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MIDDLE PALAEOLITHIC IN SOUTHERN ALBANIA: PERSPECTIVES FROM THE LITHIC INDUSTRY OF THE ISTRAISHTA SITE

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ABSTRACT**:** Neanderthal groups developed diverse mobility patterns and resource exploitation strategies across their territories. These variations are linked to different knapping methods and are likely to reflect adaptive strategies and responses at multiple ecological and cultural levels. Neanderthals associated with Discoid knapping are known to depend on context-specific, unplanned exploitation of lithic raw materials for daily subsistence and tend to be more mobile than those using different technologies. However, well-defined data are lacking for many geographical regions where this technocomplex has been identified. This study presents the open-air site of Istraishta, where the Mousterian industry is characterised by Discoid technology applied to the reduction of pebbles, thin plates, and flakes. Our multidisciplinary investigation includes an analysis on the lithic surface collection, an assessment of the quality and diversity of lithic raw materials exploited at the site, and an analysis of soil preserved in localised patches. These new findings contribute to our understanding of Neanderthal behavioural variability in the southern Balkans. We contextualise them at a macro-regional level, drawing comparisons with numerous sites in the Adriatic basin, primarily dated between MIS 5 and MIS 3.

Keywords**:** Lithic industry, Palaeopedology, Soil-micromorphology, Open-air site, Mousterian, Korça Basin, South-Western Balkans.

1. INTRODUCTION. THE MIDDLE PALAEOLITHIC SETTLEMENTS OF THE WESTERN BALKANS: A BIASED SCENARIO ?

Southern Europe was extensively inhabited by Neanderthals during the late Middle Pleistocene and Late Pleistocene. However, despite the available evidence indicating variability in settlement patterns and mobility strategies, the reconstruction of Neanderthals cultures and adaptive behaviours remains biased. Among the three peninsulas forming this part of Europe - Iberian, Italian, and Balkan (Romagnoli et al., 2022) - the Balkan Peninsula, particularly its south-westernmost region, records a low number of Mousterian sites, whether single-layered or multi-layered. These sites are located along the fringes of the Great Adriatic Po Region (Peresani et al., 2021) and the Ionian region, as well as in the mountain ranges of Dinarids and Epirus, extending to the southernmost Greek peninsula (Dogandžić, 2023; Galanidou & Papoulia, 2023; Karavanić & Banda, 2023). Cave sites are also present in the mountainous area at the southern periphery of the Pannonian basin (Mihailović, 2020), while open-air sites are clustered along the main river basins of the Sava, Drina, and Morava. Currently, the most extensively investigated sites from north to south include Krapina, Vindija Cave, Mujina Pećina, Pešturina, Kozarnika, Crvena Stijena, Bioče, Theopetra, Asprochaliko, Klissoura, Lakonis, and Kalamakia. Some of these sites remain central to debate regarding the latest presence of Neanderthals in Europe and the Mediterranean basin, as continuous updates to chronological, archaeological, and palaeoanthropological records (Higham et al., 2014; Mihailović, 2020; Déviese et al., 2017; Tourloukis, 2021; Karavanić et al., 2024). From this perspective, the region bordering the eastern Adriatic and Ionian seas, with its diverse geographic, climatic, and ecological characteristics - including coastal plains, rolling hills, and mountain ranges reaching elevations of 2,600-2,700 m a.s.l. - deserves consideration as an area that has witnessed significant population movements since the Middle Pleistocene. Its rugged terrain, intersected by major SE-NW orientated fluvial valleys connecting the southernmost part of the Balkans with the Adriatic region, may have provided refugia for temperate species and favoured Pleistocene zoogeographic diversity from the earliest times (Palombo & Mussi, 2006). However, given the scarcity of Middle Palaeolithic sites in this region, our current understanding of Neanderthal occupations, locations, territories, and adaptations to environmental and ecological diversity remains limited. It is expected that Neanderthals adapted to this geographic diversity through varying mobility strategies and technological traditions, resulting in a cultural mosaic featured by a mix of expedient and curated technologies, shifts between continuity and disruption in different productions

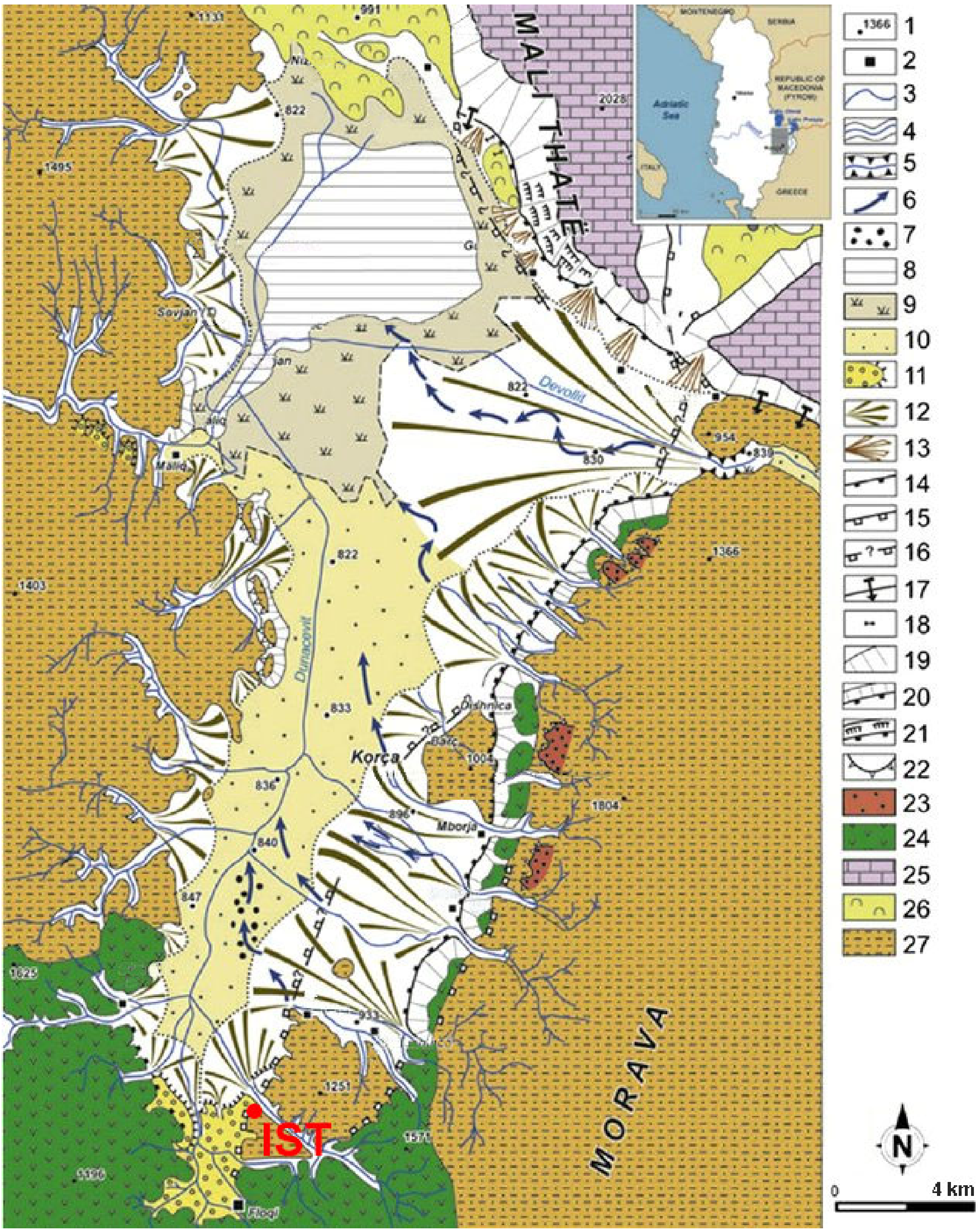

Fig. 1 - Location and geomorphological map of the Basin of Korça with position of Istraishta site. 1, height spot in metres; 2; town or village; 3, natural and channelised flowing talweg; 4, deep talweg; 5, epigenic gorge; 6, former abandoned course; 7, associated coarse spreading; 8, Maliq lake in 1948; 9, marshes related to the lake in 1948; 10, recent alluvial fillings; 11, quaternary alluvial terrace; 12, Holocene spreading cone and glacis; 13, undifferentiated quaternary colluvial deposits; 14, active quaternary fault line; 15, fault line without proven recent activity; 16, supposed fault line; 17, flexure; 18, local cleavage; 19, faceted escarpment (normalized slope); 20, faceted fault scarp; 21, steep fault scarp; 22, monoclinal steep slope; 23, pebble conglomerates; 24, ophiolites; 25, karstified limestone range; 26, Pliocene hills; 27, Neogene molasses (by Fouache et al., 2010, modified by Davide Margaritora).

and tool manufacture, and diverse modes and rhythms of site occupation and resource exploitation. Yet, this broader picture remains incomplete.

Given the current state of knowledge, this study aims to contribute to the reconstruction of Middle Palaeolithic mountain habitation through the presentation of the data from a multidisciplinary investigation - including palaeopedology, petroarchaeometry, and technological analysis - of an open-air site located in the Korça basin, near the town of Korça, in southeastern Albania. This region, previously unexplored for Palaeolithic research, provides new evidence for future cultural-behavioural comparisons of Neanderthals employing different production systems in the southwestern Balkans.

2. PRESENTATION OF THE ISTRAISHTA SITE IN THE KORÇA BASIN

2.1. The Quaternary and geomorphological context of Istraishta

The hill of Istraishta (1010 m. a.s.l.) is located at the eastern edge of an intermontane plain in the southwestern Korça basin (Fig. 1). The plain slopes gently northward, with elevations ranging from approximately 890 m a.s.l. in the south to about 820 m a.s.l. in the north. It is bordered on all sides by mountains rising between 1500 and 2000 m a.s.l. The mountains bordering the Korça plain - particularly in the south - are deeply incised by numerous small but high-energy streams and torrents that contribute sediments to the Korça depression. The Dunaveci River drains the southern portion of the plain and merges with the Devolli River in the north.

Tectonically, the Korça basin is a graben that began forming in the Late Miocene (Xhomo et al., 2002; Lindhorst et al., 2015). The basin has an asymmetric shape, with a significantly higher escarpment to the east, where limestone bedrock emerges abruptly. In contrast, molasse formations extensively surround the basin to the west (Fouache et al., 2010). Tectonic faulting is particularly developed along the eastern boundary, where the plain meets Mount Morava (Mali Morava), composed of ultrabasic rocks, and along the northern periphery of Mali i Thatë Mountain, which consists mainly of Triassic limestone. During the Pliocene, an additional extensional phase of the regional graben system linked the Ohrid and Korça grabens, forming a unified lake-river system. Pliocene to present day tectonic activity, particularly subsidence, gradually isolated the Korça graben within its current geological borders, allowing the deposition of interposed Pliocene formations in the northern part of the basin (Tagari et al., 1993; Lindhorst et al., 2015).

Subsidence led to the formation of graben-shaped Quaternary lakes and plains. During this period, the graben lakes of Korça, Elbasani, Zadrima, Tirana, Myzeqe, and others were formed. Holocene fluvial deposits overlie much of the central part of the Korça lowland, consisting mostly of alternating and discontinuous layers of variably sorted gravel, sand, ground silt, and clayey silt. The maximum thickness of Quaternary deposits in the south-central part of the plain (in the Turan-Bulgarec area) reaches approximately 300 m. Mixed alluvial and alluvial fan deposits are widely exposed along the periphery of the Korça plain (Eftimi & Sara, 2022). These deposits mainly consist of interbedded gravel, clay, and silt in highly variable sequences, while the southern part of the basin is characterised by Quaternary alluvial terraces. The eastern slope of the basin is covered by several non-active, coalescent Holocene alluvial cones and glacis.

The hill of Istraishta stands in isolation (Fig. 2a) bounded to the north and south by two deep river erosions: of the Kamenica stream valley to the north and a tributary of the Dunaveci River to the south. The relief is formed by the anticline of the nappe emplacement of Upper Triassic-Lower Jurassic limestones and the Molasse of the Albanian Thessalian basin (Middle Oligocene). The sequences are displaced by numerous normal faults orientated in a N-S to NNE-SSW direction. At the summit, a small morpho-structural relief is formed by an outcrop of Oligocene bioclastic calcarenites, approximately two meters thick, containing macro foraminifera, molluscs, and fragments of benthic colonial organisms. This unit overlies a sequence of alternating gravel-sandy-siltstone deposits with siliceous conglomerate lenses - particularly in the lower section - and marls with neritic fossils. The eastern slope of the hill is affected by gullies that erode the marly-arenaceous molasse sequence. In recent times, the hill has been altered by military installations, including repeaters stations, and the limestone bank has been exploited as a domestic quarry.

2.2. Discovery and research history of the site

The Istraishta site was discovered in 2001 during excavations at the nearby Kamenica tumulus by Albanian prehistorians Ilir Gjipali and Skënder Aliu, who visited the location during their fieldwork. Gjipali affirmed the site's early prehistoric nature, although lithic artefacts had first been noted in 1968 by Aliu, who neither published nor pursued further research at the site. From 2001 onwards, surface collections were conducted during multiple visits, and the site was briefly mentioned in publications by Gjipali, variously described as an early prehistoric, Middle Palaeolithic, and Middle and Upper Palaeolithic site (Gjipali, 2006; 2011; 2012; 2014; Aliu, 2020). In 2011, Istraishta was revisited as a part of a collaboration between Ruka and Gjipali for the former's PhD research, which culminated in an overview publication on the early prehistory of the Korça Basin, including Istraishta (Ruka, 2018). From 2012 onwards, the site was revisited on several occasions (Peresani et al., 2016) and examined in the framework of a long-term Albanian-Italian research collaboration. Initially the site was published under the name of the nearby village, Kamenica (Peresani et al., 2016). However, to avoid confusion with the excavated tumulus, it was later renamed after the hill on which it is located.

3. MATERIALS AND METHODS

The primary objective of the archaeological surveys was to analyse the spatial distribution of the artefacts, their relationship with the karst surface, and potential associations with surface deposits and soils preserved within karst fissures. Surface collection, GPS recording, and examinations of natural and artificial exposures on soil surfaces, gullies, and fluvial erosional banks were conducted (Fig. 2b). We considered potential sources of information related to the Quaternary context, including geomorphology, soil and sediment composition, and field and micromorphological features of palaeosoils. These analyses aimed to reconstruct the major geomorphic and pedological events responsible for shaping the present-day landscape. Additionally, we

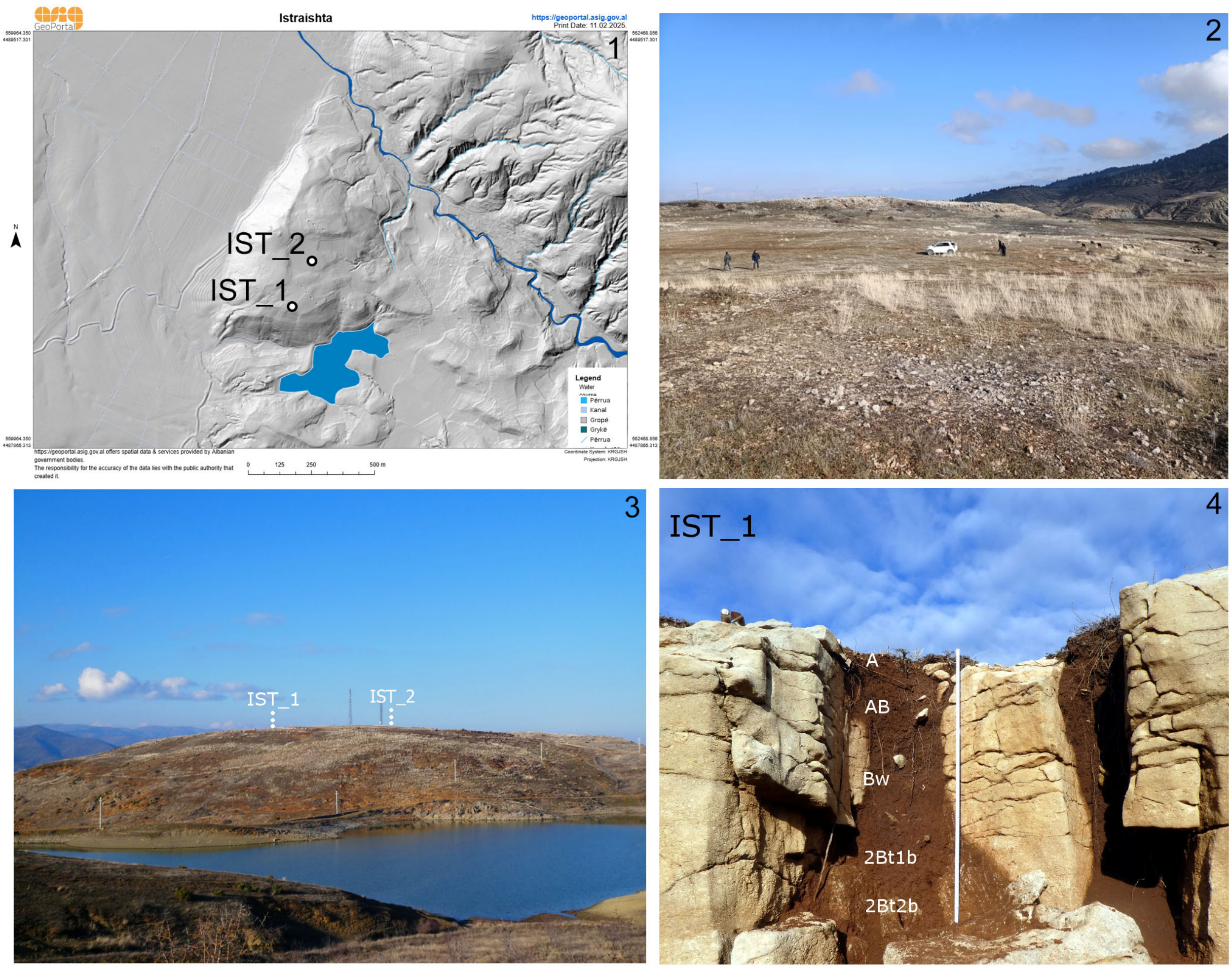

Fig. 2 - Views of Istraishta hill and soil profile: 1, DTM of Istraishta hill and surroundings with position of IST-1 and IST-2 soil profiles (from https://geoportal.asig.gov.al/); 2, the surveyed area looking north; 3, view of Istraishta hill from South-East; 4, the IST-1 soil profile.

assessed the macroscopic nature of lithic resources in the surrounding area to compare them with the artefacts, aiming to confirm their local provenance. Finally, the cultural technocomplex was defined based on the identification of the most typologically diagnostic artefacts, which were also analysed from a technological perspective.

3.1. Soil field description and micromorphology

Two soil profiles, IST_1 and IST_2, respectively located at the southern edge of the top of Istraishta hill in a karst fissure and in the central area of the plateau, were selected among other exposures identified during our surveys. These soils, which do not contain any lithic artefacts, are representative of soil patches scattered across the top of Istraishta hill in the same area where artefacts were collected. Soil horizons were described following FAO guidelines (2006), while soil classification and horizon definitions were based on the criteria of Soil Taxonomy (Soil Survey Staff, 2014) and the 'World Reference Base for Soil Resources' (IUSS Working Group WRB, 2015). Soil colours were determined in a wet state and coded using the Munsell® Soil Colour Charts (Munsell Color, 2009).

Profile IST_1 was selected for micromorphological analysis in favour of its completeness by respect to profile IST_2. Four thin sections were analysed from sediment blocks extracted during surveys from horizons AB, Bw, 2Bt1b, and 2Bt1b of profile IST_1 within a karst fissure (Fig. 2b). Thin section preparation was carried out by Laboratorio Servizi per la Geologia (Piombino, Livorno) following the method proposed by Murphy (1986). The analysis was conducted using a Prior Scientific MP3500A microscope with polarised light at 20x, 40x, 100x, and 400x magnifications. Descriptions follow the criteria established by Bullock et al. (1985), Courty et al. (1989) and Stoops (2021), while interpretations are based on Stoops et al. (2018) and Nicosia & Stoops (2017).

3.2. Lithic industry

The lithic assemblage of Istraishta consists of 1467 artefacts (see thereafter Table 4). Of these, less than 20 artefacts are unidentifiable due to intense fragmentation and physical and chromatic alterations caused by thermal stress, weathering, pedological processes, and other factors. These were, therefore, excluded from further discussion. Additionally, a subset of fewer than 40 artefacts, securely attributable to the Holocene - potentially belonging to Mesolithic, Neolithic, or later periods based

Profile 1: IST_1 (40°31'41.3''N 20°43'17.9''E 1,043.2 m. a.s.l.) Profile facing south, at the top of the southern slope of the relief	
Horizon	**Description**
A	**0-3 cm,** silt loam, dark brown (7.5YR3/3), moderate to strong very fine granular structure, not calcareous, common fine pores, friable (moist), very few subrounded fine gravel of limestone, common biological activity (burrows), common medium and fine herbaceous roots, gradual linear boundary to:
AB	**3-45 cm,** silt loam, dark brown (7.5YR3/3), moderate to strong very fine granular structure (primary) moderate fine angular blocky structure (secondary), not calcareous, common fine pores, friable (moist), few subrounded clasts of limestone (max. 7 cm) with surfaces altered by karst dissolution, common biological activity (burrows), common medium and fine herbaceous roots, gradual linear boundary to:
Bw	**45-75 cm,** silty clay loam, dark reddish brown (5YR3/3), moderate to strong very fine granular structure (primary) moderate fine angular blocky structure (secondary), not calcareous, common fine pores, friable (moist), few subrounded clasts of limestone (max. 4 cm) with surfaces altered by karst dissolution, common biological activity (burrows), common continuous clay coatings on pedfaces, gradual linear boundary to:
2Bt1b	**75-98 cm,** clay, dark reddish brown (5YR3/4), strong fine angular blocky structure, not calcareous, common very fine pores, firm (moist), common to many subrounded clasts of limestone (max. 4 cm) with surfaces altered by karst dissolution, common biological activity (burrows), few very fine Fe-Mn oxide nodules, gradual smooth boundary to:
2Bt2b	**98-110 cm,** clay, dark reddish brown-dark red (2.5YR3/4-6), strong medium angular blocky structure (secondary), not calcareous, common very fine pores, firm (moist), common to many subrounded clasts of limestone (max. 25 cm) with surfaces altered by karst dissolution, common biological activity (burrows), common very fine Fe-Mn oxide nodules, abrupt irregular boundary to: karstified bioclastic limestone.
Profile 2: IST_2 (40°31'46.167''N 20°43'19.528''E 1,040.8 m. a.s.l.) Profile facing south-west, in the central part of the flat area of the relief	
Horizon	**Description**
A	**0-2 cm,** silt loam, dark brown (7.5YR3/3), moderate to strong very fine granular structure, not calcareous, common fine pores, friable (moist), very few subrounded fine gravel of limestone, common biological activity (burrows), common medium and fine herbaceous roots, gradual linear boundary to:
2Btb	**2-25 cm,** clay loam, dark reddish brown (5YR3/4), moderate to strong very fine granular structure (primary) moderate fine angular blocky structure (secondary), not calcareous, common very fine pores, firm (moist), very few subrounded fine gravel of limestone, common biological activity (burrows), matrix infillings in pores (biogallery), few very fine Fe-Mn oxide nodule, abrupt irregular boundary to: karstified bioclastic limestone.

Tab. 1 - Field description notes for three profiles at the edge of the Istraishta hill.

on technological and typological grounds - was also excluded from the analysis, as it falls outside the scope of this study. The remaining assemblage, which exhibits diagnostic techno-typological features consistent with the Middle Palaeolithic, is examined in the following section.

To broadly identify lithic sources, we conducted petrographic determinations on a representative sample of artefacts at the PetroPaleo Laboratory at the Department of Humanities, following a standardised protocol based on macroscopic and mesoscopic scales of observation. Adhering to established nomenclature (Church, 1994; Klein, 1999). The pebbles were examined with the naked eye and under a multivariable optical stereomicroscope Optika SZ series, 45X with camera Moticam 3+ USB 3, and progressive magnifications ranging from 5X to 20x (Yonekura et al., 2008). The colour was determined according to the Munsell® Soil Colour Charts (Munsell Color, 2009).

The conceptual and analytical approach to the technological analysis of the Istraishta lithic assemblage follows Inizan et al. (1995), Boëda (1993), Peresani (1998), Bourguignon & Turq (2003), and references in Peresani (2003) regarding the Discoid reduction method. The technological analysis is further supported by well-established protocols derived from refinements of E. Boëda's foundational definitions (Mourre, 2003). In addition to counting all artefacts larger than 1 cm, we conducted a technological analysis on all the identifiable artefacts, using technological and morphological criteria to determine each flake's role and position within the reduction sequence. The overall reduction sequence was broadly reconstructed based on qualitative reasoning, employing morpho-technical, diacritic, and morphometric analyses of cores, complete blanks, and selected by-products considered significant in the production process. Certain reduction strategies, such as the exploitation of the ventral face cores on large cortical flakes, are classified as 'Kombewa-type', referring to the adaptation of Kombewa technology within the Levallois volumetric concept (Dauvois, 1981), which is also applicable to the Discoid concept (Bourguignon & Turq, 2003). Key typological features of retouched blanks are discussed in the following section. Due to the chemical-physical (patina) and mechanical surface alterations of the artefacts resulting from long-term exposure, we did not consider functional analyses to be viable.

4. RESULTS

4.1. Palaeopedology of profile 1 (IST_1)

Profile 1 (IST_1) consists of two distinct pedological units forming a complex palaeosoil. The lower unit is a Terra Rossa-like soil, 35 cm thick, truncated by an erosional surface. It comprises two horizons (2Bt1b and 2Bt2b) characterised by decarbonation, clay illuviation, and rubefaction. The upper unit represents the present-day soil (A-AB-Bw), measuring 75 cm in thickness and characterised by structural modifications caused by intensive grazing. For detailed field descriptions, see Table 1.

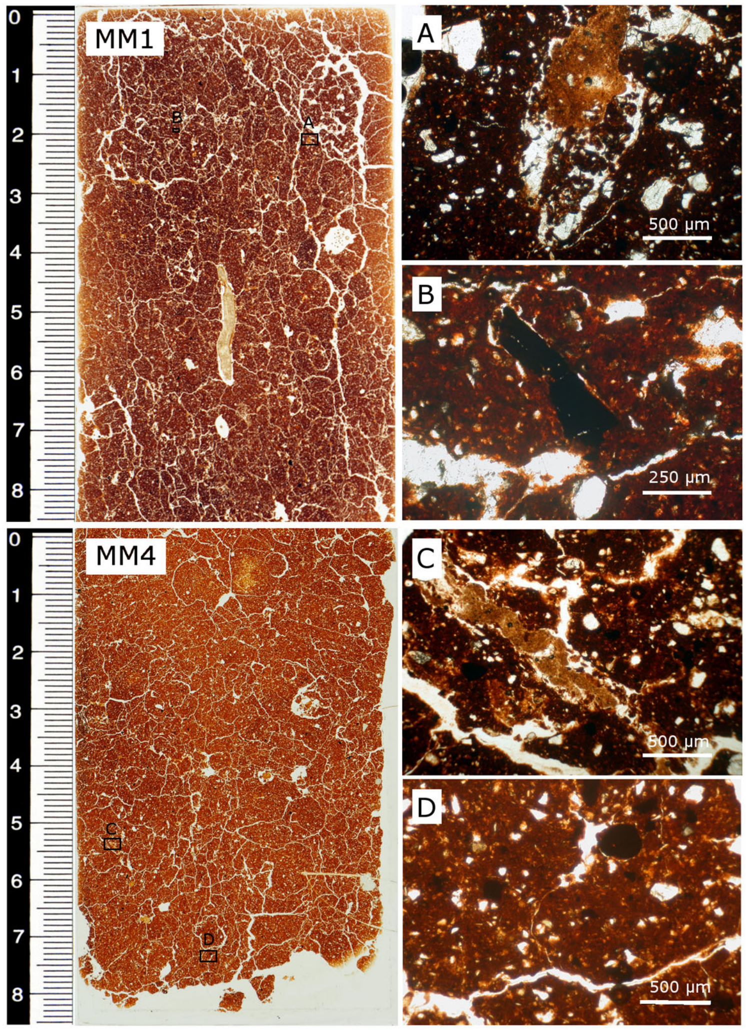

Fig. 3 - MM1 and MM4 thin sections of the IST_1 soil profile: MM1, A, loose microgranular infilling; MM1, B, charcoal particle; MM4, C, infilling of impure clay; MM4, D, brown-reddish clay groundmass with anorthic impregnative iron (hydr) oxide nodules.

The thin section analysis of the transitional AB horizon (thin section MM2; Table 2) reveals a complex microstructure, it exhibits a highly separated primary granular microstructure, a weakly separated secondary subangular blocky microstructure; and an intrapedal channel microstructure. In MM2, porosity increases compared to the lower portion of the soil (about 10%) with the presence of channels likely formed by tree roots (diameter >2.5 mm) or biogalleries (diameter <5 mm). These biogalleries contain discontinuous and loose microgranular infillings (pedotubules, Brewer 1964) attributed to soil mesofauna activities. The relative frequency distribution between the coarse (>20 µm) and the thin fraction follows an open porphyric pattern. The coarse fraction (15%) ranges in size from medium silt and fine sand with polycrystalline quartz - characteristic of the granoblastic texture of metamorphic rocks - being the dominant component. Additionally, rare subangular particles of yellowish volcanic glass and microcrystalline chert are observed. The thin fraction consists of a reddish-brown ground mass composed of clay and slit-sized mineral grains, producing a crystallitic b-fabric. Amongst the identified pedofeatures, both discontinuous and continuous loose microgranular infillings are present. These are often associated with coalesced or isolated ellipsoidal excrements produced by mesofauna. The voids contain dense, incomplete infillings of impure clay. Furthermore, both typical anorthic impregnations of iron (hydr)oxide nodules, as well as nucleic nodules with angular quartz grains inherited from ancient soils, are observed. Notably, fresh roots are found within the channels, along with Ca-oxalate (whewellite) crystals.

The Bw horizon (thin section MM1; Table 2) closely resembles the AB horizon in its microstructural characteristics and mineral composition of the ground mass. However, in Bw, the coarse fraction is notably reduced. Among the identified heavy minerals, rare amphiboles were observed.

Compared to thin section MM2, the organic content within the thin fraction decreases, while the pedofeatures remain similar. The presence of monomorphic, planar-shaped amorphous organic material with clear, sharp edges - silt-sized in dimension - suggests traces of micro-charcoal, albeit in very low quantities (<1%). Fresh roots were also identified within channels containing Ca-oxalate (whewellite) crystals (Fig. 3).

The horizon 2Bt1b (thin section MM3; Table 2) differs from the previously described horizons. Its ground mass is characterised by subangular and polyhedric peds separated by planar voids. The coarse fraction consists of quartz grains (~10%), mica, rare chert fragments, and volcanic glass. The ground mass is composed of an opaque, brown-reddish, b-fabric speckled clay. Pedofeatures indicate active mesofauna bioturbation, evidenced by passage features, loose discontinuous and continuous microgranular infillings, and coalescent ellipsoids excrements. As in the overlying horizons, dense incomplete infillings of impure clay and both typic and nucleic anorthic impregnative iron (hydr)oxide nodules - sized similarly to fine sand - are common (Fig. 3). Additionally, this horizon shows an increased presence (5%) of amorphous organic material ranging in size from silt to medium sand, with micro-charcoal still present but in low quantities (<1%).

The 2Bt2b horizon (thin section MM4) shares the

Thin section	Microstructure	Porosity	Coarse components	Fine material	Groundmass		Organic Components	Pedofeatures
					c/f related distribution pattern	b-fabric		
MM2 (AB)	Complex, highly separated primary granular microstructure, weakly separated secondary subangular blocky microstructure, and highly developed vermicular microstructure	Accommodating or partially accomodating roughness curved planes (<2mm), intrapedal channel transpedal root channel (<2,5mm) biogalleries (<5mm)	Angular prolate grains of quartz, mainly policrystalline (15%), subangular microcrystalline chert (<1%), subangular vulcanic glass (<1%)	Reddish brown clay	$c/f_{20\,\mu m}$ 15/85, open porphyric	Crystallitic	Fresh roots	Loose discontinuos and loose continuos microgranular infillings. Dense incomplete infillings of impure clay. Typic and nucleic anorthic impregnative iron (hydr)oxide nodule
MM1 (Bw)	Complex, highly separated primary granular microstructure, weakly separated secondary subangular blocky microstructure, and highly developed tertiary vermicular microstructure	Accommodating or partially accomodating roughness curved planes (<2mm), transpedal root channel (<2,5mm) biogalleries (<5mm)	Angular prolate grains of quartz, mainly policrystalline (10%), subangular vulcanic glass <1%), amphiboles (<1%)	Yellowish red clay	$c/f_{20\,\mu m}$ 10/90, open porphyric	Crystallitic	Monomorphic amorphous organic fine material (2%), fresh roots, charcoal (<1%)	Loose discontinuos and loose continuos microgranular infillings and coalescent ellipsoids excremets. Dense incomplete infillings of impure clay. Typic and nucleic anorthic impregnative iron (hydr)oxide nodule
MM3 (2Bt1b)	Complex, highly separated subangular blocky microstructure with accomodating peds (2-5mm) and highly developed secondary vermicular microstructure	Accommodating or partially accomodating roughness curved interpedal planes (<500μm), transpedal root channel (<2,5mm) biogalleries (<5mm), chamber ((1 cm), intrapedal channel	Angular prolate grains of quartz, mainly policrystalline (10%), muscovite (<2%), subangular microcrystalline chert (<1%), subangular vulcanic glass <1%), amphiboles (<1%), biotite (<1%),	Reddish brown clay	$c/f_{20\,\mu m}$ 10/90, open porphyric	Speckled, weakly grano and porostriated	Monomorphic amorphous organic fine material (<5%), fresh roots	Passage features with groundmass material, loose discontinuos and loose continuos microgranular infillings and coalescent ellipsoids excremets. Dense incomplete infillings of impure clay. Typic and nucleic anorthic impregnative iron (hydr)oxide nodule
MM4 (2Bt2b)	Complex, highly separated subangular blocky microstructure with accomodating peds (>5mm) and highly developed secondary vermicular microstructure	Accommodating or partially accomodating roughness curved interpedal planes (<500μm), transpedal root channel (<2,5mm) biogalleries (<5mm), chamber ((1 cm), intrapedal channel	Angular prolate grains of quartz, mainly policrystalline (10%), subangular vulcanic glass <1%), amphiboles (<1%), muscovite (<2%)	Reddish clay	$c/f_{20\,\mu m}$ 10/90, open porphyric	Speckled, weakly grano and porostriated	Monomorphic amorphous organic fine material (<5%)	Passage features with groundmass material, loose discontinuos and loose continuos microgranular infillings and coalescent ellipsoids excremets. Dense incomplete infillings of impure clay. Typic and nucleic anorthic impregnative iron (hydr)oxide nodule, orthic aggregate Mn-hydroxide nodule

Tab. 2 - Micromorphological features observed throughout the IST_1 soil profile.

micropedological features of MM3, with the primary distinction being the pronounced rubefaction of the clayish ground mass.

4.2. Lithic raw material sources in the Korça basin

In the Central-Eastern Hellenides/Albanides, knappable lithic resources exhibit significant heterogeneity, reflecting the complex diversification of the region's geological macro-units. The western Adria plate (Pelagonian zone) contains Mesozoic limestones, Neotethys Jurassic ophiolites, metamorphic basement slabs, and volcano-sedimentary sequences. This intricate regional geological framework results from the closure of the western sector of the Neotethys Ocean (Vardar), whose remnants persist as ophiolite nappes over the eastern margin of the Adria continental plate, as well as Palaeozoic basement plates (Schmidt et al., 2008; Bortolotti et al., 2013; Sherreiks & BouDagher-Fadel, 2021) (Fig. 4).

The sedimentary rocks of the basin and its slope contain chert nodules and layers with distinct characteristics, including variations in size, colour, texture, structure, palaeontological content, silicification degree, and overall integrity. Different types of cherts embedded within the Adria Triassic-Jurassic limestones, radiolarites occur in the ophiolite sedimentary covers, and Neogene cherts are found within flysch and molasse deposits. Additional knappable raw materials include quartzite from the metamorphic basement, ignimbrite from volcano-sedimentary formations, and silcrete from silicified encrusted soils. The post-collisional evolution of the region mainly relates to the formation and evolution of the Albanian-Thessalian foredeep basin, which has been progressively filled with flysch (since upper Cretaceous) and molasse (since Eocene). These deposits consist of siliciclastic sediments and shallow marine bioclastic calcarenites, which are locally silicified. The Korça basin, as part of this foredeep, overlies the Mirdita (ophiolites), Korabi (Palaeozoic), and Krasta-Cukali (Mesozoic platform-basin limestones).

Our survey along the eastern slopes of Istraishta focused on conglomerate horizons, which are especially common within the Eocene-Miocene molasse. In contrast, the older flysch deposits are primarily composed of siltstones and sandstones. The pebbles within these deposits predominately derived from ophiolitic rocks, with additional lithologies sourced from eroded weathered formations. Among these, silcrete (Skarpelis, 2020) was also identified.

During the Late Miocene, the region's tectonic regime shifted from compressional to extensional (Lindhorst et al., 2015), leading to the formation of several N-S orientated grabens (rifting) that were progressively filled with siliciclastic and lacustrine deposits. Extensional tectonics in the region remain active today. As a result, cherts and other knappable raw materials have been redistributed through the Quaternary and present-day terrace formations, as well as through torrential gravels in the Istraishta surroundings. Despite this rich lithic resource landscape, systematic petroarchaeological studies of lithic collections or field surveys of outcropping knappable rocks have yet to be conducted in this particular region. One of the most inclusive descriptions of the regional geological framework remains the National Geological Map of Albania and associated illustrative notes (Xhomo et al., 2002).

Our preliminary analysis suggests that most of the raw materials exploited at the site were collected as pebbles from the molasse conglomerates outcropping in the hills surrounding the southeastern and northwestern margins of the Korça plain (Fouache et al., 2010). The site itself is situated atop a molasse hill (Fig. 1). The pebbles could have been gathered both near the outcrops and from alluvial deposits. In the majority of cases, the raw materials consist of rounded pebbles exhibiting varying degrees of alteration, as indicated by yellow to dark patinas resulting from pedogenetic and lateritic processes. A smaller proportion of raw materials - specifically certain blocks of radiolarites and cherts - display fresh and unaltered surfaces, suggesting they were probably sourced directly from nearby outcrops. Ophiolite units and their sedimentary covers (radiolarites), from the southwestern margin of the Korça plain, in close proximity to the site.

The identified raw material lithotypes fall into the following categories (Table 3, Fig. 5):

1. Ra. Radiolarite groups

Ra1. Grey-green radiolarites with reddish-brown alteration surfaces, exhibiting low silicification. Contain poorly preserved white radiolarians and scattered sulphide deposits, some of which are locally oxidised. Evidence of hydrothermal metamorphism suggests an origin from the ophiolite covers (Vardar). Collected as pebbles.

Ra2. Red microlaminated radiolarites with abundant radiolarians, infilled with chalcedony (dark appearance) and pelagic mud (brown to pink). Show signs of hydrothermal metamorphism, indicating an origin from the ophiolite covers (Vardar). Collected as pebbles.

Ra3. Bi coloured green and red radiolarites with well-preserved, heterometric radiolarians infilled with chalcedony, micro quartz, or calcite. These non tectonised radiolarites are likely derived from partially calcareous deposits formed below the CCD (calcite compensation depth), possibly in the upper part of the ophiolite covers (Vardar) or along the Adria continental margins. Collected as detritus near outcrops.

2. Si. Silcrete groups

Si1. Vivid red chalcedony with massive and waxy translucency, with vacuolar porosities filled by microcrystalline quartz and locally with white quartz flames; genesis linked to laterite processes on ophiolite rocks during the Cretaceous; non-tectonised. Collected as pebbles.

Si2. Yellow fine-textured silicified laterite with a brecciated texture. Vacuolar porosities mineralised by zoned white chalcedony. Formed through laterite processes on ophiolite rocks during the Cretaceous; non-tectonised. Collected as pebbles.

Si3. Laterite with a fine-textured silicified matrix, featuring chromite mineralisation and quartz veins. Its genesis is linked to laterite processes affecting ophiolite rocks during the Cretaceous; non-tectonised. Collected as pebbles.

Si4. Very fine crystalline grey chalcedony with a white patina and waxy translucency. Contains lithoclasts and large green and dark minerals with altered reddish borders. Exhibits a brecciated texture with chalcedony and microquartz mineralisation in porosities. Formed through laterite processes on ophiolite rocks during the Cretaceous; non-tectonised. Collected from palaeosoils or alteration horizons (laterite).

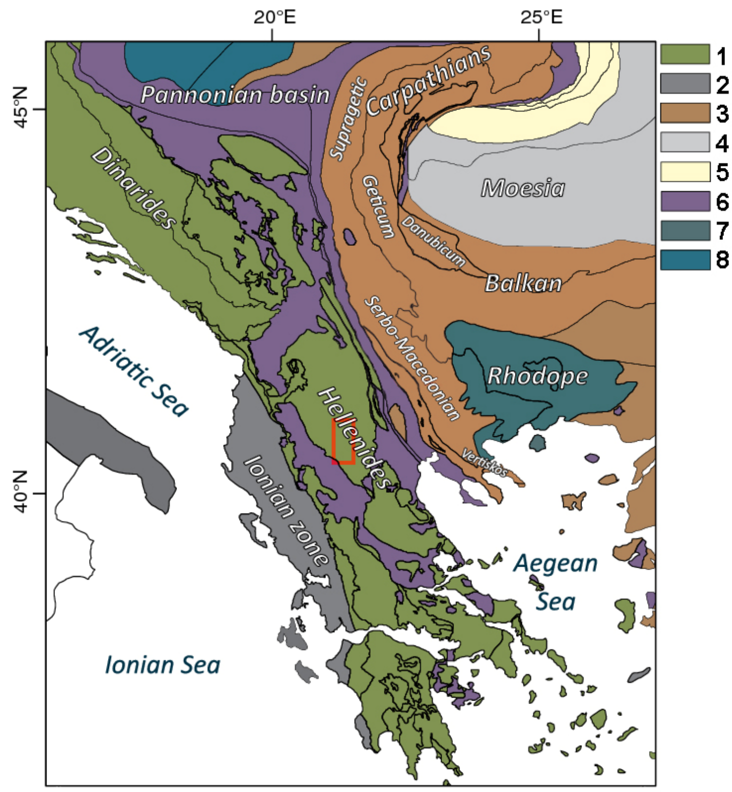

Fig. 4 - Schematic geological and tectonic map indicating the main units and basins of central-western Balkans. Key: 1, Adria derived thrust sheets; 2, Adria plate; 3, Europe derived units; 4, External foredeep; 5, Miocene thrust belt; 6, Ophiolites and sediments; 7, Rhodope complex; 8, Tisza mega-unit (after Lindhorst et al., 2015, modified by Davide Margaritora); the red frame corresponds to Fig. 1.

Raw material	(Mother) Rock Type	Color	Silicified matrix texture	Structures	Paeontological content.	Other	Diaclases	Depositional environment	Geological units	Cortex
Ra1	Radiolarite	Grey green	Microcrystalline	--	wrr	Sulphides	no	Marine basinal	Ophiolite group	Pebble
Ra2	Radiolarite	Red	Microcrystalline	Micro lamination	DRRrr	Calcite	no	Marine basinal	Ophiolite group	Pebble
Ra3	Radiolarite	Green and red	Microcrystalline	Micro lamination	DRRrr	Calcite	no	Marine basinal	Ophiolite group	Fresh
Si1	Silcrete	Red to dark red	Criptocrystalline	Voids, fissures	--	Megaquartz	no	Subaerial silicified crust	Ophiolite group	Pebble
Si2	Silcrete	Yellow	Criptocrystalline	Voids, fissures	--	Zoned quartz, megaquartz	no	Subaerial silicified crust	Ophiolite group	Pebble
Si3	Silcrete	Yellow	Criptocrystalline	Voids, fissures	--	Chromite, megaquartz	no	Subaerial silicified crust	Ophiolite group	Pebble
Si4	Silcrete	Light grey	Criptocrystalline	Voids, fissures	--	Lithoclasts, chromite, megaquartz	no	Subaerial silicified crust	Ophiolite group	Pebble
Qu1	Quartzite	White	Micro to macrocrystalline	Cleavage	--	--	yes	Metamorphic	Metamorphic basement	Pebble
Vo1	Trachyte	Grey	-	Fluidal	--	Feldpars, biotite	no	Magmatic	Volcano-sedimentary	n.d
Ch1	Wack to packstone	Light to dark grey	Microcrystalline	Weack lamination	SP, pel, bcri, biocl, fbent	--	no	Marine molasse	Korça basin, Cenozoic	Fresh and pebble
Ch2	Wack to packstone	Reddish grey	Microcrystalline	Lamination	SP, pel, bcri	Fe oxides	yes	Marine molasse	Korça basin, Cenozoic	Pebble
Ch3	Framestone	Grey to red	Micro to macrocrystalline	Fossil framework	Sponge scheleton	Calcite	yes	Marine reef	Adria plate, Mesozoic	Pebble
Ch4	Packstone	Black	Microcrystalline	Lamination	sp	Calcite, dolomite	no	Marine intra-platform basin	Adria plate, Mesozoic	Paleosoil
Ch5	Packstone to grainstone	Yellow brown	Microcrystalline	--	fbent, SP, bcri	Fe oxides	few	Marine external platform/slope	Adria plate, Mesozoic	Pebble
Ch6	Wackestone	Light yellowish brown	Criptocrystalline	--	wrr	Calcite	no	Marine basinal	Adria plate, Mesozoic	Paleosoil

Tab. 3 - Summary Tab. of the main petrographic features of the raw materials exploited in the site. RR= big radiolarians; rr= small radiolarians; sp= small spicules; SP= big spicules; fbent= benthic forams; bcr= benthic crinoids; mol= molluscs; w= white; d= dark; pel= peloids; biocl= bioclasts.

3. Qu. Quartzite group

Qu1. Fine-crystalline streaked quartzite with numerous pressure-orientated diaclases, some of which are locally filled by reddish clay. Its genesis is attributed to metamorphic processes in the crystalline basement (Paleozoic). Collected as pebbles.

4. *Vo. Volcanite group*

Vo1. Light grey trachyte with alkaline-feldspar phenocrystals.

5. Ch. Chert groups

Ch1. Silicified light grey bio-calcarenite with sponge spicules, peloids, colonial-organism bioclasts, and benthic foraminifera, and a fine laminated structure. Depositional environment: Cretaceous-Oligocene Korça foredeep. Collected as evolute pebbles with dark alteration surfaces.

Ch2. Silicified reddish grey bio-calcarenite to mudstone with small spicules, peloids, and bioclasts dispersed in a fine brown-pink matrix. Microfossils are often graded and re-sedimented; slightly tectonised. Depositional environment: Cretaceous-Oligocene Korça foredeep. Collected as evolute pebbles, with dark alteration surfaces.

Ch3. Silicified colonial organism (probably a sponge with clearly visible porosities and cellular structures). Classified as framestone (Dunham, 1962); Slightly tectonised; Depositional environment: external platform/reef. Attribution: Adria (Pelagonian) Mesozoic platform-basins system. Collected as pebbles.

Ch4. Dark, low silicified, and massive bituminous chert, with dispersed calcite/dolomite rhombic crystals and thick lamination; Depositional environment: intra-platform basins. Attribution: Triassic-lower Jurassic. Collected as rounded and altered pebbles.

Ch5. Silicified light yellow to beige, fine-textured bio-calcarenite, matte, with abundant white bioclastic detritus (benthic foraminifers and crinoids, spicules, bioclasts). Slightly tectonised. Depositional environment: continental margin (slope). Attribution: Adria (Pelagonian) Mesozoic platform-basins system.

Ch6. Very fine-textured light grey chert with an ivory-like mudstone cortex; contains numerous small white radiolarians and a few small spicules. This pelagic facies is very similar to Maiolica limestone. Depositional environment: basinal. Attribution: Adria (Pelagonian) Mesozoic platform-basins system. Collected from paleosoils.

4.3. Discoid manufacture

The lithic assemblage reflects the typical variability observed in Discoid core volumetric patterns, which in turn suggest a range of technical options employed throughout the production sequence. This resulted in two operational chains that were applied across all lithic materials (Table 4). This approach aligns with findings from previous studies of similar assemblages across

Fig. 5 - Knappable raw materials exploited at Istraishta, classified into the main lithological groups: radiolarite (ra1-ra3), silcrete (si1-si4), quartzite (qu1), volcanite (vo1), chert (ch1-ch6) (see table 3 for details).

Europe (see Peresani, 2003; Delpiano et al., 2018; Delpiano & Peresani, 2017; Arrighi et al., 2009).

The first reduction sequence involved the exploitation of medium-sized blocks and pebbles (from 5 to 12 cm on average), with primary products obtained already at the earliest stages, during both decortication and the creation of the core edge, which delimited the two core faces (Fig. 6). Some cores, measuring between 3.5 to 6 cm, were discarded at this initial stage after producing only a few flakes; these have been classified as 'partially exploited' discoid cores. The full production sequence, culminating in discard, was organised around this pivotal crest. In accordance with the substantial accordance with the Discoid criteria of predetermination, this exploitation also induced some distinct modifications to the morphological outline of the cores, reflecting the varied technical strategies employed during manufacture. Consequently, the convex flaking surface adopted a centripetal pattern primarily during the main production phase. However, technological analyses reveal both quantitative and qualitative variability in the flaking procedure. Various usable blanks were obtained at the onset of exploitation, including slightly elongated and partially cortical flakes. These flakes sometimes retain cortex along a lateral edge, opposite a cutting edge, and often exhibit one or two unidirectional detachments. When the exploitation extended along the lateral edge, preceding the typical alternation between the two main surfaces,

Main component	Artifact type	*N*	Tot *N*	Tot %
Discoid cores	Fully exploited	*16*	114	*7.8*
	Partially exploited	*41*		
	With small peripheral detachments	*11*		
	On flake	*10*		
	On flake – with small peripheral detachments	*36*		
Discoid centripetal flakes	Non cortical	*52*	81	*5.5*
	Partially cortical	*24*		
	Overpassing the apex	*5*		
Discoid debordant flakes	Non cortical debordant	*86*	253	*17.3*
	Pseudo-Levallois point	*48*		
	Debordant with cortical back	*80*		
	Debordant with cortex	*25*		
	Crested flake	*14*		
Surface cores	Flake core with natural platform(s)	*15*	18	*1.2*
	On flake	*3*		
Levallois	Core	*7*	21	*1.4*
	Flake	*14*		
Other cores	Sub-Prismatic core	*1*	31	*2.1*
	Other core	*12*		
	Other core on flake	*12*		
	Indeterminable core fragment	*6*		
Kombewa-type flake			42	*2.9*
Unidirectional flake			10	*0.7*
Retouched tools	Scraper	*15*	21	*1.4*
	Notch	*2*		
	Denticulate	*1*		
	Flake with marginal retouch	*3*		
	Retouch flake		2	*0.1*
Post-Pleistocene pieces			43	*2.9*
Cortical flake and fragment			469	*32.0*
Non cortical flake and fragment			362	*24.7*
Total			1467	*100.0*

Tab. 4 - Composition of the Istraishta lithic assemblage.

flakes with a natural back were produced. These flakes, which are well represented in the Istraishta assemblage (n=79), measure between 3.5 and 6.5 cm in length. As decortication progressed, flake size decreased, with simple removal patterns with one or two parallel or convergent removals was progressively replaced by centripetal patterns, in accordance with a reduction process gradually replaced by centripetal patterns, reflecting a reduction process applied consistently throughout the sequence.

The main production phase yielded a variety of blank types, determined by the organisation of core reduction. Detachments serve both predetermined and predeterminant functions, ensuring adherence to the technical criteria of the core organisation, including the maintenance of surface convexities and angles. The two flaking axes - centripetal and chordal relative to the core outline - allow different approaches to shaping surface convexity. From the beginning of this stage, 25 *débordant* flakes and 24 centripetal flakes with cortical surfaces attest to the attainment of full production before the complete shaping and decortication of the core, which was discarded once it has been reduced to 2.5 to 4.5 cm in length. The primary production process focuses on generating a characteristic range of Discoid blanks, including centripetal flakes (3-6 cm), core-edge removal flakes (*éclats débordants*) (2-4.5 cm), and pseudo-Levallois points (1.5-4.5 cm) (Fig. 7). This sequence was punctuated by several readjustments and core preparations. The frequency of by-products displaying flaking errors is notably high, exceeding one hundred specimens. Some core readjustments involved the partial removal of the core-edge and the reorientation of the exploitation onto a newly created surface. This technical behaviour, well documented in discoid core reduction, is evidenced here by 14 transversal or longitudinal crested flakes (2-3.5 cm) and a couple of discoid cores (2.5-3.5 cm) structured around three main surfaces (Fig. 8).

The second operational chain involves the exploitation of flakes as cores (ranging 3-5.5 cm), following a Kombewa-type reduction. This approach partially aligns with the Discoid volumetric concept and reduction pattern (Fig. 9). In this context, the core edge corresponds to the intersection plane between the two faces of the flake. Large cortical flakes are the preferred blanks for reduction, sometimes using the bulb as the primary volume of convexity. The exploitation process is relatively simple and less productive, mostly unifacial and concentrated on the ventral surface. However, small detachments on the upper surface are frequently observed, often associated with a partially worked crest.

Beyond the exploitation of various types of chert, the assemblage encapsulates the full spectrum of Discoid techno-economic strategies recognised elsewhere. The high frequency of intact cortical products suggests that core initiation occurred on-site and that the bifurca-

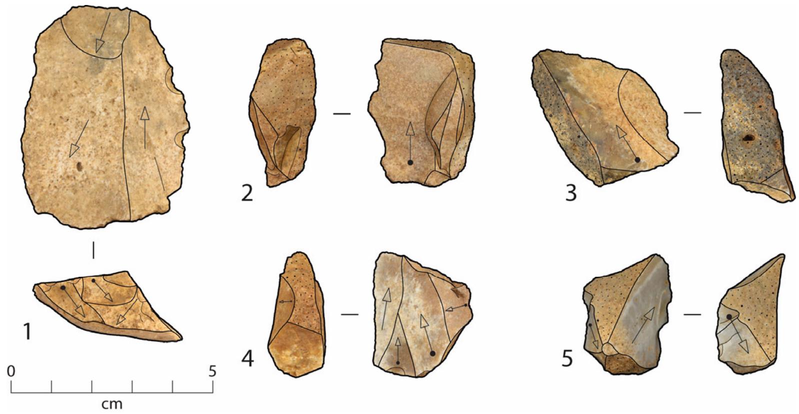

Fig. 6 - Discoid lithic assemblage: 1, Unipolar-bidirectional flake; 2-5, cortically backed flakes.

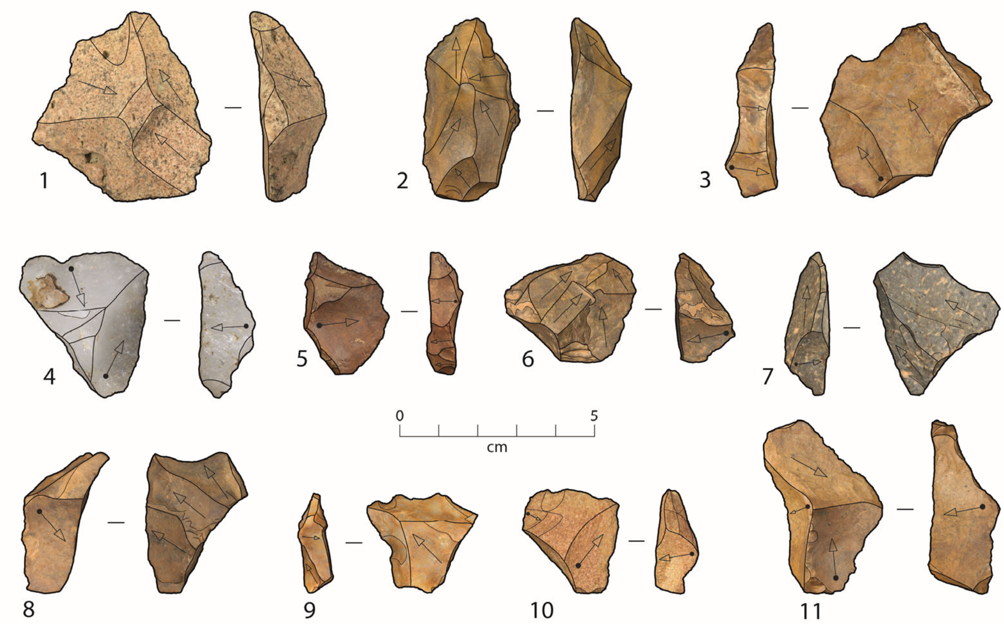

Fig. 7 - Discoid lithic assemblage: 1-2, centripetal flakes; 3, 5, core-edge removal flakes; 4, 6-11, pseudo-Levallois points.

tion of Discoid production into two operational sequences followed broadly comparable proportions. This is evidenced by the number of cores-on-flake (n=46) and the Kombewa-type flakes (n=42). Some discoid cores on thin slabs (n=11) or flakes (n=36), ranging from 4 to 6 cm in size, exhibit a very low degree of exploitation. These cores are characterised by a limited number of bifacial detachments, which shape a sinuous lateral edge, suggesting a deliberate search for exceptionally small discoid blanks. This interpretation is further supported by the diminutive size of the resulting pseudo-Levallois points and core-edge removal flakes, some of which measure less than 2 cm.

4.4. Tool shaping

The number of retouched tools is relatively low (n=21). It is reasonable to suggest that some Middle Palaeolithic retouched tools may have been introduced into the site already shaped, given the significant diversity of raw materials. However, evidence of on-site tool retouching is confirmed by the presence of two retouch flakes, attesting to the shaping of thick scrapers.

Scrapers constitute the predominant tool type (n=15) (Fig. 10). Although most of the tools are fragmented, some simple scrapers made from chert can be identified, primarily characterised by a straight longitudinal profile. Notably, two proximal fragments of double scrapers in red and green radiolarite are present. The first exhibits a double, simple, and straight retouch, while the second features a left direct scalar retouch and a right inverse flat retouch. Additionally, a fragmented convergent scraper is also made on radiolarite. The largest retouched tool in the assemblage is a simple denticulated scraper, manufactured on a 7.5 cm flake with a natural back. The assemblage is further composed of two notches, one denticulated tool, and three flakes with marginal retouch. Some other tools may belong to a more recent (post-Pleistocene) phase of human frequentation at the site.

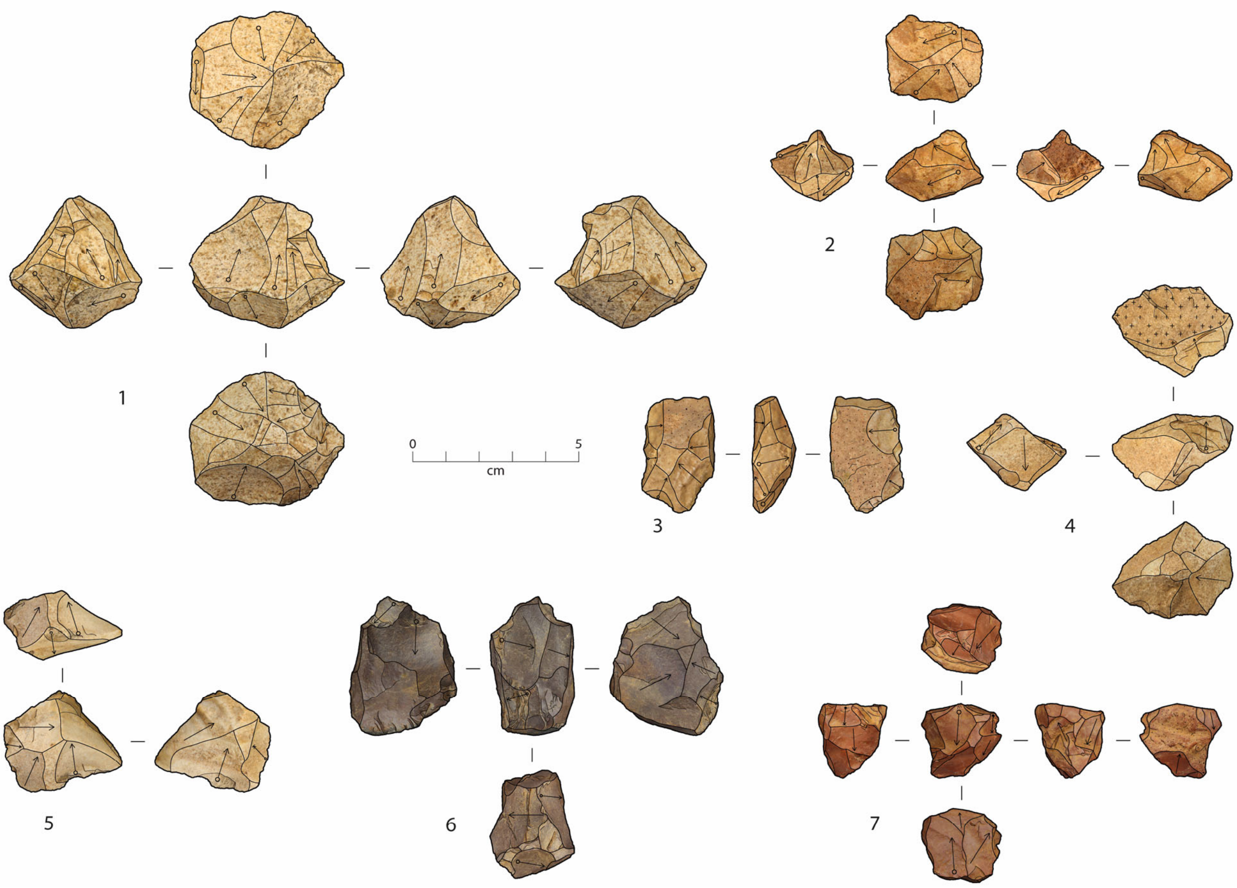

Fig. 8 - Discoid cores: 1-2, typical discoid cores; 3, bifacial core with small detachment; 4-6, partially developed discoid cores; 7, discoid core on three surfaces.

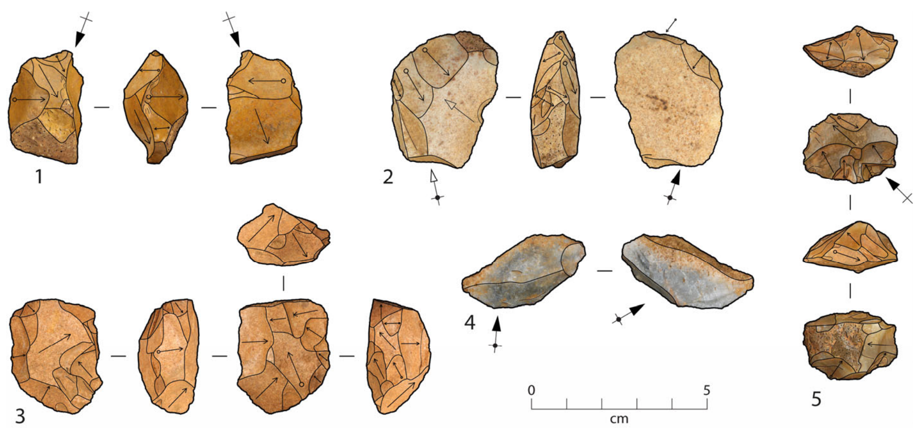

Fig. 9 - Discoid cores: 1,3,5, Discoid cores on flake; 2, core on flake with small bifacial detachments; 4, Kombewa-type flake.

4.5. Levallois flakes and cores

The assemblage also includes Levallois blanks (2.5 -5 cm) and cores (4-6 cm), along with flakes detached for the reconfiguration and maintenance of cores during reduction (Fig. 11). The raw materials used for Levallois implements are similar to those employed for Discoid lithic artefacts, with fine-grained greyish chert being the most commonly exploited, while other raw material types are much less frequently represented. Although slight differences are observed in blank selection and raw material properties, lithic production and economy remain consistent across the different lithological groups. Levallois technology is represented by a small number of artefacts, including seven cores and 14 flakes with prepared butts. Additionally, some cores and flakes exhibit knapping on a single surface and follow a similar volumetric concept with two hierarchised surfaces, albeit without the meticulous preparation of the striking plat-

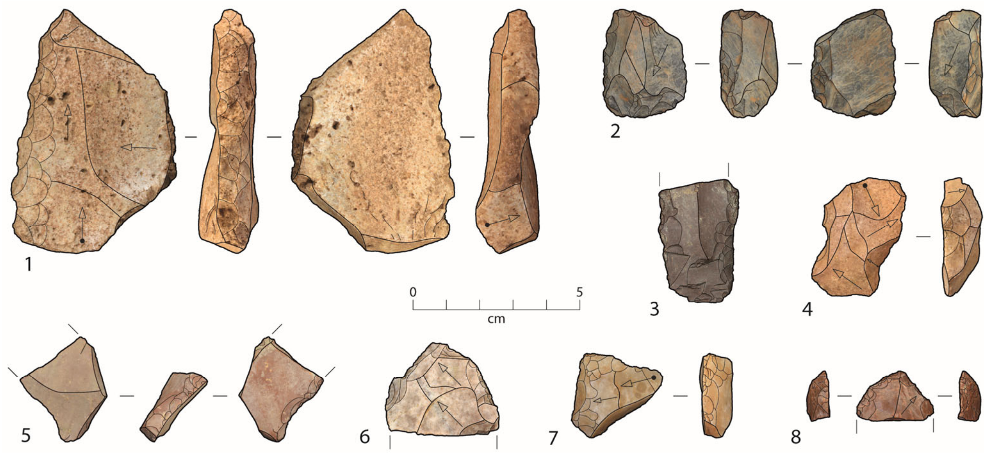

Fig. 10 - Istraishta retouched tools: 1, simple denticulated scraper; 2, double scraper with alternate retouch; 3, double scraper; 4, notch; 5, fragmented scraper; 6-8, convergent scrapers.

form.

5. DISCUSSION

5.1. The polycyclic soil of Istraishta and its Quaternary frame

Profile 1 sequence of IST_1 resembles the features typical of polycyclic soils (Duchaufour, 1983). The lower unit comprises horizons 2Bt1b and 2Bt2b (thin sections MM3 and MM4 respectively), while the upper unit is formed by horizons AB and Bw (thin sections MM1 and MM2, respectively). Both units are entirely decarbonised. The lower unit presents distinctive ‘Terra Rossa’ features and can be classified as fersiallitic soil (Duchaufour, 1983) or Luvisol (IUSS Working Group WRB, 2015). Such soils typically form a discontinuous layer of variable thickness - ranging from a few centimetres to several metres - overlying hard limestone and dolomitic rocks in karstic regions (Durn et al., 1999; Durn, 2003; Merino et al., 2006; Torrent, 2005). The soil colour, ranging from 5YR to 2.5YR (Munsell Colour, 2009), is a diagnostic feature of ‘Mediterranean Terre Rosse’ and reflects the intensity of the rubefaction processes, particularly the preferential formation of haematite over goethite (Schwertmann & Taylor, 1989). The parent material has a polygenetic origin, resulting from the karstic dissolution of the limestone substrate, followed by the pedogenetic evolution of residual clay and the incorporation of allochthonous aeolian components (quartz, mica, volcanic glass, amphiboles). Concerning micromorphology, the deep horizon 2Bt2b is characterised by a strong accumulation of sesquioxides. In addition to rubefaction and a clay-rich ground mass, there is a notable absence of textural pedological features on void surfaces. This is consistent with the development of fersiallitic soil and suggests that intense bioturbation by mesofauna has led to the complete incorporation of these features into the ground mass.

The upper unit shows similar micropedological features to the lower unit but also displays distinct characteristics in horizons Bw1 and AB (thin sections MM1 and MM2, respectively). The transitional AB horizon can be identified by an increased organic fraction within the groundmass and a significant rise in biological activity.

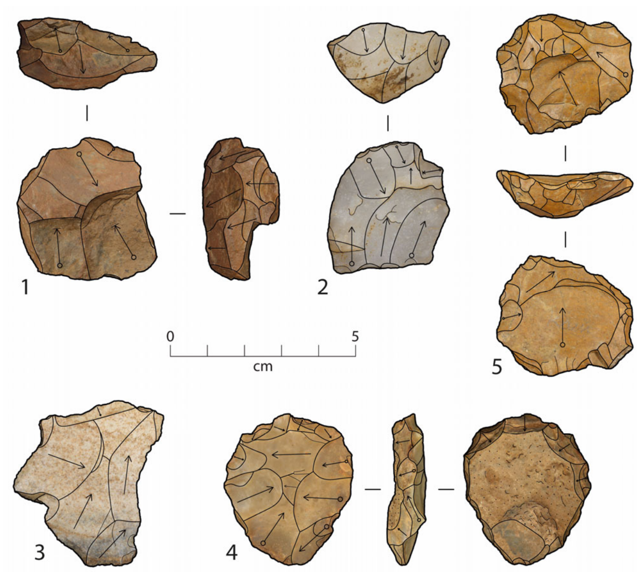

Fig. 11 - Levallois cores and products: 1-2, hierarchised cores on surface; 3, Levallois flake; 4-5, Levallois cores.

The presence of a coarse quartz fraction, combined with a fine clayish texture that imparts a porphyric-peripheric distribution to the groundmass, serves as clear evidence of an advanced stage of soil weathering. The coarse fraction, composed of less weatherable and resistant minerals such as quartz, is typical of highly weathered horizons, akin to those found in Oxisols (IUSS Working Group WRB, 2015) or laterites. Among the coarse components, subangular particles of yellowish volcanic glass - identified as palagonite - were detected, albeit in low concentrations. Additionally, the presence of fine clayish, reddish material with a heterogeneous b-fabric is indicative of sub-superficial oxic horizons undergoing a high degree of pedogenetic evolution. Such horizons typically develop on ancient and stable surfaces where a rejuvenation does not occur, marking a case of long-term pedogenesis.

The polyhedric and angular microstructure, associated with a dense groundmass with an open porphyric c/f distribution, is characteristic of soil affected by cryoturbation. In addition, the presence of an overlapping microstructure with channels containing loose discontinuous microgranular infillings - often associated with coalescent ellipsoidal faecal pellets - provides clear evidence of mesofaunal biological activity and root penetration in the sub-superficial horizon. These pedofeatures caused by mesofauna activity, combined with fresh root traces in channels characterised by whewellite crystals, indicate a recent shift in land use, notably from woodland to pasture. This transition is reflected in the gradual superimposition of a granular intrapedal and channel microstructure over the original angular polyhedral micro aggregation - possibly also prismatic, although its exact morphology is difficult to determine at the thin section scale. Dense and incomplete impure clay infillings maybe interpreted as illuviation phenomena and/or microstructural degradation resulting from vegetational cover loss. This phenomenon has also led to a significant increase in porosity in the sub-superficial portion of the rare (<1%) microcarbon particles, appearing as amorphous and monomorphic organic material with flat shapes and well-defined surfaces, having been observed.

In the absence of direct dating, determining the geochronological position of the Istraishta Palaeolithic assemblage remains challenging. The only viable approach relies on the assumption that the red clayey soil analysed at the IST_1 profile is representative of the overall broader palaeopedogenetic context that developed atop the Eocene carbonate bedrock at the summit of the hill. The IST_1 palaeosoil has been classified within the subclass of soils commonly referred to as Terra Rossa, which is largely diffused across carbonatic bedrocks in the Mediterranean rim, including an extensive belt in the Western Balkans (Durn, 2003). The processes of total decarbonation, clay illuviation, rubefaction, the enrichment of weathering-resistant mineral species, and the high concentration of Fe (hydr)oxides all correspond to the characteristics of Modal Fersiallitic Red Soils (Duchaufour, 1983), developed under stable interglacial climatic conditions, especially at mid-latitudes (Durn, 2003). Typically, these soils accumulate discontinuously, varying in thickness from a few centimetres to several meters, and are primarily preserved on surfaces, within cracks, sinkholes, or other depressions formed through the dissolution of limestones and dolomites. Non-primary red-clayey accumulations, commonly termed Terra Rossa-like materials, are often found in karst depressions or as contributors to pedo-sedimentary colluvial sequences; however, this is not the case at Istraishta. Given that the site is located on hard and permeable limestones and dolomite formations with a notably low insoluble residue content - consistent with other regions of the Balkans (Macleod, 1980) - it is likely that Terra Rossa soils here have incorporated external materials. These could have originated from volcanic events, aeolian streams, shallow water transport, and other processes, thereby diminishing the significance of the primary parent material derived from the insoluble residue of bedrocks (Yaalon, 1997). Evidence suggests that aeolian and pyroclastic material from the Tyrrhenian area was transported across both sides of the central Adriatic basin during the Pleistocene (Chiesa et al., 1990; Šušnjara et al., 1994), with no exclusion of wind-borne material from Africa (Rapp, 1984).

The addition of aeolian and volcanic dust to the Istraishta soil is likely, although the high dispersion and weathering of the silt particles observed in IST_1 makes it difficult to identify their precise sources. Loess deposition has affected Istria and the Dalmatian Archipelago since the early Middle Pleistocene (Cremaschi, 1990).

The formation of these strongly weathered paleosoils is related to a prolonged period of biostasy, uninterrupted by major climatic shifts throughout the Chibanian and Late Pleistocene. Consequently, most studies in Quaternary palaeopedology interpret Terra Rossa like a polygenetic relict soil that may have originated as early as the Tertiary, the Early Pleistocene, or during warm interglacial periods following the mid-Pleistocene climate transition (see Durn, 2003, for review). However, a more plausible interpretation is that these soils represent Vetusols (Cremaschi, 1987), in which pedogenetic processes have continuously operated over extended timescales since the Mid-Pleistocene (Bronger & Sedov, 2002) or even the latter part of the Late Pleistocene, as observed in the southern Mediterranean rim (Gvirtzman & Wieder, 2001). At Istraishta, as in comparable contexts, this prolonged pedogenic phase was subsequently influenced by later land-use conditions, as evidenced by the confirmation of unstable conditions and the transformation of the soil into brown.

In summary, the geochronological position of the Istraishta Middle Palaeolithic industry, recovered from above the Terra Rossa soil at the top of the hill, remains broadly defined between the Chibanian and the Late Pleistocene. However, it may be further constrained between the earliest presumed appearance of Discoid technological assemblages in southern Europe and the Balkans, dating to MIS5e, and the latest occurrences of these industries in MIS3, as outlined in the following section.

5.2. Discoid knapping on the edge

Beyond the extensive use of the Levallois method, Neanderthals exhibited significant technical variability, with Discoid technology serving as a particularly illustrative comparative case. Initially defined in the 90s in terms of its principal volumetric criteria (Boëda, 1993) and subsequently explored in greater detail to assess its variability of application (see Peresani, ed. 2003), this core shaping, exploitation, and maintenance strategy is traditionally considered less predetermined but more prolific and versatile/flexible than the Levallois method. Several factors support this interpretation, foremost among them being the inherently recurrent nature of its reductive and productive concept, by concatenating the exploitation of the core-faces and facilitating the detachment of both predetermining and predetermined pieces without embedded phases of shaping. This adaptability allows the production of a wide range of functional products from a qualitatively wider range of raw materials than the Levallois and other technologies. As a result, Discoid technology is particularly well-suited to overcoming ecological constraints and mitigating potential limitations associated with landscapes devoid of high-quality knappable raw materials (Turq et al., 2017). Due to its applicability to a wide spectrum of different shapes, the Discoid reduction concept can also extend to the exploitation of flakes, with maintenance stages and resulting products that are fully comparable to those produced through Discoid reduction sequences on nodules or pebbles (Bourguignon & Turq, 2003).

At several European sites, the Discoid method was used with varying frequency within the broader productive systems, ranging from ephemeral to dominant, and even exclusive in certain contexts and temporal phases. Although this reduction technique was not solely a 'supporting' procedure aimed at maximising production, it does not appear to reflect in-depth planning. Instead, it seems to be part of a place-provisioning strategy focused on short-term exploitation. In these cases, as previously investigated by Delagnes & Rendu (2011), the groups employing this technology would be characterised by increased seasonal mobility. Lithic production, being internally diverse and highly ramified, would thus have had a high potential for immediate adaptability to varying needs. The advantage of the Discoid method appears to lie in its ability to maintain a high degree of adaptability and renewal through strategies less constrained by environmental factors. This behaviour of technological flexibility can be interpreted as a rational and planned response, consistent with recent evidence of logistical planning in economic organisation in semi-local or exotic territories. This organisation would have been influenced by the quality and distance of available raw material sources, as well as by the systematic segmentation of the operative chain (Delpiano et al., 2018).

5.3. Discoid assemblages in the South-eastern European context

The presence of industries employing Discoid technology is well-documented in Late Middle Pleistocene and Late Pleistocene sites across Europe (see Peresani, 2003, and papers therein). Notable examples are also found in Eastern Italy and the Balkans, where this technology is recorded at a limited number of sites alongside Levallois reduction methods. However, these two technologies appear to have been applied differently depending on the suitability of available raw materials for knapping. Levallois is generally associated with higher quality and occasionally allochthonous raw materials, whereas the Discoid is predominantly linked to strictly local resources, irrespective of quality. In such cases, Discoid technology seems to have been primarily employed to maximise the exploitation of local resources, with final reduction sequences serving only secondary purposes.

In Eastern Italy, the distribution of Discoid-based industries spans geographical regions with diverse physical landscapes, lithic resources, and varying degrees of settlement system visibility, including the eastern Pre-Alps, the Trieste Karst, and the stretch on the Adriatic coast (Peresani, 2003). Some of these lithic assemblages were recovered from the surface at open-air sites lacking faunal remains and direct correlated pedo-stratigraphic correlation.

At Fumane Cave, the cultural significance of unit A9 has been highlighted on several occasions, both for its Discoid production technology and for various aspects of Neanderthal innovative behaviours, diet, and subsistence (Peresani, 2022, see references therein). The dates for A9 are older than 44.8 Cal ka BP, which marks the lower chronological boundary of units A5+A6. Unit A9 records an almost exclusive use of this technology positioned between two Levallois units: A10 at the base and A6 at the top. The techno-economic structure of the A9 assemblage consists of complete reduction sequences carried out on local cherts, with occasional use of materials sourced from greater distances (Delpiano et al., 2018). Additionally, the assemblage includes patinated recycled artefacts (Peresani et al., 2015). The industry is typically represented by cores, thick flakes, pseudo-Levallois points, backed flakes with sharp opposing edges, polygonal and triangular flakes, produced through a main complex reduction sequence based on blocks and nodules, and a secondary, simpler, and less productive sequence based on flake-cores, either derived from by-products or directly introduced to the site. Furthermore, like the Istraishta assemblage, cores yielded usable blanks from the initial reduction stages, with core outlines gradually shifting from a unidirectional to a discoid pattern. This process involved continuous modification, ultimately resulting in polyhedral core shapes (Delpiano & Peresani, 2017; Delpiano et al., 2017; 2018). The retouched toolset includes scrapers, points, denticulates, and tools intentionally modified to create a backed edge, either through retouching or by adapting an existing back for manual handling or potential hafting. These modifications suggest different levels of expertise and technical skill, reinforcing the notion that backing - although rarely observed - was a typical characteristic feature of Neanderthal technological repertoires (Delpiano et al., 2019). This feature is particularly prevalent in the Late Mousterian Discoid technology (Gravina & Discamps, 2015; Bodu et al., 2014); however, it is not present at Istraishta.

Few archaeological contexts are geographically close to Fumane Cave (Fig. 12). Among them is the open-air site of Monte Cason, which remains undated. Here, Levallois was applied to allochthonous chert, whereas Discoid was used on local raw materials (Bertola & Peresani, 2000). Further west, Discoid assemblages are present in the Ciota Ciara Cave (Daffara et al., 2014). A well-established MIS3 chronology is known for Rio Secco Cave, where this technology is evidenced by core-edge removal flakes and pseudo-Levallois points, in a region notably poor in chert (Peresani et al., 2014). Beyond Rio Secco, the only documented evidence of Discoid industry and tools comes from Divje Babe I in the Slovenian Alps and Caverna degli Orsi in the Trieste Karst. Late MIS5 and MIS4 sediments yielded only end-products, including a few pseudo-Levallois points made from local and allochthonous chert and limestone (Boschian, 1999-2000; Boschian & De Santis, 2011). At Divje Babe I, findings from layer 7 have been bracketed between the ^{14}C dates of layer 6 (minimum age of 43.4+1/-1.4 cal ka BP) and layer 8 (maximum age of 45.1+1.5/-18 cal ka BP) (Nelson, 1997), with later ESR dating placing them between 49.0-50.1 cal ka BP (Blackwell et al., 2009). More recent publications recognise the presence of the discoid cores alongside Levallois cores and products, suggesting a broader use of the Discoid method throughout the stratigraphy, with a higher frequency in levels A, A/B, E 2, F 2, and H (Turk & Turk, 2014; Turk, 2014). South of the Trieste Karst, in Istria, the Campanož open-air site features a large and densely packed lithic scatter, stratified between two horizons of Mediterranean Terra Rossa soil. Discoid production was organised on unifacial and bifacial cores and focused on small tools, with evidence of recycling of previously discarded artefacts. Retouched tools include scrapers and abrupt points (Banda et al., 2022). Beyond these, no other Discoid industries have been described in the Upper Adriatic region (Peresani & Tozzi, 2018).

Similar to the Eastern Adriatic, Mousterian assemblages associated with Discoid technology are absent in

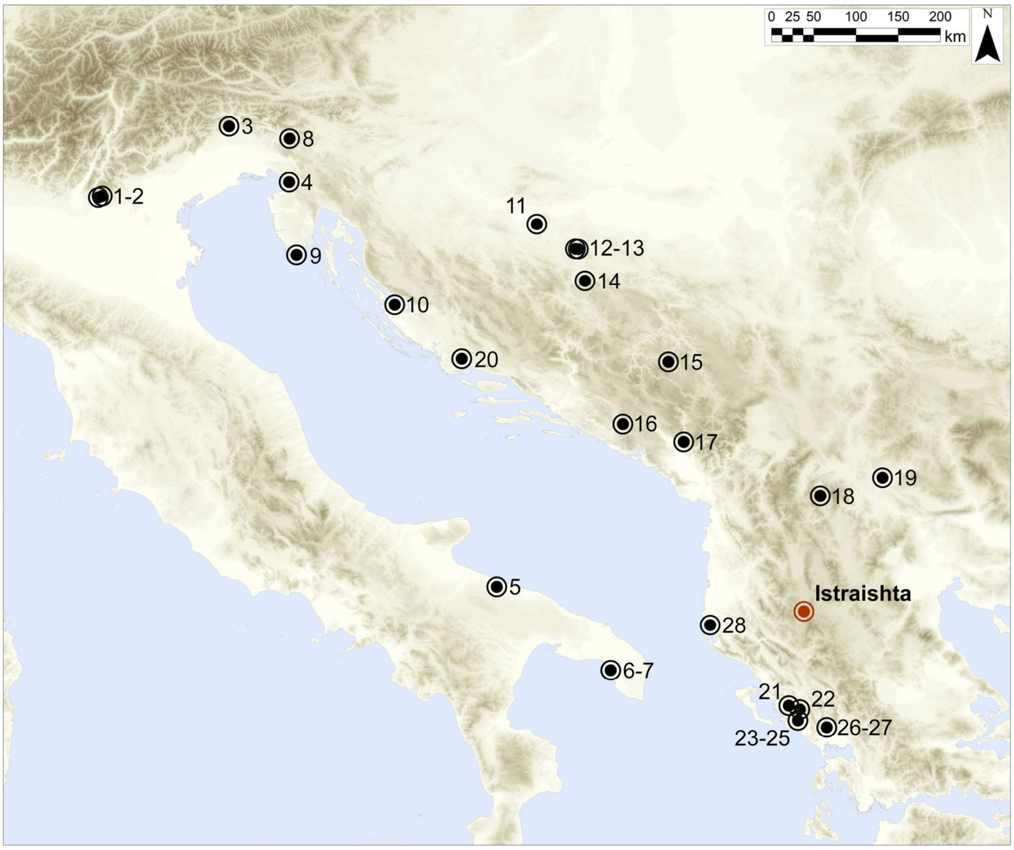

Fig. 12 - Map of sites containing discoid industries: 1, Fumane cave; 2, Tagliente shelter; 3, Rio Secco cave; 4, Caverna degli Orsi cave; 5, Santa Croce cave; 6; Mario Bernardini cave; 7, Cavallo cave; 8, Divje Babe cave; 9, Campanož; 10, Podvršje-Šibeni glava; 11, Kamen; 12, Zobište shelter; 13, Visoko Brdo; 14, Londža; 15, Mališina stijena; 16, Crvena Stijena; 17, Bioče; 18, Golema Pesht; 19, Uzun Mera; 20, Mujina pećina; 21, Molondra; 22, Eleftherochori 7; 23, Mikro Karvounari; 24, Megalo Karvounari; 25, Morfi; 26, Asprochaliko; 27, Kokkinopilos ; 28, Dalani i Vogël. The position of Istraishta is shown (map created by Davide Margaritora).

the Mid-Adriatic region of the Lower Western Adriatic basin but reappear further south in the Italian peninsula (Fig. 12). In Santa Croce di Bisceglie Cave, although undated, pedo-sedimentary and paleontological data suggests a MIS 4 chronology. Here, the reduction sequence was aimed at producing sub-triangular flakes and pseudo-Levallois points (Arrighi et al., 2009). In the Salento region, Grotta del Cavallo records Discoid technology as complementary to unipolar débitage in layers M and L, while it becomes exclusive in the upper layers FIIIa and FII. These upper layers are stratigraphically separated from the lower, more Levallois-dominated assemblages. Throughout the sequence, raw material-use strategies vary, and a notable miniaturisation in production is evident in layer M (Sarti et al., 2017). Interestingly, a recurrent débitage on secant planes, exploiting only part of the core, is reported. Following a similar reduction concept, Istraishta contains numerous cores on slabs or flakes, which we classify as 'low exploited discoid cores' used to produce very small blanks. Finally, near Grotta del Cavallo, Grotta Mario Bernardini presents an analogous sequence, featuring both unifacial and bifacial variants of Discoid debitage, along with the reduction of the ventral surface of cores-on-flakes (Carmignani & Romagnoli, 2017).

The timespan bracketed by these industries is notably broad, highlighting their affinities with other European contexts. The increased frequency of Discoid assemblages toward the end of the Middle Palaeolithic aligns with the decline of Levallois industries and a rise in technological variability - an observable trend in Italy (Marciani et al., 2020) as well as in the Iberian Peninsula (Romagnoli et al., 2022). This chronological and geographic distribution persists regardless of regional relationships, palaeo-environmental context, site typology, or associated faunal spectrum. Environmental data do not indicate a strong correlation between site type and industry, particularly in sheltered, multilayered sites. This pattern is evident in the Fumane sequence, where forest landscapes and ungulate associations remain stable despite shifts between Levallois and Discoid assemblages (López-Garcia et al., 2015).

In the Balkans, at Mujina Pećina cave, along the Dalmatian coast in Croatia, has yielded rare elements of Discoid technology, including a core and possible pseudo-Levallois point (Karavanić et al., 2008) (Fig. 12). These finds have been attributed to the Late Mousterian (Boschian et al., 2017; Karavanić et al., 2021). Another noteworthy case is Podvršje-Šibenička glava, an open-air site in northern Dalmatia, where several cores have been identified alongside various flakes, notches, denticulates, and sidescrapers. Notably, Levallois cores are absent, with only a single Levallois flake recorded (Vujević, 2009; Vujević et al., 2017). Further inland, in the Hrvatsko Zagorje region, several significant cave sites have been identified. At Veternica Cave, the lithic assemblage is composed of non-Levallois reduction methods, including centripetal cores and 'cobble wedge cores,' which require further analysis before they can be definitively classified as discoid. However, due to the loss of stratigraphic provenance, the assemblage is broadly attributed to MIS 5e-5a or MIS 4 (Banda & Karavanić, 2019). The same 'cobble wedge' cores were extensively used at Krapina Cave, whereas sidescrapers, notches, denticulates, and naturally backed knives dominate the assemblage. While Levallois blanks appear throughout the sequence, they are not common, similarly to Discoid cores, which remain occasional (Simek, 1991; Simek & Smith, 1997). A comparable technological pattern is also observed at the Late Mousterian site of Vinica cave, where a variety of reduction sequences - including unidirectional, discoidal, and bidirectional cores - were predominantly applied to quartz pebble. Although Levallois cores are absent, a few Levallois products appear to have been transported to the site as finished products (Vukosavljević et al., 2022).

Regarding Bosnia and Herzegovia, despite the lack of systematic research, an extensive presence of discoid cores has been noted at several sites, including Visoko Brdo, Kamen, Londža, and Zobište. Among these, Zobište is the only site in the region that has been TL dated, with results ranging between 97.5±7 ka and 85.5±8.5 ka (Baumler, 1987; 1988).

In Montenegro, three cave sites with Middle Palaeolithic components have been identified, each containing different levels of Discoid technology (Fig. 12). However, an increasing prevalence of Levallois centripetal core exploitation over unidirectional reduction is observed in the later Middle Palaeolithic, particularly in sequences at Crvena Stijena and Bioče (Dogandžić & Đuričić, 2017). Crvena Stijena is well-known for its extensive prehistoric sequence and recent multidisciplinary research. Discoid cores with one or two flaking surfaces, along with their associated products, appear throughout the sequence, from the deepest layers XXXI to layer XII. Notably, an emphasis on unifacial discoidal cores is recorded in the later levels XII and XIV. The overall sequence likely spans from MIS6/5 to the Campanian Ignimbrite (CI) eruption, which marks the final MP layer XII (Mihailović, 2024; Morley & Woodward, 2011; Mihailović & Whallon, ed. 2017; Monnier et al., 2020).

Bioče, another important site, was initially excavated between 1986 and 1997. Discoid technology, alongside Levallois, was recognised early within a stratigraphic sequence estimated to range from MIS 5 and MIS 4 to the CI eruption. The lithic industry, described as micro-Mousterian, remains relatively uniform throughout the sequence (Đuričić, 1997; Dogandžić & Đuričić, 2017). More recent excavations (2010-2015) uncovered deeper layers with similar characteristics. Particularly significant is upper Layer 1, which contains 90% of the total artefacts recovered and is dominated by Discoid technology. Its association with the CI eruption has been considered evidence of late Neanderthal survival in the region (Pavlenok et al., 2017; Vishnevskiy et al., 2019; Dragosavac et al., 2021).

Mališina Stijena, the third site, has received comparatively less attention. Initial excavations in the 1980's identified discoid cores and related products in layers 3b13 (southern trench) and layers 13-12 (western trench) (Radovanović, 1986). Recent excavations have confirmed these findings in newly defined Layers B2 and C1 (Derevianko et al., 2021; Shunkov et al., 2021).

Further inland, in Northern Macedonia, systematic research on the Middle Palaeolithic remains limited. The most important MP site is Golema Pešt Cave (Fig. 12), where Late MP layers (6 and 5), contain both Levallois and discoid cores on quartzite, along with numerous byproducts. CI tephra has been identified in layer 2, which is believed to overlie Early UP layers. Preliminary ESR dating of layer 3 places it between 83-61.8 ka, serving as a *terminus ante quem* for the yet unpublished ESR estimates for layers 6 and 5 (Salamanov-Korobar, 2008; 2019; Lowe et al., 2012; Blackwell et al., 2019). Additionally, the recently explored open-air site of Uzun Mera has provided evidence of MP Discoid technology (Stojanovski et al., 2018).

In Albania, small quantities of discoid cores and products have been found alongside larger Levallois assemblages in open-air sites across the western regions of Mallakastra, Shkodra, and Dalani i Vogël. Notably, Levallois artefacts from Dalani i Vogël may date as late as 42.9 cal ka BP and 38.7 cal ka BP (Runnels et al., 2009; Ruka, 2023; Badino et al., 2025).

Further south, in northwestern Greece and adjacent to southern Albania, 104 MP sites had been reported by 2015, yielding a variety of assemblages (Fig. 12). The dated contexts range from MIS 5e or slightly earlier to the first half of MIS 3 (Elefanti & Gilbert, 2015). Many openair sites. often associated with Terra Rossa deposits, are dominated by Levallois method and products but occasionally contain discoid cores and products such as the sites of Kokkinopilos, Megalo Karvounari, Mikro Karvounari, Molondra, Morphi, Eleftherochori 1 and 3, Kastoria area, Samarina 1 and 2, and Lake Smixi (Dakaris et al., 1964; Kourtessi-Philippakis, 1986; Bailey et al., 1992; Papaconstantinou & Vassilopoulou, 1997; Papagianni, 2000; Galanidou, 2007; Ligkovanlis, 2011, 2017 and 2018; Papoulia, 2011; Efstratiou et al., 2014; Biagi et al., 2017 and 2023; Papadea, 2019; Ligkovanlis et al., 2022). However, two MP sites in northwestern Greece stand out in relation to this study: Asprochaliko and Eleftherochori 7, both located in Epirus and relatively close to Istraishta. Asprochaliko is a rock shelter that has been excavated and stratigraphically divided into two main units: the Basal Mousterian was thought to be dominated by Levallois technology, while the Upper Mousterian was characterised by an exclusive use of the Discoid technology. The Upper Mousterian has been dated using two conflicting ^{14}C dates from layer 14, spit 19: one falls within the Upper Palaeolithic range (32-27.6 ka BP), while the second is regarded as *terminus ante quem* (> 44.3 cal ka BP). This latter date has been generally regarded as Upper Mousterian. Similarly, the Basal Mousterian has been dated using both ^{14}C and TL methods. A single ^{14}C date in layer 18, spit 30 produced a relatively young result (> 50-37.1 cal ka BP), whereas two TL dates from layer 18, spits 38-40, ranged between 102±14 ka and 96±11 ka (Bailey et al., 1992; Huxtable et al., 1992; Gowlett & Carter, 1997; Papaconstantinou & Vassilopoulou, 1997; Papagianni, 2000; Facorellis, 2013). More recently, the initial technological interpretations of the Basal unit have been challenged and revised. It is now considered to be predominately Discoid technology, with a minor presence of cores-on-flakes, whereas the upper unit appears to show the reverse pattern. Notably, the Basal Mousterian assemblage contains 14 cores-on-flakes, which may have repurposed flakes from earlier stages of Discoid production as blanks. These cores are 'usually semi-centripetally worked with the ventral faces of the flakes used as striking platforms' (Ligkovanlis, 2016). Such a strategy does not appear in the assemblages of Istraishta or Eleftherohori 7, although end-products such as pseudo-Levallois points are particularly abundant at all three sites. In addition, Eleftherochori 7 is an open-air site that has been surface-collected and rescue-excavated through 55 trenches. Its large lithic assemblage of MP and UP components is mixed between two layers. The MP assemblage is dominated by Discoid technology, which appears to closely resemble the Basal Mousterian of Asprochaliko (Ligkovanlis, 2013; 2017; Ligkovanlis et al., 2022).

The current evidence from the aforementioned Western Balkan sites suggests a chronological range from MIS 6/5 to MIS 3, providing a general timeframe for the Istraishta assemblage. A notable characteristic of the Istraishta lithic assemblage is its resemblance to the micro-Mousterian industries of the Balkans and the Mediterranean area. These industries are defined by the small average size of the artefacts (Mihailović, 2020; Dogandžić, 2023) and are interpreted as the result of intense local raw material exploitation linked to Neanderthal mobility and site occupation frequency (Mihailović & Whallon, 2017). This process also affected Levallois cores, which progressively diminished in size due to prolonged reduction, leading to fewer residual cores (Gowlett & Carter, 1997). The overall microlithisation of these industries maintains the same general artefact classes found in other Mousterian assemblages in southern Europe, including the Pontinian in Italy (Kuhn, 1995; Rolfo et al., 2022). However, the reasons behind the small artefact sizes vary across contexts. In some cases, artefacts were made of small, locally available, low-quality raw materials, meaning their size was not necessarily the result of extensive core reduction and did not result from the overexploitation of natural cobbles (Karavanić, 2004; Dogandžić & Đuričić, 2017; Banda et al., 2022). In other cases, the deliberate selection of small nodules, despite the availability of larger river pebbles, suggests that the production of micro-tools was an intentional technological choice (Đuričić, 2006).

Given that both raw material constraints and core reduction intensity can drive the overall reduction in artefact size, it is difficult to isolate the effects of each. In most cases, the characteristics of lithic industries result from a combination of these effects. Micro-Mousterian industries are typically characterised by retouched flakes, sidescrapers, denticulates, and notched pieces, with sidescrapers generally being the most dominant tool type. However, some assemblages - such as those from Crvena Stijena and open-air sites along the Dalmatian coast - exhibit a notable prevalence of denticulates (Karavanić & Banda, 2023). Constraints in raw material provisioning may have led to increased tool reduction, as repeated rejuvenation stages were necessary to extend tool usability. This process was influenced by both the physical properties of the knapped stones and the constraints in raw materials provisioning. However, studies from Crvena Stijena and Bioče reveal that tool reduction was not primarily driven by raw material scarcity but rather by core reduction intensity, which resulted from the frequent and repeated occupation of these sites (Dogandžić & Đuričić, 2017; Pavlenok et al., 2017).

6. CONCLUSIONS

Discoid industries were widespread across southern Europe and other parts of western Eurasia, appearing in diverse geographic and palaeo-environmental contexts, across various site types, and in association with different faunal spectrums and coexistence with other flaking methods. While the Middle Palaeolithic record of the Western Balkans shows a significant occurrence of the Discoid method, dedicated studies on its prevalence remain scarce, partly due to its limited recognition in the scientific literature. When identified, Discoid products appear in varying proportions, from minor occurrences to nearly exclusive dominance, often accompanied by small quantities of Levallois products. The latter pattern is evident at Istraishta, where Discoid technology predominates, similar to sites such as Asprochaliko, Eleftherohori 7, and further afield, Fumane.

While a general classification of these assemblages under the Discoid core reduction method is justified, each site exhibits unique characteristics. For instance, at Fumane, backed pieces were intentionally prepared, whereas in the Basal Mousterian of Asprochaliko, the ventral sides of large flakes were used as striking platforms for discoid cores. At Istraishta, Eleftherohori 7, and most of the Discoid industries, pseudo-Levallois points appear in varying frequencies, produced mainly from fully or partially developed discoid cores. A higher percentage of cores, along with a notably lower occurrence of cores on flakes, suggests a connection between Istraishta, Eleftherohori 7, and the Basal Mousterian of Asprochaliko. However, do these variations reflect merely geographical adaptations, or do they indicate broader chronological patterns and widespread cultural traditions? Given the current state of research on the western Balkans, it remains difficult to determine the underlying causes of these differences.

Recent discoveries, including surface finds and open-air sites from field surveys in northwestern Greece and southern Albania (Gjipali, 2006; Forsén et al., 2011; Adam, 2014; 2019; Ruka et al., 2014; Galanidou, 2007; et al., 2018; 2021; Ligkovanlis & Kourtessi-Philippakis, 2022), as well as along the eastern Adriatic fringe, have identified MP Discoid assemblages. Some of these findspots are related to Terra Rossa deposits, as is the case with Istraishta. Ongoing research in northwestern Greece has aimed to clarify the taphonomy and chronostratigraphic relation of the MP assemblages with Terra Rossa deposits. However, despite continuous efforts, secure results have yet to be achieved (Ligkovanlis et al., 2022), and the current resolution remains insufficient for further interpretations. Similarly, in Serbia's MP record, the so called non-Levallois facies (Mihailović & Mihailović, 2023) appear to span from MIS 5 through MIS 3, up to the onset of the Upper Palaeolithic - a pattern also observed in other parts of the Balkans (Dogandžić, 2023; Karavanić & Banda, 2023). Although chronological resolution remains limited, the variability seen in these assemblages likely stems from the inherent adaptability and versatility of the Discoid method.

As previously noted, the flexibility inherent in this reduction method would have facilitated the successful adaptations of highly mobile groups to diverse environments. Moreover, the evidence from these sites suggests that the variety of exploited raw materials did not dictate the selection of a particular flaking method. Instead, different types were indiscriminately reduced to obtain a wide range of discoid flakes. The minimal presence of Levallois cores or products at Istraishta, Eleftherohori 7, and Asprochaliko - along with varying quantities further north along the eastern Adriatic - may indicate occupational palimpsests or the interchangeable use of the two methods based on situational needs. Such fluid adaptability transcends rigid technological classifications and aligns with previous discussions on the relationship between recurrent centripetal Levallois and discoid core reduction methods, as well as other centripetal, though not strictly Levallois, reduction strategies.

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Author contributions

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Statements and Declarations

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REFERENCES

Adam E. (2014) - Entopismós Néon Théseon Epochís Tou Líthou Sto Nomó Ioannínon. Dodone XLIII-XLIV (I), 1-15.

Adam E. (2019) - Diachronikí Ekmetállefsi Tou Topíou Sto Nomó Ioannínon Katá Tin Proïstorikí Período: I Martyría Ton Lithinón Technérgon. Dodone XLV-XLVI, 15-30.

Aliu S. (2020) - Kolonja. Studime Arkeologjike. Jeta, Kultura Dhe Identiteti. Korçë, Kotti.

Arrighi S., Freguglia M., Ranaldo F., Ronchitelli A. (2009) - Production and use in the Lithic Industry of the Mousterian in Santa Croce (Bisceglie, Italy). Human Evolution, 24(2), 91-106.

Badino F., Ruka R., Pini R., Frechen M., Argante V., Susini D., El Khair D. A., Comolli R., Mazzini I., Delpiano D., Çipa K., Margaritora D., Gjipali I., Peresani M. (2025) - Palaeoenvironmental, Stratigraphic and Geochronological Study of the Coastal Site of Dalani i Vogël (Vlora, Albania): New Evidence for Late Neanderthal Occupation and Prehistoric Archaeology. Quaternary Science Reviews 349, 109111.

Bailey G., Papaconstantinou V., Sturdy S. (1992) - Asprochaliko and Kokkinopilos: TL Dating and Reinterpretation of Middle Palaeolithic Sites in Epirus, North-West Greece. Cambridge Archaeology Journal, 2(1), 136-44.

Banda M., Karavanić I. (2019) - Mustjerska industrija špilje Veternice/The Mousterian industry of Veternica Cave. Prilozi Instituta za arheologiju u Zagrebu, 36, 5-40.

Banda M., Romagnoli F., Komšo D., Čuka M., Karavanić I. (2022) - Exploring a novelty in the Middle Palaeolithic of Croatia: preliminary data on the open-air site of Campanož. Quartär, 69, 29-56.

Baumler M.F. (1987) - Core Reduction Sequences: An Analysis of Blank Production in the Middle Paleolithic of Northern Bosnia. Ph.D., Tucson, The University of Arizona.

Baumler M.F. (1988) - Core Reduction, Flake Production, and the Middle Paleolithic Industry of Zobište (Yugoslavia). In Dibble H.L., Montet-White A. (Eds.) Upper Pleistocene Prehistory of Western Eurasia. University Museum Symposium Series ,1. Pennsylvania, PA, University of Pennsylvania Museum, 255-74.

Bertola S., Peresani M. (2000) - Variabilità tecnologica in due insiemi litici di superficie dei Colli Berici. Quaderni di Archeologia del Veneto, XVI, 92-96.

Biagi P., Nisbet R., Starnini E., Efstratiou N., Michniak R. (2017) Where Mountains and Neanderthals Meet: The Middle Palaeolithic Settlement of Samarina in the Northern Pindus (Western Macedonia, Greece). Eurasian Prehistory 13 (1-2), 3-76.

Biagi P., Starnini E., Efstratiou N., Nisbet R., Hughes P. D., Woodward J. C. (2023) - Mountain Landscape and Human Settlement in the Pindus Range: The Samarina Highland Zones of Western Macedonia, Greece. Land, 12 (1), 96. Doi: 10.3390/land12010096

Blackwell B.A.B., Yu E.S.K., Skinner A.R., Turk I., Blickstein J.I.B., Skaberne D., Turk J., Lau B. (2009) - Dating and Paleoenvironmental Interpretation of the Late Pleistocene Archaeological Deposits at Divje Babe I, Slovenia. In: The Mediterranean from 50,000 to 25,000 BP: Turning Points and New Directions. Oxbow Books, 51-62.

Blackwell B.A.B., Šalamanov-Korobar L., Huang C.L.C., Zhuo J.L., Kitanovski B., Blickstein J.I.B., Florentin J.A., Vasilevski S. (2019) - Sedimentary Radioactivity in an Upper Paleolithic-Middle Paleolithic (MP-UP) Transition Site: Increasing ESR Tooth Dating Accuracy at Golema Pešt, North Macedonia. Radiation Protection Dosimetry, 186(1), 94-112.

Bodu P., Salomon H., Leroyer M., Naton H.-G., Lacarriere J., Dessoles M. (2014) - An open-air site from the recent Middle Palaeolithic in the Paris Basin (France): les Bossats at Ormesson (Seine-et-Marne). Quaternary International, 331, 39-59.

Boëda E. (1993) - Le débitage Discoïde et le débitage Levallois récurrent centripète. Bullettin de la Société Préhistorique Française, 90(6), 392-404.

Bortolotti V., Chiari M., Marroni M., Pandolfi L., Principi G., Saccani E. (2013) - Geodynamic evolution of ophiolites from Albania and Greece (Dinaric-Hellenic belt): One, two, or more oceanic basins? International Journal of Earth Science, 102(3), 783-811.

Boschian G. (1999-2000) - Early Upper Pleistocene lithic industry from Caverna degli Orsi near San Dorligo della Valle (northeastern Italy). Atti Società Preistoria Protostoria Friuli-Venezia Giulia, 12 (2001), 55-65.

Boschian G., De Santis A. (2011) - Bears and sediments at Caverna degli Orsi/Medvedja jama (Trieste, Italy). Toškan B. (Eds.) Fragments of Ice Age environments. Proceedings in Honour of Ivan Turk's Jubilee. Opera Instituti Archaeologici Sloveniae, 21, 181-207.

Boschian G., Gerometta K., Ellwood B. B., Karavanić I. (2017) - Late Neandertals in Dalmatia: Site Formation Processes, Chronology, Climate Change and Human Activity at Mujina Pećina, Croatia'. Quaternary International, 450, 12-35.

Bourguignon L., Turq A. (2003) - Une chaîne opératoire de debitage discoïde sur éclat du Moustérien a denticulés aquitain: les exemples de Champ Bossuet et de Combe-Grenal c. 14. In Peresani M. (Ed.) Discoid Lithic Technology. Advances and Implications. British Archaeological Reports International Series, 1120, 131-152.

Brewer R.C. (1964) - Fabric and Mineral Analysis of Soils. Wiley, New York

Bronger A., Sedov S.N. (2002) - Vetusols and Palaeosols: natural versus man-induced environmental change in the Atlantic coastal region of Morocco. 17th World Conference on Soil Science, Paper no. 1530, 1-12.

Bullock P., Fedoroff N., Jongerius A., Stoops G. J., Tursina T. (1985) - Handbook for Soil Thin Section Description, Waine Research Publications, Albrighton.

Carmignani L., Romagnoli F. (2017) - Revisione dell'industria litica musteriana di Grotta Mario Bernardini (Nardò, Lecce). Atti XLVII Riunione Scientifica Preistoria e Protostoria Della Puglia. Istituto Italiano di Preistoria e Protostoria, 139-144.

Chiesa S., Coltorti M., Cremaschi M., Ferraris N., Floris B., Prosperi L. (1990) - The loess and Quaternary deposits in the Marche region. In Cremaschi M. (Ed.) The Loess in Northern and Central Italy. Centro di Studio per la Stratigrafia e Petrografia delle Alpi Centrali, Gutenberg, Milan, 103-132.

Church T. (1994) - Lithic resource studies: a sourcebook for archaeologists. Lithic Technology, Special Publication, 3, pp. 255.

Courty M.A., Goldberg P., Macphail R.I. (1989) - Soils and Micromorphology in Archaeology, Cambridge Manuals in Archaeology, Cambridge University Press.

Cremaschi M. (1987) - Paleosols and Vetusols in the Central Po plain, a study in Quaternary Geology and Soil Development. Unicopli, Milan.

Cremaschi M. (1990) - The loess in northern and central Italy: a loess basin between the Alps and the Mediterranean regions. In Cremaschi M. (Ed.) The Loess in Northern and Central Italy. Centro di Studio per la Stratigrafia e Petrografia delle Alpi Centrali, Gutenberg, Milan, 15-19.

Daffara S., Arzarello M., Berruti G., Berruto G., Bertè D., Berto C., Casini A.I. (2014) - The Mousterian lithic assemblage of the Ciota Ciara cave (Piedmont, Northern Italy): exploitation and conditioning of raw materials. Journal of Lithic Studies, 1, 2.

Dakaris S.I., Higgs E.S., Hey R.W., Tippett H., Mellars P. (1964) - The Climate, Environment and Industries of Stone Age Greece: Part I. Proceedings of the Prehistoric Society 30 (December):199-244.
Doi: 10.1017/S0079497X00015139

Dauvois M. (1981) - De la simultanéité des concepts Kombewa et Levallois dans l'Acheuléen du Maghreb et du Sahara nord-occidental. In Roubet C., Hugot H.J., Souville G. (Eds.) Préhistoire Africaine. Mélanges offerts au Doyen Lionel Balout. Editions A.D.P.F, Paris, 313-321.

Delagnes A., Rendu W. (2011) - Shifts in Neandertal mobility, technology and subsistence strategies in western France. Journal of Archaeological Science, 38, 1771-1783.

Delpiano D., Heasley K., Peresani M. (2018) - Assessing Neanderthal land use and lithic raw material management in Discoid technology. Journal of Anthropological Sciences, 96, 1-22.

Delpiano D., Peresani M. (2017) - Exploring Neanderthal skills and lithic economy. The implication of a refitted Discoid reduction sequence reconstructed using 3D virtual analysis. Comptes Rendu Palevol, 16, 865-877.

Delpiano D., Peresani M., Pastoors A. (2017) - The contribution of 3D visual technology to the study of Palaeolithic knapped stones based on refitting: an application. Digital Applications in Archaeology and Cultural Heritage, 4, 28-38.

Delpiano D., Zupancich A., Peresani M. (2019) - Innovative Neanderthals: Results from an integrated analytical approach applied to backed stone tools. Journal of Archaeological Science, 110, 105011.

Derevianko A.P., Shunkov M.V., Bulatovich L., Kozlikin M.B., Anoikin A.A., Pavlenok K.K., Agadzhanyan A.K., Ulianov A.V., Vishnevskiy A.V. (2021) - Novoye v Paleolitovedenii Vostochnoy Adriatiki. Rossiysko-Chernogorskiye Issledovaniya v 2008-2021 Godakh. Novosibirsk, IAET SB RAS Publ.

Déviese T., Karavanić I., Comeskey D., Kubiak C., Korlević P., Hajdinjak M., Radović S., Procopio N., Buckley M., Pääbo S., Higham T. (2017) - Direct dating of Neanderthal remains from the site of Vindija Cave and implications for the Middle to Upper Paleolithic transition. Proceedings of the National Academy of Sciences U.S.A., 114, 10606 -10611.

Dogandžić T. (2023) - The Middle Paleolithic of the Balkans: Industrial Variability, Human Biogeography, and Neanderthal Demise Journal of World Prehistory, 36, 257-338.

Dogandžić T., Đuričić L. (2017) - Lithic production strategies in the Middle Paleolithic of the southern Balkans. Quaternary International, 450, 68-102.

Dragosavac S., Plavsic S., Predrag R. (2021) - The Impact of the Campanian Ignimbrite (CI) Eruption on Palaeolithic Settlement Patterns in the Central Balkans. In Babic S. (Ed.) Archaeology of Crisis, Belgrade, Faculty of Philosophy, University of Belgrade, 25-42.

Duchaufour P.H. (1983) - Pedologie: Pedogenesis and Classification. Mason et Cie, Paris-New York-Barcelona-Milan, 447.

Dunham R.J. (1962) - Classification of carbonate rocks according to depositional texture. American Association of Petroleum Geologists 1, 108-121.

Đuričić L. (1997) - Artifacts of Sandstone and Limestone on the Site of Bioče. Glasnik Srpskog Arheološkog Društva, 13, 59-70.

Đuričić L. (2006) - A Contribution to Research on Bioče Mousterian. Glasnik Srpskog Arheološkog Društva, 22, 179-96.

Durn G. (2003) - Terra rossa in the Mediterranean re-

gion: parent materials, composition and origin, Geologia Croatica, 56(1), 83-100.
Durn G., Ottner F., Slovenec D. (1999) - Mineralogical and geochemical indicators of the polygenetic nature of terra rossa in Istria, Croatia. Geoderma, 91, 125-150.
Efstratiou N., Biagi P., Angelucci D. E., Nisbet R. (2014) - Highland Zone Exploitation In Northwestern Greece: The Middle Paleolithic Levallois Sites of the Pindus Range of Western Macedonia. The SAA Archaeological Record 14 (3), 38-42.
Eftimi R., Sara F. (2022) - Quantity and quality of groundvater of intermountain basin of Korça in Albania and implication for sustainable management. Geologìcnij žurnal, 4, 45-64.
Elefanti P., Gilbert M. (2015) - Late Pleistocene Hominin Adaptations in Greece. In Cowar F., Wenban-Smith F., Pope M., Hosfield R. (Eds.) Settlement, Society and Cognition in Human Evolution: Landscapes in Mind. Cambridge University Press, 189-213.
Facorellis Y. (2013) - Radiocarbon Dates from Archaeological Sites in Caves and Rockshelters in Greece. In Mavridis F., Jensen J.T. (Eds.) Stable Places and Changing Perceptions: Cave Archaeology in Greece 182, 19-72. BAR International Series 2558. Oxford, Archaeopress
FAO (2006) - Guidelines for Soil Description, fourth ed. FAO, Food and Agricolture Organization of the United Nations, Rome, pp. 97.
Forsén B., Forsén J., Lazari K., Tikkala E. (2011) - Catalogue of Sites in the Central Kokytos Valley, In Forsén B., Tikkala E. (Eds.) Thesprotia Expedition II: Environment and Settlement Patterns XVI, 73-122. Papers and Monographs of the Finnish Institute at Athens. Helsinki: Suomen Ateenan instituutin säätiö (Foundation of the Finnish Institute at Athens)
Fouache E., Desruelles S., Magny M., Bordon A., Oberweiler C., Coussot C., Touchais G., Lera P., Lézine A.-M., Fadin L., Roger R. (2010) - Palaeogeographical Reconstructions of Lake Maliq (Korça Basin, Albania) between 14,000 BP and 2000 BP. Journal of Archaeological Science, 37, 525-35.
Galanidou N. (2007) - I Proïstoría Tis Anthrópinis Katagogís Sti Lekáni Tis Límnis Tis Kastoriás: Oi Martyríes Apó Ti Syllogí Pantazópoulou. To Archaiologikó Érgo Sti Makedonía Kai Thráki 21, 1-6.
Galanidou N., Papoulia C. (2023) - Between the Aegean and the Adriatic: The Balkan Palaeolithic and the Sea. In Ruiz-Redondo A., Davies W. (Eds.) The Prehistoric Hunter-Gatherers of South-Eastern Europe. Proceedings of the British Academy, 258, Oxford University Press, 225-251.
Galanidou N., Vikatou O., Stavropoulou-Gatsi M., Vasilakis A., Staikou V., Iliopoulos G., Veikou M., et al (2018) - Archaiologikí Érevna Epifaneías Sto Esoterikó Archipélagos Tou Ioníou. In To Archaiologikó Érgo Stin Aitoloakarnanía Kai Ti Lefkáda: Praktiká 2ou Diethnoús Istorikoú Kai Archaiologikoú Synedríou, I.P. 6-8 Dekemvríou 2013, 445-73. Mesolongi, Eforeía Archaiotíton Aitoloakarnanías kai Lefkádas.
Galanidou N., Gatsi M., Vikatou O., Vasilakis A., Morgan C., Forsén J., Staikou V., Papoulia C., Zervoudakis P. (2021) - Prehistoric settlement in the Inner Ionian Sea Archipelago and its Ionian island connections, In Souyoudzoglou-Haywood C., Papoulia C. (Eds.) Archaeology of the Ionian Sea: Landscapes, seascapes and the circulation of people, goods and ideas from the Palaeolithic to the end of the Bronze Age. Oxford & Philadelphia, Oxbow Books.
Gjipali I. (2006) - Recent Research on the Palaeolithic and Mesolithic Archaeology of Albania. In Bejko L., Hodges R. (Eds.) New Directions in Albanian Archaeology: Studies Presented to Muzafer Korkuti, International Centre for Albanian Archaeology Monograph Series 1. Oxbow Books, 31-42.
Gjipali I. (2011) - Kërkime Arkeologjike Për Prehistorinë e Hershme Në Shqipërinë Jugore'. In Epiri Antik-Kaonia: Simpoziumi I Dhe II Shkencor Ndërkombëtar. Universiteti 'Eqrem Çabej', Gjirokastër, 33-38.
Gjipali I. (2012) - Epoka e Gurit Dhe Shqipëria. Tiranë, Botart.
Gjipali I. (2014) - Stone Age Investigations in Albania (1998-2013) In Përzhita L., Gjipali I., Hoxha G., Muka B. (Eds.) Proceedings of the International Congress of Albanian Archaeological Studies: 65th Anniversary of Albanian Archaeology, Tiranë: Centre for Albanian Studies and Institute of Archaeology, 53-64.
Gowlett J.A.J., Carter P.L. (1997) - The basal Mousterian of Asprochaliko rockshelter, louros valley. In Bailey G. (Ed.) Klithi: Palaeolithic Settlement and Quaternary Landscapes in Northwest Greece, vol. 1. Klithi in Its Local and Regional Setting. McDonald Institute Monographs, 441-458.
Gravina B., Discamps E. (2015) - MTA-B or not to be? Recycled bifaces and shifting hunting strategies at Le Moustier and their implication for the late Middle Palaeolithic in southwestern France, Journal of Human Evolution, 84, 83-98.
Gvirtzman G., Wieder M. (2001) - Climate of the last 53,000 years in the eastern Mediterranean, based on soil-sequence stratigraphy in the coastal plain of Israel. Quaternary Science Reviews, 20/18. 1827-1849.
Higham T., Douka K., Wood R., Ramsey C.B., Brock F., Basell L., Camps M., Arrizabalaga A., Baena J., Barroso-Ruíz C., Bergman C., Boitard C., Boscato P., Caparrós M., Conard N.J., Draily C., Froment A., Galván B., Gambassini P., Garcia-Moreno A., Grimaldi S., Haesaerts P., Holt B., Iriarte-Chiapusso M.J., Jelinek A., Jordá Pardo J.F., Maíllo-Fernández J.M., Marom A., Maroto J., Menéndez M., Metz L., Morin E., Moroni A., Negrino F., Panagopoulou E., Peresani M., Pirson S., De La Rasilla M., Riel-Salvatore J., Ronchitelli A., Santamaria D., Semal P., Slimak L., Soler J., Soler N., Villaluenga A., Pinhasi R., Jacobi R., (2014) - The timing and spatiotemporal patterning of Neanderthal disappearance. Nature, 512, 306-309.
Doi: 10.1038/nature13621
Huxtable J., Gowlett J.A.J., Bailey G.N., Carter P.L., Papaconstantinou V. (1992) - Thermoluminescence Dates and a New Analysis of the Early Mousterian from Asprochaliko. Current Anthropology, 33(1), 109-14.
Inizan M.L., Reduron-Ballinger M., Roche H., Tixier J. (1995) - Préhistoire de la pierre taillée t. 4 - Technologie de la pierre taillée. Meudon, CREP.

IUSS Working Group WRB (2015) - World Reference Base for Soil Resources 2014, update 2015 International soil classification system for naming soils and creating legends for soil maps, World Soil Resources Reports 106, FAO, Rome.
Karavanić I. (2004) - The Middle Paleolithic settlement of Croatia. In Conard N. J. (Ed.) Settlement Dynamics of the Middle Palaeolithic and Middle Stone Age. Tübingen Publications in Prehistory, Introductory Volume. Tübingen, Kerns Verlag, 185-200.
Karavanić I., Banda M. (2023) - The Middle Palaeolithic of South-Eastern Europe. In Ruiz-Redendo A., Davies W. (Eds.) The Prehistoric Hunter-Gatherers of South-Eastern Europe. Proceedings of the British Academy 258. Oxford University Press, 60-106.
Karavanić I., Miracle P.T., Culiberg M., Kurtanjek D., Zupanič J., Golubić V., Paunović M., Lenardić J.M., Malez V., Šošić R., Janković I., Smith F.H. (2008) - The Middle Paleolithic from Mujina Pećina, Dalmatia, Croatia. Journal of Field Archaeology, 33(3), 259-77.
Karavanić I., Hellstrom J., Rabeder G., Vukosavljević N., Banda M., Smith F.H. (2021) - New U-Th dates from Vindija, Velika Pećina (Kličevica) and Mujina Pećina and their implications for chronology of the Middle Paleolithic in Croatia. Collegium Antropologicum, 45(1), 1-10.
Karavanić I., Bronić I.K., Sironić A., Radović S., Banda M., Smith F.H. (2024) - Chronology of hominin activity at Vindija Cave, Croatia: new dates recorded via standard and ultrafiltration AMS. Antiquity, 98(398), e7.
Klein C. (1999) - Manual of Mineralogy. John Wiley & Sons Inc, New York.
Kuhn S.L. (1995) - Mousterian lithic technology: An ecological perspective. Princeton University Press.
Kourtessi-Philippakis G. (1986) - Le paléolithique de la Grèce continentale: État de la question et perspectives de recherche. Histoire ancienne et médiévale 16. Paris, Éditions de la Sorbonne.
Ligkovanlis S. (2011) - Megalo Karvounari Revisited. In Thesprotia Expedition II: Environment and Settlement Patterns, edited by Björn Forsén and Esko Tikkala, XVI,159-80. Papers and Monographs of the Finnish Institute at Athens. Helsinki, Suomen Ateenan instituutin säätiö (Foundation of the Finnish Institute at Athens).
Ligkovanlis S. (2013) - A Rare Case of "Technological Connectivity" across the Adriatic Sea during the Middle Palaeolithic: The Eleftherochori 7 Mousterian Lithic Assemblage in its South/Southeast European Context. In Bombardieri L., D'Agostino L., Guarducci G., Orsi V., Valentini S. (Eds.) SOMA 2012 Identity and Connectivity. Proceedings 16th Symposium on Mediterranean Archaeology, Florence, BAR International Series 2581. Oxford, Archaeopress, II, 645-56.
Ligkovanlis S. (2016) - On Lithic Technology Terms and Semantics. The Example of the Asprochaliko Rockshelter Middle Palaeolithic Stone Industry. In Elefanti P., Andreasen N., Kardulias P.N., Marshall G. (Eds.) Lithics Past and Present. Perspectives on Chipped Stone Studies in Greece. Studies in Mediterranean Archaeology. Uppsala, Åströms Förlag, CXLIV, 95-110.
Ligkovanlis S. (2017) - New Insights into the Upper Pleistocene Archaeology of Northwestern Greece: The Evidence from Three Open-Air Sites and Its Implication for Middle and Upper Palaeolithic Hunter-Gatherers Activity and Behaviour in Southeastern Europe. Journal of Greek Archaeology, 2 (January), 1-32.
Ligkovanlis S. (2018) - Neanderthals Kai Homo Sapiens Katá to Anótero Pleistókaino Sti Voreiodytikí Elláda. Néa Stoicheía Apó Laxevménes Lithologíes Pétra Ton Ypaíthrion Chóron Tis Thesprotías. In To Archaiologikó Érgo Sti Voreiodytikí Elláda Kai Ta Nisiá Tou Ioníou: Ioánnina; Praktiká, 237-48.
Ligkovanlis S., Kourtessi-Philippakis G. (2022) - Palaeolithic Chipped Stone Industries from Zakynthos, Ionian Islands, Greece. Interpreting the New Evidence within the Western Greek and Adriatic Context. In Souyoudzoglou-Haywood C., Papoulia C. (Eds.) Archaeology of the Ionian Sea: Landscapes, Seascapes and the Circulation of People, Goods and Ideas from the Palaeolithic to the End of the Bronze Age, 41-51. Oxford & Philadelphia, Oxbow Books.
Ligkovanlis, S., Iliopoulos G., Palli O., Tzortzatou A., Tsakanikou P. (2022) - Palaeolithic Artifact Taphonomy in Terra Rossa Sites at Northwestern Greece Revisited: Two New Case Studies. Mediterranean Archaeology and Archaeometry 22(3), 215-29.
Lindhorst K., Krastel S., Reicherter K., Stipp M., Wagner B., Schwenk T. (2015) - Sedimentary and tectonic evolution of Lake Ohrid (Macedonia/Albania). Basin Research, 27(1), 84-101.
López-García J.M., Dalla Valle C., Cremaschi M., Peresani M. (2015) - Reconstruction of the Neanderthal and Modern Human landscape and climate from the Fumane cave sequence (Verona, Italy) using small-mammal assemblages. Quaternary Science Reviews 128, 1-13.
Lowe J., Barton N., Blockley S., Bronk Ramsey Ch., Cullen V.L., Davies W., Gamble C., Grant K., Hardiman M., Housley R., et al. (2012) - Volcanic Ash Layers Illuminate the Resilience of Neanderthals and Early Modern Humans to Natural Hazards. Proceedings of the National Academy of Sciences, 201204579.
Macleod D.A. (1980) - The origin of the red Mediterranean soils in Epirus, Greece. Journal of Soil Science, 31, 125-136.
Marciani G., Ronchitelli A., Arrighi S., Badino F., Bortolini E., Boscato P., Boschin F., Crezzini J., Delpiano D., Falcucci A. (2020) - Lithic techno-complexes in Italy from 50 to 39 thousand years BP: An overview of lithic technological changes across the Middle-Upper Palaeolithic boundary. Quaternary International 551, 123-149. Doi: 10.1016/j.quaint.2019.11.005
Merino E., Banerjee A., Dworkin S. (2006) - Dust, terra rossa, replacement, and karst: serendipitous geodynamics in the critical zone. Geochimica et Cosmochimica Acta, 70, (18), A416.
Mihailović D. (2020) - Push-and-pull factors of the Middle to Upper Paleolithic transition in the Balkans. Quaternary International, 551, 47-62.
Mihailović D. (2024) - Middle Paleolithic Assemblages from Crvena Stijena: Insights from the 1954-1963 Excavations. Prehistoric Settlements in Caves and Rock-Shelters of Serbia and Montenegro, Fasci-

cule III. Faculty of Philosophy, University of Belgrade, Center for Archaeological Research.
Mihailović D., Mihailović B.R. (2023) - Chronology and Succession of Palaeolithic Technocomplexes in Serbia. Zbornik Narodnog Muzeja - Archeologija, 26(1), 11-37.
Mihailović D., Whallon R. (2017) - Crvena Stijena Revisited: The Late Mousterian Assemblages. Quaternary International, 450, 36-49.
Monnier G., Tostevin G., Pajović G., Borovonić N., Baković M. (2020) - Nova Istraživanja Paleolitskog Nalazišta Crvena Stijena, Istorijski Kontekst. Istorijski Zapisi XCIII, (1-2), 71-108.
Morley M.W., Woodward J.C. (2011) - The Campanian Ignimbrite (Y5) Tephra at Crvena Stijena Rockshelter, Montenegro. Quaternary Research, 75(3), 683-96.
Mourre V. (2003) - Discoïde ou pas Discoïde? Réflexions sur la pertinence des critères techniques définissant le débitage Discoïde. In Peresani M. (Ed.) Discoid Lithic Technology. Advances and Implications. British Archaeological Reports, International Series, 1120.
Munsell Color (2009) - Munsell Soil Color Charts - Revised Edition, New Windsor, Munsell® Color.
Murphy C.P. (1986) - Thin Section Preparation of Soils and Sediments. AB Academic Publishers, Berkhamsted, pp. 149.
Nelson E. (1997) - Radiocarbon dating of bone and charcoal from Divje babe I Cave. In Turk I. (Ed.) Mousterian ‘bone flute’ and other finds from Divje Babe i Cave siet in Slovenia. Opera Instituti Archaeologici Sloveniae 2. Ljubljana, Znanstvenoraziskovalni Center SAZU, 51-54.
Nicosia C., Stoops G. (2017) - Archaeological Soil and Sediment Micromorphology, Chichester, Wiley Blackwell, pp. 475.
Palombo M.R., Mussi M. (2006) - Large mammal guilds at the time of the first human colonization of Europe: the case of the Italian Pleistocene record. Quaternary International 149, 94-103.
Papaconstantinou V., Vassilopoulou D. (1997) - The Middle Palaeolithic Industries of Epirus. In Klithi: Palaeolithic Settlement and Quaternary Landscapes in Northwest Greece. Vol. 2: Klithi in its local and regional setting, edited by Geoff Bailey, 459-80. McDonald Institute Monographs. Cambridge, McDonald Institute for Archaeological Research.
Papadea A. (2019) - Anazitóntas Tous Palaiolithikoús Anthropídes Sta Vouná Tis Thesprotías: Oi Ypaíthries Théseis Eleftherochóri 1 Kai 3. In Chouliaras Ioannis P. & G.Th. Pliakou G. (Eds) Thesprotia I. Proceedings 1st International Conference on the Archaeology and History of Thesprotia. Ioannina, Ministry of culture and sports, Ephorate of antiquities of Thesprotia, pp. 21-36.
Papagianni D. (2000) - Middle Palaeolithic Occupation and Technology in Northwestern Greece: The Evidence from Open-Air Sites. BAR International Series 882. Oxford, BAR Publishing.
Papoulia C. (2011) - Mikro Karvounari in Context: The New Lithic Collection and Its Implications for Middle Palaeolithic Hunting Activities. In Thesprotia Expedition II: Environment and Settlement Patterns, edited by Björn Forsén and Esko Tikkala, XVI, 123-58. Papers and Monographs of the Finnish Institute at Athens. Helsinki, Suomen Ateenan instituutin säätiö (Foundation of the Finnish Institute at Athens).
Pavlenok K.K., Kozlikin M.B., Kandyba A.V., Bulatović L., Derevianko A.P., Shunkov M.V. (2017) - Style, Deficit or Reduction? Analysing the Bioče Micro-Mousterian. Quartär, 64, 95-106.
Peresani M. (1998) - La variabilité du débitage Discoïde dans la Grotte de Fumane (Italie du nord). Paléo 10, 123-146.
Peresani M. (Ed.) (2003) - Discoid Lithic Technology. Advances and Implications. British Archaeological Reports, International Series, 1120.
Peresani M. (2003) - An initial overview of the middle Palaeolithic discoid industries in Central-Northern Italy. In Peresani M. (Ed.) Discoid Lithic Technology. Advances and Implications. British Archaeological Reports, International Series, 1120, 209-223.
Peresani M. (2022) - Inspecting human evolution from a cave. Late Neanderthals and early sapiens at Grotta di Fumane: present state and outlook. Journal of Anthropological Sciences, 100, 71-107.
Peresani M., Tozzi C. (2018) - Il Paleolitico e il Mesolitico del Friuli-Venezia Giulia: quarant’anni di studi e ricerche. In Borgna E., Càssola G.P., Corazza S. (Eds.) Preistoria e Protostoria del Caput Adriae, Atti XLIX Riunione Scientifica Istituto Italiano di Preistoria e Protostoria. Studi di Preistoria e Protostoria, 5, 45-59.
Peresani M., Romandini M., Duches R., Jéquier C., Nannini N., Pastoors A., Picin A., Schmidt I., Vaquero M., Weniger G.C. (2014) - New evidence for the Mousterian and Gravettian at Rio Secco Cave, Italy. Journal of Field Archaeology, 39/4, 401-416.
Peresani M., Boldrin M., Pasetti P. (2015) - Assessing the exploitation of double patinated artifacts during the Late Mousterian. Implications for lithic economy and human mobility in the North of Italy. Quaternary International 361, 238-250.
Peresani M., Gjipali I., Romandini M., Ruka R. (2016) - Shqipëria Jug-Perëndimore, Një Korridor Gjatë Paleolitit Për Në Brigjet Veriore Të Mesdheut. In Lepore G. (Ed.) Qytetet Antike Dhe Peizazhi Në Shqipëri: Një Shekull Kërkimesh Arkeologjike Italo -Shqiptare. Muzeu Historik Kombëtar. Adrias. Bari, Edipuglia, 12, pp. 159-63.
Peresani M., Monegato G., Ravazzi C., Bertola S., Margaritora D., Breda M., Fontana A., Fontana F., Janković I., Karavanic I., Komšo D., Mozzi P., Pini R., Furlanetto G., De Amicis G.M., Perhoč Z., Posth C., Ronchi L., Rossato S., Vukosavljević N., Zerboni A. (2021) - Hunter-gatherers across the Great Adriatic-Po Region during the Last Glacial Maximum: environmental and cultural dynamics. Quaternary International, 581-582, 128-163.
Radovanović I. (1986) - Novija Istraživanja Paleolita i Mezolita u Crnoj Gori. Glasnik Srpskog Arheološkog Društva, 3, 63-77.
Rapp A. (1984) - Are terra rossa soils in Europe eolian deposits from Africa? Geologiska Foreninges et Stockholm Forhandlingar 105, 161-168.
Rolfo M.F., Ceruleo P., Marra F., Jicha B., Gatta M. (2022) - Exploring the lithic variability of the Mousterian (MIS 9-3) open-air sites of the Pontine Plain (Central Italy). Journal of Paleolithic Archaeology,

5, 1-28.
Romagnoli F., Chabai V., Gravina B., Hérisson D., Hovers E., Moncel M.H., Peresani M., Uthmeier T., Bourguignon L., Chacón M.G., Di Modica K., Faivre J.P., Kolobova K., Malinski-Buller A., Neruda P., Rios Garaizar J., Weiss M., Wiśniewski A., Wragg Sykes R. (2022) - Neanderthal technological variability: a wide-ranging geographical perspective of the final Middle Palaeolithic. In Romagnoli F., Rivals F., Benazzi S. (Eds.) Updating Neanderthals. Elsevier monographies, 163-204.
Ruka R. (2018) - An Overview on Early Prehistoric Evidence from the Korça Basin'. In Lamboley J.-L., Përzhita L., Skënderaj A. (Eds.) L'Illyrie Méridionale et l'Epire Dans l'antiquité, Actes Du VI Colloque International de Tirana (20-23 Mai 2015). Tiranë, ALSA.
Ruka R. (2023) - The Lithic Assemblages. In Archaeological Investigations in a Northern Albanian Province: Results of the Projekti Arkeologjik i Shkodres (PASH): Volume Two: Artifacts and Artifact Analysis, edited by Michael L. Galaty and Lorenc Bejko, 1-43. Memoirs of the Museum of Anthropology, University of Michigan 64. Ann Arbor, Michigan, University of Michigan Museum of Anthropological Archaeology.
Doi: 10.3998/mpub.12208577
Ruka R., Gjipali I., Galaty M.L., Bajramaj N. (2014) - Lithics at One End of Circum-Adriatic: Case Studies from the Southernmost Albanian Coastal Lowland. In Përzhita L., Gjipali I., Hoxha G., Muka B. (Eds.) Proceedings of the International Congress of Albanian Archaeological Studies, 65th Anniversary of Albanian Archaeology (21-22 November, Tirana 2013), 93-106. Tiranë, Centre for Albanian Studies and Institute of Archaeology.
Runnels, C., Korkuti M., Galaty M. L., Timpson M. E., Stocker S. R., Davis J. L., Bejko L., and Muçaj S. (2009) - Early Prehistoric Landscape and Landuse in the Fier Region of Albania. Journal of Mediterranean Archaeology 22 (2), 151-82.
Doi: 10.1558/jmea.v22i2.151
Salamanov-Korobar L. (2008) - First Paleolithic Research in the R. Macedonia (FYROM): The Cave Golema Pesht near the Village Zdunje - Preliminary Results. In Darlas A., Mihailović D. (Eds.) The Palaeolithic of the Balkans, Proceedings of the XV World Congress UISPP (Lisbon, 4-9 September 2006). BAR International Series 1819. Oxford, Archaeopress, 17, 85-92.
Šalamanov-Korobar L. (2019) - Analiza Na Delkanite Kameni Artefakti Od Srednopaleolitskite Sloevi vo Pešterata Golema Pešt'. Macedoniae Acta Archaeologica, 21, 11-36.
Sarti L., Romagnoli F., Carmignani L., Martini F. (2017) - Grotta del Cavallo (scavi Sarti): tradizione e innovazione nella sequenza musteriana sulla base dell'indicatore litico, Studi di Preistoria e Protostoria (4), Preistoria e Protostoria della Puglia, 131-138.
Schmidt S.M., Bernoulli D., Fügenschuh B., Matenco L., Schefer S., Schuster R., Tischler M., Ustaszewski K. (2008) - The Alpine-Carpathian-Dinaridic orogenic system: correlation and evolution of tectonic units. Swiss Journal of Geosciences, 01, 139-183.
Schwertmann U.T.R.M., Taylor R.M. (1989) - Iron oxides. Minerals in soil environments 1(1989), 379-438.
Sherreiks R., BouDagher-Fadel M. (2021) - The closure of the Vardar Ocean (the western domain of the northern Neotethys) from early Middle Jurassic to Paleocene time, based on surface geology of eastern Pelagonia and the Vardar zone, biostratigraphy, and seismic-tomographic images of the mantle below the Central Hellenides. UCL Open, Environment Preprint.
Shunkov M.V., Anoikin A.A., Kozlikin M.B., Bulatovich L., Derevianko A.P. (2021) - Mnogosloynaya Paleoliticheskaya Stoyanka Malishina Stena v Chernogorii: Rezul'taty Issledovaniy (2021) Goda. Problemy Arkheologii, Etnografii, Antropologii Sibiri i Sopredel'nykh Territoriy, 27, 349-54.
Simek J. (1991) - Stone Tool Assemblages from Krapina (Croatia, Yugoslavia). In Montet-White A. and Holen S. Raw material economies among Prehistoric hunter-gatherers. University of Kansas Publications in Anthropology 19. Lawrence: University of Kansas Press, 59-72.
Simek J.F., Smith F.H. (1997) - Chronological Changes in Stone Tool Assemblages from Krapina (Croatia). Journal of Human Evolution, 32(6), 561-75.
Skarpelis N, (2020) - Silcrete and chert as source rocks of early prehistoric artifacts: the case of central Evia (Greece). Mediterranean Archaeology and Archaeometry, 21(1), 1-19.
Soil Survey Staff (2014) - Keys to Soil Taxonomy, 12th ed. USDA-Natural Resources Conservation Service, Washington DC, pp. 360.
Stojanovski D., Arzarello M., Nacev T. (2018) - Middle Paleolithic Stone-Tool Technology from the Central Balkans: The Site of Uzun Mera (Eastern Republic of Macedonia). Quaternary International, 476 (May), 63-69.
Stoops G. (2021) - Guidelines for Analysis and Description of Soil and Regolith Thin Sections, 2nd Edition, Wiley & Sons, Inc, pp. 240.
Stoops G., Marcelino V., Mees F. (Eds) (2018) - Interpretation of Micromorphological Features of Soils and Regoliths, 2nd Edition, Amsterdam, Elsevier.
Šušnjara A., Šćavničar B., Gabrić A. (1994) - The occurrence of vitric tuff in the Quaternary deposits of Gljev in Dalmatia (Southern Croatia). Geologia Croatica, 47(2), 193-198.
Tagari D., Vergely P., Aliaj S. (1993) - Tectonique polyphasée plio-quaternaire en Albanie orientale (région de Korça-Pogradeçi). Bulletin de la Société Géologique Française, 164(5), 727-737.
Torrent J. (2005) - Mediterranean soils. Encyclopedia of Soils in the Environment, 2, 418-27.
Tourloukis V. (2021) - Palaeolithic Archaeology: A Review of Recent Research." Archaeological Reports 67, 61-79.
Turk M. (2014) - Tipologija kamnitih artefaktov. In Turk I. (Ed.) Divje babe I: Upper Pleistocene Palaeolithic site in Slovenia, Part 2: Archaeology. Opera Instituti Archaeologici Sloveniae 29. Ljubljana, ZRC SAZU, Založba ZRC, 153-70.
Turk M., Turk I. (2014) - Tehnologija, uporabljena pri izdelavi artefaktov. In Turk I. (Ed.) Divje babe I: Upper Pleistocene Palaeolithic site in Slovenia, Part 2: Archaeology. Opera Instituti Archaeologici Sloveniae 29. Ljubljana, ZRC SAZU, Založba ZRC, 57-78.

Turq A., Faivre J.P., Gravina B., Bourguignon L. (2017) - Building models of Neanderthal territories from raw material transports in the Aquitaine Basin (southwestern France). Quaternary International, 433, 88-101.

Vishnevskiy A.V., Pavlenok K.K., Kozlikin M.B., Ulyanov V.A., Derevianko A.P., Shunko M.V. (2019) - A Neanderthal Refugium in the Eastern Adriatic. Archaeology, Ethnology & Anthropology of Eurasia, 47(4), 3-15.

Vujević D. (2009) - The Relationship between the Middle Palaeolithic Sites in the Zadar Hinterland and the Zadar Islands. In Forenbaher S. (Ed.) A Connecting Sea: Maritime Interaction in Adriatic Prehistory. BAR International Series 2037. Oxford, Archaeopress, 1-11.

Vujević D., Perhoč Z., Ivančić T. (2017) - Micro-Mousterian in Northern Dalmatia. Quaternary International, 450, 50-67.

Vukosavljević N., Gužvica G., Radanović-Gužvica B., Kurtanjek D., Karavanić I. (2022) - Mousterian Lithic Assemblage from Vinica Cave (Hrvatsko Zagorje, Croatia) - New Insights into Regional Middle Paleolithic Technological Behavior. Arheološki Vestnik, 73, 7-28.

Xhomo A., Kodra A., Xhafa Z., Shallo M. (2002) - Gjeologjia e Shqipërisë. Stratigrafia, Magmatizmi, Metamorfizmi, Tektonika, Neotektonika dhe Evolucioni Paleogjeografik dhe Gjeodinamik, Tirana, pp. 464.

Yaalon D.H. (1997) - Soils in the Mediterranean region: what makes them different? Catena, 28, 157-169.

Yonekura K., Hasegawa H., Hotta A., Suzuki T. (2008) - A novel approach to studies of prehistoric exploitation of stone tools materials using material composition, surface morphology, microstructure and mechanical properties, Archaeometry, 50/5, 727-746.

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