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Introduction

1.1. What Were the Interactions Between Sapiens and Neanderthals at the End of the Middle Palaeolithic?

The period between 60,000 and 40,000 years BP is crucial in prehistory, as it encompasses the demise of *Homo neanderthalensis* and the diffusion of *Homo sapiens* groups in Eurasia. The timeline of *sapiens*' arrival in Europe is continually being updated. Current research suggests that the earliest fossil of *sapiens* in Europe might come from Apidima in Greece, dated to 210,000 years BP (Harvati et al., 2019). If subsequent data were to support this earlier wave of dispersion, it would indicate that *sapiens* entered Europe much earlier than the previously estimated ~50,000 years BP, necessitating a revision of the notion that Neanderthals were the sole inhabitants of Europe and the exclusive makers of Middle Palaeolithic technocomplexes. Recent evidence indicates that, beginning around 54,000 years BP, several waves of *Homo sapiens* introduced technological innovations in Europe, associated with distinctive technocomplexes (Vallini et al., 2022).

Fossils of *Homo sapiens* dating to 54,000 years BP were recovered at Grotte Mandrin in France, in association with the Neronian technocomplex (Slimak et al., 2022). Additionally, the fossil from Zlatý kůň, Czech Republic, dated to 45,000 years BP, confirms the presence of *sapiens* in northern Europe (Prüfer et al., 2021). The expansion of *sapiens* into northern Europe around 45,000 years ago is further evidenced by remains from Bacho Kiro, Bulgaria, associated with the Bachokirian-Initial Upper Palaeolithic (Fewlass et al., 2020; Hublin et al., 2020), and from the Ilsenhöhle site in Ranis, Germany, associated with the Lincombian-Ranisian-Jerzmanowician (LRJ) (Mylopotamitaki et al., 2024).

Additionally, from approximately 43,000 years ago, *Homo sapiens* associated with the Uluzzian technocomplex were found at Grotta del Cavallo and possibly Roccia San Sebastiano in Italy (Benazzi et al., 2011a; Moroni et al., 2018; Marciani et al., 2020a; Oxilia et al., 2022; Higham et al., 2024).

Homo sapiens are commonly associated with the recurrent occurrence of cultural innovations, such as the development of projectile weapons like bows and arrows (Brooks et al., 2018.; Shea, 2006; Villa and Lenoir, 2006; Lombard and Haidle, 2012; Backwell et al., 2018; Walls, 2019; Lombard, 2022), diversified bone technology (Arrighi et al., 2020), and sophisticated hunting strategies that include the trapping of small prey and the incorporation of fish and seafood into their diet. Additional innovations include the creation of figurative art and symbolic artefacts, as well as the practice of burials accompanied by grave goods (d'Errico et al., 2003; Henshilwood and Marean, 2003; Mellars, 2007; Conard, 2010; Shea and Sisk, 2010).

The final phase of the Middle Palaeolithic is of particular interest not only regarding the dynamics of *sapiens*' dispersion but also in relation to the behaviours exhibited by the resident human population. The last inhabitants of the European Middle Palaeolithic were the Neanderthals, a flexible species capable of adapting to various climates and environments, and of developing different technologies and survival strategies over approximately 400,000 years (for an updated review Romagnoli et al., 2022a). Neanderthals were skilled artisans, proficient in working different types of stone with sophisticated reduction technologies (Boëda, 1994; Marciani et al., 2018; Gasparyan and Glauberman, 2022). In addition to stone, there is evidence of their use of other materials, such as bone (Baumann et al., 2022), plant material (Aranguren et al., 2018; Niekus et al., 2019; Hardy, 2022), and shells (Douka and Spinapolice, 2012; Romagnoli et al., 2016). The use of adhesive substances has also been identified (Boëda et al., 1996a Niekus et al., 2019), along with the production of composite tools (Sykes, 2015; Hoffecker, 2018). Their hunting skills are evidenced by the predation of large, medium, and sometimes small fauna (Blasco et al., 2022; Rendu, 2022; Rivals et al., 2022). The use of plant resources for food and medicinal purposes has also been identified (Hardy, 2022). Their resource management reflects a profound knowledge of the environment (Perlès, 1991; Arzarello and Peretto, 2005; Porraz, 2005; Park, 2007; Peresani, 2012) and a careful organisation of living areas, as shown by different spatial arrangements of the camps (Spagnolo et al., 2020a; Vaquero, 2022). Neanderthals also exhibited aesthetic sensibilities through the use of pigments, shells, and feathers as ornaments (d'Errico et al., 2003; Zilhao et al., 2010; Peresani et al., 2011; 2013a; Finlayson et al., 2012; Radovčić et al., 2015; Majkic et al., 2017; Morin et al., 2020; Romandini et al., 2020a; Jaubert et al., 2022). They are also potentially responsible for figurative artefacts and musical instruments (Chase and Nowell, 1998; Otte, 2000; Marquet and Lorblanchet, 2003; Morley, 2006; Soressi and D'Errico, 2007; Zilhão, 2007; Tuniz et al., 2012; Rodríguez-Vidal et al., 2014; Diedrich, 2015).

The question of why Neanderthals disappeared remains a topic of debate, with several hypotheses suggesting a range of causes, including technological and cognitive competition between groups, demographic pressures, and environmental factors, as well as the potential interactions between these causes (Vaesen et al., 2021). Genetic studies

indicate interbreeding occurred between Neanderthals and *Homo sapiens* before the disappearance of Neanderthals (Fu et al., 2015; Hajdinjak et al., 2021). The occurrence of interbreeding may also suggest the possibility of cultural exchange. However, identifying traces of this cultural interchange is exceptionally challenging. Primarily, it is not possible to determine the species of the makers based solely on the lithic material. Secondly, many sites contain only lithic evidence, and few have lithic materials associated with human fossils that could help determine the species. This complicates the establishment of a clear connection between a specific human group and their technological outputs. This difficulty in associating specific biological species with their respective techno-complexes impacts our understanding of the bio-cultural dynamics during the transition from the Middle to Upper Palaeolithic.

1.2. Was the Late Mousterian in Italy a Uniform or Fragmented Techno-Complex?

The Italian Peninsula has played a significant role in the ongoing discourse regarding the late Middle Palaeolithic period. In Italy, the Mousterian tradition has been conventionally attributed solely to Neanderthals, based on the co-occurrence of Mousterian lithic assemblages and Neanderthal fossils (Palma di Cesnola, 1996). This association has been established at various archaeological sites across Italy, such as Buca del Tasso (Cotrozzi et al., 1985), Grotta delle Fate (Giacobini et al., 1984), Grotta Fumane (Benazzi et al., 2014), Riparo Tagliente (Arnaud et al., 2016), Grotta Nadale (Arnaud et al., 2017), Grotta Breuil (Manzi and Passarello, 1995), Grotta del Fossellone (Mallegni, 1992), Grotta Guattari (Arnaud et al., 2015), Riparo del Molare (Mallegni and Ronchitelli, 1987), Grotta del Cavallo (Messeri and Palma di Cesnola, 1967; Fabbri et al., 2016), Grotta del Bambino (Blanc, 1962a; 1962b), Grotta Taddeo (Benazzi et al., 2011b), Riparo del Broion (Romandini et al., 2020b), and Grotta di Roccia San Sebastiano (Oxilia et al., 2022).

Due to its unique geographical characteristics, Italy – a long and narrow landmass framed by the Mediterranean Sea, situated at the edge of the European continent, and only a few kilometres away from the coasts of Africa and the Balkans – may have functioned as a cul-de-sac in the complex dynamics of human and animal migrations. It is possible that, because of its location, Italy served as a refuge during glacial periods. A "refugium" refers to an environment with favourable conditions that supported both humans and animals during challenging times (Jochim, 1987). The Iberian Peninsula, the Italian Peninsula, and the Balkan Peninsula in southern Europe are now widely recognised as glacial refugia during the Palaeolithic period (Jones, 2022). The Italian Peninsula, in particular, holds a strategic position at the heart of the Mediterranean Sea and boasts diverse internal sub-regions and microhabitats due to its varied physiographic features, including significant geomorphological and vegetational diversity (Badino et al., 2020).

The concept of a refugium is crucial for understanding the evolution of culture and technologies, as ecological changes often led to the migration and extinction of animal species. These shifts in fauna had a profound impact on the daily lives of Palaeolithic people, likely driving them to enhance their technological expertise. Additionally, Italy's landscape is characterised by remarkable variability and fragmentation, encompassing the Apennine Mountain range – which divides the peninsula from north to south – hilly and flat terrains, and extensive coastal regions along its entire length, bordered by the Ionian, Adriatic, and Tyrrhenian Seas. These geomorphological features contributed to a diverse array of available resources and resulted in a mosaic-like pattern of human settlement across the peninsula over time. The situation becomes even more complex when considering the region of Puglia in southern Italy.

Puglia possessed a unique context due to its location in the far southeastern corner of Italy. It served as a crossroads between several distinct areas in southern Italy: the southern Salento region, the northern Puglia area encompassing Murge and the Gargano promontory, and the Gulf of Taranto along with the Basilicata region. Additionally, this location is in close proximity to the coasts of Greece and Albania, which facilitated the dispersion and early arrivals of cultures associated with the first groups of *Homo sapiens*, specifically the Uluzzian culture, dating back to around 44,000 years BP (Benazzi et al., 2011a; Higham et al., 2014; Moroni et al., 2018; Marciani et al., 2020a; Rossini et al., 2022).

It is conceivable that *Homo sapiens* arrived in southern Italy after Neanderthals had already left the region (Higham et al., 2024). In fact, the most recent Neanderthal fossil found in the late Mousterian deposit of Roccia San Sebastiano Cave in Mondragone, Italy, is dated to around 45,000-44,000 years BP (Oxilia et al., 2022). Meanwhile, the oldest *Homo sapiens* fossil appears to fall within the range of 44,000-43,000 years BP, based on current information from the Uluzzian levels of Grotta del Cavallo (Benazzi et al., 2011a). Even more recent are the dates for a second *Homo sapiens* deciduous tooth, possibly from the Uluzzian levels of Roccia San Sebastiano, dating back to 43,000-42,000 years BP (Oxilia et al., 2022).

To fully comprehend this pivotal period, particularly given Italy's dual role as both a refuge for standing populations and a crossroads for incoming groups due to its varied geomorphology, it is essential to explore the characteristics of the last Neanderthal techno-complexes. This study examines the final aspects of the Mousterian culture, focusing on its material culture, particularly lithic evidence. I intentionally avoid comparing these findings with techno-complexes from the Middle to Upper Palaeolithic transition. Instead, my research centres on the conclusive phases of the Middle Palaeolithic, evaluating the variability within the Mousterian to understand its continuities and discontinuities.

This monograph investigates Neanderthal stone tool production, with a particular focus on the adaptability of the Levallois concept of debitage through an analysis of lithic assemblages from a key Middle Palaeolithic site in Italy: Oscurusciuto rockshelter. The goal is to place the evidence of Oscurusciuto within the broader Italian Mousterian framework and to provide a concise overview of the wider European scenario.

1.3. Are There Continuities or Discontinuities in Technology at Oscurusciuto Rockshelter?

Oscurusciuto rockshelter is a crucial site for understanding the technology, subsistence and settlement strategies of Neanderthals. This rockshelter offers a long, reliable deposit, approximately 6 metres in depth, comprising several levels of Middle Palaeolithic occupation. The series investigated thus far (from SU 1 to SU 15) range between 42,724±716 cal BP (Beta 181165 AMS) (SU 1) (Boscato and Crezzini, 2012) and 55 ± 2 kyrs (40Ar/39Ar) (SU 14 – tephra identified as the Mount Epomeo Ischia green tuff (Marciani et al., 2020b).

What makes Oscurusciuto particularly valuable for research is its status as a closed system within a well-defined space. The rockshelter provides a rich supply of knappable lithic raw materials in the nearby Ginosa ravine and evidence of prey hunted in the vicinity. Additionally, it offers a relatively narrow timeframe spanning from 42,000 to 55,000 years BP. Moreover, extensive previous research conducted at the site, dating back to 1998, has covered various aspects such as lithics, faunal remains, spatial organisation, and hearths (Boscato et al., 2004; Ranaldo, 2005; Boscato and Ronchitelli, 2006; 2017; Villa et al., 2009; Ronchitelli et al., 2011; 2014; Boscato and Crezzini, 2012; Spagnolo, 2013; 2017; Marciani, 2013; 2018; Spagnolo et al., 2016; 2019; 2020a; Marciani et al., 2016; 2018; 2020b; Ranaldo et al., 2017; Martini et al., 2020).

At Oscurusciuto, we have a unique opportunity to study Neanderthal occupation over time within a single location, all of which is set against a clearly defined chronological framework. This site features four structurally distinct levels, each presenting different archaeological evidence and patterns of occupation. Within these confines, this study aims to identify, from a diachronic perspective, the continuities and discontinuities between these lithic complexes. Thus, this research comprises the integrated study of the lower section of the series investigated at the Oscurusciuto rockshelter: SU 15, SU 14, SU 13, and SU 11. These stratigraphic units are particularly important in the reconstruction of Neanderthal behaviour, as each has yielded decisive material showing peculiarities in terms of structural elements, spatial management, type of occupation, and lithic production systems.

For instance, SU 15 represents a living floor with signs of abandonment, marked by stone alignments defining two structures, and is sealed by the deposition of the SU 14 tephra. SU 14 is a relatively sterile layer composed of approximately 60 cm of volcanic ash, with traces of brief visitation located just below the top of the layer. SU 13 is a short palimpsest, representing the first stable re-occupation of the site after the environmental impact caused by the volcanic ash deposition. In this layer, 10 aligned hearths were found, which divide the site into areas devoted to different activities. The overlying SU 11 is a palimpsest about 30 cm thick, characterised by the superimposition of numerous hearths.

The specific goal of this study is to address a set of questions regarding the lithic production at Oscurusciuto. What role does lithic production play in these four levels? Do the lithic complexes share recurring elements, and if so, why? Do they exhibit divergent features, and what do these differences signify? What were the intentions and/or necessities driving the variability in these lithic complexes? To address these questions, an integrated study of the lithic material will be conducted, encompassing descriptions of the economic behaviour related to the identification, acquisition, and exploitation of lithic raw materials. Additionally, the study will delve into the phases of the reduction sequence, defining the concepts, methods, dynamics, and objectives of the debitage. This technological analysis will be applied to all four levels: SU 15, SU 14, SU 13, and SU 11; encompassing a total of 48,382 items studied.