (2008, 2015 and 2018) and from three archaeological layers framed as Early Epigravettian (AH 2.2 and AH 2.3) and Late Gravettian (AH 2.5).

Beside the ones from the field survey, this study also includes geological samples of Paleogene cherts from the gravels of Nechit Valley (right-hand tributary of Bistrița River, lower course) and Secu creek (right-hand tributary of Neamţ River). The samples from Nechit Valley were collected during the field surveys conducted in 2013 (unpublished data) as part of the archaeological research at Buda-*Dealu Viilor* and Lespezi-*Lutărie* sites (Al. Ciornei 2015, p. 61, and references therein). The samples from Secu creek were collected in February 2021 during the archaeological diagnostic research on the feature path of A8-Unification Freeway (Târgu Neamț-Tulgheș sector).

The archaeological raw materials were identified through comparison with the geological samples from this study and with other materials available in the lithoteque at the "Vasile Pârvan" Institute of Archaeology (Petroarchaeology Laboratory). The lithoteque is still in the phase of gathering samples from various geological deposits and lacks archaeologically relevant rocks from many areas. To compensate for the gaps in the lithoteque, the supposed non-local (or outside of the surveyed area) and long-distance raw materials from BL III were confirmed by comparison with control samples from representative UP sites:

a) Toplița-*Pârâul Baicăului* (Harghita County) for the "Toplița chert" on the Upper Mureș Valley (M. Anghelinu *et alii* 2012, p. 272; 2013, p. 187; this is the closest known UP use of "opal" from local sources);

b) Cremenea-*Malu Dinu Buzea*, Gîlma-*Roate*, and Costanda-*Lădăuți* (Covasna County) for the Sita Buzăului chert on the Upper Buzău Valley (C.S. Nicolăescu-Plopşor, I. Pop 1959, p. 33; Al. Păunescu 1966, p. 324; Al. Păunescu, I. Pop 1961, p. 33; M. Cosac *et alii* 2014; 2015);

c) Ripiceni-*La Izvor* (Botoșani County, Romania; Al. Păunescu 1999, p. 45-46) and Oselivka-*Chisla Nedjimova* (Chernivtsi oblast, Ukraine)[1] for the "Prut-Dniester flint" (Middle Prut-Dniester area).

Throughout the paper, these sites will be called origin sites and the samples used for comparison will be called origin control samples (Al. Ciornei, I. Mariș 2020, p. 43). Though unorthodox, this methodological approach relies on a few prerequisites:

1) the sites exploiting the respective raw materials are culturally similar and more or less chronologically synchronous to BL III;

2) the sites are located very close or on top of the raw material source they exploit;

3) the raw material used for comparison is predominant in the assemblage and shows all reduction stages (from cortex removal to exhausted cores and tools).

The origin sites are not assumed to be the actual source of the compared raw materials, but rather a proxy (a general location) for their possible provenience when confirmed for a given site (such as BL III).

[1] The site was discovered by Ceslav Ambrojevici in 1925 (N.N. Moroşan 1933, p. 16-17; 1938, p. 106). The samples for thin sections were taken from the lithic collection curated at "Vasile Pârvan" Institute of Archaeology. The lithics, representing all reduction stages (with abundant cortical pieces and various tools), are knapped from several varieties of Prut-Dniester flint and Dniester Globotruncanidae flint (Al. Ciornei, I. Mariș 2020, p. 47, tab. 3). The lithic industry was considered (Al. Păunescu 1999, p. 43) as near identical to the Epigravettian one from Dorohoi-*Stracova* (Botoșani County).

A bibliographic review regarding the geological occurrences of knappable siliceous rocks was conducted to supplement the area covered by the field surveys. This was focused on the rock types similar to the ones sampled from geological deposits during the field surveys or similar to the raw materials described from BL III.

The macroscopic examination of the geological samples (collected during the field surveys), the additional geological samples, the origin control samples, and the artefacts from BL III provided general-propose characterizations and a basis for the thin section sampling. The macroscopic examination (naked eye, hand lens) was focused on recording the external (colour, type and consistency of cortex/rind, and naked eye visible fossils) and the internal features (type of fracture/break, light transmittance, lustre, colour and play of colours, absence or presence and distribution of inclusions, visible fossils or their absence).

The microscopic analysis was conducted at the Faculty of Geology and Geophysics (University of Bucharest) on an Olympus BX-40 petrographic microscope (at magnifications of 4×/0.10 P, 10/0.25 P, 20×/0.40 P, and 40×/0.65 P). Photomicrographs were taken with a DSLR camera attached on a Nikon Eclipse E200 Pol microscope at magnifications of 4× and 10×, 20×. Additionally, thin section photographs (at magnifications of 0.5× and 1×) were captured using a macro photography rig composed of a DSLR camera, a macro lens, a copystand, and a lightbox (for a detailed description of this technique, see M. Haaland *et alii* 2019, p. 105, and references therein). Images in plane polarized light (PPL) and cross-polarized light (XPL) were obtained using a sheet of polarizing film under the thin section and a circular polarizing filter on the macro lens.

The chert samples were classified according to microfacies criteria (primary constituents, such as the amounts and types of grains, matrix, and cement; mineralogy; depositional fabrics and associated environments; diagenetic fabrics; for details, see Al. Ciornei *et alii* 2014, p. 139; Al. Ciornei 2015, p. 46-49, and references therein). The amounts of primary constituents were estimated against visual comparison charts using the 1× photographs and directly in thin sections under the microscope with the 4× and 10× objectives.

The mudstones and sandstones were characterized according to the systematic petrography of siliciclastic rocks (F. Pettijohn *et alii* 1987; P. Potter *et alii* 2005; S. Boggs 2009). For the sandstone samples, the 15% matrix (normalized from the estimated amount at thin section surface) was used as threshold to distinguish between arenites and greywackes (F. Pettijohn *et alii* 1987, p. 144-146). The amount of quartz, feldspar and lithoclasts (plotted in the QFL ternary plot) were used to distinguish between quartz, arkose, and lithic arenite/greywacke. Throughout this paper, the term mudstone will be used generically for all fine-grained massive (non-fissile) indurated argillaceous rocks with at least 50% silt- and clay-sized particles in subequal amounts (P. Potter *et alii* 2005, p. 256-258).

No.	Date	Field survey	Walked distance (km)	Area (km²)	Stops (Observation and sampling points)	No. of samples		Objectives
						Collected	Thin sections	
01	19.06.2018	Audia - Audia creek - Obcina Hangului creek	14.6	0.13	8	76	16	Identify the occurrences and take samples of siliceous glauconitic sandstones and "Audia black schist" (Gr. Alexandrescu 1968, p. 140)
02	08.08.2019	Curmătura la Scaune - Cabana Dochia - Jgheabul cu Hotar - Durău	17.3	9.24	8	8	4	Identify the occurrences and take samples of siliceous rocks from the Ceahlău conglomerates (M. Săndulescu 1990, p. 36)
03	10.08.2019	Tarcău - Crasna Creek - Potoci creek	19.8	0.79	14	3	0	Verify and take samples of Oligocene menilites mentioned on Potoci creek (T. Filimon, A. Damian 1965, p. 43)
04	11.08.2019	Poiana Largului - Țiganului creek	7.3	0.03	14	49	11	Identify the occurrences and take samples of siliceous glauconitic sandstones and "Audia black schist" (Gr. Alexandrescu 1968, p. 141)
05	12.08.2019	Durău - Cabana Fântânele - Cabana Dochia - Piatra cu Apă	21	0.02	11	18	8	Identify the occurrences and take samples of siliceous rocks from the Ceahlău conglomerates; take samples from the siliceous rocks found in the limestone blocks (C. Grasu 1965, p. 73-74) contained by these conglomerates
06	13.09.2019	Hangu - Obcina Hangului creek - Grozăvești - Hangu	9.8	0.40	13	16	13	Identify the occurrences and take samples of siliceous glauconitic sandstones and "Audia black schist" (Gr. Alexandrescu 1968, p. 140)
07	14.08.2019	Izvorul Muntelui - Izvorul Muntelui creek	13.9	0.11	10	5	2	Identify the occurrences and take samples of siliceous rocks
08	15.08.2019	Tulgheș - Bălai creek	13	0.83	13	19	7	Identify the occurrences and take samples of Triassic and/or Jurassic radiolarites (M. Săndulescu 1975, p. 47-50)
09	16.08.2019	Pintec - Pârâul cu Pești creek	21.6	2.10	8	13	4	
10	03.08.2021	Curmătura la Scaune - Bistra Mică - Piatra Sură	17.7	9.70	10	24	0	Identify the occurrences and take samples of siliceous rocks from the Ceahlău conglomerates (P. Șoigan, Gr. Alexandrescu 1976, p. 226-229)
11	08.08.2021	Durău - Toaca - Cabana Dochia - Piatra Lată din Ghedeon	17.9	0.03	11	16	0	Take samples of siliceous rocks from the Ceahlău conglomerates (M. Săndulescu 1990, p. 36)
			173.9	**23.38**	**120**	**252**	**65**	

Tab. 1. General data regarding the field surveys conducted in the Middle Bistrița and Bistricioara basins (northeastern Romania).
Informații generale privind cercetările de teren realizate în bazinele Bistriței mijlocii și Bistricioarei (nord-estul României).

◈ 4. Results

4.1. Lithic raw materials from the study area

The field surveys are equally spread between the four research perimeters mentioned above, and cover 14 km² (pl. I, tab. 1). The geological samples collected from the four research perimeters, together with the additional geological samples from Nechit and Secu creeks and the origin control samples from Toplița define an extended study area between Târgu Neamț, Borlești (South of Piatra Neamț), Lacu Roșu, and Toplița.

The samples collected during the field surveys (pl. II-IV), those from additional geological locations, and the ones from the origin site were macroscopically classified and grouped in four rock categories (tab. 2; pl. V). The focus of the subsequent lines are the samples in categories 1-3 (tab. 3, pl. VI-XII). Our presentation will focus on those petrotypes that are for the first time described in a petroarchaeological work and are relevant for the archaeological materials (tab. 4, pl. XIII-XIV). The thin sections analysed from the fourth category are not the subject of this study (their main role was to provide supporting information when collected together with samples from categories 1-3).

Sampling areas	Geological context	Samples			(1)		(2)		(3)		(4)	
		Stops	Macroscopic analysis (MA)	Thin sections (TS)	Chert		Black mudstone		Sand-stone		Lime-stone, dolostone, marlstone	
					MA	TS	MA	TS	MA	TS	MA	TS
Secu	creek gravels	1	10	0	9	0	0	0	1	0	0	0
Nechit	creek gravels, Paleogene deposits	7	37	6	6	5	0	0	15	0	16	1
Potoci	Paleogene deposits, creek gravels	14	3	0	0	0	0	0	1	0	2	0
Izvorul Muntelui	Paleogene deposits, creek gravel	10	5	2	3	1	1	1	1	0	0	0
Hangu-Audia	Audia Fm, Hangu Fm, creek gravels	20	92	29	4	2	15	12	47	13	26	2
Țiganului	Audia Fm, Cârnu-Șiclău Fm, Hangu Fm	14	49	11	1	1	2	1	23	5	23	4
Ceahlău	Ceahlău cg, Neagra Mică Sst, Poiana Macilor Sst	40	71	12	59	11	0	0	2	0	10	1
Bălai-Pintec	creek gravels, Triassic dolostones and limestones, Wildflysh Fm	21	32	11	10	6	1	1	0	0	21	4
Toplița-Pârâul Baicăului	-	-	10	10	10	10	0	0	0	0	0	0
		127	**309**	**81**	**102**	**36**	**19**	**15**	**90**	**18**	**98**	**12**

Fm – Formation; Sst – Sandstone; cg – conglomerates.

Tab. 2. Rock samples from geological deposits and origin sites in the extended study area.
Probe de roci din depozite geologice și situri de origine din zona extinsă de studiu.

4.1.1. Paleogene cherts

The field surveys in Tarcău-Izvorul Muntelui area failed to locate any occurrences of Paleogene cherts as presumed from the available geological information and settings. Although not excluded, the possibility that the primary geological deposit might have been missed is very slim, as the presence of such cherts was not observed in the gravels of any of the surveyed creeks (Crasna, Potoci, and Izvorul Muntelui).

The samples of menilite (from the gravels of Secu and Nechit valleys) are dark brown to blackish, have greasy to glassy lustre, with whitish laminae at regular intervals and fractures oblique or perpendicular to the lamination (pl. V/1). The shape of the samples indicates this is a bedded chert from 3-5 to 8 cm thick, though some of the Secu samples reached a maximum thickness of 12-15 cm. No thin sections were prepared from this material, but previous petrographic descriptions indicate this is a chemical siliceous rock composed of crypto- to microcrystalline quartz groundmass enclosing radial concretions (chalcedony), subangular silt-sized detrital quartz (low content), pyrite, laminar or ocellar yellowish to brown organic bituminous matter, with no identifiable fossils and fine fractures filled by secondary quartz or iron oxide-hydroxides (see tab. 5; also M.G. Filipescu 1936, p. 611-612; C. Grasu *et alii* 1988, p. 142-144; D. Puglisi *et alii* 2006, p. 114-115)[2]. When struck, this chert breaks in uneven chunks (splintery break), more or less determined by the lamination and the oblique fractures and veins. The menilite can be found in both the Oligocene and Miocene deposits of the Tarcău and Marginal Folds nappes, which have a wide occurrence in the extended study area (tab. 5/33-37, pl. XV). The menilite outcrops are located at distances of 25-46 km ESE, E, and SE from BL III. They are also mentioned on Tarcău Valley, south of Schitu Tarcău, some 41 km SSE.

The Eocene chert, previously described from Lespezi-*Lutărie* archaeological samples as variety 4b (Al. Ciornei 2015, p. 50-51), was also identified in thin sections from Nechit valley. The Nechit samples have a medium greyish-brown colour, sometimes beige or dark greyish-brown, with yellowish-whitish cortex, translucent to semi-opaque, greasy to dull, smooth surface (pl. V/1). The quartz clasts are conspicuous in both hand samples (sparkling in the light) and in thin sections (coarse silt to fine sand, subangular to subrounded, 10-15%), and represent one of the main traits of this chert type. Based on the abundance of the various microfossils, two microfacies were distinguished (tab. 3): one dominated by the carbonaceous bioclasts (pl. VI/1-4), and one by sponge spicules and radiolarians (pl. VI/5-8). Planktonic and benthic foraminifera are abundant (pl. VI/8). Burrowing of the sediment is evidenced as irregular shaped areas with very fragmented and jumbled bioclasts (pl. VI/7). These observations are suggestive for a deep shelf depositional setting. This chert has suffered a late episode of siderite/ankerite replacement by calcite, resulting in a particular appearance that leaves the impression of the chert being poorly silicified.

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[2] In thin sections, the Oligocene menilite from Valea Morii Fm. (Valea Morii, Vișeu de Jos, Maramureș County) exhibits two microfacies: one is composed of a microcrystalline quartz groundmass with disseminated amorphous iron oxy-hydroxides and organic matter (dark brownish-yellowish) oriented parallel to the stratification plane, poorly preserved microfossils (?) (passed through a mould stage and filled with chalcedony), rare silty quartz and phyllosilicate clasts, opaque minerals, and abundant rhombohedral siderite/ankerite crystals; the second one has a similar composition, but shows clear evidence of a calcitization process (with variable amount of calcite pseudomorphs after rhombohedral siderite/ankerite crystals). The Oligocene menilites from Maramureș exhibit signs of brittle deformation: systematic and overprinting fractures, oblique and perpendicular to the stratification plane, but also breccia fabric (unpublished data, Ciornei *et alii*, in preparation).

Based on the microfauna contained, the supposed primary geological deposit of this chert is the Doamna limestone Fm. that outcrops on Nechit Valley (pl. XV/1), not reached during the field surveys from 2013. The Doamna limestones are known to contain chaille-type cherts. The petrographic traits of the samples from Nechit Valley are in accordance with the petrographic description of the Doamna limestone and of the siliceous accidents found in them (tab. 5). In the extended study area, these deposits outcrop in the Marginal Folds Nappe, from S of Nechit Valley and up to N of Cracău Valley (tab. 5/28-32, pl. XV), stretching 40-45 km on a NNW-SSE direction.

4.1.2. Cretaceous detrital-rich siliceous rocks and sandstones

The Cretaceous deposits of the Audia and Tarcău nappes exposed on Hangu and Țiganului valleys yielded three categories of knappable siliceous rocks: the Audia detrital siliceous rocks, the Audia glauconitic sandstones, and the Cârnu-Șiclău radiolarian chert.

The analysed thin sections of Audia detrital siliceous rocks come mainly from the outcrop on Hangu Valley (GPS point Au 00, Middle Mb. of Audia Fm., Audia Nappe). Just one sample (detrital-rich spiculite) was analysed from the Middle Mb. of Audia Fm. (Tarcău Nappe, GPS point Tig 01) outcropping on Țiganului Valley. On Hangu Valley, the grey and black shales are interlayered with apparently massive blackish and greyish mudstone, limestone, and sandstone layers (pl. II), which exhibit partings (5, 10 or 15 cm thick) along the bedding plane. The thin sections (11) continuously prepared from an apparently massive (45 cm thick) rusty weathered blackish mudstone layer (Au 00-7, pl. II/2-3) reveal a fining-upward depositional sequence (tab. 3): a medium-dark greyish laminated layer (7 cm thick) with detrital-rich spiculite (Au [00-7J-A.1]) and calcareous glauconitic sublithic arenite (Au [00-7J-A.2]); a dark greyish-blackish layer (15 cm thick) with glauconitic lithic greywacke (Au [00-7J-B], Au [00-7J-C]); a dark greyish-blackish layer (10 cm thick) with glauconitic lithic greywacke (Au [00-7J-D.1]), detrital-rich spiculite (Au [00-7J-D.2]), and glauconitic lithic greywacke (Au [00-7J-E]); a medium-dark greyish laminated layer (3 cm thick) containing a detrital-rich spiculite packstone/radiolarian wackestone (Au [00-7J-F]); a dark greyish-blackish layer (10 cm thick) of carbonaceous mudstone (Au [00-7J-G], Au [00-7J-H], Au [00-7J-I]). This sequence (detrital-rich spiculite-lithic greywacke-mudstone) repeats itself in layers Au 00-13 (laminated detrital-rich spiculite, Au [00-13.1], and glauconitic lithic greywacke, Au [00-13.2]) and Au 00-10 (carbonaceous mudstone, Au [00-10]) found 3-4 metres SW from layer 7 (pl. II/4-5).

Macroscopically, the detrital-rich spiculite and the sublithic arenite have a medium-dark greyish laminated appearance, dull and rough surface (pl. V/2). The detrital-rich spiculite contains abundant siliceous sponge spicules, radiolarians, quartz clasts, benthic and planktonic foraminifera, organic matter, and opaque minerals (pl. VIII/1-2). The particles are well-sorted medium to fine sand with a strong orientation parallel to the bedding plane. The laminated calcareous glauconitic sublithic arenite is composed of quartz clasts, lithoclasts, benthic and planktonic foraminifera, fragments of various fossils (echinoderms, algae), and glauconite. In both petrotypes, the predominant interparticle cement is crypto- to microcrystalline calcite, with overgrowths on bioclasts and pseudomorphs after rhombohedral crystals of siderite/ankerite.

The glauconitic lithic greywacke is blackish, dull, opaque, with thin discontinuous laminae, oval, or lens-shaped whitish inclusions arranged parallel to the bedding plane and describing a lineation fabric (pl. V/2). It is composed of medium sand sized detrital quartz, mica, carbonaceous bioclasts, coarse sand sized siliceous and argillaceous oval-shaped rock fragments, carbonate intraclasts (similar to sample Au [00-8], which is a bioclastic ferruginous cryptocrystalline limestone), all encompassed in a mixed mud and cryptocrystalline silica groundmass. The particles have parallel orientation to the bedding plane, which is outlined by thin dark brownish anastomosing dissolution seams, discontinuous laminae with quartz grains, but also accumulations of organic matter, flattened siliceous and argillaceous rip-up clasts (pl. VII/3-4). Both the oval and the flattened shaped ones are composed of cryptocrystalline silica with radiolarians (conserved in cryptocrystalline silica, sometime calcitized), silty quartz clasts, and very fine-grained phyllosilicates. The ones with a flattened shape have one straight lateral outline and the other shredded (or both shredded). Further in the sequence, the carbonaceous mudstone (sample Au [00-7J-G]) contains similar siliceous rip-up clasts, only they are smaller.

Sample Au [00-7J-F] has a dull medium-dark greyish laminated appearance (pl. V/2) which corresponds to a compositional lamination. The lower half of the thin section, towards sample Au [00-7J-E], is composed of alternating thick laminae of detrital-rich spiculite packstone (sponge spicules, radiolarians, detrital quartz, phyllosilicates, carbonaceous bioclasts, intraclasts) and very thin laminae of mudstone with organic matter accumulations. The upper half of the thin section, towards sample Au [00-7J-G], is composed of alternating thicker laminae of radiolarian wackestone (with radiolarians, sponge spicules, detrital quartz, phyllosilicates) and thin laminae of mudstone with organic matter accumulations (pl. VII/5-6). The particles are well-sorted very fine sand (to coarse silt) and show a strong orientation parallel to the bedding plane. The overall groundmass is a mix of mud and cryptocrystalline silica (as matrix) and crypto- to microcrystalline calcite cement, calcite pseudomorphs after siderite/ankerite, and syntaxial overgrowth calcite cement.

The carbonaceous mudstone, previously designated as Audia "black schist" MF 2 (Al. Ciornei, I. Mariș 2020, p. 47, tab. 3), is blackish to dark greyish, dull, opaque, very fine-grained, with a smooth surface and conchoidal break (pl. V/2). It is composed of a mixed siliceous and mud groundmass invaded by calcite (mostly pseudomorphs after siderite/ankerite), with radiolarians, sponge spicules, fragmented carbonate bioclasts, silty quartz clasts and phyllosilicates. The silt-sized particles are well sorted and fixed in a mud and cryptocrystalline silica groundmass invaded by calcite pseudomorphs after siderite/ankerite (pl. VII/7-8, VIII/3-4). The phyllosilicates are very fine-grained mica (sericite) forming a continuous foliation. The presence of calcite pseudomorphs after siderite/ankerite, the radiolarians filled with calcite, the cryptocrystalline calcite cement, and the syntaxial overgrowth calcite cement on carbonate bioclasts point out to a later episode of calcitization. By comparison, sample Le-Lu [07] (variety 2b) from Lespezi-*Lutărie* is similar to the samples from Au 00, but is even more carbonaceous.

The sample of "black schist" found in the gravels of Izvorul Muntelui creek (IzMu [02.3]) was determined as a laminated detrital-rich radiolarian chert (tab. 3, pl. VIII/5-6). The groundmass is a mix of cryptocrystalline silica and organic matter. Beside radiolarians, this petrotype also contains sponge spicules (siliceous), planktonic foraminifera, carbonate bioclasts, opaque minerals, siderite/ankerite, pseudomorphs after siderite/ankerite, silty quartz clasts, and very fine-grained mica (sericite) forming a continuous foliation. This petrotype is partially relatable to sample Au [00-7J-F].

Most of the Audia sandstone samples analysed in this study were collected from the poorly exposed outcrops on Hangu Valley (GPS points Au 11-15, Upper Mb. of Audia Fm., Audia Nappe, pl. III/1-2), but also from the better exposed outcrops on Țiganului Valley (GPS points Tig 02-02d, Upper Mb. of Audia Fm., Tarcău Nappe, pl. III/3-4). In fresh break, the sandstones are medium to dark grey or slightly grey-greenish, with greasy or glassy lustre and smooth surface or with dull and rough surface (pl. V/3). They are composed of angular/subangular to subrounded quartz clasts (with undulose extinction or subgrain boundaries), lithoclasts, bioclasts (fragments of echinoderms, algae, bivalve and mollusc shells, sponge spicules), phyllosilicates (mostly white mica), and feldspars. The content of heavy minerals is around 0.5%, with a notable amount of 1% in sample Au [09.1]. The average content of glauconite peloids is around 5% (up to 7-8% in some samples). Based on their matrix to cement content, the samples can be described as sublithic arenites and lithic greywackes (tab. 3, pl. IX). Further differentiation is given by grain size, samples ranging from very fine sand (pl. IX/1-2), fine sand (pl. IX/5-8) to medium sand (pl. IX/3-4). All samples are poorly (sometimes moderately) sorted with larger subrounded/rounded quartz clasts and smaller angular/subangular quartz clasts in-between the larger ones. The predominant cement type holding the particles together is either siliceous (pl. IX/1-6) or calcareous (pl. IX/7-8). All samples contain various amounts of dispersed rhombohedral crystals of siderite/ankerite, most of them replaced by calcite (giving the false appearance of a fine-grained "carbonate matrix"). The calcareous and siliceous sublithic arenite petrotypes are very similar with varieties 1c (Le-Lu [03], [05]) and 1d (Le-Lu [04]) from Lespezi-*Lutărie*, which were described as quartzarenites (Al. Ciornei 2015, p. 49). After reanalysis and comparison with the ones from this study, they were reclassified as sublithic arenites.

Some different types of sandstones were collected from other geological deposits, but most of them were deemed (macroscopically) not compatible with the archaeological materials or not suitable for knapping. Of these, one sandstone sample from Audia Valley (GPS point Au 01, Hangu Fm., Late Campanian-Maastrichtian, Tarcău Nappe) caught our attention. It has a medium grey-greenish dull and rough surface and conchoidal break (pl. V/3). This is a calcareous glauconitic sublithic arenite (very fine sand) composed of quartz clasts, lithoclasts (metamorphic and sedimentary rocks), bioclasts, feldspars, glauconite peloids (10%), and phyllosilicates held in a calcite cement, but without the siderite/ankerite pseudomorphs very conspicuous in the Audia sandstones.

On Țiganului Valley, a greenish fine-grained bedded chert (4-5 cm thick) is intercalated within the greenish and reddish shales of the Cârnu-Șiclău Fm. (Tarcău Nappe, GPS point Tig 03, pl. III/5-6). This chert is composed of radiolarians and subangular silty quartz clasts held together in a cryptocrystalline silica, organic matter and fine chlorite groundmass (tab. 3, pl. V/2, VIII/7-8). The peculiarity of this chert is the overprint of the groundmass by sericite forming a continuous foliation subparallel to the orientation of the radiolarians.

The Audia detrital siliceous rocks, the Audia glauconitic sandstones, and the Cârnu-Șiclău radiolarian chert are derived from geological formations that outcrop together in the Audia (as a narrow E-W strip, but continuous on the N-S direction) and Tarcău (as anticlines) nappes (tab. 5/41-42, pl. XV). Similar siliceous rocks are mentioned in the Sărata and Upper Tisaru formations (chronostratigraphic equivalents of the Audia and Cârnu-Șiclău formations) outcropping in the Marginal Folds Nappe, around Piatra Neamț (tab. 5/38-40, pl. XV).

4.1.3. Ceahlău cherts

The field surveys in the Ceahlău Mountain documented the presence of siliceous rocks at several locations in the Ceahlău conglomerates (Ceahlău Nappe, pl. IV/1-8), the Urgonian limestones block at Piatra cu Apă (GPS point Chl 14, pl. IV/9), and creek gravels (pl. IV/10). These siliceous rocks exhibit similar petrographic traits ranging from chert to silicified limestone. The chert has a medium greyish or greyish-brownish to dark greyish colour, greasy lustre, translucent to semi-translucent. The silicified limestone is medium grained, grey-brownish to dark grey, dull and rough surface, opaque, with abundant detrital quartz. The chert gradually transitions outwards or contains within a medium-grained, dull, beige or grey carbonaceous material. The silicified limestone contains mm-sized cherty patches, sometimes becoming extensive cm-sized areas. Some of the samples have a laminated appearance, with brownish or dark greyish chert laminae alternating with greyish or beige silicified limestone ones. Other samples represent a laminated chert composed of a thicker chert layer with thin laminae of silicified limestone, transitioning outwards to a beige or grey-whitish carbonaceous material. The chert and the silicified limestone occur in the conglomerates as subangular fragments of pebble-cobble size with a morphology suggesting a tabular (lens-like) initial shape. At Piatra cu Apă, the silicified limestone occurs in primary position as small nodules (<10 cm), but C. Grasu (1965, p. 74) mentioned ellipsoidal silicified areas longer than 30 cm.

Thin sections of these materials show benthic and planktonic microfauna and small intraclasts/peloids held together in a microcrystalline silica cement. Very conspicuous is the presence in several samples of involutinid foraminifera with monocrystalline test (in the centre of pl. X/4). The abundance and association of various fossils and non-skeletal particles allows separating three microfacies: (1) dominated by sponge spicules and radiolarians (MF 1); (2) with abundant echinoderm fragments (MF 2); (3) dominated by carbonaceous small intraclasts/peloids with subordinated sponge spicules and radiolarians (MF 3). These so-called small intraclasts/peloids are composed of micrite, have uniform size (40-250 μm), spherical or ovoid shaped (rarely rod-like), no internal structure, and are most probably faecal pellets. Hence, MF 3 might represent a poorly silicified pelletal limestone. The combination of these microfacies results into two main petrotypes composed of MF 1, respectively MF 2, with laminae or irregular areas of MF 3 (tab. 3, pl. X/1-4). A third petrotype is represented by the laminated chert, which is composed of alternating laminae of MF 3, MF 2 and MF 1 (pl. X/7-8)[3]. The silicified limestone from Piatra cu Apă has a near identical petrographic composition to MF 1, but represents a patchy silicified limestone showing ample evidence of a later calcitization episode affecting the particles (partially or totally infilling the sponge spicules and radiolarians, and with syntaxial overgrowth cement on carbonaceous bioclasts and non-skeletal particles) and the siliceous groundmass (tab. 3, pl. V/4, X/5-6).

All samples contain rhombohedral crystals with slightly curved outlines, dispersed in the groundmass, as interparticle cement, and as intraparticle cement (partially infilling the interior of sponge spicules or other bioclasts), most probably representing dolomite. The dolomitization is later then the silicification process. The syntaxial overgrowth calcite cement on carbonate bioclasts bordering the rhombohedral crystals, or several crystals bounded by a syntaxial calcite cement, together with the dark coloured coatings on the rhombohedral crystals indicate a dedolomitization process (replacement of dolomite by calcite). Many of the chert samples display evidence of pressure solution (stylolites) and tensile fracturing (systematic fractures filled with opaque minerals and amorphous iron oxide-hydroxides or with sparry calcite). All evidence points towards a dolomitized chert later affected by an episode of calcitization. This process seems stronger in the silicified limestone samples from Piatra cu Apă and in MF 3, both of which seem less affected by the dolomitization process.

On one hand, the Ceahlău chert petrotypes exhibit broad petrographic similarity with the descriptions for the Callovian-Oxfordian silicified pelletal limestones, the Kimmeridgian-Tithonian silicified limestones, and the Jurassic-Lower Cretaceous cherts mentioned in the Ceahlău conglomerates (tab. 5/43, pl. XV/4). On the other hand, the samples of Ceahlău cherts

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[3] After re-examination, sample Le-Lu [06] from Lespezi-*Lutărie* was found to fit within this description.

and silicified limestone from this study have similar petrographic traits. Hence, it is very possible that the Ceahlău conglomerates comprise several different materials (of which only a few were sampled and described in this study) originally derived from distinct geological deposits. The sampling points are located at a distance of 7-16 km S, SSW, and SE from BL III, but such materials might be present in the creeks descending from Ceahlău Mt. towards Bistriţa Valley (such as Schitu creek).

4.1.4. Hăghimaș syncline cherts

Under this heading, we include those siliceous rocks generally called by Romanian archaeologist radiolarites/jaspers derived from the Mesozoic deposits in the Hăghimaș syncline. Such cherts were identified in the gravels of Bălai and Pintec creeks and their tributaries (GPS points Bal 01-04, 07, Chi 01, Pin 01-02). They are very fine-grained and have various shades of green, red, or show bicoloured lamination. Similar siliceous rocks were also identified on Ceahlău Mountain in the conglomerates (GPS points Chl 10, 22, and 23b). The primary geological deposits with such rocks have not been located during the field surveys.

The analysed thin sections were prepared only from the samples collected from the gravels of Bălai creek. Based on their petrographic traits, two groups were differentiated: radiolarian-bearing siliceous rocks and mollusc shells chert (pl. V/5, XI). The sample (Bal [07.1]) determined as mollusc shells chert is composed of a reddish, translucent, greasy siliceous part which transitions outwards to a greyish-beige limestone. In thin section, the reddish part is characterized by densely packed mollusc shells (packstone) held in a microcrystalline silica cement with voids filled by botryoidal chalcedony and megaquartz cements (tab. 3, pl. XI/1-2). The limestone part of the sample has the same petrographic composition, only it retains the original mineralogy (calcite).

The radiolarian-bearing siliceous rocks have various amounts of radiolarians with different mineralogy and fabrics (tab. 3). From a mineralogical point of view, the samples can be classified as chert (Bal [03.1], [02.2]), carbonaceous chert (Bal [01.3]), mixed siliceous-carbonaceous (Bal [04.1]) or siliceous-ferruginous-carbonaceous (Bal [04.2]) rocks. The mixed types are dull and opaque in hand samples, while the cherts are semi-translucent and have greasy lustre. The amount of radiolarians (J. Halamić, S. Klindžić 2009, p. 19-20) gives the basic division between radiolarian cherts (<50%) and radiolarites (>50%). Further differentiation is provided by the groundmass composition (crypto- or microcrystalline silica with chlorite or amorphous iron oxides-hydroxides), the content of detrital quartz and phyllosilicates, or the presence of calcite cement replacing the groundmass and the radiolarians (pl. XI/3-8). Specific radiolarian genus associations allowed discriminating between Triassic (dominated by *Liosphaera* and *Cenosphaera*) and Jurassic (dominated by *Heliodiscus*, *Rhopalastrum*, *Hagiastrum*, *Cenosphaera*) radiolarian-bearing siliceous rocks (tab. 3; pl. XI/4, XI/6, XI/8). Two petrotypes (the medium greenish, Bal [03.1], and the light greenish, Bal [02.2]) have a low detrital content and no carbonate cement. The intense greenish radiolarian chert (Bal [01.3]) has a high content of detrital quartz and phyllosilicates, shows ample evidence of calcite replacing the silica (in the groundmass and radiolarians), but also areas with chlorite disseminated in the groundmass and infilling the radiolarians (pl. XI/6). The mixed petrotypes (reddish, Bal [04.2], and bicoloured laminated, Bal [04.1]) have a low content of silica (for the most part replaced by calcite) and a high content of detrital quartz and phyllosilicates. The radiolarian-bearing siliceous rocks exhibit deformational fabric elements such as systematic conjugate fractures (crackle breccia fabric), microfolds, stylolites, and sericite disjunctive spaced foliation. When struck, some of them break along these fabric elements, resulting in irregular chunks.

The petrographic composition of the radiolarian-bearing siliceous rocks is in general agreement with the descriptions of similar rocks encountered in the Triassic, Jurassic and Lower Cretaceous deposits from Hăghieș-Criminiș area (tab. 5/44-47, pl. XV), but also from Chicera Mt., Stânei Valley, and Lacu Roșu-Valea Rece area (tab. 5/48-51, pl. XV). Such rocks are also mentioned in the Ceahlău conglomerates (tab. 5/43, pl. XV/4).

4.1.5. Toplița chert

The analysed samples come from the origin site of Toplița-*Pârâul Baicăului* near Toplița town (Harghita County), in the Upper Mureș Valley (between Călimani and Gurghiu Mts.). The geological context of the origin site is represented by the Neogene Fâncel-Lăpușna Volcaniclastic Fm. (D. Rădulescu *et alii* 1973, p. 21-22; T. Bandrabur, V. Codarcea 1974, p. 34, 36-38): pyroclastic breccias and microbreccias with intercalations of tuffs, epiclastic rocks, and flows of basaltic andesites; lacustrine deposits (conglomerates, microconglomerates, sands, sandstones, clays) alternating with coarse and fine pyroclastic rocks (Andreneasa, Lunca Bradului, Neagra, and Toplița lacustrine basins). The epiclastic deposits contain incarbonized or silicified ligneous and herbaceous remains.

The samples of Toplița chert have an attractive gem-like appearance as they are variably and intensely multi-coloured, with very fine-grained and smooth surfaces (sometimes medium-grained and a rough surface), from dull and opaque to greasy and translucent (pl. V/6). Some of the samples have a whitish very fine-grained "tuff-like" cortex. The petrographic composition allows discriminating between two types of chert: one devoid of fossils and one fossiliferous (tab. 3).

Eight out of the ten samples analysed depict a very well silicified material with a variety of non-sedimentary fabrics which can be abridged as follows: massive fabric with microcrystalline silica groundmass containing disseminated opaque minerals and amorphous iron oxide-hydroxides, irregular veins and voids filled with chalcedony or amorphous iron oxide-hydroxides (pl. XII/1-2); breccia fabric with irregular shaped clasts (microcrystalline quartz, chalcedony, amorphous iron oxide-hydroxides/opaque minerals) vaguely outlined either by surrounding crypto- to microcrystalline silica groundmass/amorphous iron oxide-hydroxides or by irregular voids filled with chalcedony and/or iron oxide-hydroxides (pl. XII/3-4); flow-banding fabric with microcrystalline silica or amorphous iron oxide-hydroxides bands wrapping around oval or rectangular shaped silicified clasts (pl. XII/5-6). These fabrics together with the notable absence of fossils and the texture of the silica polymorphs (well-developed microcrystalline quartz and chalcedony) indicate a hydrothermal related silicification in volcaniclastic deposits.

Two of the analysed samples contain fossils: one is composed of algae, charophyta gyrogonites, and mollusc shells fixed in a microcrystalline silica groundmass impregnated with amorphous iron oxide-hydroxides and organic matter (tab. 3, pl. XII/7-8); the other sample shows laminae of whole algae or algal fragments/detritus alternating with laminae of microcrystalline silica, amorphous iron oxide-hydroxides, and organic matter. The fossils indicate a lacustrine/lagoon depositional environment. The silicification is less strong, but displays the same well-developed microcrystalline quartz and chalcedony. The fossiliferous samples indicate a hydrothermally related silicification of lacustrine deposits.

The petrographic traits of Toplița chert (i.e., hydrothermally silicified volcaniclastic rocks and lake sediments, in stark contrast to all materials presented above) confirms a handful of mentions (missing a petrographic description) from Toplița area, which trace a recurrent occurrence of siliceous rocks in a specific volcanic setting (tab. 5/52-56, pl. XV/6).

Rock category and petrotype		Geological context	Particles	Matrix	Cement	Fabric
Eocene chert	detrital-rich bioclastic chert	Nechit creek gravels (derived from the Doamna Limestone Fm., Eocene)	CarbBio, SpoSpi, Radio, Qd (coarse silt-fine arenite)	RS	Qcc, RhoPse	detrital-rich bioclastic cementstone (MF 1)
	detrital-rich bioclastic (spiculitic) chert		SpoSpi, Radio, PlaFo, BenFo, CarbBio, Qd (coarse silt-fine arenite)	RS	Qcc, RhoPse	detrital-rich bioclastic wackestone (MF 2)
Audia detrital siliceous rocks	detrital-rich spiculite	Audia Fm., Middle Mb. (Late Barremian-Early Albian)	SpoSpi, Radio, BenFo, PlaFo, rip-up clasts, CarbBio, Qd, Phyl, Gla, Opq	mud	Cal, SyntCal, Rho, RhoPse	detrital-rich packstone or packed wackestone spiculite
	laminated calcareous glauconitic sublithic arenite (very fine sand)		Qd, CarbBio, SpoSpi, BenFo, PlaFo, Gla, Phyl, rip-up clasts, Opq	mud	Cal, Rho, RhoPse	calcareous sublithic arenite
	glauconitic lithic greywacke (medium sand)		Qd, CarbBio, SpoSpi, rip-up clasts, Phyl, PlaFo, BenFo, Gla, Opq, Feldspars	mud+Qcc	Sid, RhoPse	lithic greywacke
	laminated detrital-rich spiculite/radiolarian wackestone		SpoSpi/Radio, PlaFo, CarbBio, rip-up clasts, Phyl+Qd, Gla, Opq	mud	Cal, Rho, RhoPse	laminated detrital-rich spiculite/radiolarian wackestone
	carbonaceous black mudstone		Radio, SpoSpi, PlaFo, CarbBio (?), rip-up clasts, Phyl+Qd, Gla, Opq	mud+Qcc	Rho, RhoPse	carbonaceous siliceous mudstone
	laminated carbonaceous black radiolarian chert	Izvorul Muntelui creek gravels	Radio, SpoSpi, PlaFo, CarbBio (?), InCl, Phyl+Qd, Gla, Opq	mud+Qcc	Rho, RhoPse	laminated carbonaceous radiolarian wackestone
Audia glauconitic sandstones	calcareous glauconitic sublithic arenite (fine sand)	Audia Fm., Upper Mb. (Early-Late Albian)	Qd, lithoclasts (metamorphic, radiolarian and micaceous chert, argillaceous, carbonate), Gla, CarbBio, SpiSpo, Phyl, Feldspars, Opq	mud	Cal, SyntCal, Rho, RhoPse, Qcc	calcareous sublithic arenite
	siliceous glauconitic sublithic arenite (medium to fine sand)				Qcc, Rho, RhoPse, SyntCal	siliceous sublithic arenite
	siliceous glauconitic lithic greywacke (medium to fine sand)				Qcc, Rho, RhoPse, SyntCal	siliceous lithic greywacke
	siliceous-calcareous glauconitic lithic greywacke (very fine sand)				Qcc, RhoPse, SyntCal, Rho	siliceous-calcareous lithic greywacke
Cârnu-Șiclău radiolarian chert		Cârnu-Șiclău Fm. (Upper Cretaceous)	Radio, SpoSpi, Phyl, Qd	Qcc+RS +chlorite	-	sericite-rich radiolarian wackestone

BenFo – benthic foraminifera; PlaFo – planktonic foraminifera; InvoFo – involutinid foraminifera; CarbBio – carbonaceous bioclasts (echinoderms, algae, sponge spicules, mollusc, bivalves); InCl – intraclasts; SpoSpi – siliceous sponge spicules; Radio – radiolarians.
Qd – detrital quartz clasts; Phyl – phyllosilicate clasts; Phyl+Qd – silty fraction of detrital quartz and phyllosilicate clasts; RS – residue; OM – organic matter.
Qcc – cryptocrystalline quartz (1-4 μm); Qm – microcrystalline quartz (4-20 μm); Qf – chalcedony; MQ – drusy megaquartz (> 20 μm, subhedral to euhedral crystals); Cal – crypto- or microcrystalline calcite cement; SyntCal – syntaxial overgrowth calcite cement; Rho – rhombohedral siderite/ankerite/dolomite crystals; RhoPse – calcite pseudomorphs after siderite/ankerite/dolomite; Fe ox-hy – amorphous iron oxide-hydroxides; Opq - opaque minerals; Gla – glauconite peloids; MF – microfacies; Mb. – Member; Fm. – Formation.

Tab. 3. Petrographic characteristics of the samples from geological deposits and origin sites.
Caracteristicile petrografice ale probelor din depozite geologice și situri de origine.

	Rock category and petrotype	Geological context	Particles	Matrix	Cement	Fabric
Ceahlău cherts	spiculitic-intraclastic chert	Ceahlău conglomerates (Albian)	SpoSpi, Radio, CarbBio, small InCl/peloids, InvoFo, Qd, Phyl	RS	Qm, RhoPse, SyntCal, Cal	dedolomitized spiculitic-intraclastic wackestone (MF 1) + dedolomitized intraclastic/peloidal packed wackestone (MF 3)
	bioclastic-intraclastic chert		CarbBio, SpoSpi, Radio, small InCl/peloids, InvoFo, Qd, Phyl	RS	Qm, Qf, RhoPse, SyntCal, Cal	dedolomitized bioclastic-intraclastic wackestone (MF 2) + MF 3
	laminated chert		small InCl/peloids, CarbBio, SpoSpi, Radio, Qd, Phyl	RS	Qm, RhoPse, SyntCal, Cal	alternating laminae of MF 3, MF 2, MF 1
	spiculitic-intraclastic calcareous chert	Urgonian limestone	SpoSpi, CarbBio, Radio, small InCl/peloids, InvoFo, Qd, Phyl	RS	Cal, RhoPse, Qm	dedolomitized spiculitic-intraclastic wackestone
Hăghimaș syncline cherts	greenish radiolarite (Bal [03.1])	Jurassic, Bucovinian Nappe	Radio (60%), SpoSpi, Qd, Phyl	Qm+RS	-	packed wackestone radiolarite
	light greenish radiolarian chert (Bal [02.2])		Radio (40%), SpoSpi, Qd, Phyl	Qcc+RS +chlorite	-	sericite-rich radiolarian wackestone
	intense greenish carbonaceous radiolarian chert (Bal [01.3])		Radio (40%), PlaFo, InvoFo, Qd, Phyl, Gla	Qcc+RS +chlorite	Rho, RhoPse, SyntCal	carbonaceous radiolarian wackestone
	bicoloured laminated radiolaritic siliceous-carbonaceous rock (Bal [04.1])		Radio, InvoFo, Qd, Phyl	RS+Qm	SyntCal	laminae with detrital-rich carbonaceous radiolarian packed wackestone; laminae with detrital-rich carbonaceous packed wackestone radiolarite
	reddish radiolaritic siliceous-ferruginous-carbonaceous rock (Bal [04.2])		Radio, SpoSpi, PlaFo, Phyl, Qd, Feldspars	Fe ox-hy+Qcc+ RS	SyntCal	laminae with detrital-rich ferruginous radiolarian mudstone; laminae with detrital-rich carbonaceous radiolarian packed wackestone; laminae with detrital-rich wackestone radiolarite
	mollusc shells chert (Bal [07.1])	(?)	mollusc shells (70-75%)	RS	Qm, Qf+MQ	mollusc shells packstone
Toplița chert	non-fossiliferous chert	Fâncel-Lăpușna Volcaniclastic Fm. (Neogene)	-	-	Qm+Opq+Fe ox-hy	massive, breccia, and flow banding
	fossiliferous chert		algae, charophyta gyrogonites, mollusc shells	Fe ox-hy+Opq+OM	Qm	bioclastic packed wackestone; laminated wackestone

Tab. 3. *Continued.*
Continuare.

Sample ID	Archaeological horizon	Cultural framework	Macroscopic appearance		Petrotype and raw material category	
BL III [729]	AH 2.2	Early Epigravettian	**"Menilite"**	medium grey-brownish	Eocene chert - MF 1	**Eocene chert**
BL III [404]	AH 2.2			beige	Eocene chert - MF 3 – detrital-rich bioclastic chert with planktonic foraminifera	
BL III [316]	AH 2.3			beige		
BL III [360]	AH 2.2			dark and light grey-brownish laminae	Eocene chert – laminated detrital-rich bioclastic chert (with laminae of Qd, MF 1, MF 2 or MF 3)	
BL III [463]	AH 2.2			beige and grey-brownish laminae		
BL III [331]	AH 2.3			grey-brownish with whitish dots, beige partial patina		
BL III [1117]	AH 2.3		**"Audia black schist"**	blackish	Audia siliceous black mudstone	**Audia detrital siliceous rocks**
BL III [453]	AH 2.2			blackish, medium grey-greenish patina		
BL III [803]	AH 2.2			blackish		
BL III [575]	AH 2.3			blackish with light grey-whitish laminae	Audia laminated black radiolarian chert	
BL III [684]	AH 2.2		**"Siliceous sandstone"**	grey-brownish	Audia detrital-rich spiculite chert	
BL III [560]	AH 2.2			dark grey-greenish		
BL III [731]	AH 2.2			dark and light grey laminae	Audia laminated siliceous glauconitic sublithic arenite (very fine sand)	
BL III [452]	AH 2.2		**"Opal"**	grey-blackish and whitish-rosy patina	Toplița non-fossiliferous chert with breccia fabric	**Toplița chert**
BL III [626]	AH 2.2			whitish-rusty patina		
BL III [640]	AH 2.2			whitish-rusty patina		
BL III [632]	AH 2.2			whitish patina with a rusty-brown undulating lamination	Toplița non-fossiliferous chert with flow banding	
BL III [366]	AH 2.2		**"Radiolarites"**	reddish and grey-greenish	Detrital-rich bicoloured radiolarite	**Hăghimaș syncline cherts**
BL III [590]	AH 2.2			greenish	Detrital-rich greenish radiolarian chert	
BL III [666]	AH 2.2			medium grey-bluish	**Sita Buzăului radiolarian chert**	
BL III [367]	AH 2.2		**"Prut-Dniester flint"**	grey-brownish, whitish patina	**Prut-Dniester spiculite flint**	
BL III [513]	AH 2.2			medium grey, whitish-bluish patina		
BL III [389]	AH 2.3			dark grey, bluish patina	**Dniester Globotruncanidae flint**	
BL III [SI-A3-02]	AH 2.5	Late Gravettian		grey-bluish and whitish patina		
BL III [SIII-Pas-04]	AH 2.5			whitish-bluish patina		

Qd – detrital quartz; MF – microfacies; AH – archaeological horizon

Tab. 4. Petrographic characteristics of the samples from Bistricioara-*Lutărie III*.
Caracteristicile petrografice ale probelor de la Bistricioara-*Lutărie III*.

No. in Pl. XV	Occurrence area	Siliceous rock type and petrographic traits	Geological context	References
28	left side of Cracău (Țiganului and Șerpelui creeks)	silicified areas (chaille-type siliceous accidents, small lens-like, 10 cm in thickness) in fine-grained limestones (10-25 m thick) [greyish, greenish or beige, whitish on alteration surfaces, as 5-30 cm thick beds; micrites with 25-30% sponge spicules, calcareous foraminifera, coccolithophorids, glauconite, detrital quartz]	Doamna Limestone Fm. (Eocene), Marginal Folds Nappe	T. Joja 1959, p. 92; C. Olteanu 1952, p. 45-46; 1953, p. 17; O. Mirăuță 1962, p. 48; O. Mirăuță, E. Mirăuță 1964, p. 140; M. Micu 1976, p. 56
29	right side of Cracău (Pocivnicu and Porcăroaia creeks)			
30	between Cuejdiu and Horăița valleys (Gherman, Recea, Țiganca creeks)			
31	left side of Bistrița valley (Runcu, Sărata, and Plopușoru creeks)	whitish-greenish limestones with dark coloured inhomogeneous siliceous accidents (chaille-type) in discontinuous beds parallel to the stratification siliceous sponge spicules, echinoderm and bryozoan fragments, foraminifera (nummulites, globigerines), detrital angular quartz grains		M. Frollo 1937, p. 78-79
32	Doamna Valley basin (Bighirea, Gliguța, and Jgheabul Mare creeks),			
-	Picioarele Hill, near Târgu Ocna			
33	between Cuejdiu and Agapia valleys	blackish menilite in 1-7 cm thick beds with millimetre thick intercalations of dysodile shales and quarzitic sandstones (3-8 m thickness)	Lower Menilites Fm. (Oligocene), Marginal Folds Nappe	O. Mirăuță, E. Mirăuță 1964, p. 141-142; M. Micu 1976, p. 58; T. Joja 1959, p. 92; C. Olteanu 1952, p. 46; 1953, p. 18;
34				
35	between middle Pângărăcior and Cuejdiu creeks (Răchitiș, Stirigoești, Bisericani, and Valea Mare)			
36	Doamna Valley basin (Jgheabul Mare)			
37	near the confluence of Horăița and Lingurarului creeks (Poiana village)	brownish menilite (3-4 m thick), banded, in 1-2 cm thick beds	Upper Dysodilic Shales and Menilites Fm. (Miocene), Marginal Folds Nappe	M. Micu 1976, p. 58; O. Mirăuță, E. Mirăuță 1964, p. 142
-	Bîtca Răchiței-Înțărcătoarea-Picioru Făgețelu syncline (Merișor, Tărcuța, and Tarcău creeks)	brownish-blackish menilite as 1-4 cm thick beds (with compact an hard areas passing laterally to a slightly clayish material and splits along the stratification planes) interlayered with rusty silicified marls (4-5 intercalations at the base of the brownish bituminous marls) lighter and darker coloured laminae/stripes composed of cryptocrystalline silica impregnated with a yellowish-brown substance (more concentrated in the darker stripes), pyrite and magnetite	Lower Menilites Fm. (Oligocene), Tarcău Nappe	L. Ionesi 1957, p. 381; 1962, p. 194
-	Ardele-Tarcăul Mare anticline	menilite intercalations, lens-like shape (10 cm thick)		
-	Potoci creek (left side tributary of Tarcău, Tarcău village)	calcareous bituminous brownish marls and dysodile shales with 4 intercalations of menilite (0.3-0.85 m thick)		T. Filimon, A. Damian 1965, p. 43

Tab. 5. Occurrences of siliceous rocks in the extended study area.
Ocurența rocilor silicioase în zona extinsă de studiu.

No. in Pl. XV	Occurrence area	Siliceous rock type and petrographic traits		Geological context	References
38	Cuejdiu-Horăița valleys	small chaille in very fine-grained limestones (with globigerina, *Inoceramus* fragments, *Globotruncanae*, sponge spicules)		Lepșa Fm. (K2), Marginal Folds Nappe	O. Mirăuță, E. Mirăuță 1964, p. 135-136
		blackish, reddish and greenish shales (20 m thick), in 2-6 m beds, with greenish radiolarites (sometimes banded) in 2-5 cm thick beds	cryptocrystalline silica and chloritized clay groundmass (greenish) with radiolarians (*Spumellaria*, *Nasselaria*) conserved in chalcedony, detrital clasts (5% - quartz-chlorite schist, quartz, biotite), and glauconite	Tisaru Fm. (K2), Marginal Folds Nappe	O. Mirăuță, E. Mirăuță 1964, p. 134-135
		medium to coarse grained greyish limestones (60-100 m thick) in 10-100 cm thick beds with greyish-blackish or whitish spongolithic siliceous accidents (chaille, 2-6 cm in thickness)	chalcedony groundmass with numerous sponge spicules (chalcedony), radiolarians, and detrital quartz	Upper Mb., Sărata Fm. (K1), Marginal Folds Nappe	Mirăuță 1962, p. 48; O. Mirăuță, E. Mirăuță 1964, p. 133-134
	Cuejdiu-Horăița valleys	lydite horizon (60-100 m thick) with dark grey or black shales and jasper-like blackish siliceous rocks (lydite) in 2-20 cm thick beds (very hard, banded, with conchoidal break)	mix of chalcedony and clay, detrital quartz, glauconite, organic matter and pyrite; transition from rocks with small foraminifera to rocks with radiolarians (*Spumellaria*) and sponge spicules (chalcedony) in an isotropic brownish-blackish groundmass	Middle Mb., Sărata Fm. (K1), Marginal Folds Nappe	O. Mirăuță, E. Mirăuță 1964, p. 132-133; T. Joja 1959, p. 89; C. Olteanu 1952, p. 44; 1953, p. 15; Mirăuță 1962, p. 48
39	between Sărata, Valea Mică, and Tisei creeks				
40	Doamna Valley basin (Gliguța and Jgheabul Mare creeks)				
41	Cârnu-Izvorul Muntelui-Straja area	siliceous rock (lydite/ spongolite) in 5-10 cm beds, hard and compact, black with tar-like lustre, conchoidal break	siliceous groundmass (chalcedony, 80%) with sponge spicules and radiolarians; the clay-carbonate mix (20%) appears as sporadic clusters in interstitial spaces, with calcite rhombohedral crystals in the groundmass and the sponge spicules	Audia Fm. (K1), Tarcău Nappe	I. Băncilă 1955, p. 1205; I. Băncilă, V.C. Papiu 1962a, p. 21
42	Ața, Izvorul, Secul, and Bulătăul creeks	spongolite		Audia Fm., Audia Nappe (K1)	J. Gherman, M. Solcanu 1969, p. 182
		siliceous glauconitic sandstones, hard, with conchoidal fracture			
-	Ceahlău Mt.	blocks and fragments of radiolarites		Ceahlău conglomerates (Albian), Ceahlău Nappe	M. Săndulescu 1990, p. 36
		Urgonian limestone blocks (found at the same level as the sandstone intercalations) with ellipsoidal silicified areas (30 cm long)			C. Grasu 1965, p. 74; M. Săndulescu 1990, p. 37
43	between the Bistra Mare and Bistra Mică basins (Piatra Sură Peak, Ceahlău Mt.)	polymictic conglomerates with elements of: limestones and metamorphic rocks; Callovian-Oxfordian dark coloured cherts (with radiolarians and sponge spicules); Callovian-Oxfordian silicified pelletal limestones (alternating laminae of silica and biomicrite, with sponge spicules and radiolarians); Kimmeridgian-Tithonian silicified limestones (with sponge spicules calcitized or with calcite rhombohedral crystals); Jurassic-Lower Cretaceous cherts (with calcitized radiolarians)			P. Șoigan, Gr. Alexandrescu 1976, p. 226-229; M. Săndulescu 1990, p. 36

Tab. 5. *Continued.*
Continuare.

No. in Pl. XV	Occurrence area	Siliceous rock type and petrographic traits		Geological context	References
44	the northern extremity of Hăghieș Mt.	greenish and reddish radiolarites intercalated in quarzitic sandstones	cryptocrystalline silica groundmass (sometimes with microcrystalline silica agglomerations) with disseminated chlorite; the reddish varieties contain haematitic pigment uniformly disseminated or as parallel areas; the radiolarians (*Liosphaera*, *Cenosphaera*, rarely *Heliodiscus*) are uniformly disseminated or concentrated in parallel stripes; rare uniseriate foraminifera (silicified); detrital quartz is found in various amounts up to arenaceous radiolarites	Radiolarite facies (Seisian, Triassic), Bucovinian Nappe	M. Săndulescu 1975, p. 47-48
45	West of Cupașu Mt.				
	near the springs of Suhardu creek				
46	on the norther slope of Păltiniș Mt. (South of Toșorog-Tulgheș road)	light green and yellowish radiolarites in quarzitic sandstones			
-	Bălai creek basin, on the right side tributaries (North of Toșorog-Tulgheș road)	radiolarites intercalated in massive dolostones		Radiolarite facies (Campilian-Anisian, Triassic), Bucovinian Nappe	M. Săndulescu 1975, p. 49-50
			silicified areas in dolostones composed of a microcrystalline dolomite groundmass with partially silicified radiolarians		
			carbonaceous radiolarites with untransformed areas of microcrystalline dolomite		
47	Eastern side of Criminiș Mt.	calcareous dolostones and silicified limestones with reddish and greenish radiolarites		Triassic klippe in the Wildflysch Fm. (Lower Cretaceous)	M. Săndulescu 1975, p. 55
-	Piatra Crăpată Peak	dolostones with radiolarites		Triassic klippe at the base of Hăghimaș Nappe	M. Săndulescu 1975, p. 52
-	Western bank of Lacu Roșu	circular and elliptic silicified areas (chaille) in blueish-grey sandy limestones		Aalenian-Bathonian, Bucovinian Nappe	M. Săndulescu 1975, p. 67
-	Bicaz Valley				
48	Chicera Mt.	reddish and greenish radiolarites in 4-7 cm beds (intercalated with reddish and greenish siliceous shales), compact, greasy lustre, conchoidal fracture (sometimes rectangular chunks)	cryptocrystalline silica groundmass pigmented with chlorite (or haematite for the reddish ferruginous ones), containing radiolarians (*Heliodiscus*, *Rhopalastrum*, *Hagiastrum*, *Cenosphaera*) and variable amounts of detrital material and calcite	Callovian-Oxfordian, Bucovinian Nappe	M. Săndulescu 1975, p. 68; I. Preda, M. Pelin 1963, p. 213-214
49	West of Lacu Roșu				
-	between Cheile Bicazului and Telecu Peak				
-	on the northern side of Muntele Fagului creek				

Tab. 5. *Continued.*
Continuare.

-	Fagului ridge	greyish and greenish cherts with abundant radiolarians (radiolarites) and a high content of chlorite		Lunca Beds (Tithonian-Valanginian), Bucovinian Nappe	M. Săndulescu 1975, p. 76-77
50	Western flank of the Hăghimaș syncline (Lapoș Valley, Ciofronca creek, North of Piatra Unică, Fagul Oltului creek)	reddish, greenish or blackish-grey radiolarites in 2-5 cm beds (with thin intercalations of radiolarian clays or greenish tuffites or cinerites	siliceous groundmass (chloritic pigment for the greenish jaspers, chloritic-haematitic for the reddish ones) with numerous radiolarians	Wildflysch Fm. (Lower Cretaceous), Bucovinian Nappe	M. Săndulescu 1975, p. 100-101, 103
-	Ghiciminișului Hill				
51	Stânei Valley				
	Stânei creek (tributary of Toșorog creek	siliceous rocks (reddish-brown to greenish, greyish or blackish jaspers) and reddish-brown argillite (as 30-60 cm thick beds) in agglomerates and diabase tuff (5 m thick)	the greenish-grey or blackish jaspers are composed of hydrothermal opal and a dark grey isotropic vitroclastic material (some contain rhombohedral dolomite); for the bicolored jasper, the reddish area is composed of 60-80% radiolarians and sponge spicules (fine-grained chalcedonic groundmass pigmented with haematite, low amount of detrital material), while the grey-greenish area is composed of cryptocrystalline silica pigmented with chlorite with vague radiolarian shapes; the two areas are sharply marked by a sinuous line of haematite concentration randomly cutting through the organisms	volcanoclastic complex, Lower Cretaceous (Wildflysch Fm.), Bucovinian Nappe	I. Băncilă, V.C. Papiu 1962b, p. 28-32
-	Valea Rece (Poiana Fagului ridge)	reddish and greenish silicified area intercalated in blackish detrital-pyroclastic schist	silica (chalcedony) groundmass pigmented with haematite (reddish areas) or chlorite (greenish areas), detrital material (quartz, muscovite, zircon), radiolarians (barely recognisable)	Sinaia Fm. (*Aptychus* Beds), Lower Cretaceous, Ceahlău Nappe	I. Băncilă, V.C. Papiu 1962b, p. 37-40
52	Ciobotani (unknown location)	waxy opal		Fâncel-Lăpușna volcaniclastic Fm., Neogene	V. Ghiurcă 1996, p. 20; 1999, p. 33; Gh. Lazarovici *et alii* 2011, p. 58; C.-M. Lazarovici *et alii* 2018, p. 28
53	Călimănel (unknown location)	opal			
54	Pârâul Baicăului (Toplița)	opal			
-	Toplița (unknown location)	jasper, opal, silicified wood			
-	Pârâul Sec (Toplița)	opal			
55	Cisc Valley (Gălăuțaș)	reddish and yellowish opal			
56	Sărmaș-Hodoșa (behind the train station)	amber-coloured opal			
-	Sărmaș	opal, silicified wood			

Tab. 5. *Continued.*
Continuare.

4.2. Lithic raw materials from Bistricioara-*Lutărie III*

The macroscopic analysis of the BL III raw materials established six groups of raw materials, here labelled under the glorified archaeological terminology (in brackets) for the sake of continuity with previous accounts (pl. V/8). The microfacies analysis carried on 25 thin sections (from three archaeological layers framed as Late Gravettian and Early Epigravettian) has discriminated 14 petrotypes, grouped in seven raw material categories (tab. 4).

4.2.1. Eocene chert

The samples of archaeological "menilite" show significant macroscopic variation, from simple greasy medium grey-brownish (BL III [729]) or dull beige (BL III [316], [404]) to laminated beige-brownish (BL III [463], [331]) or dark-medium grey (BL III [360], which is macroscopically similar to samples of variety 3 from Lespezi-*Lutărie*). This macroscopic variation is underlined by a petrographic diversity corresponding to several microfacies of the Eocene chert. One sample was matched to MF 1 defined in this study (pl. XIII/1). Two samples represent a microfacies compositionally similar to MF 1 or MF 2, but in which the predominant microfossils are planktonic foraminifera, henceforth described as MF 3 of the Eocene chert (pl. XIII/2). Three samples exhibit compositional lamination represented by alternating laminae of MF 1/MF 2/MF 3 and detrital quartz (pl. XIII/3-4), henceforth described as laminated Eocene chert, which is very similar to variety 3 from Lespezi-*Lutărie* (Al. Ciornei 2015, p. 50). This was dubbed "menilite" despite the acknowledged discrepancy with the geological descriptions of the Oligocene menilite, but also disregarding the petrographic similarities with the Eocene chert samples from the same study. In light of the current petrographic analysis, variety 3 from Lespezi-*Lutărie* should be considered as a laminated version of the Eocene chert. The Eocene chert outcrops (the Doamna limestone Fm.) are located at distances of 25-51 km NE to SE from BL III (tab. 6).

4.2.2. Audia detrital siliceous rocks

Two samples of "Audia black schist" (pl. XIII/5) were identified as Audia siliceous black mudstone, previously described in origin samples from Ceahlău-*Dârțu* as Audia "black schist" MF 1 (Al. Ciornei, I. Mariș 2020, p. 47, tab. 3). Sample Chl-Dâr [06] contains two areas, which show the transition from the carbonaceous (see the description in previous section) to siliceous mudstone. This is composed of a mixed siliceous and mud groundmass with radiolarians, sponge spicules, silty detrital quartz, rhombohedral siderite/ankerite crystals, and very fine-grained phyllosilicates. The siliceous mudstone (pl. XIII/5) is different from the carbonaceous one (pl. VII/7-8, VIII/3-4) in several ways: (1) it lacks the calcite pseudomorphs after the rhombohedral crystals of siderite/ankerite; (2) has a higher percentage of rhombohedral crystals of siderite/ankerite; (3) it does not contain planktonic foraminifera or they are extremely rare (hence they have a low visibility in thin sections); (4) it has a low amount of carbonate bioclasts. These observations indicate slightly different depositional conditions for the two types of mudstones, which might have spatially distinct occurrences within the sedimentary basin.

One sample (BL III [575]) is a laminated detrital-rich radiolarian chert with a cryptocrystalline silica and mud groundmass, radiolarians, sponge spicules, planktonic foraminifera, bioclasts, organic matter, opaque minerals, and rhombohedral siderite/ankerite crystals. This material also contains a small area where the primary constituents suffered a calcitization process, giving it a carbonaceous composition. This petrotype, henceforth described as Audia laminated radiolarian chert (pl. XIII/6), is similar with the more carbonaceous one from Izvorul Muntelui creek (IzMu [02.3], pl. VIII/5-6), both of which have a broad resemblance (but a mineralogical mismatch) with the upper half of sample Au [00-7J-F] (pl. VII/5-6). In comparison, sample Le-Lu [08], variety 2c from Lespezi-*Lutărie* (Al. Ciornei 2015, p. 50; Al. Ciornei, I. Mariș 2020, p. 47, tab. 3), is a laminated radiolarian carbonaceous mudstone with radiolarians, sponge spicules, planktonic foraminifera, bioclasts, and abundant rhombohedral siderite/ankerite crystals held together by a siliceous groundmass. This sample is partially similar to BL III [575], but is more carbonaceous overall and has a lower content of radiolarians.

Two of the three samples macroscopically designated as siliceous sandstones were identified as detrital-rich spiculite chert (pl. XIII/7), a petrotype which corresponds to variety 1a (Le-Lu [01]) from Lespezi-*Lutărie* (Al. Ciornei 2015, p. 49). The detrital-rich spiculite chert has a similar particle content and packing to the detrital-rich spiculite from Audia Fm., the difference being represented by the cryptocrystalline silica cement (instead of the cryptocrystalline calcite) encompassing the particles. The particles (sponge spicules, radiolarians, subangular-subrounded quartz, glauconite peloids) are moderately sorted fine-medium sand. Hence its macroscopic appearance similar to a siliceous sandstone. The other sample was identified as a laminated siliceous glauconitic sublithic arenite (pl. XIII/8), and has a similar composition to sample Au [00-7J-A.2], but with a cryptocrystalline silica groundmass. Towards one of the thin section's margins, there is a small area of detrital-rich spiculite chert. The sample shows substantial evidence of calcitization (pseudomorphs after rhombohedral siderite/ankerite crystals).

The detrital-rich spiculite chert and the laminated siliceous glauconitic sublithic arenite, considered together with the laminated radiolarian chert and the siliceous mudstone, suggest the same fining-upward depositional sequence as the samples from Au 00 (layer 7, see above), but they are siliceous and less affected by calcitization.

The sampling locations from Hangu and Țiganului valleys are located at 7 km E, and 8 km NE respectively from BL III (tab. 6), but these materials might also be found in the gravels from Țiganului, Poiana Largului, Hangu, and Bistrița valleys. The mismatch between the archaeological and geological samples of Audia detrital siliceous rocks and the resemblance between the laminated radiolarian chert samples from Izvorul Muntelui and BL III opens the possibility to consider the outcrops from Izvorul Muntelui-Cârnu-Straja (at 16-22 km SSE) and Piatra Neamț (30-33 km ESE) areas as potential sources for the archaeological materials (tab. 6).

4.2.3. Toplița chert

The analysed "opal" samples have whitish-rusty to dark grey alteration surface (sometimes with a laminated appearance) which impedes other macroscopic observations. In thin sections, the "opal" samples exhibit similar petrographic traits to the Toplița non-fossiliferous chert described in this study: three samples have breccia fabrics, one of which contains a fragment of silicified wood (pl. XIV/1); one sample has a flow banding fabric (pl. XIV/2). Variety 5b (Le-Lu [16]) from Lespezi-*Lutărie* was previously described as a blackish translucent cementstone chert and, despite its lack of clearly identifiable microfossils, included in the "Prut flint" type (Al. Ciornei 2015, p. 51). Reanalysed, sample Le-Lu [16] can be reclassified as a non-fossiliferous Toplița chert, further confirmed by another two samples recently made and analysed (Le-Lu [32], [33]). The geological occurrences of siliceous rocks from Toplița area are located at a distance of 44-47 km WSW from BL III (tab. 6).

4.2.4. "Radiolarites"

Three samples were macroscopically recognized under this heading. The first one (BL III [366]) is a bicoloured detrital-rich radiolarite with two areas petrographically different: the reddish area is composed of an amorphous iron oxide-hydroxide and cryptocrystalline silica groundmass enclosing radiolarians (55%), sponge spicules, planktonic foraminifera, detrital quartz clasts, phyllosilicates, siliceous-argillaceous and radiolarian chert lithoclasts; the grey-greenish area is composed of radiolarians (55%), sponge spicules, planktonic foraminifera, detrital quartz clasts, and phyllosilicates, fixed in a microcrystalline silica and fine chlorite groundmass (pl. XIV/3). The second sample (BL III [590]) is composed of a microcrystalline silica and fine chlorite groundmass with rare radiolarians, detrital quartz clasts, phyllosilicates, and syntaxial overgrowth calcite cement on rhombohedral crystals and carbonate bioclasts (pl. XIV/4). These samples show a petrographic composition similar to the Hăghimaș syncline radiolarites (tab. 5/39-46, pl. XV). The radiolarians (*Liosphaera*, *Cenosphaera*), the notable amounts of detrital quartz and phyllosilicates, and the syntaxial overgrowth calcite cement indicate a broad likeness to the Triassic radiolarites and radiolarian cherts from Hăghimaș syncline. The outcrops of Mesozoic radiolarites are found at distances ranging between 21 km SW (Bălai) and 32 km SSW (Lacu Roșu-Valea Rece), and as close as 8-11 km S from BL III (Ceahlău Mt., in Ceahlău conglomerates; tab. 6).

Another sample (BL III [666]) matches the Sita Buzăului radiolarian chert petrotype previously described in origin samples from Sita Buzăului area (Al. Ciornei, I. Mariș 2020, p. 45). This is composed of a cryptocrystalline quartz groundmass with dispersed larger rhombohedral and very small anhedral to euhedral dolomite crystals, radiolarians, sponge spicules and carbonate bioclasts. It also contains the specific involutinid foraminifera (in the centre of pl. XIV/5). Such involutinid foraminifera are also present in the Ceahlău chert. Unlike the Bălai radiolarian cherts/radiolarites and the Ceahlău chert, the Sita Buzăului radiolarian chert contains almost no detrital quartz and shows no signs of dedolomitization. This is a true long-distance raw material, as the origin sites from Sita Buzăului lie 155 km to the S from BL III (tab. 6).

4.2.5. "Prut-Dniester flint"

Most of the "Prut-Dniester flint" samples have whitish, whitish-bluish or greyish-bluish alteration surfaces (highly specific for this raw material), with small areas (rarely one entire surface) that maintain their true colour (such as sample BL III [389], very translucent dark grey-blackish). Out of the five analysed thin sections of "Prut-Dniester flint", two were recognised as Prut-Dniester spiculite flint, and three as Dniester Globotruncanidae flint. The Prut-Dniester spiculite flint is composed of a crypto- to microcrystalline quartz groundmass with fragmented sponge spicules (microcrystalline quartz, chalcedony) and silicified fragments of echinoderms, but also planktonic and benthic foraminifera (pl. XIV/6). This is described from Ripiceni-*La Izvor* origin samples (mostly grey-light brownish, translucent, with spotty carbonate remains), derived from the Cenomanian deposits in the Prut-Dniester interfluve (Al. Ciornei, I. Mariș 2020, p. 47). This is the same as variety 5cd (Le-Lu [19]) from Lespezi-*Lutărie* (Al. Ciornei 2015, p. 51, pl. 14/4-6). The Dniester Globotruncanidae flint is composed of a cryptocrystalline quartz groundmass with silicified bioclasts (echinoderms, algae, bivalves, ostracods, sponge spicules). The characteristic note is given by the presence of planktonic foraminifera (from which the *Globotruncana* stands out) and Phitonella (Pl. XIV/7-8). This is described only from Oselivka-*Chisla Nedjimova* origin samples, and probably derived from chalks similar to those near Dubivtsi village, Western Ukraine

(Al. Ciornei, I. Mariș 2020, p. 47, and references therein). This is the same as variety 5bc (Le-Lu [19]) from Lespezi-*Lutărie* (Al. Ciornei 2015, p. 51, pl. 13/1-3). Both petrotypes are very well silicified and have a particular trait in thin sections (seen in PPL), namely the siliceous groundmass it is very clean (low amount of residuals, micrite, opaque minerals, and amorphous iron oxide-hydroxides), hence in hand specimens it is very translucent (even in thicker flakes). The origin sites from the Prut-Dniester interfluve are located at 135-162 km NE from BL III (tab. 6).

Raw material	Location	Distance* to	Direction	Distance
Eocene chert	Neamț-Doamna-Nechit valleys	Sec 01	NE	27 km
		Cracău	ENE	25 km
		E of Doamna	ESE	33 km
		Nec 03b	SE	51 km
Audia detrital siliceous rocks	Hangu Valley	Au 00	E	7 km
	Țiganului Valley	Tig 01	NNE	9 km
	Izvorul Muntelui	IzMu 02	SSE	16 km
	Cârnu-Straja	NW of Straja	SE	22 km
	Cuejdiu-Horăița valleys	Cuejdiu	ESE	30 km
	Doamna Valley basin	E of Doamna	ESE	33 km
Ceahlău cherts	Ceahlău Mountain	Chl 08	S	7 km
		Chl 14	S	10 km
		Chl 19	SSW	15 km
		IzMu 01b	SE	16 km
Hăghimaș syncline cherts	Ceahlău Mountain	Chl 10	S	8 km
		Chl 23b	S	11 km
	Bălai-Pintec	Bal 03, 04	SW	21 km
	Lacu Roșu-Valea Rece	Lacu Roșu	SSW	32 km
Toplița chert	Toplița area	Toplița-*Pârâul Baicăului*	WSW	47 km
		Hodoșa	WSW	44 km
Sita Buzăului chert	Upper Buzău Valley	Sita Buzăului	S	155 km
"Prut-Dniester flint"	Prut Valley	Ripiceni	NE	135 km
	Dniester Valley	Oselivka	NNE	162 km

* The distance is calculated in a straight line from BL III to a locality (town, village), origin site or a GPS point.

Tab. 6. Distances between Bistricioara-*Lutărie III* and possible supply sources.
Distanțe între Bistricioara-*Lutărie III* și surse posibile de aprovizionare.

◈ 5. Discussion

5.1. Bistricioara-*Lutărie III*: possible supply sources

In this study, seven categories of knappable siliceous rocks (each of them with several petrotypes) were characterized from geological and origin samples in the extended study area. Their petrographic characteristics suggest a diversity of geological settings and ages (tab. 3, pl. XV). Seven raw material categories were differentiated for BL III (tab. 4, pl. XV), four of them matched to geological occurrences in the extended study area, and three to origin samples from the Prut-Dniester and Sita Buzăului areas.

The petrographic description of the Eocene chert relies on the samples collected from the gravels of Nechit Valley, which confirm the characteristics outlined in thin sections from Lespezi-*Lutărie*. The samples from BL III fit well in this description and augment its compositional variability. This petrographic variability might be linked to sedimentary and diagenetic traits specific for physiographically distinct outcrops of this material and/or to vertical variations within such outcrops. All the samples from BL III recognised macroscopically as archaeological “menilite” proved to be Eocene chert. The importance of this outcome resides in the slightly distinct geological occurrences for the Eocene chert and menilite, but especially in their suitability for knapping. The Doamna limestones are restricted to the exterior of the Eastern Carpathians Flysch (the Doamna Lithofacies of the Tarcău and Marginal Folds nappes), while the menilite can also be found more to the interior (such as Tarcău Valley, S of Schitu Tarcău). More so, its mode of occurrence, i.e. as thin beds and lenses (frequently 1-4 cm thick, rarely 7 or 10 cm thick), coupled with its splintery break (resulting in uneven chunks) make the menilite mostly unsuitable for knapping. On the other hand, the Eocene chert occurs as 5/10 to 30 cm thick lens-like nodules and beds and breaks conchoidally.

None of the BL III samples matches the description of the Audia glauconitic sandstones (Upper Mb. of Audia Fm.). The Cârnu-Șiclău radiolarian chert from Țiganului Valley has unique petrographic traits and bears no resemblance to any of the other radiolarian-dominated samples from this study. This does not mean that these raw materials are absent from the BL III assemblages, but either were missed during sampling or the batch macroscopically analysed did not contained any.

The Audia detrital siliceous rocks described in this study represent a fining-upward depositional sequence repeating itself within multiple black mudstone beds in the Middle Mb. of Audia Fm. The geological samples show ample evidence of diagenetic calcite replacing the silica and other mineral phases, which is the opposite of the BL III samples. The difference between the carbonaceous and the siliceous mudstone may suggest a provenience from physiographically and/or stratigraphically distinct occurrences. Altogether, the facts presented above (sections 4.1.2 and 4.2.2) can be interpreted in at least two ways: as evidence of sampling misfortune and lateral variation within the sampled beds (also locally and diversely affected by the diagenetic precipitation of calcite); or as evidence that the black mudstone beds sampled on Hangu Valley (GPS point Au 00) do not represent the actual geological source for the archaeological materials, most probably derived from a similar fining-upward sequence found somewhere else in the Audia Fm. or its chronostratigraphic equivalent from the Marginal Folds Nappe.

Given the mismatch between the archaeological samples and those from Hangu, the above-mentioned outcrops (sections 4.1.2 and 4.2.2) widen the initially presumed source area eastwards up to Piatra Neamț. The outcropping areas of the Audia and Sărata formations generate a more extensive possible supply area and, more importantly, describe different transport directions and distances than initially presumed.

Although none of the samples from BL III was identified as Ceahlău cherts and silicified limestone, their abundance and occurrence area confirm the existence of a raw material source on Ceahlău Mt. (i.e., not “Polița Cremenișului” per se, as put forward by previous research, but the whole area covered by the Ceahlău conglomerates with the Urgonian limestones). The Ceahlău cherts and silicified limestone, either considering their widespread abundance in the Ceahlău conglomerates, or their existence, yet to be proved, in the gravels of the creeks descending towards Bistrița valley, were one of the few true local raw materials available to the UP hunter-gatherers from Ceahlău Basin. Some archaeologists working here have identified this material (by word-of-mouth) as “menilite” (i.e., the Eocene chert), to which it shows a certain degree of macroscopic resemblance (colour, lamination). Thus, confirming its presence in the UP assemblages from Ceahlău Basin is just a matter of time.

The presence of Mesozoic radiolarites in the BL III lithic assemblage is undoubtable and confirms prior archaeological suppositions. The petrographic overlap recognized for the Triassic and the Jurassic radiolarites can be bypassed by carefully identifying and differentiating between the specific radiolarian genus associations (M. Săndulescu 1975, p. 68). Even so, the extension of the possible supply area is considerably larger than previously thought. Since there are Hăghimaș syncline cherts present in the Ceahlău conglomerates (and hence in the creeks descending towards Bistrița valley?), tracing the exact provenience of such materials found in the UP assemblages becomes more difficult. The radiolarite and radiolarian chert from BL III are most probably derived from the Triassic deposits of the Hăghimaș syncline, but pinpointing the area from which they were sourced requires more work, not only in terms of occurrences, but also in terms of their abundance and availability.

Four samples from BL III were identified as Toplița chert, thus confirming C.S. Nicolăescu-Plopşor's view on the origin of the "opal" used at the UP sites from Ceahlău Basin. The possible provenience from Toplița area for the "opal" recognised in the BL III lithic assemblage also relies on the physiographic proximity and a few connecting facts that indicate a mutual raw material transfer between the two areas. On one hand, there is a significant and very little-known concentration of Late Upper Palaeolithic (Epigravettian) sites (Hodoșa-*Dealul Hodoșa*, Gălăuțaș-*Dealul Cisc*, Toplița-*Pârâul Baicăului*; Al. Păunescu 2001, p. 395-396; Gh. Lazarovici *et alii* 2011, p. 58; M. Anghelinu *et alii* 2012, p. 272) exploiting the local sources of "opal" from Toplița area (pl. XV/6). On the other hand, two raw materials frequently found in the Ceahlău Basin are present in some of these sites: a retouched blade on "Audia black schist" at Toplița-*Pârâul Baicăului* (M. Anghelinu *et alii* 2013, p. 187); a burin on Prut-Dniester flint (with greyish-dark bluish patina) at Hodoșa-*Dealul Hodoșa*[4].

The presence of the Sita Buzăului radiolarian chert at BL III is no surprise as this raw material was hitherto confirmed in several UP assemblages from Ceahlău Basin (Al. Ciornei, I. Mariș 2020, p. 49, tab. 4). The broad spectrum of siliceous rocks found in the Eastern Carpathians (sampled from a limited number of field surveys and analysed in this study alone, not counting the various mentions in the geological literature), some of which bear petrographic resemblance with the material here called Sita Buzăului chert (see above, section 4.2.4), warrants a prudent approach and closer sources should not be yet excluded.

The Prut-Dniester spiculite flint and the Dniester Globotruncanidae flint recognised in the lithic assemblage from BL III reiterates an already confirmed presence in other UP sites from Ceahlău Basin (Al. Ciornei, I. Mariș 2020, tab. 4) and from further downstream (Lespezi-*Lutărie*). The "Prut flint" is one of the initial "exotic" raw materials recognised in the Ceahlău Basin UP assemblages, which facilitated a straightforward connection with the UP sites from the Middle Prut Valley. The presence of two materials (one of which has several petrotypes) derived from different geological deposits seems to provide a more down-to-earth explanation for the geochemical mismatch (L. Moreau *et alii* 2019, p. 530) between the "Prut flint" samples from BL III and the black and grey flint from the Cenomanian chalky limestone in the Middle Prut Valley (Cotul Mic and Cotu Miculinți). The Dniester Globotruncanidae flint makes the connect with the UP sites from the Middle Dniester Valley and casts a new light on the technological and typological similarities recognised by some archaeologists (Al. Păunescu 1999, p. 43; M. Bitiri-Ciortescu *et alii* 1989, p. 21; M. Bitiri 1981, p. 337-338).

[4] Based on the macroscopic analysis of 36 lithics curated at "Vasile Pârvan" Institute of Archaeology.

5.2. Bistricioara-*Lutărie III*: transport distances and directions

Four raw material categories (Audia detrital siliceous rocks, Eocene chert, Hăghimaș syncline cherts, and Toplița chert) were supplied from sources found within a radius of 50 km from BL III. This distance is generally considered as a threshold between local and non-local raw materials in the reconstruction of the UP procurement territories (L. Kaminska *et alii* 2000, p. 66; J. Féblot-Augustins 2009, p. 38). The long-distance raw materials were supplied from sources situated at 155 km S (Sita Buzăului chert) and >130 km NE (Prut-Dniester spiculite flint, Dniester Globotruncanidae flint), in line with transfer distances often described from Gravettian and Epigravettian sites (J. Féblot-Augustins 2009, tab. 3.2 to 3.4).

Nevertheless, we stress out that BL III (and the other UP sites from Ceahlău Basin) should not be blindly bent to this line of thinking. The distinction between local and non-local sources has to be refined using shorter transport distances combined with other criteria, such as the physiographic characteristics of the landscape. In this particular case, the mountainous landscape with periglacial conditions should not be underestimated as a factor influencing the transport distances: short straight-line distances, such as 10-20 km, are not short at all.

The transfer directions for the raw materials found within the 50 km radius point to almost all cardinal directions. The long-distance raw materials represent two opposite transfer directions: one from NE/NNE, and the other from S. These transport directions might reflect multiple pathways and arrivals from different directions towards Ceahlău Basin.

In a diachronic perspective (tab. 7), the cultural layers outline a major change in raw material use, from predominantly NE distant provisioning and minor local input (Late Gravettian) to less consistent, but more nuanced NE and S distant provisioning and major local input (Epigravettian). Contrasting to the Late Gravettian layer (with an assemblage made on „Prut-Dniester flint”), the Epigravettian assemblages exhibit a melange of raw materials with variable quantities throughout time.

Raw material*		**menilite, black schist, sandstone**		**“radiolarite/…” + opal**		**Others**		**Undetermi-ned**		**Long-distance raw materials**	
AH 2.5 (Late Gravettian)	Lithics	60	2.17%	11	0.50%	44	1.98%	43	1.94%	2059	92.87%
	Tools	0	0.00%	2	1.15%	0	0.00%	0	0.00%	172	98.85%
AH 2.3 (Early Epigravettian)	Lithics	860	61.34%	164	11.70%	4	0.29%	24	1.71%	350	24.96%
	Tools	52	61.90%	8	9.52%	0	0.00%	0	0.00%	24	28.57%
AH 2.2 (Early Epigravettian)	Lithics	3059	51.83%	1707	28.92%	70	1.19%	858	14.54%	208	3.52%
	Tools	130	54.85%	70	29.54%	0	0.00%	25	10.55%	12	5.06%
AH 2.1 (Late Epigravettian)	Lithics	1189	42.43%	355	12.67%	41	1.46%	49	1.75%	1168	41.68%
	Tools	7	16.67%	18	42.86%	0	0.00%	0	0.00%	17	40.48%
AH 1.1 (Late Epigravettian)	Lithics	948	48.17%	311	15.80%	14	0.71%	45	2.29%	650	33.03%
	Tools	32	50.00%	7	10.94%	0	0.00%	1	1.56%	24	37.50%

*Table compiled with data from M. Anghelinu *et alii* 2021a, p. 218-224.

Tab. 7. Raw material quantities from Bistricioara-*Lutărie III*.
Cantitățile de materii prime de la Bistricioara-*Lutărie III*.

However, an informed discussion on any synchronic/diachronic raw materials exploitation, acquisition patterns, procurement territories, and scale of mobility cannot be discussed based on the preliminary results obtained in this study. This high-range objective needs a more comprehensive petrographic analysis (artefact-by-artefact raw material identification) and a detailed techno-economic analysis of the BL III lithic assemblages (for an example and references therein, see A. Ciornei *et alii* 2021).

◈ 6. Conclusions

In line with some other recent contributions, the present study attempted at setting the characterization of the lithic raw materials used during the UP in Ceahlău Basin on a solid petrographic basis, corroborated by direct field identification of actual geological occurrences. The petrographic diversity and inner variability of the lithic raw materials exceeds by far the rough categories used in the archaeological literature. Moreover, one of the common such categories, the "menilite" from BL III proved to be in fact Eocene chert derived from the Doamna limestones. Although this requires confirmation through a more comprehensive examination of the lithic collections, it is an important discovery that might be replicated in other (all?) UP sites from the Middle and Lower Bistrița Valley.

The current analysis has fallen short from decisively settling the provenience problem of the Eastern Carpathians Flysch raw materials or the Hăghimaș syncline radiolarites/jaspers (Tulgheș-Lacu Roșu area). Both the geological occurrence of these rocks and their actual knapping potential has to be verified in the upcoming field research.

We have provided a thicker description and discussion for the siliceous rocks derived from the Audia Fm. because their provenience has been taken for granted for a long time now, despite the paucity of petrographic (or geochemical) analyses comparing the archaeological materials with samples from geological occurrences. As those before us, we assumed the same provenience and went to the outcrops exposed on Hangu Valley to collect samples and make a formal confirmation. However, the results need to be clarified by further research.

This study has also brought to attention, for the first time, the presence of Toplița chert in the Early Epigravettian assemblages at BL III, confirming the long held archaeological suppositions regarding the use of "opals" in various UP assemblages in the area. In this study, the Toplița chert is described based on samples from an origin site, not a geological source. The Sita Buzăului chert, the Prut-Dniester spiculite flint, and the Dniester Globotruncanidae flint are in the same situation as the Toplița chert. Thus, forthcoming research needs to identify and fully characterize their petrographic nature and geological contexts. This is especially important as these raw materials widen the procurement territories in three distinct directions, each with different implications for the past mobility patterns.

Although somehow outbalanced between petrographic description and archaeological inferences and deliberately careful in terms of conclusions, this petroarchaeological analysis ultimately serves the archaeologically driven goals, such as the lithic raw material economy, procurement territories, scale of mobility, cultural contacts, and so forth. An accurate petrographic description of the raw materials and a better understanding of the transport directions and procurement territories, by identifying the outcrops of the above-mentioned siliceous rocks that supplied the archaeological materials, can provide a window into the mobility scale of the UP foragers from the Bistrița Valley.

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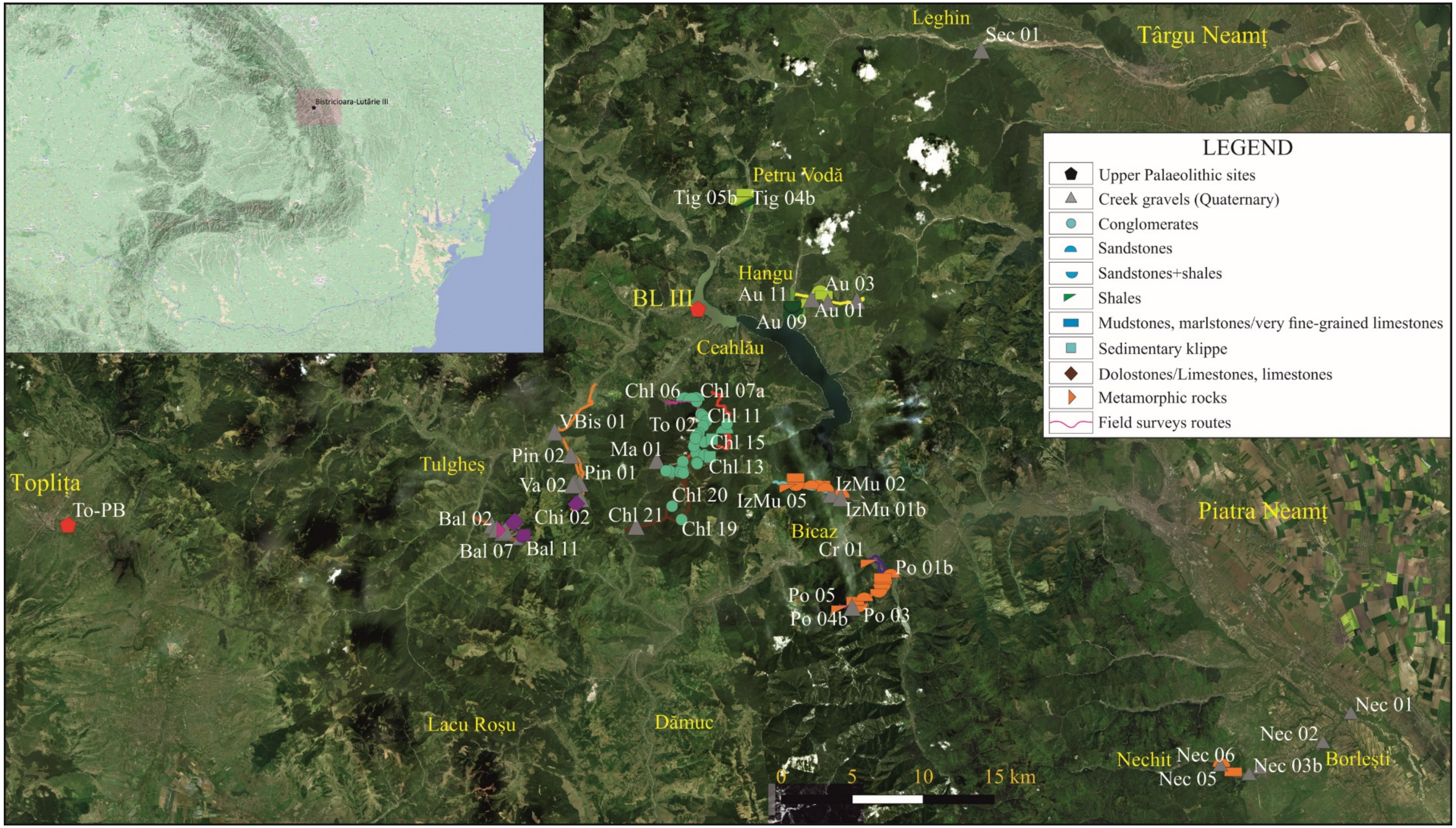
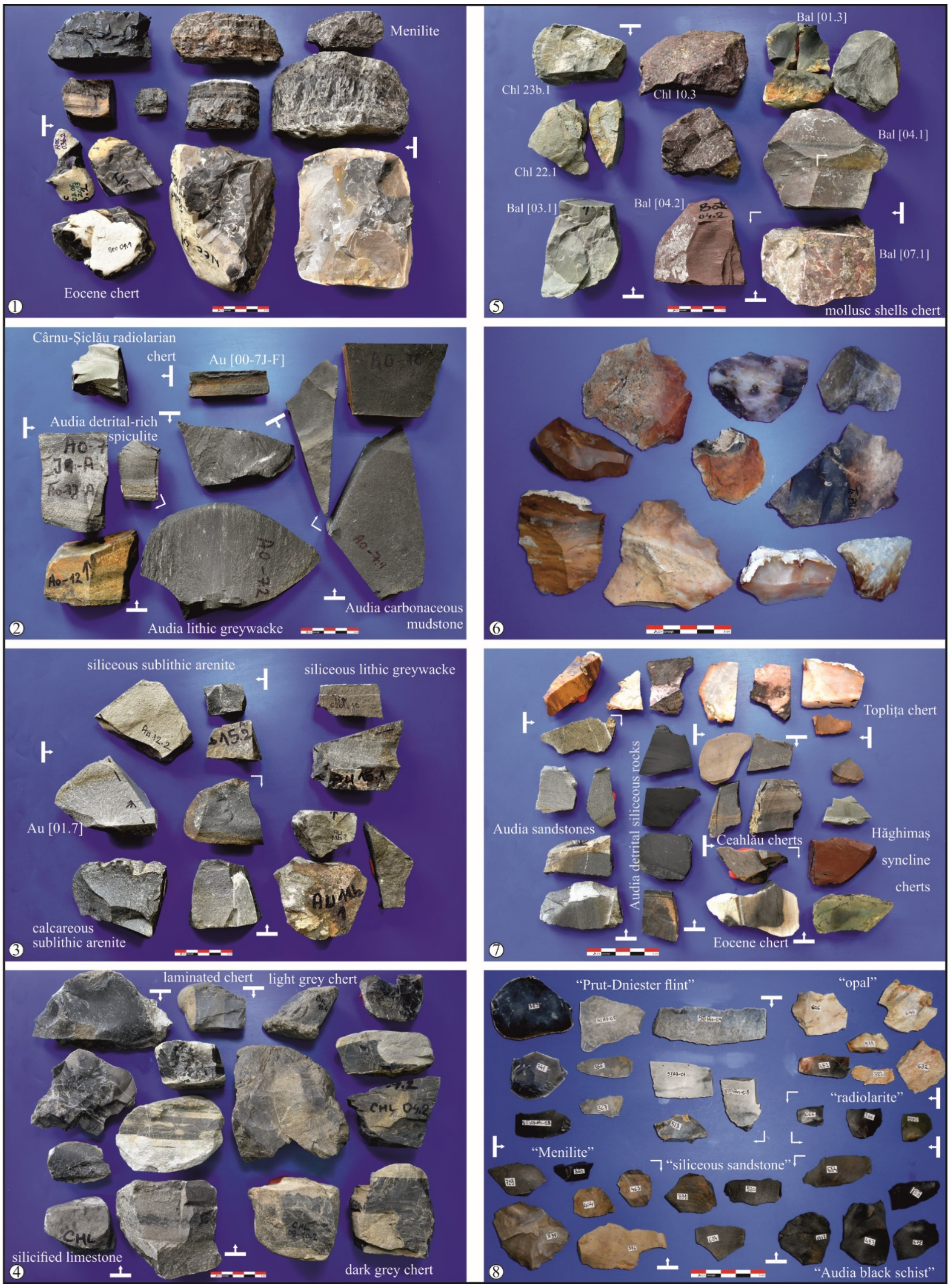


Pl. I. Map of the sampling locations (Annexes 1-7) in the extended study area (To-PB - Toplița-*Pârâul Baicăului*; BL III - Bistricioara-*Lutărie III*; map created in QGIS, projection is latitude-longitude WGS-84).
Hartă a locațiilor de eșantionare din zona extinsă de studiu.

Pl. II. Outcrop of Audia Formation (Middle Member, Audia Nappe) on Hangu creek (GPS point Au 00, Hangu village, Neamț County): 1. General view of the outcrop with black and grey shales alternating with blackish and greyish mudstones and limestones (10-40 cm thick), and greyish micaceous/calcareous sandstones (in layers of 10-20 cm thick); 2-3. Detail of the blackish mudstone with the position of samples Au [00-7J] and the thin sections (11) continuously prepared (perpendicularly to the bedding plane) from the top (left side) to the bottom (right side) of the layer; 4. Detail of layer 13 (laminated detrital-rich spiculite and blackish lithic greywacke); 5. Detail of layer 10 (black mudstone); layers 1-11 were sampled in 2018, while layers 12 and 13 were sampled in 2019 (right above layer 10); hammer is 32 cm long (photographs by Al. Ciornei 2018-2019).
Aflorimentul al Formațiunii de Audia (Membrul Mijlociu, Pânza de Audia) pe pârâul Hangu.

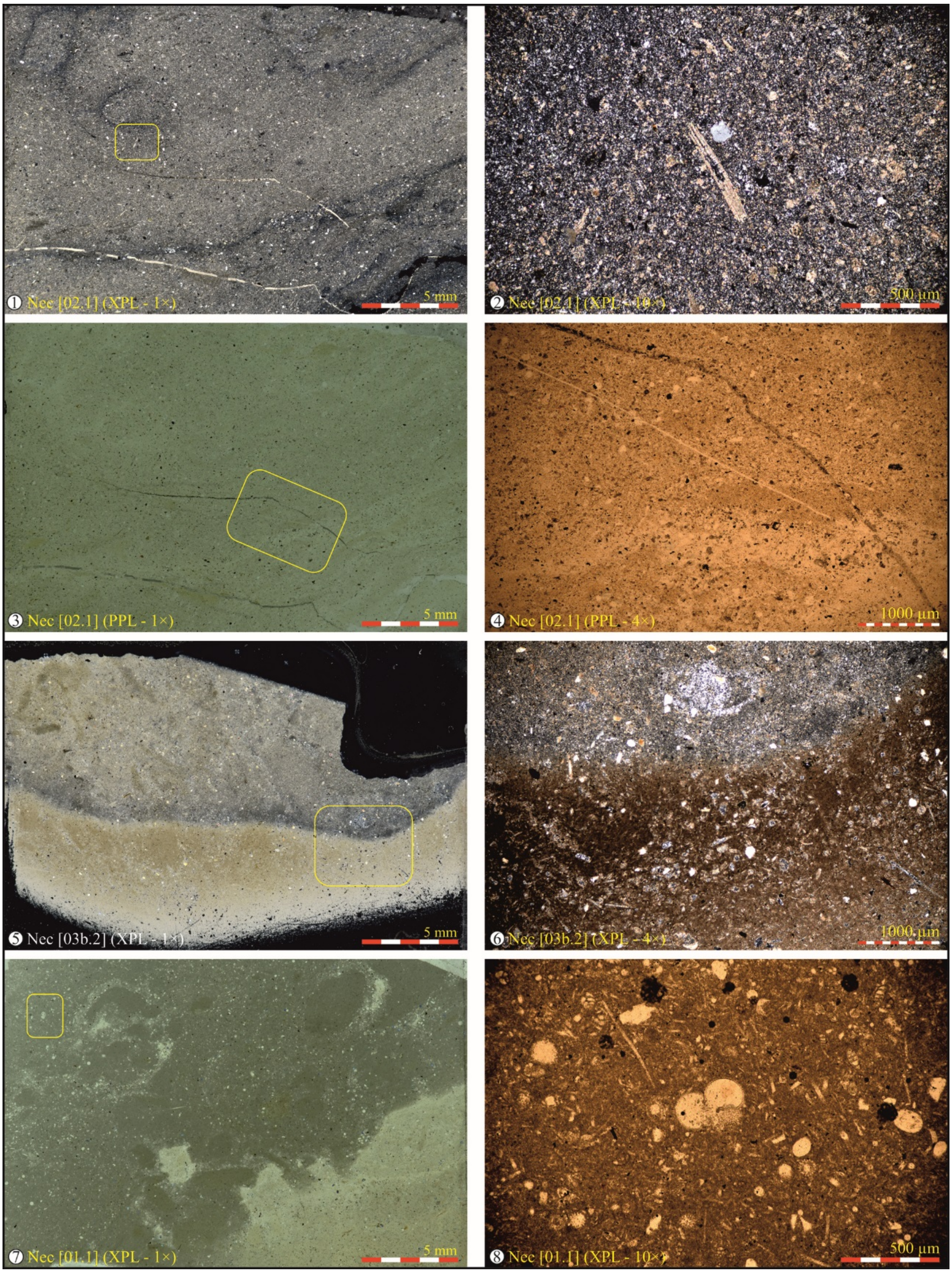
Pl. III. Outcrops of Audia (1-4) and Cârnu-Șiclău formations (5-6): 1-2. General view and details of massive sandstones with greyish shale intercalations in an outcrop on the left bank of Hangu creek (GPS location Au 15, Hangu village, Neamț County, Upper Member of Audia Formation, Audia Nappe); 3-4. General view and detail of massive sandstone layers with blackish or greyish shale intercalations in an outcrop along the right bank of Țiganului creek (GPS point Tig 02, Petru Vodă village, Neamț County, Upper Member of Audia Formation, Tarcău Nappe); 5-6. General view and detail of variegated shales with radiolarian cherts in an outcrop on the left side of Țiganului valley (GPS point Țig 03, Petru Vodă village, Neamț County, Cârnu-Șiclău Formation, Tarcău Nappe); hammer is 32 cm long (photographs by Al. Ciornei 2019).
Aflorimente ale formațiunilor de Audia și Cârnu-Șiclău.

Pl. IV. Chert and silicified limestone in the Ceahlău conglomerates (1-8), Urgonian limestones (9, Piatra cu Apă), and creek gravels (10, Martin creek) on Ceahlău Mountain (Ceahlău Nappe); hammer is 32 cm long (photographs by Al. Ciornei 2019, 2021).
Silicolit și calcar silicifiat în Conglomeratele de Ceahlău, în calcarele urgoniene și în piterișurile pâraielor de pe muntele Ceahlău.

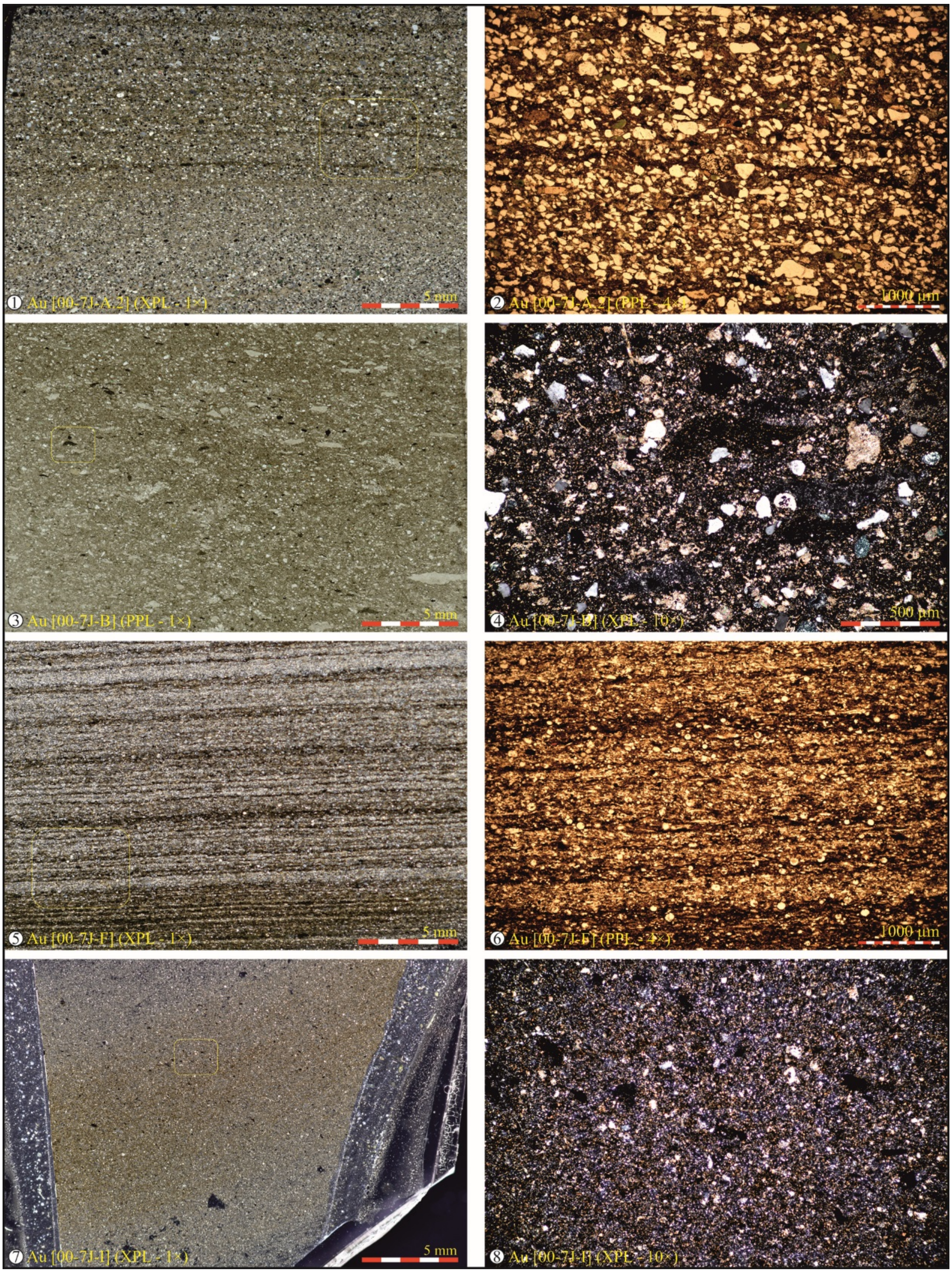


Pl. V. Rock categories from geological deposits (1-5), origin sites (6), and Bistricioara-*Lutărie III* (8): 1. Eocene chert and Menilite; 2. Audia detrital siliceous rocks and Cârnu-Şiclău radiolarian chert; 3. Sandstones; 4. Ceahlău cherts and silicified limestone; 5. Hăghimaş syncline cherts; 6. Topliţa chert; 7. Rock slices (from the preparation of thin sections) showing the main rock categories; 8. Raw material categories from Bistricioara-*Lutărie III*; all scales are 5 cm (photographs by Al. Ciornei 2019-2021).

Categorii de roci din depozite geologice, situri de origine şi de la Bistricioara-*Lutărie III*.

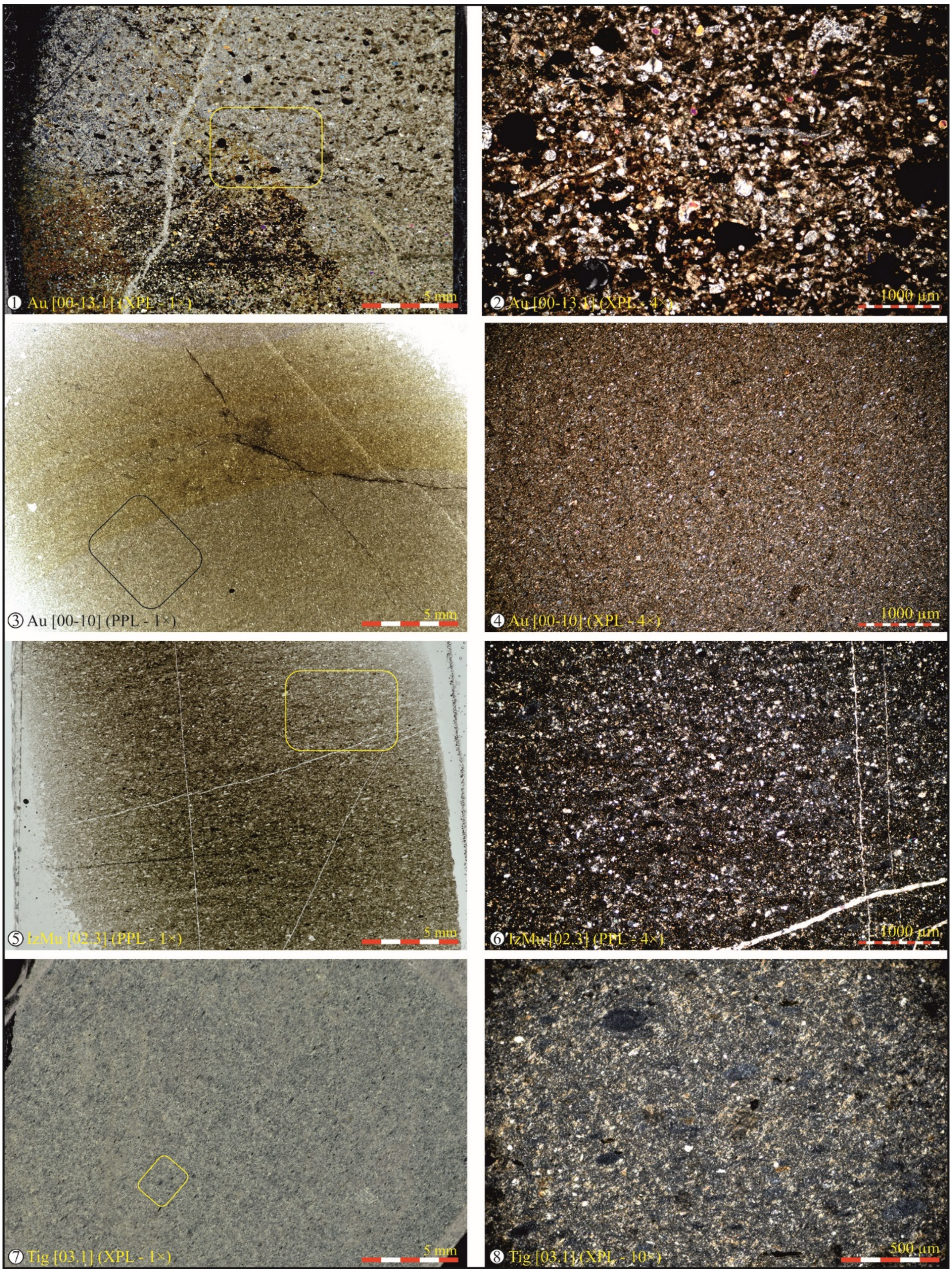


Pl. VI. Photomicrographs of cherts from Nechit Valley (Neamț County): 1-4. Eocene chert (MF 1), detrital-rich bioclastic wackestone (with echinoderms, algae, sponge spicules, radiolarians, planktonic foraminifera); 5-8. Eocene chert (MF 2), detrital-rich bioclastic wackestone (sponge spicules, radiolarians, planktonic foraminifera); PPL - plane polarized light; XPL - cross-polarized light (photographs by Al. Ciornei 2021).
Fotomicrografii de silicolite de pe valea Nechit (jud. Neamț).



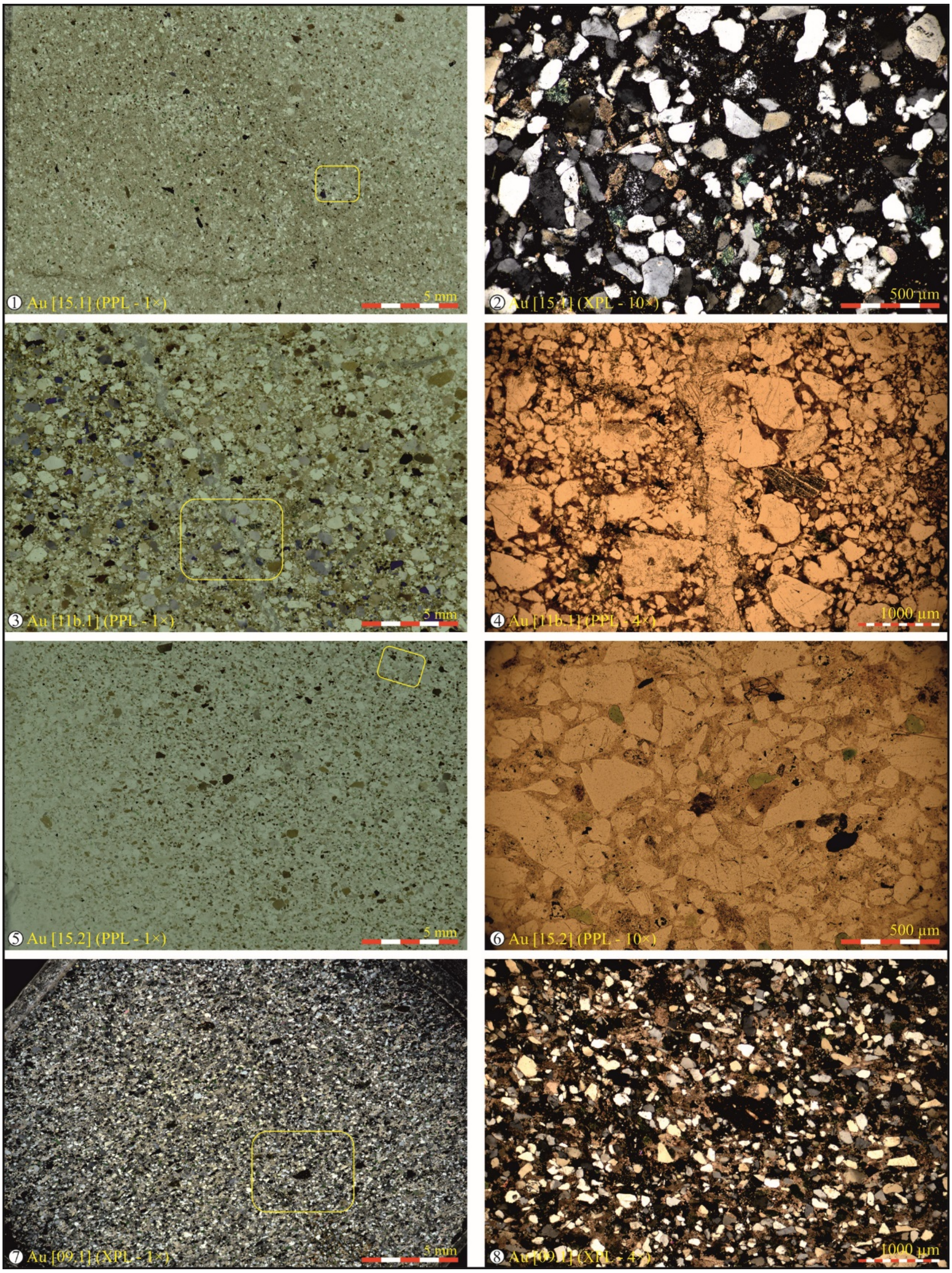
Pl. VII. Photomicrographs of samples from the fining up-ward depositional sequence in the Middle Mb. of Audia Fm. (Audia Nappe, GPS point Au 00, layer 7, Hangu village, Neamț County): 1-2. Laminated calcareous glauconitic sublithic arenite; 3-4. Glauconitic lithic greywacke; 5-6. Laminated detrital-rich spiculite packstone/radiolarian wackestone; 7-8. Carbonaceous mudstone; PPL - plane polarized light; XPL - cross-polarized light (photographs by Al. Ciornei 2021).

Fotomicrografii de probe din secvența depozițională fining up-ward din Membrul Mijlociu al Fm. de Audia.



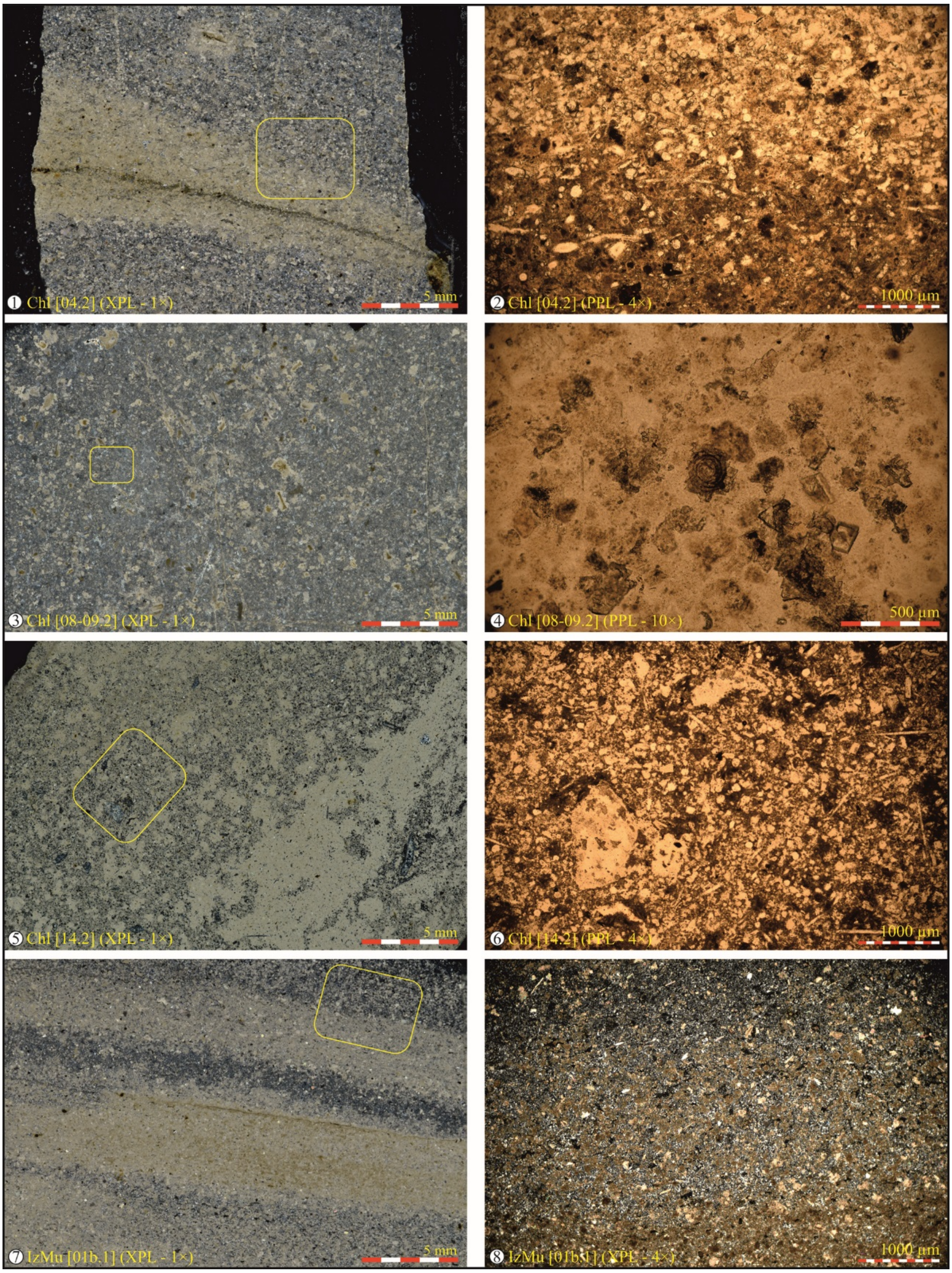
Pl. VIII. Photomicrographs of siliceous rocks from Hangu (1-4), Izvorul Muntelui (5-6), and Țiganului valleys (7-8): 1-2. Audia detrital-rich spiculite; 3-4. Audia carbonaceous black mudstone; 5-6. Audia laminated carbonaceous black radiolarian chert; 7-8. Cârnu-Șiclău radiolarian chert; PPL - plane polarized light; XPL - cross-polarized light (photographs by Al. Ciornei 2021).

Fotomicrografii de roci silicioase de pe văile Hangu, Izvorul Muntelui și Țiganului.

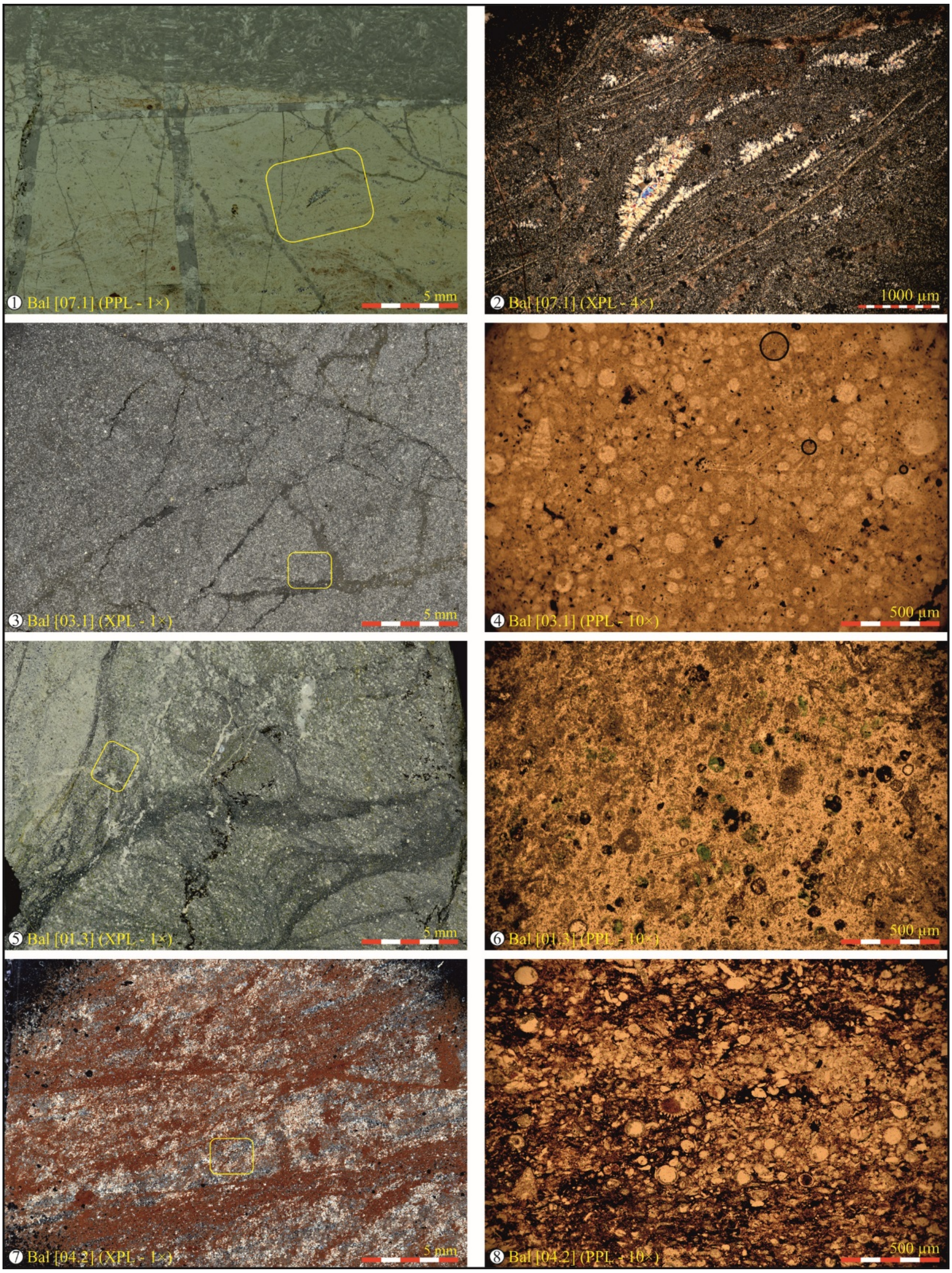


Pl. IX. Photomicrographs of Audia sandstones: 1-2. Siliceous-calcareous glauconitic lithic greywacke; 3-4. Siliceous glauconitic lithic greywacke; 5-6. Siliceous glauconitic sublithic arenite; 7-8. Calcareous glauconitic sublithic arenite; XPL - cross-polarized light (photographs by Al. Ciornei 2021).

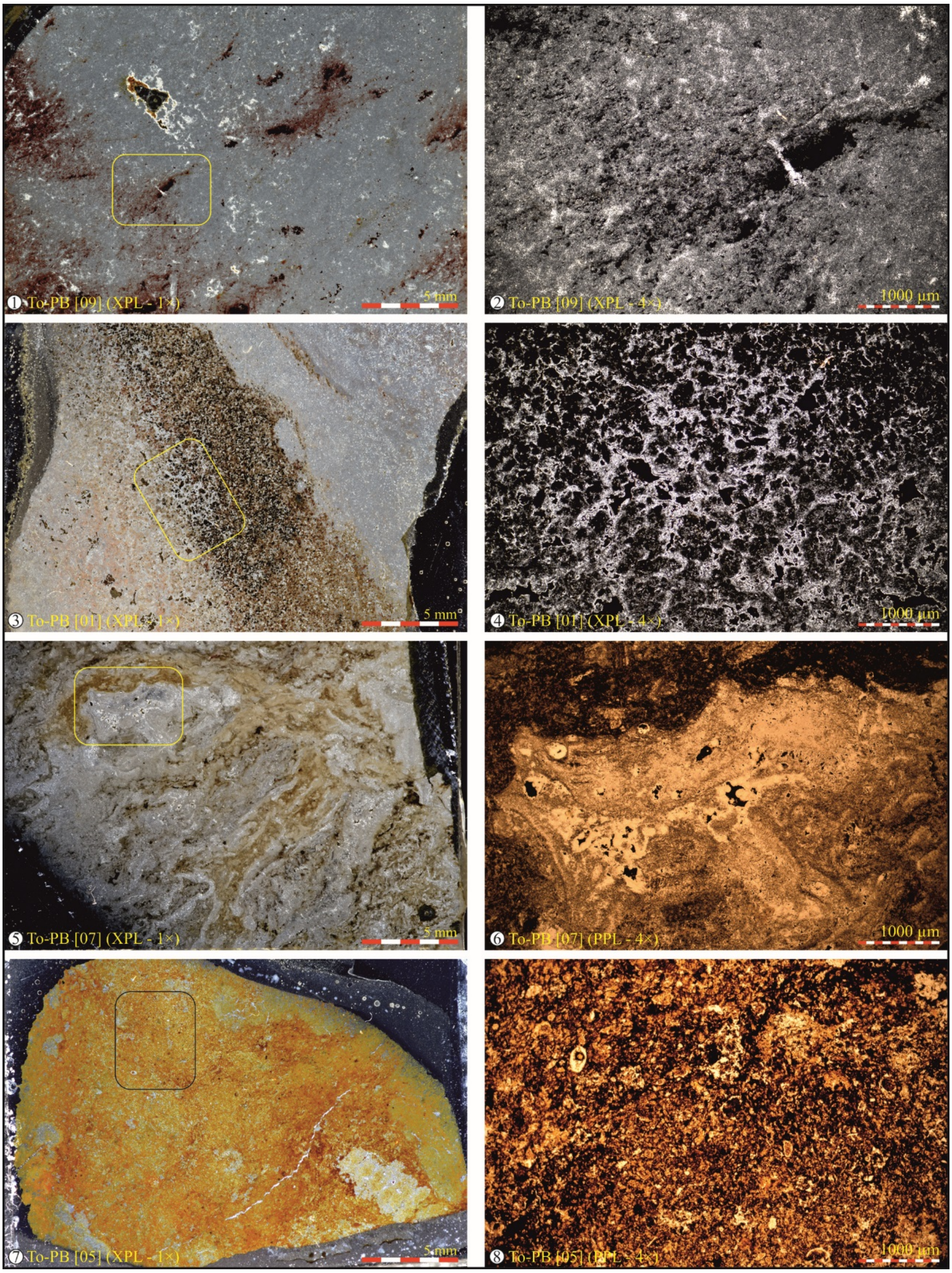
Fotomicrografii cu gresii de Audia.



Pl. X. Photomicrographs of samples from Ceahlău Mountain (1-6) and Izvorul Muntelui creek (7-8): 1-2. Ceahlău chert, dedolomitized spiculitic-intraclastic wackestone (MF 1) with a lamina of dedolomitized intraclastic packed wackestone (MF 3); 3-4. Ceahlău chert, dedolomitized bioclastic-intraclastic wackestone (MF 2); 5-6. Dedolomitized, partially silicified bioclastic wackestone limestone; 7-8. Ceahlău chert with alternating laminae of MF 3, MF 2, and MF 1; PPL - plane polarized light; XPL - cross-polarized light (photographs by Al. Ciornei 2021).
Fotomicrografii ale unor probe de pe muntele Ceahlău și de pe pârâul Izvorul Muntelui.

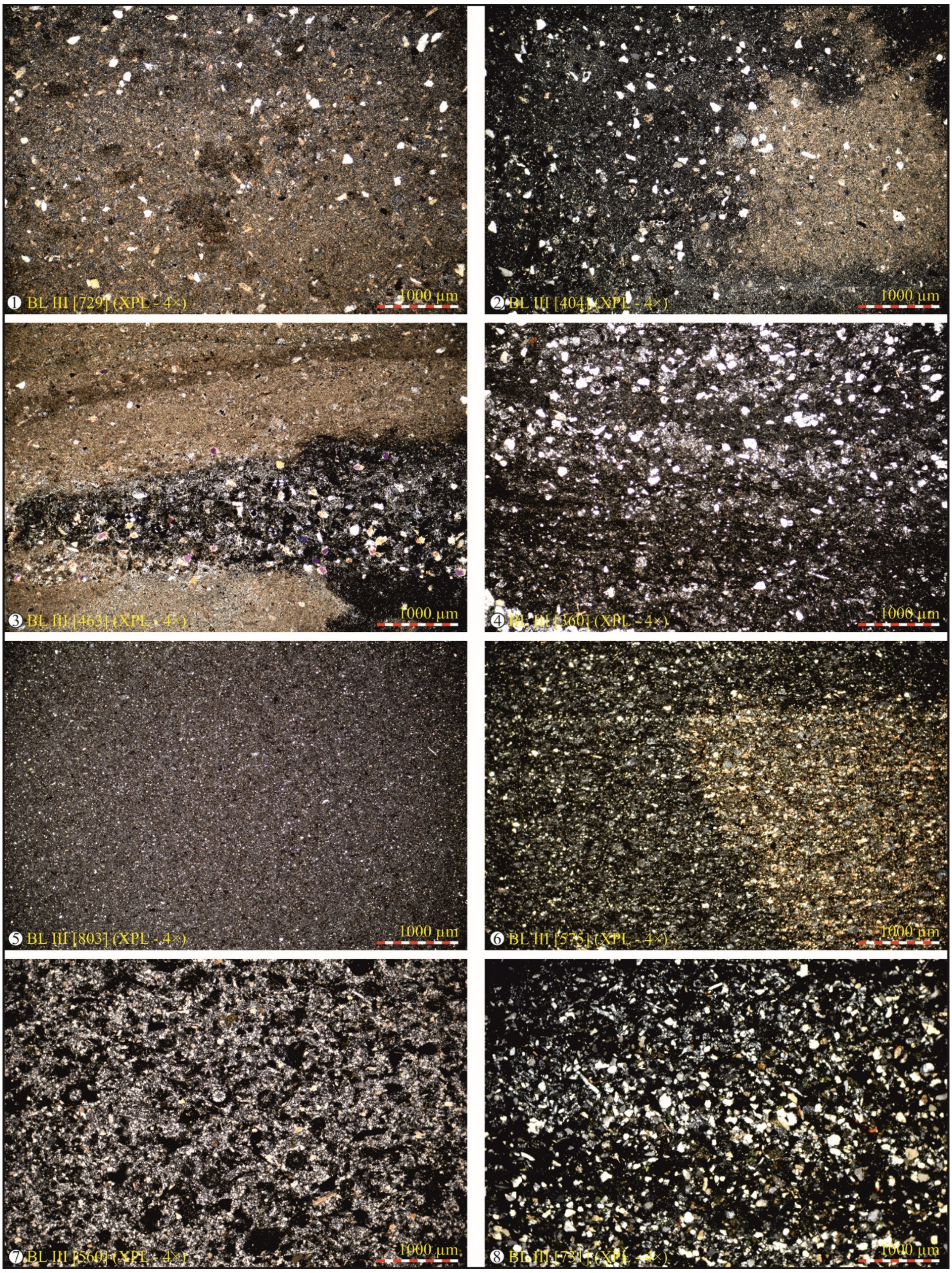


Pl. XI. Photomicrographs of Hăghimaș syncline cherts: 1-2. Mollusc shells chert (packstone); 3-4. Jurassic greenish radiolarite (packed wackestone); 5-6. Triassic carbonaceous radiolarian chert (wackestone); 7-8. Triassic reddish radiolaritic siliceous-ferruginous-carbonaceous rock (packed wackestone); PPL - plane polarized light; XPL - cross-polarized light (photographs by Al. Ciornei 2021).
Fotomicrografii cu silicolite din sinclinalul Hăghimaș.

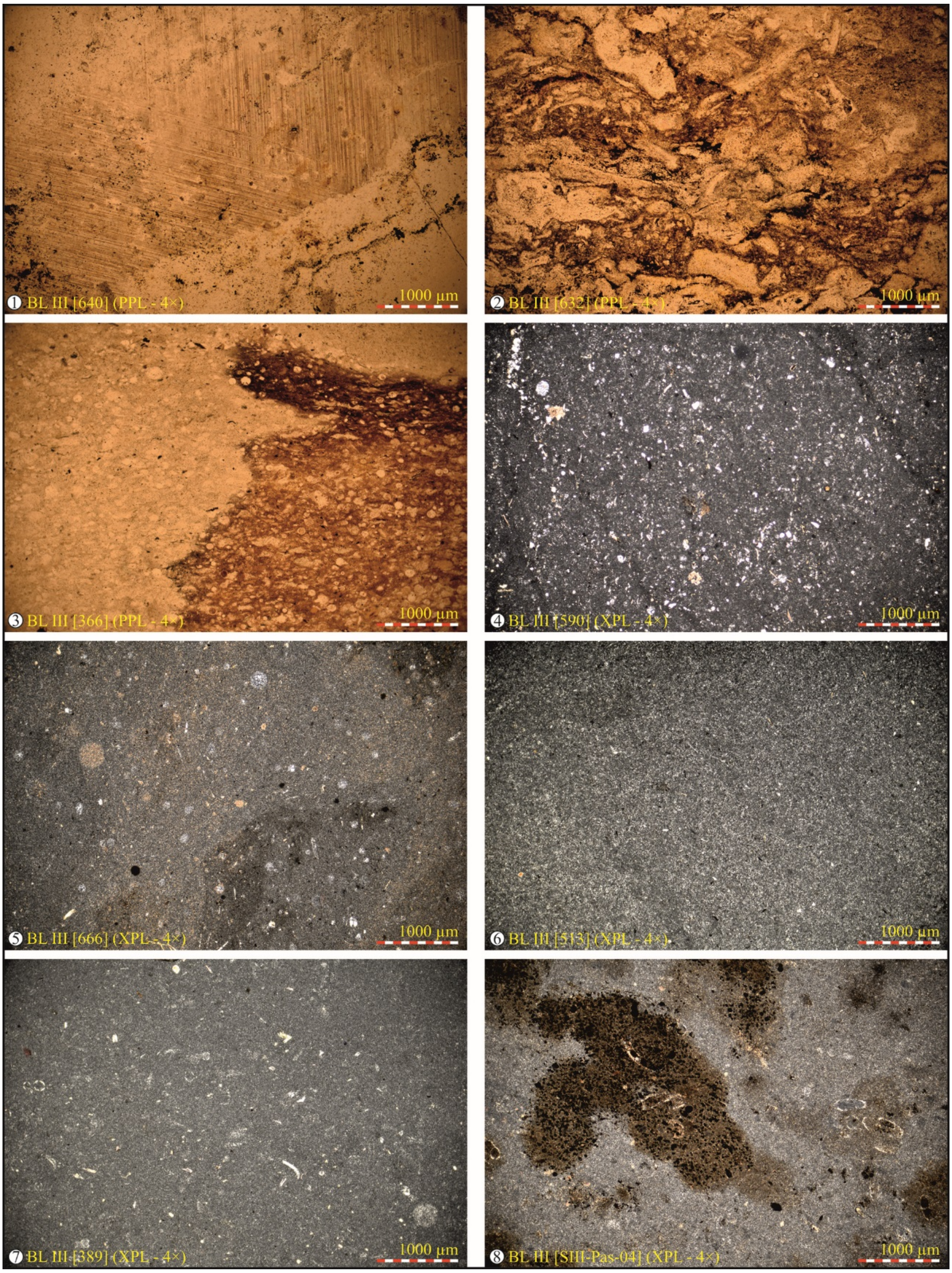


Pl. XII. Photomicrographs of origin samples from Toplița-*Pârâul Baicăului* (Harghita County): 1-2. Toplița non-fossiliferous chert with massive fabric; 3-4. Toplița non-fossiliferous chert with breccia fabric; 5-6. Toplița non-fossiliferous chert with flow banding; 7-8. Toplița fossiliferous chert with bioclastic packed wackestone fabric (algae fragments, mollusc shells, and charophyte gyrogonites); PPL - plane polarized light; XPL - cross-polarized light (photographs by Al. Ciornei 2021).

Fotomicrografii cu probe de origine de la Toplița-*Pârâul Baicăului* (jud. Harghita).

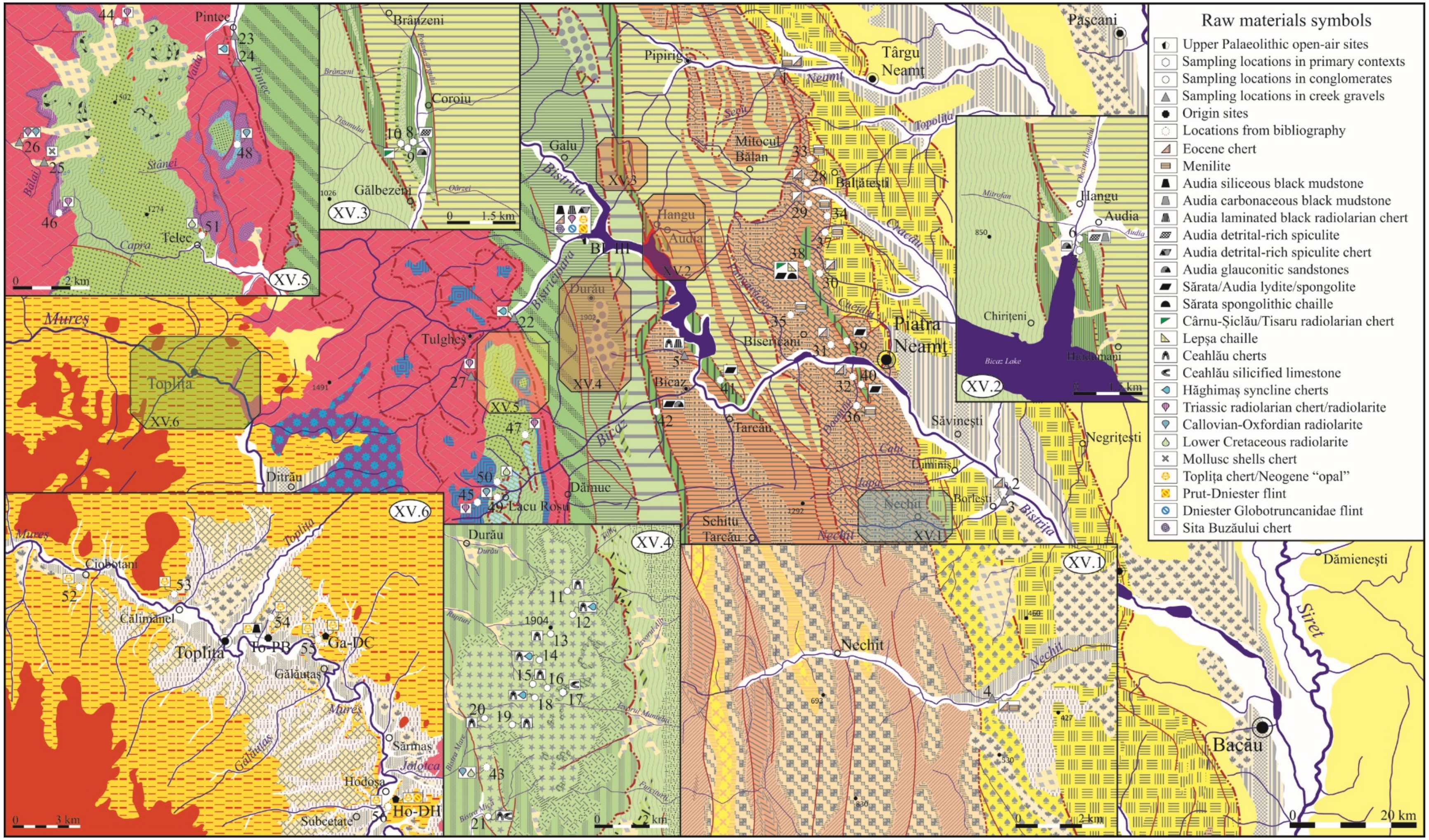


Pl. XIII. Photomicrographs of samples from Bistricioara-*Lutărie III* (Neamț County): 1. Eocene chert (MF 1); 2. Eocene chert (MF 3), detrital-rich bioclastic chert (with planktonic foraminifera); 3-4. Eocene chert, laminated detrital-rich bioclastic chert; 5. Siliceous black mudstone; 6. Audia laminated black radiolarian chert; 7. Audia detrital-rich spiculite chert; 8. Audia laminated siliceous glauconitic sublithic arenite (very fine sand); XPL - cross-polarized light (photographs by Al. Ciornei 2021).
Fotomicrografii de probe de la Bistricioara-*Lutărie III* (jud. Neamț).

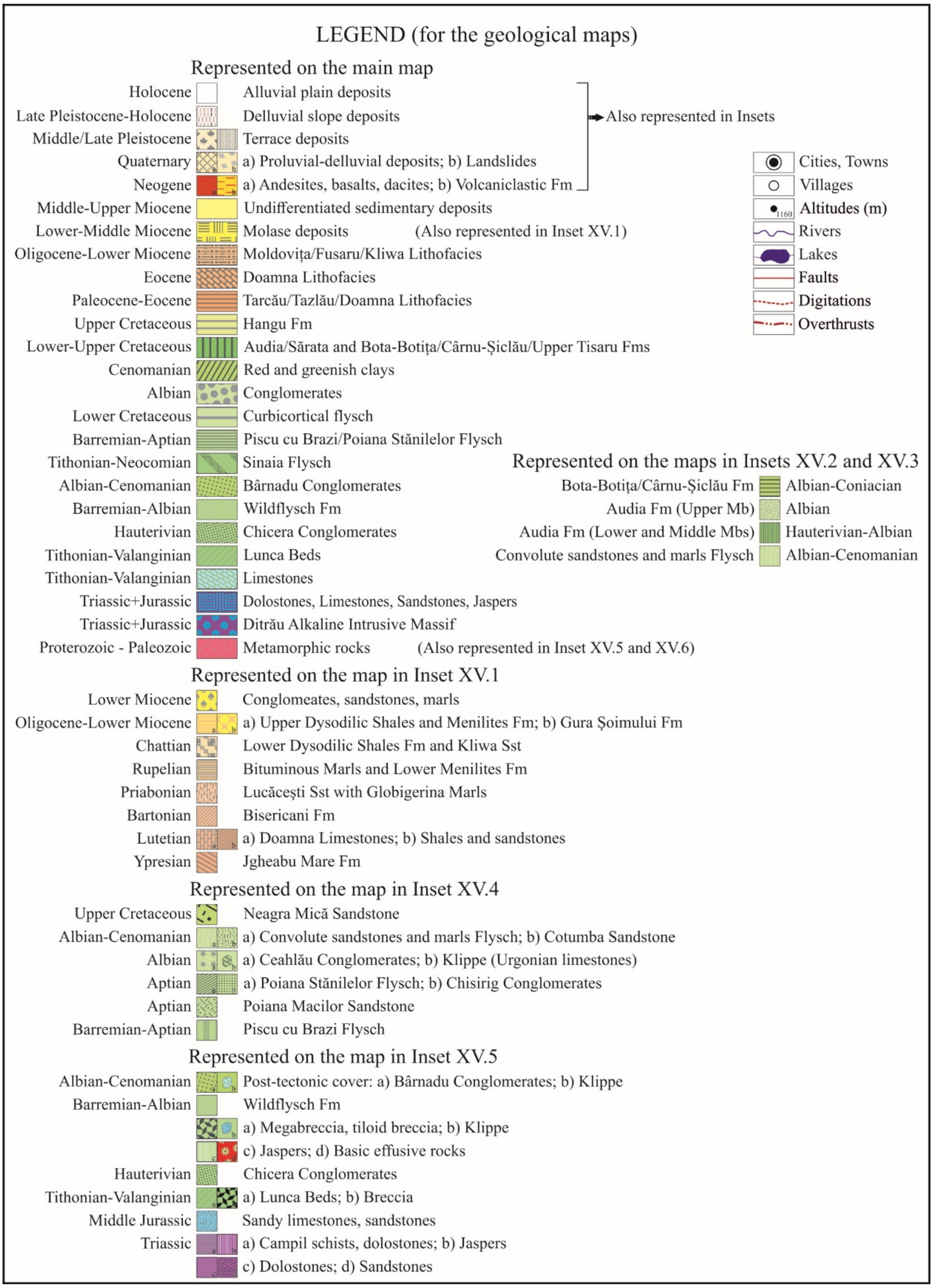


Pl. XIV. Photomicrographs of samples from Bistricioara-*Lutărie III* (Neamț County): 1. Toplița non-fossiliferous chert with breccia fabric and fragments of silicified wood; 2. Toplița non-fossiliferous chert with flow banding; 3. Bicoloured detrital-rich radiolarite; 4. Detrital-rich radiolarian chert; 5. Sita Buzăului radiolarian chert; 6. Prut-Dniester spiculite flint; 7-8. Dniester Globotruncanidae flint; PPL - plane polarized light; XPL - cross-polarized light (photographs by Al. Ciornei 2021).

Fotomicrografii de probe de la Bistricioara-*Lutărie III* (jud. Neamț).



Pl. XV. Occurrence map of archaeologically relevant siliceous rocks in the extended study area. Occurrences of siliceous rocks: 1-27. Sampling locations from this study (Annexes 1-7); 28-56. Locations from bibliography (Table 5); Upper Palaeolithic sites: BL III, To-PB (see legend of Pl. I); Ga-DC - Gălăuțaș-*Dealul Cisc*; Ho-DH - Hodoșa-*Dealul Hodoșa*.
Harta ocurenței de roci silicioase de importanță archeologică în zona extinsă de studiu.



Pl. XV. *Continued*. Legend for the geological maps. The map supports were redrawn and modified after parts from the Geological Map of Romania 1: 1000000 (Pl. XV - M. Săndulescu *et alii* 1978), Tazlău Sheet (Inset XV.1 - M. Micu *et alii* 1983), and geological maps from published papers (Insets XV.2, XV.3 - Gr. Alexandrescu 1968; Inset XV.4 - M. Săndulescu 1990 and C. Grasu 1965; Inset XV.5 - M. Săndulescu 1975; Inset XV.6 - T. Bandrabur, V. Codarcea 1974).
Continuare. Legenda pentru hărțile geologice.

No. in Pl. XV	**Stops**	**Elevation (m)**	**GPS co-ordinates (Lat. N)**	**GPS co-ordinates (Long. E)**	**Context**			**Rock types sampled/observed and recorded**	**Samples**		
					Lithology (predominant)	**Geological deposit**	**Stage/Period**		**Co**	**MA**	**TS**
1	Sec 01	-	47.21869	26.21180	gravel	creek gravel	Quaternary	menilite, greyish-brownish chert, greenish siliceous sandstone	10	10	0
2	Nec 01	-	46.80131	26.55260	gravel	gravel bar	Quaternary	greyish-brownish chert, sandstones, mudstones/marlstones, various metamorphic rocks	19	19	1
3	Nec 02	-	46.78292	26.52683	gravel	gravel bar	Quaternary	greyish-brownish chert	1	1	1
-	Nec 03a	-	46.76666	26.46884	marlstone	Salt Fm.	Lower Miocene	light grey-greenish marlstone and greywacke	3	3	0
4	Nec 03b	-	46.76285	26.45877	gravel	gravel bar	Quaternary	greyish-brownish chert, menilite, laminated grey-brownish bituminous marlstone	5	5	4
-	Nec 04	-	46.76256	26.44416	marlstone	Lower Dysodilic Shales Fm. and Kliwa Sst.	Oligocene-Lower Miocene	greyish-brownish bituminous marlstone, sandstone and vein quartz	5	5	0
-	Nec 05	-	46.76839	26.43326	sandstone	Bisericani Fm.	Eocene	whitish-beige calcareous sandstone, beige very fine grained limestone, dark grey marlstone	3	3	0
-	Nec 06	-	46.76851	26.43230	gravel	creek gravel	Quaternary	grey-greenish laminated siliceous sandstone	1	1	0
									47	**47**	**6**

Co – collected; MA – macroscopic analysis; TS – thin sections; Fm. – Formation; Mb. – Member; Sst. – sandstones.

Annex 1. Stops recorded along Nechit and Secu creeks (Neamț County).
Stopuri înregistrate de-a lungul văilor Nechit și Secu (jud. Neamț).

No. in Pl. XV	Stops	Elevation (m)	GPS co-ordinates (Lat. N)	GPS co-ordinates (Long. E)	Context			Rock types sampled/observed and recorded	Samples		
					Lithology (predominant)	Geological deposit	Stage/Period		Co	MA	TS
-	Cr 01	399.60	46.89899	26.1087	shale and sandstone	Podu Secu Fm.	Eocene	-	0	0	0
-	Po 01b	431.00	46.88762	26.12855	sandstone	Fusaru Fm., Arenitic Mb.	Lower Miocene	-	0	0	0
-	Po 01a	418.92	46.88682	26.12193	sandstone and shale	Podu Secu Fm.	Eocene	-	0	0	0
-	Po 02a	423.00	46.88587	26.12182	sandstone and shale			-	0	0	0
-	Po 02b	437.47	46.88504	26.12099	sandstone and shale			medium grey micaceous mudstone	1	1	0
-	Po 02c	438.00	46.88485	26.12098	marlstone, shale and sandstone			-	0	0	0
-	Po 02d	452.00	46.88368	26.12045	sandstone and shale			-	0	0	0
-	Po 06a	490.00	46.88065	26.11758	shale and sandstone			-	0	0	0
-	Po 06b	507.00	46.88060	26.11738	sandstone and shale			-	0	0	0
-	Po 03b	616.00	46.87282	26.10403	sandstone	Fusaru Fm., Arenitic Mb.	Lower Miocene	-	0	0	0
-	Po 03	659.84	46.87140	26.09904	sandstone and shale	Fusaru Fm., Pelitic-arenitic Mb.	Lower Miocene	-	0	0	0
-	Po 04	692.92	46.87013	26.09567	marlstone, sandstone and shale			medium grey micaceous sandstone	1	1	0
-	Po 04b	727.03	46.86914	26.09292	gravel	creek gravel	Quaternary	medium grey-brownish marlstone	1	1	0
-	Po 05	910.35	46.87017	26.08161	shale and sandstone	Tarcău Sst Fm.	Eocene	-	0	0	0
									3	**3**	**0**

Co – collected; MA – macroscopic analysis; TS – thin sections; Fm. – Formation; Mb. – Member; Sst. – sandstones.

Annex 2. Stops recorded along Potoci and Crasna creeks (Neamț County).
Stopuri înregistrate de-a lungul văilor Potoci și Crasna (jud. Neamț).

No. in Pl. XV	Stops	Elevation (m)	GPS co-ordinates (Lat. N)	GPS co-ordinates (Long. E)	Context			Rock types sampled/observed and recorded	Samples		
					Lithology (predominant)	Geological deposit	Stage/Period		Co	MA	TS
-	IzMu 01	463.86	46.93792	26.08268	sandstone	Fusaru Fm., Arenitic Mb.	Lower Miocene	-	0	0	0
5	IzMu 01b	464.00	46.93795	26.08252	gravel	creek gravel	Quaternary	dark grey chert	1	1	1
	IzMu 02	492.72	46.94020	26.07362	gravel	creek gravel	Quaternary	light brown-beige siliceous rock, blackish siliceous mudstone	3	3	1
-	IzMu 02b	512.00	46.94180	26.06830	sandstone	Fusaru Fm., Arenitic Mb.	Lower Miocene	-	0	0	0
-	IzMu 03	521.42	46.94304	26.06465	marlstone	Bituminous Marls Fm.	Oligocene	-	0	0	0
-	IzMu 04	530.87	46.94368	26.06141	sandstone and shale	Fusaru Fm., Arenitic Mb.	Lower Miocene	-	0	0	0
-	IzMu 05	568.37	46.94335	26.05530	sandstone			-	0	0	0
-	IzMu 06b	593.20	46.94758	26.04104	sandstone and shale			-	0	0	0
-	IzMu 06	594.20	46.94770	26.04071	mudstone/marlstone and sandstone	Fusaru Fm., Pelitic-arenitic Mb.	Lower Miocene	-	0	0	0
-	IzMu 07	617.46	46.94638	26.03384	shale and sandstone	Tarcău Sst Fm.	Eocene	medium grey micaceous sandstone	1	1	0
									5	**5**	**2**

Co – collected; MA – macroscopic analysis; TS – thin sections; Fm. – Formation; Mb. – Member; Sst. – sandstones.

Annex 3. Stops recorded along Izvorul Muntelui Valley (Neamț County).
Stopuri înregistrate de-a lungul văii Izvorul Muntelui (jud. Neamț).

No. in Pl. XV	Stops	Elevation (m)	GPS co-ordinates (Lat. N)	GPS co-ordinates (Long. E)	Context			Rock types sampled/observed and recorded	Samples		
					Lithology (predominant)	Geological deposit	Stage/Period		Co	MA	TS
-	Au 05	-	47.06178	26.09721	gravel	creek gravel	Quaternary	medium grey very fine-grained limestones and sandstones	8	8	0
-	Au 06	-	47.06054	26.07041	gravel	creek gravel	Quaternary	greyish very fine-grained limestones and sandstones	5	5	0
-	Au 04	-	47.06230	26.06682	marlstone/very fine-grained limestone and sandstone	Hangu Fm.	Late Campanian-Maastrichtian	medium grey very fine-grained limestones/marlstones and sandstones	4	4	1
-	Au 03	-	47.06586	26.06337	sandstone			greyish sandstone	1	1	0
-	Au 02	-	47.06290	26.05577	gravel	creek gravel	Quaternary	grey very fine-grained limestones/marlstones and sandstones	15	15	0
-	Au 01	-	47.06303	26.05382	shale and sandstone	Hangu Fm.	Late Campanian-Maastrichtian	grey very fine-grained limestones/marlstones and sandstones	13	13	1
-	Au 01b	-	47.06255	26.05367	shale and sandstone			grey very fine-grained limestones/marlstones and sandstones	4	4	0
6	Au 00	559.00	47.06142	26.03798	shale, mudstone, very fine-grained limestone, sandstone	Audia Fm, Middle Mb.	Late Barremian-Early Albian	blackish mudstones, greyish sandstones, dark grey limestones, laminated chert	29	29	16
-	Au 07	581.41	47.05481	26.03793	shale and sandstone			medium grey sandstone	1	1	1
7	Au 16	536.00	47.06064	26.03787	sandstone and shale	Audia Fm., Upper Mb.	Early-Late Albian	-	0	0	0
	Au 15	535.35	47.06035	26.03795	sandstone and shale			dark grey sandstone	2	2	2
	Au 14	533.84	47.05978	26.03797	sandstone and shale			medium grey siliceous sandstone	1	1	1
	Au 13	533.82	47.05968	26.03798	sandstone and shale			dark grey siliceous sandstone	1	1	1
	Au 12b	533.41	47.05952	26.03787	sandstone and shale			grey-greenish sandstone	2	2	0
	Au 12	533.65	47.05945	26.03788	sandstone and shale			grey-brownish and greenish sandstone	2	2	2
	Au 11b	566.39	47.05928	26.03759	sandstone and shale			grey-greenish siliceous sandstone	2	2	2
	Au 11	564.85	47.05931	26.03776	sandstone and shale			dark grey-greenish siliceous sandstone	1	1	1
	Au 10	563.62	47.05882	26.03765	sandstone and shale			-	0	0	0
	Au 09	618.95	47.05678	26.03957	sandstone and shale			dark grey siliceous sandstone	1	1	1
	Au 08	629.50	47.05678	26.03991	sandstone and shale			-	0	0	0
									92	**92**	**29**

Co – collected; MA – macroscopic analysis; TS – thin sections; Fm. – Formation; Mb. – Member; Sst. – sandstones.

Annex 4. Stops recorded along Audia and Hangu valleys (Neamț County).
Stopuri înregistrate de-a lungul văilor Audia și Hangu (jud. Neamț).

No. in Pl. XV	Stops	Elevation (m)	GPS co-ordinates (Lat. N)	GPS co-ordinates (Long. E)	Context			Rock types sampled/observed and recorded	Samples		
					Lithology (predominant)	Geological deposit	Stage/Period		Co	MA	TS
8	Tig 01	600.49	47.12651	25.99642	shale, sandstone, mudstone	Audia Fm., Middle Mb.	Late Barremian-Early Albian	blackish mudstone, laminated chert	4	4	1
9	Tig 02	602.37	47.12603	25.99541	sandstone and shale	Audia Fm., Upper Mb.	Early-Late Albian	medium to dark grey sandstone and mudstone	4	4	1
	Tig 02b	606.61	47.12585	25.99507	sandstone and shale			-	0	0	0
	Tig 02c	616.02	47.12686	25.99538	sandstone and shale			-	0	0	0
	Tig 02d	627.49	47.12655	25.99499	sandstone, mudstone and shale			dark grey micaceous sandstone, dark grey greywackes	9	9	2
10	Tig 03	620.27	47.12649	25.99460	shale and marlstone	Cârnu-Șiclău Fm.	Late Albian-Coniacian	grey-greenish rough chert, medium greenish siliceous marlstone	2	2	1
-	Tig 04b	633.07	47.12632	25.99424	very fine-grained limestone/marlstone, shale, sandstone			greyish marlstone/very fine-grained limestone	3	3	1
-	Tig 03b	625.07	47.12641	25.99414	shale and sandstone			-	0	0	0
-	Tig 04a	646.63	47.12649	25.99353	shale, sandstone, marlstone/very fine-grained limestone	Hangu Fm.	Late Campanian-Maastrichtian	medium grey and burgundy marlstone/very fine-grained limestone	4	4	1
-	Tig 05b	654.62	47.12665	25.99261	shale, very fine-grained limestone/marlstone, sandstone			medium grey and greenish marlstone/very fine-grained limestone, medium grey sandstone	6	6	0
-	Tig 05	657.00	47.12667	25.99187	shale, very fine-grained limestone/marlstone, sandstone			reddish and grey-greenish marlstone/very fine-grained limestone	6	6	2
-	Tig 06b	658.54	47.12660	25.99117	shale and marlstone/very fine-grained limestone			grey and grey-greenish marlstone/very fine-grained limestone	10	10	2
-	Tig 06a	658.94	47.12677	25.99061	shale and marlstone/very fine-grained limestone			-	0	0	0
-	Tig 07	660.69	47.12667	25.98917	shale and sandstone			medium grey siliceous sandstone	1	1	0
									49	**49**	**11**

Co – collected; MA – macroscopic analysis; TS – thin sections; Fm. – Formation; Mb. – Member; Sst. – sandstones.

Annex 5. Stops recorded along Țiganului Valley (Neamț County).
Stopuri înregistrate pe valea Țiganului (jud. Neamț).

No. in Pl. XV	Stops	Elevation (m)	GPS co-ordinates (Lat. N)	GPS co-ordinates (Long. E)	Context			Rock types sampled/observed and recorded	Samples		
					Lithology (predominant)	Geological deposit	Stage/ Period		Co	MA	TS
-	Ma 01	-	46.96140	25.91278	creek gravel	creek gravel	Quaternary	chert	0	0	0
-	Sc 01	1226.00	46.95483	25.92132	surface	passim	Quaternary	chert	2	2	0
20	Chl 01b	-	46.95488	25.92421	surface	altered Ceahlău conglomerates	Quaternary	chert	1	1	0
	Chl 01	1359.29	46.95410	25.92608				chert	1	1	0
-	Chl 02	1657.77	46.95662	25.93611	conglomerates with sandstone layers	Ceahlău conglomerates	Albian	limestone	1	1	0
-	Chl 03	1739.19	46.96065	25.93680				limestone	1	1	0
-	Chl 17	1709.00	46.95426	25.93339				-	0	0	0
19	Chl 17b	1698.00	46.95408	25.93462				chert	1	1	0
	Chl 18	1682.00	46.95348	25.93731				chert	1	1	0
-	Chl 19	1299.00	46.92417	25.93569				silicified limestone, chert, quartzite	5	5	0
21	Chl 20	1259.00	46.93260	25.92685				silicified limestone, chert	6	6	0
	Chl 20b	1259.00	46.93285	25.92700	creek gravel	creek gravel	Quaternary	chert, silicified limestone, sandstone	6	6	0
-	Chl 21	875.00	46.91998	25.89375				chert, quartzite	2	2	0
-	Chl 16	1189.00	46.97462	25.96377	Urgonian limestone klippe	Ceahlău conglomerates	Albian	-	0	0	0
-	Chl 15	1381.00	46.97297	25.95625	conglomerates with sandstone layers			-	0	0	0
17	Chl 14	1508.00	46.96360	25.96179	Urgonian limestone klippe			limestone, silicified limestone	6	6	3
16	Chl 13	1566.82	46.96476	25.95681	conglomerates with sandstone layers			chert	1	1	1
18	Chl 23c	1597.00	46.95936	25.95012	surface	altered Ceahlău conglomerates	Quaternary	chert	1	1	0
	Chl 23b-23c	-	-	-				chert	1	1	0
	Chl 23b	1630.00	46.95992	25.94950				greenish jasper	1	1	0
	Chl 23a	1640.00	46.96006	25.94954				-	0	0	0
15	Chl 04	1757.44	46.96597	25.94897	conglomerates with sandstone layers	Ceahlău conglomerates	Albian	chert	4	4	4
14	Chl 22	1701.00	46.97037	25.94685	surface	altered Ceahlău conglomerates	Quaternary	chert, greenish jasper	3	3	0
-	To 03	-	46.97529	25.94833				-	0	0	0
-	To 02-03	-	-	-				chert	4	4	0
13	To 02	-	46.97687	25.94916	conglomerates with sandstone layers	Ceahlău conglomerates	Albian	chert	2	2	0
	To 01	1904.00	46.97755	25.94988				chert	1	1	0

Annex 6. Stops recorded on Ceahlău Mountain (Neamț County).
Stopuri înregistrate pe muntele Ceahlău (jud. Neamț).

No. in Pl. XV	Stops	Elevation (m)	GPS co-ordinates (Lat. N)	GPS co-ordinates (Long. E)	Context			Rock types sampled/observed and recorded	Samples		
					Lithology (predominant)	Geological deposit	Stage/ Period		Co	MA	TS
-	Chl 12	1731.07	46.97858	25.95172	conglomerates with sandstone layers	Ceahlău conglomerates	Albian	limestone	1	1	0
12	Chl 11	1704.00	46.98297	25.95555	surface	altered Ceahlău conglomerates	Quaternary	chert	1	1	0
	Chl 10	1564.91	46.98605	25.95862	conglomerates with sandstone layers	Ceahlău conglomerates	Albian	chert, limestone, reddish jasper	4	4	0
	Chl 09-10	-	-	-	surface	altered Ceahlău conglomerates	Quaternary	chert	3	3	0
11	Chl 09	1398.10	46.98934	25.95533	conglomerates with sandstone layers	Ceahlău conglomerates	Albian	chert	2	2	0
	Chl 08-09	-	-	-	surface	altered Ceahlău conglomerates	Quaternary	chert	5	5	3
	Chl 08	1341.25	46.99047	25.95357				chert	3	3	1
-	Chl 07b	1268.34	46.99848	25.94954	conglomerate	Ceahlău conglomerates	Albian	-	0	0	0
-	Chl 07a	1251.31	46.99878	25.94886	sandstone			-	0	0	0
-	Chl 06b	1116.00	46.99843	25.94509	sandstone and conglomerate	Poiana Macilor Sandstone	Aptian	-	0	0	0
-	Chl 06	987.41	46.99866	25.93864	sandstone			-	0	0	0
-	Chl 05	1034.39	46.97816	25.97527	sandstone	Neagra Mică Sandstone	Turonian-Senonian	grey-brownish micaceous sandstone	1	1	0
-	Chl 05b	1017.00	46.98430	25.97752	conglomerate and sandstone			-	0	0	0
									71	**71**	**12**

Co – collected; MA – macroscopic analysis; TS – thin sections; Fm. – Formation; Mb. – Member; Sst. – sandstone.

Annex 6. *Continued.*
Continuare.

No. in Pl. XV	Stops	Elevation (m)	GPS co-ordinates (Lat. N)	GPS co-ordinates (Long. E)	Context			Rock types sampled/observed and recorded	Samples		
					Lithology (predominant)	Geological deposit	Stage/Period		Co	MA	TS
22	VBis 01	613.44	46.97934	25.81869	gravel	creek gravel	Quaternary	reddish jasper	0	0	0
-	Va 01	743.38	46.94683	25.83657	gravel			blackish very fine-grained limestone	1	1	1
-	Va 02	751.61	46.94617	25.83524	gravel			grey-burgundy laminated crystalline limestone	1	1	1
23	Pin 01	732.20	46.94715	25.84174	gravel			dark greenish jasper	0	0	0
-	Pin 02	665.84	46.96476	25.83360	gravel			reddish jasper	0	0	0
24	Chi 01	792.46	46.93748	25.84289	gravel			reddish jasper	0	0	0
-	Chi 02	860.56	46.93411	25.83859	dolostone/limestone	Dolostones and limestones	Triassic	medium grey and grey-greenish crystalline limestone	6	6	0
-	Chi 03	862.51	46.93391	25.83844	dolostone/limestone			medium grey and grey-rosy crystalline limestone	5	5	2
27	Bal 01	751.91	46.92079	25.76092	gravel	creek gravel	Quaternary	reddish and greenish jasper	3	3	1
	Bal 02	768.85	46.91827	25.76528	gravel			reddish and greenish jasper	2	2	1
26	Bal 03	808.77	46.91629	25.77118	gravel			reddish and greenish jasper	2	2	1
	Bal 04	828.28	46.91723	25.77303	gravel			bicoloured red and green jasper	2	2	2
-	Bal 05	833.75	46.91761	25.77368	metapelites	Rarău gneiss Fm.	Proterozoic-Palaeozoic	-	0	0	0
-	Bal 06	958.08	46.92205	25.78082	dolostone/limestone	Dolostones and limestones	Triassic	-	0	0	0
-	Bal 08	981.56	46.92276	25.78180	dolostone/limestone			-	0	0	0
-	Bal 09	987.73	46.92304	25.78205	dolostone/limestone and mudstone			grey-brownish crystalline limestone	2	2	0
-	Bal 10	989.01	46.92312	25.78187	dolostone/limestone			-	0	0	0
25	Bal 07	992.64	46.91174	25.78473	gravel	creek gravel	Quaternary	burgundy jasper	1	1	1
-	Bal 11	1056.59	46.91333	25.78831	conglomerate	Wildflysh Fm.	Barremian-Albian	-	0	0	0
-	Bal 12	1073.15	46.91416	25.78893	conglomerate			-	0	0	0
-	Bal 13	1105.25	46.91443	25.79092	dolostone/limestone klippe			light grey-greenish-rosy limestone	7	7	1
									32	**32**	**11**

Co – collected; MA – macroscopic analysis; TS – thin sections; Fm. – Formation; Mb. – Member; Sst. – sandstones.

Annex 7. Stops recorded along Bălai and Pintec valleys (Harghita County).
Stopuri înregistrate de-a lungul văilor Bălai și Pintec (jud. Harghita).